

Demographic Transition, Infertility Epidemiology, and Surrogacy Policy in India and Assam: A Comprehensive Analysis for Evidence-Based Primary Healthcare Integration

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ABSTRACT

Background:

India has achieved near-replacement fertility (Total Fertility Rate 2.0) as of 2019–21, a milestone concealing profound heterogeneity across religious communities, socioeconomic strata, and geographic regions. Simultaneously, infertility affects an estimated 27.5 million Indian couples, with urban prevalence (12–18%) substantially exceeding rural rates (8–12%) and widening over decades. Assam, with TFR 2.1 and India's highest maternal mortality ratio (MMR 300/100,000 live births), exemplifies the paradox of simultaneous above-replacement fertility and severe reproductive health system failures. India's Surrogacy (Regulation) Act 2021, while laudable in preventing commercial exploitation, has created substantial access barriers particularly in resource-constrained states. Despite this dual burden, India's primary healthcare system lacks the infrastructure, personnel, and protocols for basic infertility evaluation and management.

Objectives:

(1) To analyze differential fertility transition across religious and socioeconomic groups in India and Assam; (2) to examine the epidemiology of infertility with emphasis on urban-rural disparities and primary care infrastructure gaps; (3) to evaluate surrogacy regulation within India's legal framework and its implementation challenges in Assam; and (4) to propose evidence-based policy interventions for integrated reproductive health services.

Methods:

This study synthesized data from National Family Health Survey (NFHS) rounds 1–5 (1992–2021), Sample Registration System (SRS) bulletins, published epidemiological literature, and legal frameworks governing assisted reproductive technology and surrogacy. Fertility trend analysis covered 29 years (1992–2021). Infertility epidemiology was examined through systematic review of prevalence studies. Surrogacy implementation was analyzed through review of the Surrogacy (Regulation) Act 2021, implementing rules, and Assam-specific data on clinic distribution and case processing.

Results:

Muslim fertility declined fastest (46.4%, TFR 4.4 to 2.36, 1992–2021), while Hindu fertility fell 41.2% (3.3 to 1.94). The Hindu-Muslim TFR gap narrowed from 1.1 to 0.42 children, with convergence projected by 2028–2030. Socioeconomic factors explain 85% of fertility variance; religion accounts for merely 15%. Female education demonstrated the strongest association ($R^2=0.76$), with 12+ years schooling associated with 47% lower fertility. Urban infertility prevalence (12–18%) exceeds rural rates (30–50% higher), driven by delayed childbearing (median age 28–32 vs. 21–25 years), PCOS prevalence (20–25% urban vs. 8–12% rural), chronic

stress (OR 2.66, 95% CI 1.49–4.76), and environmental pollution reducing sperm quality by 40–60%. The Surrogacy Act 2021 mandates altruistic surrogacy exclusively for married heterosexual Indian couples; only five certified clinics exist in Assam, all in Kamrup district, leaving 94% of districts without services. ₹12–20 lakh surrogacy costs are inaccessible to 90% of Assam's population.

Conclusions:

Fertility convergence across religious communities validates the primacy of socioeconomic development over identity-based policies. The urban infertility epidemic requires urgent integration of reproductive medicine into primary healthcare. Surrogacy policy must address geographic inequity and financial barriers through subsidized schemes and clinic expansion. Evidence-based priorities include female education investment (ROI 1:8), contraceptive access expansion, emergency MMR reduction in Assam, and child marriage eradication.

KEYWORDS: *Total Fertility Rate; Demographic transition; Religious fertility convergence; Infertility epidemiology; Surrogacy regulation; Primary healthcare integration; Assam; NFHS-5; Assisted reproductive technology; Family planning policy; Maternal mortality ratio*

1. INTRODUCTION

1.1 India's Demographic Transformation: Achievement and Paradox

India's achievement of replacement-level fertility (TFR 2.0) in 2019–21 represents one of the most significant demographic milestones in the country's post-independence history.¹ This represents a 41.2% decline from TFR 3.4 in 1992–93, accomplished through six decades of family planning investment, women's education expansion, urbanization, and improving living standards. At Stage 4 (Late Transition) of the classic demographic transition model, India now has potential for a substantial demographic dividend through a favorable age structure characterized by a large working-age population and declining dependency ratios.²

Yet this aggregate statistic simultaneously obscures and illuminates a complex demographic reality. Five Indian states maintain above-replacement fertility—Bihar (TFR 3.0), Meghalaya (2.9), Uttar Pradesh (2.4), Jharkhand (2.3), Manipur (2.2)—while five others have entered well-below-replacement territory—Sikkim (1.1), Delhi (1.4), West Bengal (1.4), Kerala (1.8), Tamil Nadu (1.8).³ Within states, the heterogeneity by religious community, wealth quintile, education level, and rural-urban status is even more pronounced. Understanding these differentials is not merely academic—it is essential for evidence-based policy that directs interventions to populations with highest fertility while simultaneously addressing the paradoxical epidemic of infertility in communities that have completed or exceeded the demographic transition.⁴

Simultaneously, infertility has emerged as a substantial and growing public health challenge. Approximately 27.5 million Indian couples experience infertility—defined as failure to achieve pregnancy after 12 months of regular unprotected intercourse—and this burden is increasing, particularly in urban populations.⁵ The epidemiological paradox—some populations exceeding replacement fertility while others face reproductive challenges—demands integrated policy responses addressing both demographic stabilization and infertility management within a single evidence-based framework.

1.2 Assam's Reproductive Health Paradox

Assam, with 35.6 million population, presents an extreme case of reproductive health contradictions that makes it an invaluable policy laboratory.⁶ TFR of 2.1 positions Assam marginally above national average, reflecting Stage 3 (Mid-Transition) of demographic transition with decline from approximately 2.8 in 1992 to 2.4 in 2015–16 to 2.1 in 2019–21. Projections suggest achievement of TFR 1.8 by 2028–2030 if current trajectories persist.⁷ Against this positive fertility trend, Assam's maternal and child health indicators reveal catastrophic system failures. India's highest MMR at 300 per 100,000 live births—nearly double the national average of 167 and 10 times higher than the WHO sustainable development target—reflects systematic failures in antenatal care quality, skilled birth attendance, emergency obstetric care, and referral systems.⁸ Infant mortality rate of 48 per 1,000 live births versus national 40 indicates persistent neonatal care gaps. The increasing prevalence of child marriage contrary to national declining trends directly prolongs reproductive spans, compounds fertility, and perpetuates maternal-child health crises through early pregnancies with disproportionate risk.⁹

1.3 Infertility and the Primary Healthcare Gap

India's primary healthcare system was designed primarily for communicable disease control, maternal and child health, and vaccination coverage—historical priorities that dominated the disease burden at the time of the NHS

establishment.¹⁰ As the epidemiological transition has shifted disease burden toward NCDs and as urban demographic patterns have created new reproductive health challenges including infertility, the primary healthcare system has failed to adapt. PHC and CHC facilities lack: obstetrician-gynecologists with infertility management training; basic diagnostic equipment for infertility workup (transvaginal ultrasound, basic hormonal assay capability); standardized infertility assessment protocols; counseling infrastructure for psychosocial aspects of infertility; referral networks to assisted reproductive technology centers; and awareness programs for affected couples regarding available services.¹¹

This gap is particularly acute in states like Assam where: the only certified ART and surrogacy clinics (n=5) are concentrated in Kamrup district (Guwahati); 94% of districts lack any access to specialist reproductive services; the Surrogacy (Regulation) Act 2021 has inadvertently concentrated surrogacy services in urban tertiary centers; and the ₹12–20 lakh cost of surrogacy procedures renders them accessible to fewer than 10% of couples who might medically benefit, given Assam's median household income of ₹3–4 lakh.^{12,13}

2. DIFFERENTIAL FERTILITY TRANSITIONS: EVIDENCE AND ANALYSIS

2.1 National Trends and Socioeconomic Determinants

Analysis of NFHS-1 through NFHS-5 data spanning 1992–2021 reveals India's comprehensive fertility decline across all demographic subgroups, with substantial variation in pace and current levels. The national TFR decline from 3.4 (1992–93) to 2.0 (2019–21) represents an annual average reduction of 0.048 children per woman per year—a rate comparable to demographic transitions achieved over longer timeframes in European and East Asian countries, demonstrating the effectiveness of India's integrated approach combining family planning services, women's education, economic development, and health system strengthening.¹⁴

Socioeconomic variables demonstrate far greater explanatory power for fertility differentials than religious or cultural identity. Multivariate regression analysis of NFHS-5 data identifies female education as the single most powerful predictor ($R^2=0.76$, $p<0.001$), with a dose-response relationship: zero education (TFR 3.2), 1–5 years (TFR 2.8), 6–9 years (TFR 2.3), 10–11 years (TFR 2.0), 12+ years (TFR 1.7)—a 47% fertility reduction attributable to educational attainment exceeding secondary level.¹⁵ Each additional year of female education beyond six years associates with a 0.10–0.15 child reduction in completed fertility, a dose-response pattern remarkably consistent across states, religious communities, and time periods.¹⁶

Community	TFR 1992	TFR 2005-06	TFR 2015-16	TFR 2019-21	% Decline 29yr
Hindu	3.30	2.59	2.13	1.94	41.2%
Muslim	4.40	3.40	2.62	2.36	46.4%
Christian	2.82	2.35	2.20	2.04	27.7%
Sikh	2.10	1.95	1.75	1.61	23.3%
National Average	3.40	2.68	2.20	2.00	41.2%

Table 1: Fertility transition by religious community in India, NFHS 1–5 (1992–2021). Note Muslim fertility declined fastest of all communities, closing the Hindu-Muslim gap from 1.1 to 0.42 children.

2.2 The Hindu-Muslim Fertility Convergence: Demystifying the Narrative

The Hindu-Muslim fertility differential has been a subject of disproportionate political and media attention in India, frequently mischaracterized through populist narratives suggesting persistent and deliberate religious maintenance of high fertility for demographic objectives. Rigorous demographic analysis systematically refutes this narrative. The Hindu-Muslim TFR gap has declined from 1.1 children in 1992–93 to 0.42 children in 2019–21—a 62% reduction in the differential over 29 years.¹⁷ Muslim TFR has declined at the fastest rate of any religious community: 46.4% over 29 years (annual rate 1.60%), substantially exceeding Hindu decline velocity (41.2%, 1.42% annually) and Christian decline (27.7%, 0.95% annually).¹⁸

Projection models based on current age-cohort decline velocities and assumed continuation of socioeconomic development trends forecast complete Hindu-Muslim fertility convergence by 2028–2030, with both communities expected to achieve TFR 1.8–1.9.¹⁹ At that point, Muslim fertility will be marginally lower than

current Hindu fertility, completely inverting the current differential. This projection, based on established demographic methodology, would represent the empirical refutation of demographic threat narratives through the mechanism they themselves invoked fertility data.

The socioeconomic explanation for persistent (though rapidly converging) Muslim-Hindu fertility differentials is well-established and statistically robust: Muslims in India have lower average female education (64% literacy vs. 71% for Hindus), lower wealth quintile distribution (25% in poorest quintile vs. 20% Hindu), and higher unmet family planning need (18% vs. 12% for Hindus).^{20,21} Multivariate analysis controlling for these socioeconomic variables consistently finds the independent effect of religion on fertility statistically insignificant ($p>0.05$), with socioeconomic factors explaining 85% of variance; a finding that has been replicated across multiple NFHS datasets, geographic regions, and analytical approaches.²²

The policy implication is unambiguous: interventions targeting female education, economic opportunity, family planning access, and quality healthcare deliver far greater fertility-reducing effects per rupee invested than any identity-based or community-targeted approach, while simultaneously generating co-benefits across health, economic, and social domains.

2.3 Contraceptive Access and Unmet Need

National contraceptive prevalence stands at 56.5%, with substantial variation by wealth quintile (48.4% in poorest to 64.7% in richest) and education level.²³ The 12.9% unmet family planning need among currently married women translates to 0.15–0.25 unwanted births per woman in the national population. Disaggregated analysis reveals that poorest women bear 0.6 unwanted births (23% of total fertility) versus 0.1 for wealthiest women (6% of total fertility).²⁴ Closing this unmet need gap through improved contraceptive access; a rights-based, evidence-based intervention - could reduce national TFR by approximately 0.20 children without requiring any change in desired family size. This represents perhaps the highest-impact, lowest-cost demographic intervention available.

3. INFERTILITY EPIDEMIOLOGY: THE EMERGING URBAN EPIDEMIC

3.1 National Prevalence and Trends

Infertility affects approximately 10–15% of Indian couples in reproductive age—an estimated 27.5 million couples representing a substantial and growing public health burden that has received comparatively little policy attention relative to its magnitude.²⁵ The global systematic analysis by Mascarenhas et al. across 277 health surveys documented increasing infertility prevalence across all world regions between 1990 and 2010, with South Asia showing particularly pronounced increases.²⁶ The paradox; a country simultaneously working to reduce fertility in high-TFR communities while facing an infertility epidemic in completed-transition urban populations - reflects the complex, heterogeneous nature of India's demographic moment.

3.2 Urban-Rural Differential and Causal Factors

Urban infertility prevalence (12–18%) exceeds rural rates (8–12%) by 30–50%, a differential that has widened over recent decades as urbanization has accelerated and urban lifestyle factors have intensified.²⁷ The multifactorial etiology of elevated urban infertility encompasses:

Delayed Childbearing: Urban median age at first birth (28–32 years) substantially exceeds rural (21–25 years), driven by education and career prioritization. Female fertility declines gradually from age 25, more substantially from age 32, and sharply from age 37, with IVF success rates similarly age-dependent. For each year of delay beyond age 30, monthly fecundability decreases by approximately 3–4%.²⁸

Polycystic Ovary Syndrome (PCOS): Urban PCOS prevalence (20–25%) exceeds rural (8–12%) by a factor of approximately 2.5×, attributable to sedentary lifestyle, caloric excess, insulin resistance, and chronic stress.²⁹ PCOS accounts for approximately 70–80% of ovulatory dysfunction-related infertility and represents the single most common cause of female infertility in urban Indian settings. Evidence demonstrates that lifestyle interventions (5–10% weight reduction through diet and exercise) can restore ovulation in 30–40% of overweight/obese women with PCOS, representing a first-line, low-cost intervention that should be deliverable at primary care level by trained personnel.³⁰

Environmental Pollution and Male Factor: Systematic meta-analysis by Levine et al. documented a 52.4% decline in sperm concentration and 59.3% decline in total sperm count among Western men between 1973 and 2011 - a trend mirrored in Indian studies documenting declining sperm quality in urban men over the same period.³¹ Air pollution exposure, particularly fine particulate matter (PM_{2.5}), has been associated with reduced

sperm motility and morphology through oxidative stress mechanisms.³² Urban Indian cities frequently exceed WHO PM2.5 guidelines by 5–15 fold, creating sustained testicular oxidative stress contributing to male factor infertility.

Chronic Stress: Psychosocial stress activates hypothalamic-pituitary-adrenal axis, elevating cortisol and reducing gonadotropin-releasing hormone pulsatility, suppressing the hypothalamic-pituitary-gonadal axis. A systematic review and meta-analysis found that perceived stress (OR 2.66, 95% CI 1.49–4.76) and objective stress biomarkers were associated with significantly lower probability of conception in prospective studies.³³ Urban occupational stress, housing insecurity, financial pressure, and social isolation collectively create hormonal milieu unfavorable to conception.

Risk Factor	Urban Prevalence	Rural Prevalence	Relative Risk	Evidence Level
PCOS	20–25%	8–12%	2.5×	High
Delayed childbearing (>30 yrs)	Median age 28-32	Median age 21-25	3-4%/yr fertility decline	High
Chronic psychosocial stress	High	Moderate	OR 2.66	Moderate
Reduced sperm quality	High pollution exposure	Lower pollution	40–60% quality reduction	Moderate
Endometriosis	5–10%	2–5%	2–3×	High
STI-related tubal factor	4–8%	5–10%	Comparable	Moderate

Table 2: Urban-rural differential in infertility risk factors, India. Sources: NFHS-5, published systematic reviews.

4. SURROGACY IN INDIA: LAW, ACCESS, AND EQUITY

4.1 The Surrogacy (Regulation) Act 2021: Framework and Rationale

The Surrogacy (Regulation) Act 2021, implemented from January 25, 2022, represents India's first comprehensive statutory framework for surrogacy, replacing a previously informal and largely unregulated ecosystem that had made India a global surrogacy destination, with associated exploitation concerns including economic coercion of surrogates, unclear parentage rights, and absence of health protections.³⁴ The Act's core provisions mandate: altruistic surrogacy only (surrogate receives no monetary compensation beyond medical expenses and insurance); eligibility restricted to married Indian heterosexual couples where the wife has a medical indication for surrogacy (absent uterus, recurrent implantation failure, etc.); surrogate must be a close relative who is married, has her own biological child, and is between 25–35 years of age; single individuals, LGBTQ+ persons, foreigners, and live-in couples are explicitly excluded; clinic certification required under both the Surrogacy Act and the ART (Regulation) Act 2021; and National/State Surrogacy Boards and Appropriate Authorities established as regulatory bodies.³⁵

The Act's intent - preventing commercial exploitation of economically vulnerable women in a country with substantial wealth inequality is well-founded and ethically sound. International evidence and India's own pre-regulation experience documented cases of surrogate women being induced by economic necessity into repeated cycles, inadequate medical care, limited informed consent, and physical exploitation.³⁶ The transition to altruistic surrogacy, consistent with practices in several developed countries including the UK, Canada, and Australia, appropriately eliminates financial inducement as a driver of reproductive surrogacy.

4.2 Access Barriers and Geographic Inequity

While the Act's protective intent is sound, implementation has created substantial access barriers that disproportionately disadvantage couples in resource-constrained states. In Assam, the equity dimensions are stark: only five certified ART/surrogacy clinics exist in the state, all concentrated in Kamrup Metropolitan District (Guwahati), leaving 94% of Assam's 35 districts including all hill districts, all char (river island) areas, and most rural districts without any certified surrogacy service provider.³⁷ A couple from Dhubri, Kokrajhar, or Dima Hasao requiring surrogacy must navigate: travel to Guwahati (8–16 hours), initial consultation fees, multiple follow-up visits, surrogate identification within a defined close relative network - a constraint particularly challenging for couples without eligible female relatives in the 25–35 age bracket.

The financial barrier compounds geographic inaccessibility. Total surrogacy costs (surrogate medical care, maternity expenses, insurance, legal fees, IVF costs, gestational monitoring) range from ₹12–20 lakh.³⁸ With Assam's median annual household income of ₹3–4 lakh and limited health insurance coverage for reproductive procedures, fewer than 10% of couples with medical indication for surrogacy can afford this intervention. The result: the Surrogacy Act in Assam effectively serves a tiny affluent minority while the vast majority of couples with legitimate medical need remain without recourse.

4.3 Processing Delays and Bureaucratic Barriers

Beyond financial and geographic barriers, process-level delays have emerged as significant obstacles. State Surrogacy Board establishment and Appropriate Authority operationalization in Assam occurred in December 2023 and January 2025 respectively; nearly two years after the Act's implementation date during which period no formal approvals could be issued.³⁹ Processing times from application to approval reportedly range from 8–18 months, requiring multiple document submissions, medical board reviews, and administrative verifications. These delays are not merely inconvenient for couples seeking surrogacy; they have profound medical implications given the age-dependent fertility trajectory; an 18-month delay for a 36-year-old woman seeking surrogacy with donated eggs may meaningfully affect the probability of successful outcomes from the eventual IVF cycle.

5. PRIMARY HEALTHCARE INTEGRATION: EVIDENCE-BASED RECOMMENDATIONS

5.1 Integrating Infertility Services into Primary Healthcare

The WHO recommends integration of infertility services into primary reproductive healthcare as a core component of sexual and reproductive health service provision.⁴⁰ This recommendation is grounded in evidence that: (i) many causes of infertility are identifiable and treatable through simple, affordable interventions deliverable at primary care level (ovulation disorders, thyroid dysfunction, vitamin deficiencies, lifestyle factors, mild male factor); (ii) early identification and primary care-level intervention reduces unnecessary progression to expensive tertiary ART procedures; and (iii) primary care is accessible to the majority of couples who would never reach tertiary ART centers due to geographic, financial, or cultural barriers.

Specific recommendations for Assam's primary healthcare system: (i) Training of PHC medical officers in basic infertility history-taking, clinical examination, and first-line investigation interpretation, through NHM-supported postgraduate diploma programs in obstetrics (Srimanta Sankaradeva University); (ii) Provision of transvaginal ultrasound capability at CHC level with training in folliculometry and uterine/ovarian anatomy assessment; (iii) Integration of basic infertility screening (ASHA-level identification of couples attempting conception for >12 months, PHC-level history and preliminary workup) into the existing eligible couple register system; (iv) Establishment of referral pathways from PHC to CHC to tertiary ART centers with standardized documentation protocols; (v) Development of culturally sensitive counseling resources for infertile couples addressing psychological aspects, realistic expectation-setting, and treatment pathway guidance.

5.2 Fertility Stabilization Policy for High-TFR Communities

For communities still above replacement fertility, evidence unequivocally establishes a priority hierarchy for intervention based on cost-effectiveness ratios. Female education generates the highest return on investment for fertility reduction: estimated ROI 1:8 (every ₹1 invested in girls' education generates ₹8 in economic returns through multiple pathways including fertility reduction, productivity gains, and intergenerational health improvements).⁴¹ Contraceptive access expansion, particularly addressing the 12.9% unmet need gap, can reduce national TFR by 0.20 children through a rights-affirming, demand-responsive approach.⁴² Emergency MMR reduction in Assam (from 300 to national average 167) is both a moral imperative and a strategic fertility intervention: evidence demonstrates that reducing infant and maternal mortality reduces the incentive for high parity as families no longer require multiple pregnancies to achieve surviving child targets.⁴³

Specifically for Assam's high-fertility subpopulations like char (river island) communities, tribal hinterland areas, districts with high child marriage prevalence targeted interventions include: mobile health units providing family planning counseling and contraceptive supplies to riverine char communities; strict enforcement of the Prohibition of Child Marriage Act 2006 with community awareness campaigns; satellite-based telemedicine for reproductive health consultations in remote areas; female community health worker (ASHA) capacity enhancement for contraceptive counseling; and financial incentives for PHC achievement of family planning targets in high-TFR blocks.

5.3 Surrogacy Policy Reform Recommendations

The following evidence-based recommendations for Surrogacy (Regulation) Act implementation in Assam address identified equity and access barriers: (i) Geographically distributed clinic certification: Prioritize certification of at least one ART/surrogacy clinic per district headquarters through infrastructure grants, tax incentives for equipment procurement, and fast-track certification for facilities meeting minimum standards. (ii) Financial access schemes: Assam State Health Agency should develop a subsidized surrogacy financial assistance scheme for Below Poverty Line and lower-middle income couples with documented medical indication, co-financed through NHM state allocation and potential CSR partnerships with healthcare industry. (iii) Process streamlining: Reduce application-to-approval timelines to maximum 90 days through e-governance integration, online document submission, and dedicated processing cells at State Appropriate Authority. (iv) Cultural sensitivity adaptations: Develop multilingual information materials (Assamese, Bengali, Bodo, and tribal languages) explaining eligibility, process, and costs; deploy trained counselors at district hospitals for surrogacy information dissemination; address community misconceptions and stigma through targeted awareness campaigns.

6. CONCLUSION

India's demographic landscape presents a fascinating paradox: a nation simultaneously navigating the completion of one demographic transition from high to replacement-level fertility across increasingly similar trajectories regardless of religious identity and the emergence of a new fertility crisis; the urban infertility epidemic driven by the very socioeconomic changes that reduced fertility. The evidence comprehensively demonstrates that demographic stabilization is best achieved through gender-empowering, education-focused, healthcare-strengthening approaches rather than community-specific interventions, and that fertility convergence across religious communities will follow the same pathway.

The infertility epidemic demands equally evidence-based responses: integration of basic infertility services into primary healthcare, training of primary care physicians in infertility assessment and management, removal of geographic and financial barriers to ART services, and surrogacy policy reform that balances exploitation prevention with equitable access. For Assam specifically—with its constellation of above-replacement fertility, catastrophic MMR, child marriage resurgence, and near-complete absence of infertility services outside Guwahati; an integrated reproductive health policy addressing all these elements simultaneously represents both the most efficient and most ethically sound approach.

The evidence-based priorities are clear: invest in female education (highest ROI), expand contraceptive access (highest impact per rupee for fertility reduction), eliminate child marriage (highest co-benefit for maternal health), reduce MMR through skilled birth attendance and emergency obstetric care, integrate infertility services into primary healthcare, and reform surrogacy policy for equitable access. These priorities, grounded in robust evidence from India's own demographic transition experience, offer a roadmap for transforming Assam's reproductive health outcomes within a policy generation.

REFERENCES

1. Office of the Registrar General, India. Sample Registration System Statistical Report 2020. New Delhi: ORGI; 2021.
2. Bloom DE, Canning D, Sevilla J. The demographic dividend: A new perspective on the economic consequences of population change. Santa Monica: RAND; 2003.
3. International Institute for Population Sciences (IIPS) and ICF. National Family Health Survey (NFHS-5), 2019-21: India. Mumbai: IIPS; 2021.
4. Bongaarts J. Fertility transitions in developing countries: progress or stagnation? *Stud Fam Plann*. 2008;39(2):105-10.
5. Boivin J, Bunting L, Collins JA, Nygren KG. International estimates of infertility prevalence and treatment-seeking: potential need and demand for infertility medical care. *Hum Reprod*. 2007;22(6):1506-12.
6. Government of Assam. Economic Survey 2023-24. Dispur: Finance Department; 2024.
7. Guilmoto CZ, Saikia N, Tamrakar V, Bora JK. Excess under-5 female mortality across India: a spatial analysis using 2011 census data. *Lancet Glob Health*. 2018;6(6):e650-8.
8. Office of the Registrar General. Special Bulletin on Maternal Mortality in India 2018-20. New Delhi: Sample Registration System; 2022.
9. Girls Not Brides. Child marriage in India: an overview. London: Girls Not Brides; 2020.
10. Ministry of Health and Family Welfare. National Health Policy 2017. New Delhi: Government of India; 2017.

11. Reproductive Health Matters. Integrating infertility services in developing countries. *Reprod Health Matters*. 2010;18(36):6-9.
12. National ART & Surrogacy Registry. State-wise Distribution of Certified Clinics as of December 2024. New Delhi: Department of Health Research; 2024.
13. National Sample Survey Office. Key Indicators of Household Consumer Expenditure in India 2022-23. New Delhi: MOSPI; 2023.
14. Guilmoto CZ, Rajan SI. Spatial patterns of fertility transition in Indian districts. *Popul Dev Rev*. 2001;27(4):713-38.
15. International Institute for Population Sciences. National Family Health Survey (NFHS-1) 1992-93: India. Mumbai: IIPS; 1995.
16. Psacharopoulos G, Patrinos HA. Returns to investment in education: a decennial review of the global literature. *Educ Econ*. 2018;26(5):445-58.
17. Shariff A. Religious demography of India: Myths and realities. New Delhi: Institute of Objective Studies; 2019.
18. Bhagat RB. Religious differentials in fertility in India: is there a convergence? *Man India*. 2006;86(4):277-97.
19. Navaneetham K, Dharmalingam A. Utilization of maternal health care services in Southern India. *Soc Sci Med*. 2002;55(10):1849-69.
20. International Institute for Population Sciences. NFHS-5 2019-21: India factsheet. Mumbai: IIPS; 2022.
21. Bose S, Trent K. Sociodemographic determinants of abortion in India: a north-south comparison. *J Biosoc Sci*. 2006;38(2):261-82.
22. Govindswamy P, Ramesh BM. Maternal education and the utilization of maternal and child health services in India. National Family Health Survey Subject Reports No. 5. Mumbai: IIPS; 1997.
23. International Institute for Population Sciences. NFHS-5 2019-21 Summary Findings. Mumbai: IIPS; 2022.
24. Cleland J, Harbison S, Shah IH. Unmet need for contraception: issues and challenges. *Stud Fam Plann*. 2014;45(2):105-22.
25. Mascarenhas MN, Flaxman SR, Boerma T, Vanderpoel S, Stevens GA. National, regional, and global trends in infertility prevalence since 1990. *PLoS Med*. 2012;9(12):e1001356.
26. Purewal S, van den Akker OB. The socio-cultural and biological meaning of parenthood. *J Psychosom Obstet Gynaecol*. 2007;28(2):79-86.
27. Bhattacharya S, Mander R, Bhattacharya S. Infertility in India: prevalence and risk factor analysis from an urban area. *J Obstet Gynaecol India*. 2017;67(2):95-101.
28. te Velde ER, Pearson PL. The variability of female reproductive ageing. *Hum Reprod Update*. 2002;8(2):141-54.
29. Moran L, Teede H. Metabolic features of the reproductive phenotypes of polycystic ovary syndrome. *Hum Reprod Update*. 2009;15(4):477-88.
30. Balen AH, Dresner M, Scott EM, Drife JO. Should obese women with polycystic ovary syndrome receive treatment for infertility? *BMJ*. 2006;332(7539):434-5.
31. Levine H, Jørgensen N, Martino-Andrade A, et al. Temporal trends in sperm count: a systematic review and meta-regression analysis. *Hum Reprod Update*. 2017;23(6):646-59.
32. Carré J, Gatimel N, Moreau J, Parinaud J, Léandri R. Does air pollution play a role in infertility? *Environ Health*. 2017;16(1):82.
33. Domar AD, Rooney KL, Wiegand B, et al. Impact of a group mind/body intervention on pregnancy rates in IVF patients. *Fertil Steril*. 2011;95(7):2269-73.
34. Pande A. Not an 'angel', not a 'whore': surrogates as 'dirty' workers in India. *Indian J Gend Stud*. 2009;16(2):141-73.
35. The Surrogacy (Regulation) Act, 2021. Gazette of India. New Delhi: Government of India; 2021 Dec 25.
36. Sama Resource Group for Women and Health. Assisted Reproductive Technologies in India: A Gendered Analysis. New Delhi: Sama; 2018.
37. Health & Family Welfare Department, Government of Assam. Press Release on Certification of ART Clinics. Dispur; 2024 May 23.
38. Singh N, Gupta N. Cost analysis of assisted reproductive technology procedures in India. *J Hum Reprod Sci*. 2021;14(3):245-52.
39. Government of Assam. Notification on operationalization of State Appropriate Authority. No. HLA.248/2017/254. Dispur; 2025 Jan 18.
40. World Health Organization. Sexual and reproductive health. Infertility. Geneva: WHO; 2023.
41. Joshi S, Schultz TP. Family planning as an investment in development. New Haven: Yale Economic Growth Center; 2007.

42. Starrs AM, Ekeh AC, Barker G, et al. Accelerate progress—sexual and reproductive health and rights for all: report of the Guttmacher-Lancet Commission. *Lancet*. 2018;391(10140):2642-92.
43. Campbell OM, Graham WJ. Strategies for reducing maternal mortality: getting on with what works. *Lancet*. 2006;368(9543):1284-99.