

Birth Interval Trajectories during Fertility Transition in India, 1992–2021: Socio-Demographic Correlates and Regional Heterogeneity

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Birth Interval Trajectories during Fertility Transition in India, 1992-2021: Socio-Demographic Correlates and Regional Heterogeneity

Abstract:

India's fertility transition presents a striking paradox: the Total Fertility Rate (TFR) fell from 3.4 to 2.0 between 1992-93 and 2019-21, yet the median birth interval increased only marginally, from 31.6 to 32.7 months, a mere 1.1-month gain over nearly three decades at the national level and significantly uneven progress across states. About one quarter of births still occur within 24 months of a previous birth, underscoring that India's demographic transition remains incomplete in its qualitative dimensions. Using a 'person-period' format pooled birth history sample of women from all five rounds of the National Family Health Survey (NFHS) and de-normalized weights, this study employs complementary log-log (CLL) models to estimate parity progression ratios and birth interval trajectories alongside their time and region-fixed effect correlates, the first such comprehensive analysis in India. Birth order, maternal age, age at first birth, breastfeeding duration, household wealth, and education emerge as significant correlates. Pronounced regional heterogeneity is documented: southern, western, and north-eastern states experienced substantial birth interval lengthening, while central and northern states showed stagnation or contraction. The findings reveal that India's sterilization-centric family planning program has successfully reduced fertility quantum with a marginal improvement in optimal birth spacing, constituting an unfinished agenda for maternal health, child survival, nutrition, and women's reproductive agency.

Keywords: Birth Intervals; Fertility Transition; Family Planning; India; Complementary log-log regression model

1. Introduction

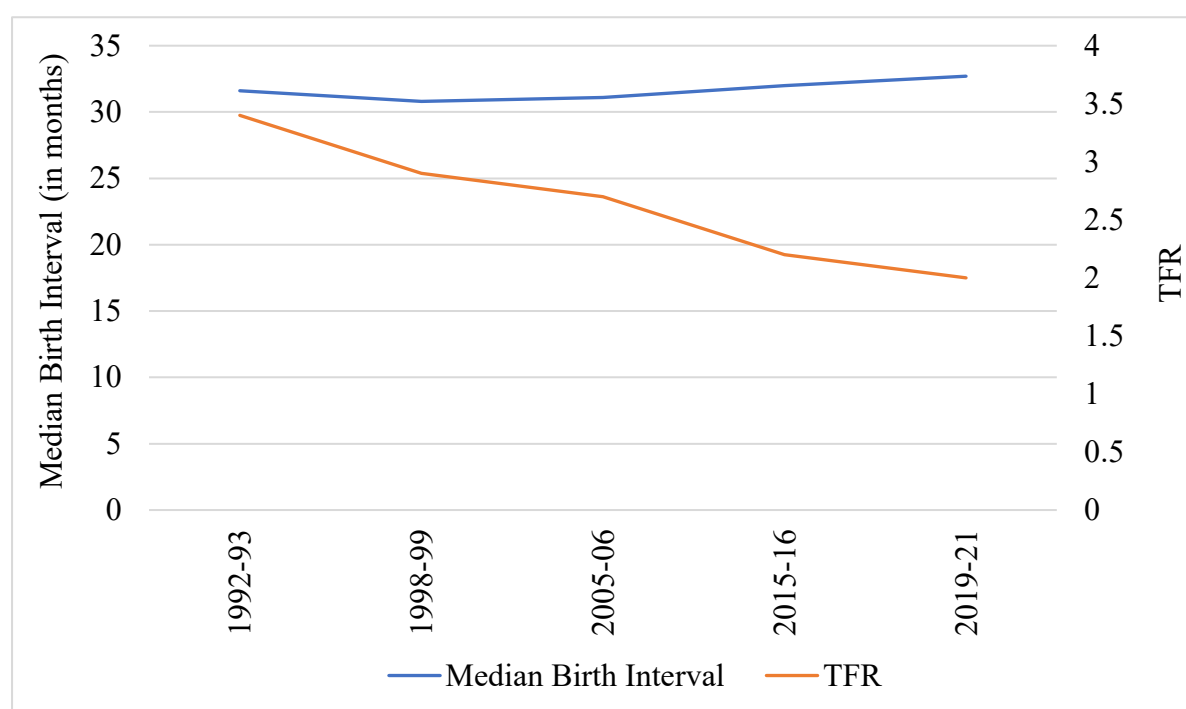
India's fertility transition has run alongside a birth spacing transition that is, at best, *partial* and *uneven*, varying markedly by birth order and region. Closing this gap, making the spacing transition as complete and equitable as the fertility transition, is India's next major demographic challenge. Birth intervals are a critical determinant of reproductive, maternal, child, and nutritional health outcomes. Short birth intervals (less than 24 months) are strongly linked to adverse outcomes, including higher maternal mortality, pregnancy complications like haemorrhage and anaemia, as well as increased risks of preterm births, infant mortality, child and maternal undernutrition (Rutstein, 2005; Conde-Agudelo et al., 2007, 2012; Shachar & Lyell, 2012; Gemmill & Lindberg, 2013; Casterline & Odden, 2016; Rana & Goli, 2018; Karra et al., 2022). Conversely, very long birth intervals (exceeding 60 months) are associated with risks such as preeclampsia and labor dystocia (Skjærven et al., 2002; Conde-Agudelo et al., 2007, 2012; Cecatti et al., 2008). Consequently, the World Health Organization recommends an optimal interval of 24 to 36 months between pregnancies to mitigate these risks (Marston, 2006). Unlike developed countries that completed fertility transitions at much lower infant mortality levels, India continues to experience relatively high childhood mortality (Khan et al., 2020). Despite a rapid decline in fertility, healthier birth spacing remains essential for advancing maternal, child health, and nutrition outcomes in the country (Rana et al., 2019). In this study, fertility transition is conceptualized as a multidimensional process involving not only the decline in fertility levels (measured by Total Fertility Rate [TFR]), but also changes in the timing, spacing, and progression of births.

Beyond health outcomes, the birth interval directly influences the *tempo* and *quantum* of fertility in a population and thereby women's agency (Bongaarts, 1999; Samari, 2017; Molitoris et al., 2019; Pörtner, 2022). According to Bongaarts' (1978) model, the physiological foundation of the birth interval comprises of four components: postpartum amenorrhea, the time from first ovulation to next conception, gestation, and the duration of any pregnancies ending in miscarriage or stillbirth. These biological factors, in turn, are influenced by a complex interplay of behavioral and socio-demographic determinants (Baschieri, 2004; Bhalotra & Soest, 2008; Aleni et al., 2020; Miller & Karra, 2020). While proximate behavioural factors like contraceptive use (which lengthens the interval) and breastfeeding practices (which can shorten it) are primary drivers, involuntary biological factors such as spontaneous abortion and maternal age also play a critical role (Casterline & Odden, 2016; Wood, 2017). These mechanisms are, in turn, strongly shaped by a broader socio-demographic context, including factors such as age at marriage and first birth, education, previous birth interval, gender preference, region, use

of contraception, wealth status, place of residence, religion, and exposure to mass media (Nath et al., 2000; Raj et al., 2010; Rabbi et al., 2013). People's culture, lifestyle (Caldwell et al., 1987, 1992), and socioeconomic conditions may differ according to the place of residence and administrative divisions (Rutstein, 2005), which may play a vital role in the distribution of birth intervals. In specific contexts like India, cultural dimensions such as son preference and existing family composition further exert a powerful influence on birth spacing decisions, making the determinants of birth intervals both multifaceted and context-dependent (Pörtner, 2022; Nath, 2023).

Figure 1: Trends and patterns in TFR and median birth intervals in India from 1990-91 to 2019-21

Source: Authors' estimates from the National Family Health Survey (DHS), India.



Note: Birth intervals are measured in months.

The usual complexities of lengthening birth intervals are exacerbated by the historical orientation of India's family planning program toward limiting fertility instead of promoting spacing (Srinivasan, 2017; Park et al., 2023; Shekhar et al., 2024). As a result, although the country has reduced its TFR, this success has been accompanied by uneven changes in birth spacing, creating a central demographic puzzle. This deviation is starkly revealed in national trends. For instance, India's TFR fell dramatically from 3.4 to 2.0, while the median birth interval increased marginally from 31.6 to 32.7 months, a mere 1.1-month increase over nearly three decades (*see* Figure 1), even as some states and regions saw substantial shifts in spacing patterns (Desai et al., 2022; Shekhar et al., 2024). Consequently, about a quarter of all births still occur within 24 months of a previous birth (IIPS and ICF, 2021), underscoring that India's fertility transition remains incomplete, particularly in terms of birth spacing and timing, despite achieving replacement level fertility. Thus, *partial* and *uneven* birth-spacing transition in birth spacing continues to hinder the full realization of improved maternal and child health outcomes, reproductive agency and gender dividend (Samari, 2017; Rana & Goli, 2021).

While the broad spatial patterns of India's fertility decline are well-documented (Jadhav, 2014; Singh et al., 2022; Park et al., 2023; Shekhar et al., 2024), the specific trajectories of birth intervals remain unclear. Although predictors of birth interval have been studied at specific points in time (Ajayi & Somefun, 2020; Belachwe et al., 2024) their transition patterns remain underexplored. To the best of our knowledge, no previous studies have comprehensively investigated these patterns or identified the time- and region-fixed effect correlates. This gap is particularly important given the incomplete nature of India's fertility transition, especially regarding birth spacing and timing. By jointly examining both national and state-level variation, this study highlights how aggregate patterns can mask substantial

regional heterogeneity in birth spacing. In this context, this study addresses a critical evidence gap by arguing that the next research and policy priority must shift from a singular focus on 'limiting' to a concerted effort to extend 'spacing' and 'timing' of births. Specifically, drawing on birth histories from five rounds of the National Family Health Survey (NFHS) restructured into a person-period format, we address three questions. (1) How have birth-interval trajectories changed during India's fertility transition across NFHS rounds? (2) To what extent do these trajectories differ by birth order, consistent with a partial and uneven birth-spacing transition? (3) How does heterogeneity across states and regions shape national patterns, and when do national medians mask divergent subnational trends in birth spacing? These questions aim to move beyond descriptive trends and provide a structured assessment of the relationship between fertility decline and birth spacing dynamics in India.

This study makes three contributions to the literature. First, it provides the first pooled cross-sectional, parity-specific analysis of birth interval trajectories in India using five rounds of NFHS data (1992-2021). We move beyond prior India-focused studies (e.g. Chowdhury et al., 2023), which largely examine determinants at a single point in time. We aim to trace the trajectories of birth intervals across three decades of fertility transition using restructured birth histories of women in a 'person-period format'. Second, unlike existing studies (e.g., Casterline & Odden, 2016), it demonstrates that the global pattern of lengthening birth intervals, including the evidence from LMICs, does not uniformly apply in the Indian context. Third, by integrating parity progression ratios with birth interval analysis in a unified framework, we show that fertility decline in India has been driven primarily by stopping behaviour rather than spacing. Hence, we are providing recent evidence on the decoupling of *quantum* and *tempo* components of fertility transition.

2. Background and Literature Review

India's demographic transition is characterized by a paradox: notable success in fertility decline is tempered by an unfinished agenda in family planning, reproductive, maternal, and child health (James & Goli, 2016). While the country has achieved replacement-level fertility, this aggregate success masks critical disparities in the tempo of childbearing. A growing body of evidence suggests that the "timing" and "spacing" of births, key components of the fertility transition, have not kept pace, having significant implications for maternal and child health (Rana & Goli, 2018, 2021). This section reviews why analyzing birth interval trajectories is essential for evaluating the unfinished goals of India's demographic transition and its broader agenda of family welfare programmes.

2.1 Family Planning Program and Birth Intervals

India's family planning program, established in the 1950s, has been primarily aimed at limiting births. The program initially emphasized sterilization before evolving into a family welfare approach that, despite later policies advocating for voluntary choice and expanded methods, continues to prioritize limiting births (Srinivasan, 2017). This historical focus has had a lasting impact where female sterilization continues to be the dominant contraceptive method (Joshi et al., 2015; Jadhav et al., 2016; Jadhav & Vala-Haynes, 2018; Kannaujiya et al., 2020; Karra & Canning, 2024), utilized by 77% of contraceptive users, while only 23% use modern reversible methods like pills, condoms, or IUDs (Misra et al., 2021). This persistence is often attributed to its cost-effectiveness and, historically, coercive promotion practices that limited informed choice (Rana & Jain, 2020). While permanent methods like sterilization have been effective in reducing fertility levels (Srinivasan, 2017), they do not address birth spacing. India's programs' overemphasis on terminal methods has thus failed to extend the birth interval, creating a critical gap in reproductive health outcomes (Padmadas et al., 2004; Shekhar et al., 2024).

2.2 Fertility Transition and Birth Intervals

The complete fertility transition goals consist of three key components: postponement of first childbirth, reduction in lifetime births, and increased birth spacing. Wider contraceptive choice facilitates greater birth spacing (Rana & Jain, 2020), which in turn reduces maternal and infant mortality. Contraceptives lower mortality by reducing pregnancy-related health risks and the incidence of abortions from unintended pregnancies. Saha and van Soest (2013) found that contraceptive use following a birth

extended the birth interval by 60% and decreased infant mortality for subsequent births. Thus, family planning enables women to achieve several beneficial outcomes such as delayed marriage, pregnancy initiation at optimal ages, extended birth intervals, and overall fertility reduction. India's achievement in reducing the quantum of fertility, without a consistent and widespread improvement in spacing, therefore, represents an incomplete transition.

2.3 Socio-Economic Transition and Birth Intervals

The relationship between education and birth intervals, however, is complex (Sahoo, 2013). Higher education can lead to delayed marriage and childbearing, thereby shortening the reproductive window and reducing family size (Dommaraju, 2009). Conversely, women who marry later may compress their childbearing soon after marriage, potentially leading to shorter intervals. This suggests that the association between education and birth spacing may not be linear, and observed intervals may reflect timing constraints rather than deliberate spacing behaviour. Likewise, child marriage remains prevalent in India and is associated with several negative reproductive outcomes such as higher fertility rates, lower contraceptive use, increased fertility rates, unwanted pregnancies, rapid repeat pregnancies, pregnancy terminations, and inadequate birth spacing (Raj et al., 2009, 2010).

3. Conceptual Framework: Linking Fertility Decline and Birth Spacing

To guide the empirical analysis, we develop a conceptual framework that integrates demographic transition theory, the proximate determinant of fertility framework, and perspectives on reproductive agency and family planning programs. We conceptualize birth spacing as the outcome of these three interacting processes. First, proximate determinants (Bongaarts, 1978) directly regulate fertility through biological and behavioural mechanisms, including contraception, breastfeeding, postpartum amenorrhea, and fecundability. These factors shape subsequent births and therefore determine the length of interbirth intervals. Second, behavioral factors, including fertility preferences, son preferences, and socioeconomic conditions, influence how individuals translate fertility preferences into reproductive outcomes. Third, structural context, especially family planning programs and socioeconomic conditions, shape access to and use of fertility regulation methods. Building on this framework, we examine whether fertility decline in India has been accompanied by improvements in birth spacing, and how this relationship varies across time, parity, and regions.

In India, the correlation between the fertility transition and social development is positive, yet the government's family planning initiatives have been less effective in promoting consistent improvements in birth intervals. Overall, the existing literature suggests that the Indian demographic narrative is one of a targeted, policy-driven fertility decline that has paradoxically overlooked the crucial dimension of birth spacing. The historical emphasis on sterilization within the family planning program, combined with a socio-economic transition, has created a scenario where fertility rates have fallen, but improvements in birth intervals have been partial and uneven. This disjunction underscores a critical gap in our understanding. While India's fertility transition is well documented (Jadhav, 2014; Shekhar et al., 2024), the trajectories of its birth interval transition, and their time- and region-fixed correlates, remain largely unexplored. The present study seeks to address the above-mentioned gaps by analyzing the regional heterogeneity of birth interval trajectories in India from 1992 to 2021, thereby critically evaluating the completeness of the nation's demographic transformation.

4. Data and Variables

This study utilizes nationally representative data from five rounds of India's National Family Health Survey (NFHS), covering all districts and states: NFHS-1 (1992-93), NFHS-2 (1998-99), NFHS-3 (2005-06), and NFHS-5 (2019-21) (IIPS & ICF, 2021; IIPS & ICF, 2017; IIPS & Macro International, 2007; IIPS & ORC Macro, 2000; IPS, 1995). As a cross-sectional sample survey, the NFHS collects comprehensive demographic, health, and complete birth history data. The five survey rounds interviewed 89,777; 90,303; 124,385; 699,686; and 724,115 women, respectively. Our analysis incorporates birth histories from all five NFHS rounds. The analysis is restricted to currently married women, consistent with the focus on marital fertility in India. Births to unmarried mothers are not included in the analytical sample.

All NFHS rounds interviewed women aged 15-49 years, collecting detailed birth histories for each respondent. While the surveys may contain reporting errors, particularly regarding birth omissions from the distant past or deceased children, we utilized the provided women's birth histories, excluding births that occurred at maternal ages of 14 years or younger, and reconstructed a woman-person-period exposure file from the complete birth-history records. For each woman, parity-specific episodes are created beginning at marriage for the transition to first birth and at each observed birth for subsequent parity transitions. Episodes either ended with the next live birth or were right-censored at the interview date. Women who did not progress to the next parity are retained as censored observations, and childless married women contributed exposure to the marriage-to-first-birth transition. Each episode is expanded into discrete time intervals, allowing estimation of complementary log-log discrete-time hazard models for parity progression and birth intervals (see Table S1 for details).

We applied de-normalized weights to account for unequal sample sizes across survey rounds. The denormalized weights are computed using existing women's weights in the respective survey rounds and population sizes obtained from the corresponding Census of India data. Following standard methodology, we calculated birth intervals based on the termination of each interval (e.g., the "second birth interval" refers to the period between the first and second births). Our analysis includes only closed birth intervals. We excluded first intervals (between marriage and first birth) as they represent distinct phenomena lacking postpartum behavioural components. For multiple births (twins/triplets), we treated each event as a single birth, though we acknowledge that each child in such births affects birth order and subsequent interval calculations.

All national and state-level estimates presented in this study are derived from the same underlying sample and are constructed using consistent definitions, sample restrictions, and weighting procedures. The application of de-normalized weights ensures that estimates remain representative at both the national and state levels across survey rounds, thereby allowing direct comparability between aggregate and disaggregated results. The NFHS sampling design provides representative estimates at both national and state levels; however, variations in sample sizes across states and survey rounds may affect the precision of state-level estimates.

4.1 Variable Description

Outcome Variable: Our dependent variable is the birth interval, measured as the duration in months between two consecutive live births to the same mother. This represents the time elapsed between the birth of the index child and their immediately preceding sibling.

Predictor Variables: Multiple socioeconomic and demographic factors serve as distal determinants of birth interval length (Aleni et al., 2020), including maternal age at marriage and childbirth, preceding birth interval duration, sex preference, residence type, regional location, contraceptive use, employment status, religious affiliation, household wealth index, media exposure, maternal education level, child's birth order, and survival status (Rabbi et al., 2013). In developing countries like India, where son preference remains pervasive, existing family composition significantly influences birth spacing patterns. The wealth index has been shown to directly affect birth interval duration (Nath et al., 2000), while variations in lifestyle, cultural practices (Basu, 1993), and socioeconomic conditions (Khan et al., 2016) across different administrative regions and residential areas further shape birth interval distributions.

Building on established literature (Jadhav, 2014; Ajayi & Somefun, 2020; Chowdhury et al., 2023; Belachwe et al., 2024), we examine multiple predictors associated with birth interval duration. Maternal factors include age (age at index birth and first birth) and educational attainment (none, primary, secondary, and higher). Reproductive history encompasses breastfeeding duration, postpartum abstinence, amenorrhea, twin status (single and multiple), and birth order. Child characteristics involve the sex of the preceding child and parental sex preference for the indexed child. Socioeconomic indicators comprise caste (SC/ST and other than SC/ST), religion (Hindu, Muslim, and Christian), place of residence (urban and rural), and wealth quintile (poorer, poorest, middle, richer, and richest). Spatiotemporal variables include the survey period (1992-93 to 2019-21) and geographic region (North,

South, Central, West, East, and Northeast). Household wealth status, derived from asset-based indices, serves as a socioeconomic proxy. Birth order is categorized ordinally (1st-6th+), while twin births are dichotomized (single and multiple), with all classifications following standard NFHS categorizations using the standard recode manual for DHS-7.

5. Methods

The empirical approach of this study includes, first, descriptive analyses of birth intervals by region, the distribution of births by birth order, and their corresponding intervals. Second, it employs a complementary log-log model (CLL Model) for multivariate analysis of parity progression ratios and birth intervals and their socio-demographic correlates. These models also reduce unobserved heterogeneity and omitted-variable bias by incorporating regional and time dummies within a pooled data framework.

5.1 Parity Progress Ratios

We employed the CLL model, a multivariate discrete-time survival model of parity progression and birth intervals, to examine how socioeconomic and demographic factors influence birth intervals. Further, this model help in estimating multivariate Parity Progression Ratios (PPRs), means, and median closed birth intervals by birth order (Casterline & Odden, 2016). Although originally designed for cohort data, we adapted the CLL approach for period data by running separate multivariate models for each parity transition. The CLL specification derives from the continuous-time Cox proportional hazards model (Cox, 1972; Prentice & Gloeckler, 1978; Long & Freese, 2014; Casterline & Odden, 2016). For each parity transition, we fitted the CLL model using expanded datasets constructed by converting the original person-level records into 'person-period' observations. We created period-specific datasets by right censoring all 'person-period' observations occurring more than five years after the survey date.

The basic mathematical notation for multivariate PPRs and parity transition is:

- p_B = transition from one's birth to her marriage (B-M).
- p_M = transition from one's first marriage to first birth (M-1).
- p_1 = transition from first birth to second birth (1-2).
- p_2 = transition from second birth to third birth (2-3).
- p_3 = transition from third birth to fourth birth (3-4).
- p_4 = transition from fourth birth to fifth birth (4-5).
- p_5 = transition from fifth birth to sixth birth (5-6).

More generally, for parity index k , we write p_k as the transition probability from the k^{th} birth to the $(k+1)^{\text{th}}$ birth, and p_{r+} represents the open-ended higher-order parity progression probability from parity r or higher to the next higher-order birth.

$$p_k = \Pr(B_{k+1} | B_k) \quad (1)$$

Where B_k denotes the occurrence of the k^{th} birth

5.2 Total fertility rate from PPRs

We compute the total fertility rate (TFR) from the PPRs as a sum of successive parity-progression products, with the final open-ended term written as a fraction so that the division applies only to that term.

$$TFR = p_M + p_M p_1 + p_M p_1 p_2 + \dots + p_M p_1 p_2 \dots p_{r-1} + \frac{p_M p_1 \dots p_{r-1} p_{r+}}{1 - p_{r+}} \quad (2)$$

In this formulation, p_b is not included because the fertility accounting begins from the first marriage, through the transition from marriage to first birth.

5.3 Discrete-time hazard model

For each parity transition, we estimate a discrete-time hazard model using a CLL specification on a person-period (life-table interval) dataset, in which the outcome is the conditional probability of experiencing the next event in interval t , given survival to the start of that interval.

$$\log[-\log(1 - P_{it})] = a_t + \sum_{j=1}^J b_j X_{ij}. \quad (3)$$

In Equation (3), i indexes the i th observation, t indexes the t th life-table time interval (with $t = 1, 2, \dots$), and P_{it} is the discrete predicted probability of failure in interval t . Further, the term a_t denotes the baseline component that varies with duration t ; the predictors X_{ij} and coefficients b_j capture covariate associations, with predictor index j used (rather than k) to avoid confusion with parity indexing in Equation (1).

Equation (3) is the compact form of the model; we parameterize the baseline component a_t non-parametrically using life-table time-interval dummy variables, as shown in Equation (4).

5.4 Expanded baseline hazard

We expand the baseline term a_t into an intercept plus a set of time-interval indicator variables so that the baseline hazard is approximated as a step function over discrete durations.

$$\log[-\log(1 - P_{it})] = a_{30} + \sum_{s=1}^{29} c_s T_{is} + \sum_{j=1}^J b_j X_{ij} \quad (4)$$

In Equation (4), T_{is} is a dummy variable indicating whether the person-period record for individual i falls in the s th life-table time interval (with the 30th interval treated as the reference category), a_{30} is the intercept, and c_s are coefficients fitted to the expanded files for the baseline duration pattern.

Equation (4) is obtained from Equation (3) by writing $a_t = a_{30} + \sum_{s=1}^{29} c_s T_{is}$, so that the intercept and time dummies jointly represent the duration dependence in the baseline component. In addition, the baseline component a_t is treated as a function of duration t alone (parameterized via the time-dummy expansion in Equation (4)), and the predictor index is written as j to distinguish it from parity indexing in the PPR definitions.

6. Results

The results are presented in three sections: first, an assessment of transition patterns in birth intervals; second, the socio-economic correlates of birth intervals; and finally, the regional heterogeneity in the evolving patterns and its relationship with fertility.

6.1 Transitional Patterns in Birth Intervals

Table 1 shows the distribution of births for each survey period by birth order and corresponding birth intervals across five survey rounds (1992-93 to 2019-21). We categorize birth intervals into three distinct ranges: <24 months, 24-47 months, and >48 months. These patterns indicate that while fertility levels have declined, changes in birth spacing remain uneven across birth orders and over time.

Table 1: Percentage distribution of births according to birth order and their birth interval, 1992-93 to 2019-21

Birth order	Birth Interval	1992-93	1998-99	2005-06	2015-16	2019-21
1 st	<24 months	13.0	14.9	12.6	17.3	17.9
1 st	24 to 47 months	6.3	6.6	8.5	10.6	11.1

1 st	>48 months	8.2	7.5	9.2	10.3	10.1
2 nd	<24 months	6.7	6.7	7.9	9.0	9.1
2 nd	24 to 47 months	12.7	13.5	13.6	15.2	15.1
2 nd	>48 months	4.4	5.5	5.4	7.5	9.0
3 rd	<24 months	4.2	4.1	4.3	4.0	4.1
3 rd	24 to 47 months	10.0	10.1	8.6	7.6	7.4
3 rd	>48 months	3.4	3.5	3.3	3.7	3.9
3+th	<24 months	7.1	5.7	7.0	3.7	3.4
3+th	24 to 47 months	17.5	15.8	14.4	7.4	6.0
3+th	>48 months	6.5	6.1	5.0	3.1	2.6

Source: Authors' estimation based on the National Family Health Survey, 1992-93 to 2019-21.

This analysis reveals uneven and parity-specific patterns in birth spacing across birth orders in India. For first-order births, birth intervals <24 months increased significantly from 13.0% (1992-93) to 17.9% (2019-21), while birth intervals 24-47 months rose from 6.3% to 11.1%. Birth intervals >48 months remained relatively stable, showing only a modest increase from 8.2% to 10.1%. Second-order births exhibited similar trends: birth intervals <24 months grew from 6.7% to 9.1%, birth intervals 24-47 months increased from 12.7% to 15.1%, and birth intervals >48 months nearly doubled from 4.4% to 9.0%. However, third and higher-order births showed significant declines across all interval categories except for birth intervals >48 months.

These findings demonstrate two key demographic shifts: (1) improved spacing for first and second births, and (2) a marked reduction in higher-order births (≥ 3), reflecting both greater adoption of family planning methods and changing societal preferences toward smaller families in India.

6.2 Parity Progression Ratios

Table 2 presents period estimates of PPRs, mean and median age at marriage, closed birth intervals, and TFR in India for two periods: 1992-93 and 2019-21, obtained using the CLL model. A higher PPR indicates a greater likelihood of progressing to the next birth. An open birth interval refers to the duration between marriage and first childbirth, while a closed birth interval measures the time between two consecutive births. Between 1992-93 and 2019-21, the probability of fourth-parity women progressing to fifth parity experienced the largest decline (from 0.315 to 0.097). This is followed by a decrease in progression from second to third parity (from 0.609 to 0.400). In contrast, the likelihood of first-parity women advancing to second parity slightly increased (from 0.927 to 0.931).

Table 2: Period estimates of PPRs, mean and the median age at marriage and closed birth interval, and TFR in India, derived from the CLL models, 1992-93 and 2019-21.

Transitions		NFHS-1 (1992-93)	NFHS-5 (2019-21)
B-M	PPR (pB)	0.702	0.740
	Mean Age at Marriage	16.650	19.160
	Median Age at Marriage	16.000	19.000
M- P1	PPR (PM)	0.997	0.989
	Mean Open Birth Interval	68.500	44.200
	Median Open Birth Interval	40.000	37.000
P1-P2	PPR (p1)	0.927	0.931
	Mean Closed Birth Interval	35.600	42.400
	Median Closed Birth Interval	31.000	34.000
P2-P3	PPR (p2)	0.609	0.400
	Mean Closed Birth Interval	36.000	36.910
	Median Closed Birth Interval	31.000	30.000
P3-P4	PPR (p3)	0.332	0.158

	Mean Closed Birth Interval	35.000	33.990
	Median Closed Birth Interval	30.000	28.000
P4-P5	PPR (p4)	0.315	0.097
	Mean Closed Birth Interval	34.200	33.270
	Median Closed Birth Interval	31.000	28.000
All	TFR	3.400	2.000

Source: Authors estimation based on the National Family Health Survey (1992-93) and 2019-21.

Note: Birth intervals (in months) are model adjusted predictions.

The results indicate a decline in the probability of progression from second to third parity and subsequent births (Table 2). The likelihood of women transitioning from marriage to first birth remained largely unchanged during the inter-survey period. In Indian society, where child marriage has been well-documented, the increase in median age at first marriage from 16 to 19 years during this period is encouraging. The median birth interval between first marriage and first birth decreased by nearly three months (from 40 to 37 months) between survey periods. Conversely, the median interval between first and second births widened by approximately three months (from 31 to 34 months). For higher-order births, both the mean and median closed birth intervals have decreased.

6.3 CLL Model Estimates

Table 3 presents CLL regression estimates of factors associated with birth intervals shorter than 24 months, controlling for unobserved heterogeneity across regions and over time. The model examines various demographic, biological, and socioeconomic factors to determine their influence on the likelihood of short birth intervals. The regression results reveal that the hazard of a short birth interval in India is driven by demographic and biological factors with clear economic underpinnings. A preceding female child exhibits a positive coefficient ($\beta=0.030$), indicating a slightly higher hazard of a short subsequent birth interval compared to a preceding male child, which may reflect continued fertility preferences for sons. The respondent's current age exhibits a large positive coefficient ($\beta=5.893$), indicating that older women face a significantly higher hazard of a short subsequent interval, likely reflecting a compressed biological timeline to achieve desired fertility. This is counterbalanced by the powerful negative effect of the age at first birth ($\beta=-4.233$), which establishes delayed motherhood as a primary mechanism for increasing spacing. As anticipated, the duration of breastfeeding was inversely related to the short birth interval ($\beta= -0.632$), underscoring its role as a natural determinant of birth spacing. The analysis of birth order shows a pattern consistent with fertility targeting; the hazard is highest for the second birth ($\beta=2.842$) and declines monotonically, suggesting households strategically accelerate childbearing to achieve a two-child norm quickly before slowing the pace.

The relationship between socio-economic status and birth spacing is notably non-linear, challenging straightforward assumptions. The observed education and wealth gradients are not uniformly monotonic, suggesting that socioeconomic status shapes spacing partly through shifts in the timing of family formation rather than through a direct linear effect on spacing itself. Education demonstrates a threshold effect: only secondary education yields a small but significant reduction in the hazard ($\beta = -0.031$) compared to no education, while primary and higher education show no significant effect. The wealth gradient is similarly non-linear and U-shaped: the middle quintile shows a significantly lower hazard ($\beta = -0.047$) than the poorest, while the richest quintile exhibits a significantly higher hazard ($\beta = 0.106$). In particular, delayed marriage and later onset of childbearing can compress the time available to achieve desired family size, potentially producing shorter subsequent intervals among women who proceed to higher parities, so-called "catch-up" fertility behavior, even as entry into childbearing is delayed. Interpreting socioeconomic differentials in spacing therefore requires distinguishing changes in the onset of childbearing from changes in spacing conditional on parity progression.

Significant spatial and temporal fixed effects display an intriguing picture. Regionally, the more developed Southern region has a significantly lower hazard ($\beta=-0.060$) than the Northern region, highlighting the role of broader developmental contexts. Temporally, the hazard of a short interval was elevated in 1998-99 and 2015-16 compared to the 1992-93 baseline, before showing no statistical

difference in the most recent period (2019-21). This indicates that the risk of short spacing intensified during the mid-transition, potentially as families adjusted to declining fertility targets, and has only recently stabilized.

Table 3: CLL regression estimates: Factors associated with less than 24 months birth interval

Variables	β	95% Confidence Interval	
		Lower Limit	Upper Limit
<i>Sex of the preceding child</i>			
Male®			
Female	0.030***	0.011	0.050
The current age of respondent	5.893***	5.755	6.030
Duration of breastfeeding (in months)	-0.632***	-0.688	-0.576
Duration of amenorrhea	0.099***	0.092	0.107
Duration of abstinence	0.023***	0.014	0.033
Age of respondent at first birth	-4.233***	-4.337	-4.130
<i>Birth order</i>			
1st order ®			
2nd order	2.842***	2.766	2.919
3rd order	2.276***	2.209	2.343
4th order	1.768***	1.707	1.829
5th order	1.312***	1.253	1.372
6th or higher order	0.846***	0.783	0.909
<i>Twin status</i>			
Single ®			
Multiple	0.458***	0.371	0.546
<i>Respondent's education</i>			
No education ®			
Primary education	0.011	-0.020	0.042
Secondary education	-0.031**	-0.060	-0.002
Higher education	-0.011	-0.067	0.046
<i>Partner's education</i>			
No education ®			
Primary education	0.069***	0.035	0.103
Secondary education	0.037**	0.005	0.068
Higher education	0.029	-0.012	0.070
Partner's age	0.121***	0.041	0.202
<i>Sex of the preferred child</i>			
Male®			
Female	0.001	-0.021	0.023
<i>Social Category</i>			
SC/ST®			
Other than SC/ST	0.004	-0.018	0.026
<i>Religion</i>			
Muslim®			
Hindu	0.005	-0.022	0.031
Christian	0.015	-0.055	0.084
<i>Wealth quintile</i>			
Poorest®			
Poorer	0.003	-0.025	0.031
Middle	-0.047***	-0.079	-0.016
Richer	-0.024	-0.061	0.014
Richest	0.106***	0.058	0.154
<i>Place of residence</i>			
Rural®			
Urban	0.017	-0.010	0.044
<i>Survey period</i>			
1992-93®			
1998-99	0.308***	0.281	0.334
2015-16	0.095***	0.063	0.127
2019-21	0.032	-0.009	0.074
<i>Region</i>			

Northern region®			
Central region	0.023	-0.011	0.056
Eastern region	0.041**	0.004	0.078
North-eastern region	0.084***	0.034	0.134
Western region	0.005	-0.032	0.043
Southern region	-0.060***	-0.099	-0.020
Constant	-9.627***	-9.928	-9.326
Mean dependent var	0.740	SD dependent var	0.439
Number of Obs.	73216	Chi-square	12504.220
Prob > chi2	0.000	Akaike crit. (AIC)	73367.600

Level of Significance: *** p<.01, ** p<.05, * p<.1

Table 4 presents results from the CLL model for birth intervals exceeding 60 months. The respondent's current age shows a strong positive association ($\beta = 12.995$), indicating that the hazard of a long interval increases dramatically for older women, likely reflecting the natural conclusion of childbearing or secondary infertility. A higher age at first birth is strongly associated with a reduced hazard of a prolonged interval ($\beta = -7.838$), suggesting that women who start childbearing later have a compressed reproductive timeline, minimizing both very short and very long gaps. The protective effect of breastfeeding is even more pronounced for long intervals ($\beta = -1.456$), as its duration directly reduces the time to the next conception.

Socioeconomic factors show a strikingly different and linear relationship with long intervals compared to short ones. Unlike the U-shaped wealth effect for short intervals, higher wealth is monotonically associated with a greater hazard of a long interval, with the richest quintile showing a substantial positive coefficient ($\beta = 0.338$). Similarly, both the respondent's and her partner's education are consistently positive and significant predictors. This suggests that higher socioeconomic status, rather than compressing birth intervals, is associated with a lengthening of the birth interval distribution, likely due to greater career aspirations, higher opportunity costs of childbearing, and more successful use of contraception for spacing rather than just limitation.

The hazard of a long interval was significantly higher in all subsequent survey rounds compared to the 1992-93 baseline, indicating a secular increase over India's fertility transition. This could signal a growing ability to plan and space births. Regionally, the Southern region shows a significantly lower hazard ($\beta = -0.156$) than the North, consistent with its earlier and more rapid fertility decline, where families likely completed childbearing more efficiently without extended delays. In contrast, the Eastern and Northeastern regions show a higher hazard, which may reflect a different fertility regime characterized by longer, potentially involuntary spacing.

Table 4: CLL regression estimates: Factors associated with greater than 60 months of birth interval

Variables	B	95% Confidence Interval	
		Lower Limit	Upper Limit
<i>Sex of the preceding child</i>			
Male®			
Female	0.035	-0.011	0.082
Current age of respondent	12.995***	12.731	13.259
Duration of breastfeeding (in months)	-1.456***	-1.628	-1.283
Duration of amenorrhea	0.007	-0.012	0.026
Duration of abstinence	0.059***	0.038	0.080
Age of respondent at 1st birth	-7.838***	-8.003	-7.672
<i>Birth order</i>			
1st order®			
2nd order	6.46***	6.303	6.618
3rd order	4.915***	4.779	5.050
4th order	3.735***	3.599	3.871
5th order	2.730***	2.590	2.869
6th or higher order	1.744***	1.586	1.902
<i>Twin status</i>			
Single®			
Multiple	1.116***	0.951	1.282

<i>Respondent's education</i>			
No education®			
Primary education	0.099**	0.022	0.177
Secondary education	0.149***	0.076	0.223
Higher education	0.131**	0.014	0.248
<i>Partner's education</i>			
No education of partner®			
Primary education of partner	0.183***	0.097	0.270
Secondary education of partner	0.208***	0.125	0.291
Higher education of partner	0.163***	0.060	0.266
Partner's age	0.302***	0.100	0.504
<i>Sex of the preferred child</i>			
Male®			
Female	-0.035	-0.090	0.020
<i>Social Category</i>			
SC/ST®			
Other than SC/ST	-0.030	-0.084	0.024
<i>Religion</i>			
Muslim®			
Hindu	-0.076**	-0.137	-0.016
Christian	-0.208***	-0.362	-0.054
<i>Wealth quintile</i>			
Poorest®			
Poorer	-0.005	-0.078	0.067
Middle	0.130***	0.051	0.209
Richer	0.050	-0.041	0.141
Richest	0.338***	0.231	0.444
<i>Place of residence</i>			
Rural®			
Urban	0.103***	0.042	0.165
<i>Survey period</i>			
1992-93®			
1998-99	0.486***	0.419	0.552
2015-16	0.242***	0.169	0.314
2019-21	0.233***	0.142	0.324
<i>Region</i>			
Northern region®			
Central region	0.018	-0.066	0.102
Eastern region	0.134***	0.046	0.223
Northeastern region	0.151***	0.045	0.258
Western region	-0.107**	-0.201	-0.014
Southern region	-0.156***	-0.249	-0.063
Constant	-29.222***	-29.878	-28.565
Mean dependent var	0.115	SD dependent var	0.319
Number of Obs	73216	Chi-square	17886.470
Prob > chi2	0	Akaike crit. (AIC)	33446.800

Level of significance: *** p<.01, ** p<.05, * p<.1

7. Regional Heterogeneity in Birth Spacing and Its Evolving Relationship with TFR

This section investigates the profound regional disparities in birth spacing patterns across India and their complex, non-uniform relationship with the national decline in the TFR. The analysis reveals a clear geographical divergence: states in the south, west, and northeast have experienced a substantial lengthening of birth intervals, while a cluster of central and northern states shows stagnation or even contraction. Crucially, this regional heterogeneity demonstrates that the trajectory of fertility decline is not universally coupled with increased birth spacing. Further heterogeneity analysis confirms that the risk of short birth intervals remains significantly elevated in specific regions, underscoring the critical influence of unobserved state-level contextual (specifically state-level cultural) factors beyond individual socio-economic characteristics.

Table 5 shows trends in median birth intervals across Indian states over five survey rounds, from 1992-

93 to 2019-21. The data reveal a clear regional divergence in birth spacing patterns over nearly three decades. A majority of states, particularly those in the South (e.g., Kerala, Tamil Nadu), the West (e.g., Maharashtra, Gujarat), the North (e.g., Punjab, Himachal Pradesh, Jammu & Kashmir), and all Northeastern states, experienced a substantial lengthening of birth intervals, with the significant increases observed in Assam (55.0%), Kerala (45.3%), and Mizoram (37.7%). In contrast, a significant cluster of states, primarily in the central and northern heartland, demonstrated a trend of shortening or stagnating birth intervals, with notable declines seen in Andhra Pradesh (-14.3%) and Bihar (-8.9%).

Table 5: Median birth interval (in months) since preceding birth, 1992-93 to 2019-21

States	1992-93	1998-99	2005-06	2015-16	2019-21	% Change from 1992-93 to 2019-21
Andhra Pradesh	33.4	31.1	31.4	28.9	28.6	-14.3
Assam	29.8	30.6	37	42.3	46.2	55
Bihar	33.9	32.3	30.9	32	30.9	-8.9
Goa	35.2	34.8	37.4	39.3	43.3	23
Gujarat	30	29	29.2	33.9	33.4	11.3
Haryana	28.1	30	30.4	29.1	31.5	12.1
Himachal Pradesh	28.3	29.4	29.9	33.2	36.5	29
Jammu & Kashmir	30.9	32.5	32	35.3	36.7	18.8
Karnataka	29.9	29.7	30.3	30.7	31.3	4.7
Kerala	34.9	38.1	41.2	49.5	50.7	45.3
Madhya Pradesh	32.1	30.2	30.2	30	30.9	-3.8
Maharashtra	28.7	29	31.9	31.8	34	18.5
Manipur	31.6	31.8	35.4	40	41.1	30.1
Meghalaya	27.5	28.5	31.7	32.5	31.3	13.8
Mizoram	27.6	28.4	30.6	37.1	38	37.7
Nagaland	28.1	27.5	28.6	30.2	29.6	5.3
Orissa	32.7	32.9	33.8	41	43.6	33.3
Punjab	29.3	28	29.7	33.9	36.9	25.9
Rajasthan	32.5	29.5	30.2	30.3	30.8	-5.2
Tamil Nadu	31.6	30.5	31.4	32	35.6	12.7
Uttar Pradesh	32.1	30.4	29.9	31.1	31.8	-1

Source: Authors' estimation based on the National Family Health Survey, 1992-93 to 2019-21.

Note: State-level estimates are reported for states with sufficient sample sizes across survey rounds to ensure reliable estimation. States with limited observations or inconsistent data availability were excluded from the analysis.

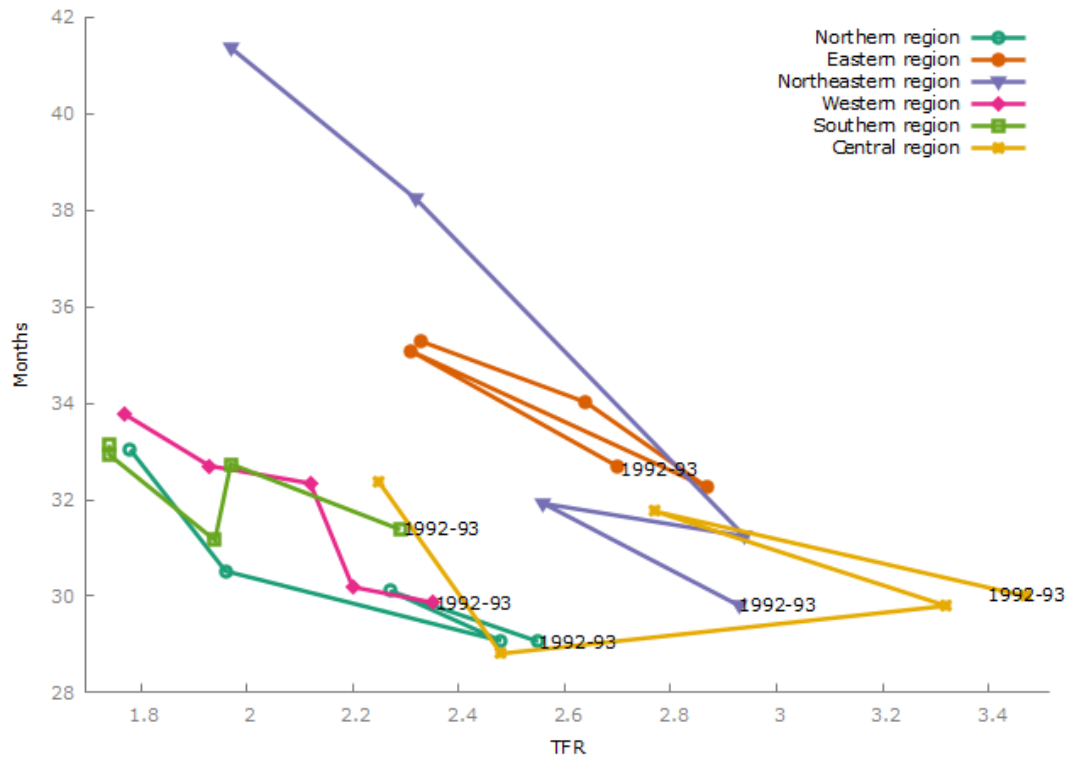
Although many states exhibit notable increases in median birth intervals, the overall national increase remains modest. This apparent divergence reflects the population-weighted nature of national estimates, where trends in highly populous states exert a disproportionate influence. In particular, stagnation or slower improvements in high fertility and populous states can offset gains observed in smaller or faster progressing states.

To assess the evolution of fertility and birth spacing, we focus on the second inter-birth interval, which is less susceptible to the selectivity trends that can affect higher-order intervals and therefore more reliably reflects behavioural change. Trends in the median second birth interval are summarised in Figure 2. A deeper analysis of these trends reveals a critical finding that contextualises the state-level patterns: there is no clear-cut relationship between changes in this spacing metric and the decline of the TFR across India's major regions. Despite universal fertility decline, the trajectories of birth spacing have been distinctly varied. The Northern and Southern regions witnessed only modest increases in the median second birth interval alongside substantial TFR declines to below-replacement levels. Conversely, the Eastern and, notably, the Northeastern regions demonstrated a strong concurrent increase in both spacing and fertility decline; the Northeast's second birth interval expanded dramatically from 29.8 to 41.4 months as its TFR fell from 2.93 to 1.97. This regional heterogeneity is a central finding of the study.

This stark regional divergence underscores that a reduction in fertility does not automatically precipitate a proportional or uniform increase in birth spacing, highlighting the independent dynamics

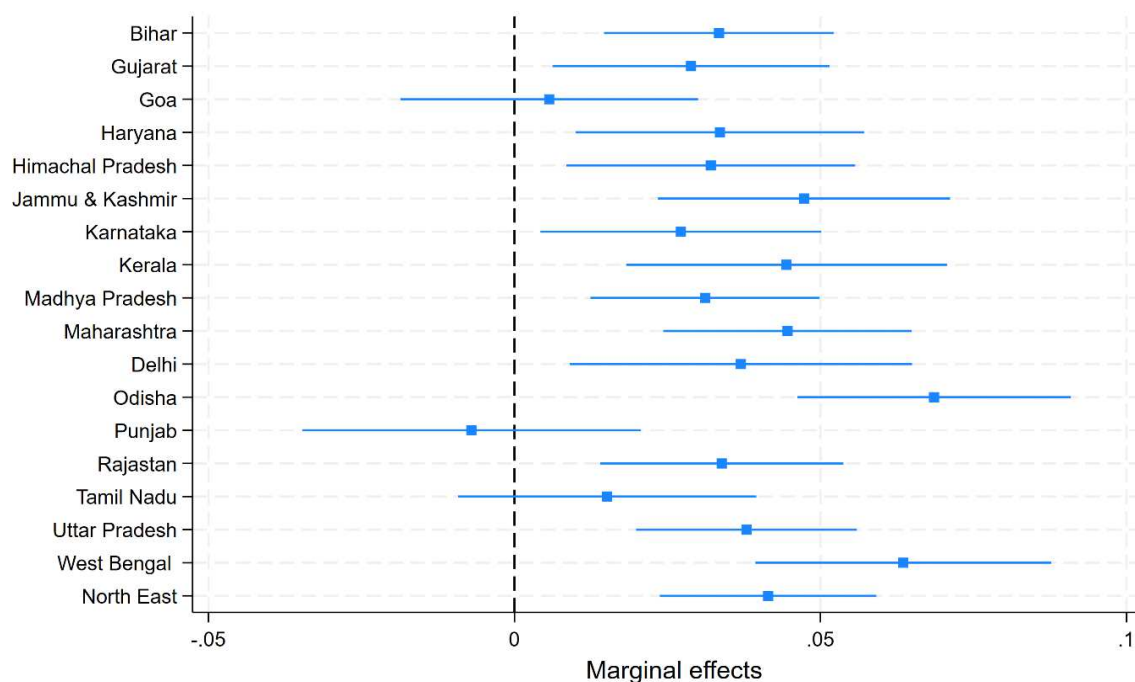
of these two demographic components and the complex nature of India's ongoing fertility transition.

Figure 2: Co-evolution plots: Fitted lines showing the relationship between trends in median second birth interval and TFR by region in India.



The CLL regression results reveal significant state-level heterogeneity in the hazard of short birth intervals, which may arise from underlying cultural or biological factors, even after controlling for socio-economic confounders. Figure 3 presents marginal effects estimated relative to Andhra Pradesh (the reference category), and therefore reflects differences in the likelihood of short birth intervals compared to this baseline rather than absolute levels. A clear geographical pattern emerges, with states in the eastern and north-eastern regions, such as Odisha ($dy/dx=0.069$), West Bengal (0.064), and the aggregated Northeast (0.041), exhibiting the highest statistically significant hazards, indicating a persistently higher risk of short birth spacing relative to Andhra Pradesh. Conversely, states like Punjab demonstrate a negative, though statistically insignificant, marginal effect, suggesting a comparatively lower hazard relative to the reference category. Other major states, including Uttar Pradesh, Bihar, and Madhya Pradesh, show significant positive marginal effects, and several states cluster closely around the reference category. These patterns confirm that the risk of short birth intervals is not uniformly distributed across India but is concentrated in specific regions. Additionally, regional differences are characterized by relative deviations rather than uniformly large disparities across all states. This stark regional divergence underscores that, beyond individual-level socio-economic factors, unobserved state-specific contextual factors (Basu, 1993), potentially related to health system performance, cultural norms, or the implementation of family planning programs, play a critical role in shaping reproductive timing. These findings highlight the limitations of national one-size-fits-all policies and emphasize the need for targeted, state-specific public health interventions to address the elevated risk of short birth intervals in high-focus regions.

Figure 3: Marginal effect estimates from the CLL regression model showing the relative risk of having shorter birth spacing for major states (reference category: Andhra Pradesh)



Note: Model is controlled for all the variables listed in the regression table

8. Discussion

This study highlights an important paradox in India's much-celebrated fertility transition: a dramatic decline in the TFR from 3.4 to 2.0 between 1992-93 and 2019-21, while birth spacing has shown only modest and uneven improvements, with the median birth interval increasing only marginally from 31.6 to 32.7 months. This divergence reveals that India's demographic transition, though quantitatively advanced, remains incomplete in its qualitative dimensions, particularly with respect to birth spacing and timing, despite a substantial decline in fertility levels. Our study is the first to offer a comprehensive account of examining birth interval trajectories and their time- and region-fixed effect correlates across five rounds of NFHS data, identifying several key findings that resonate with and diverge from global patterns. The findings are consistent with the conceptual framework developed in section 2.4 that birth spacing is shaped by the interaction of proximate, behavioural, and structural factors. Biological and behavioural mechanisms, such as age at first birth, breastfeeding, and parity-specific fertility preferences, continue to influence birth intervals. In a structural context, the dominance of sterilization within the family planning program has shifted reproductive behaviour toward 'limiting' rather than 'spacing'.

In India, fertility decline reflects an interaction between programmatic influences and changing reproductive preferences. However, because the contraceptive method mix has been dominated by terminal methods, increases in reproductive agency have not consistently translated into improved birth spacing. Instead, the agency often operates within a context that favors stopping over spacing.

The Paradox of Socio-Economic Status, Fertility Transition, and Birth Spacing

Our CLL models reveal a complex and non-linear relationship between socio-economic status and birth intervals. Contrary to linear assumptions, the wealth gradient for short birth intervals is U-shaped: the middle wealth quintile has a significantly lower hazard than the poorest quintile, whereas the richest quintile has a significantly higher hazard. This suggests that higher income does not inherently promote optimal spacing and may even be associated with shorter intervals. This pattern is observed net of key demographic controls such as age at marriage and first birth, which are explicitly controlled for in the model. Therefore, the observed wealth gradient likely reflects other behavioural or contextual mechanisms linking socio-economic status to birth spacing, such as differences in fertility preferences, better access to health care and resources, and a greater ability to outsource economic and childcare costs (Wegbom et al., 2022; Carlson et al., 2024; Van Wijk & Billari, 2024). Education shows a threshold

effect, where only secondary education significantly reduces the hazard of a short birth interval. This context-dependent relationship is observed elsewhere; for instance, higher education was associated with shorter birth intervals in Ethiopia (Kassie et al., 2023), indicating that the interplay between education, wealth, and reproductive behavior is not universally predictable. These patterns likely reflect 'compression' and 'decompression' within the reproductive span driven by behavioural responses and fertility preferences across socio-economic groups. In particular, shorter intervals among higher socio-economic groups may reflect a tendency to achieve desired family size within a constrained reproductive window, rather than differences in the timing of entry into childbearing, which are accounted for in the model. In contrast, earlier onset among lower socio-economic groups allows a more decompressed pattern with wider spacing.

Role of Education and Wealth in Birth Spacing

While existing theory suggests that higher levels of education and wealth are associated with longer birth intervals, our findings reveal more complex, and at times non-linear, relationships. The U-shaped wealth gradient for short birth intervals, where the middle quintile shows the lowest hazard while the richest quintile shows an elevated hazard, likely reflects heterogeneous behavioural mechanisms. Wealthier women tend to marry later and enter childbearing at an older age, but subsequently compress births into a narrower reproductive window (catch-up fertility), resulting in shorter intervals despite higher socioeconomic status. This is compounded by their greater ability to access childcare and maternal healthcare, which reduces the opportunity cost of closely spaced births (Van Wijk & Billari, 2024; Carlson et al., 2024). Similarly, the threshold effect of education - whereby only secondary education significantly reduces the hazard of short intervals - may reflect the fact that more educated women who marry late attempt to achieve their desired family size rapidly once they begin childbearing, producing compressed spacing. In both cases, therefore, shorter birth intervals do not necessarily indicate a lack of spacing preferences, but rather the need to complete fertility within a constrained reproductive window. These findings underscore the importance of distinguishing between *timing-driven* and *preference-driven* spacing patterns, and caution against interpreting socioeconomic advantage as straightforwardly conducive to optimal birth spacing.

The Key Demographic, Biological, and Behavioral Correlates

Demographic and biological factors are key predictors of birth intervals, consistent with global mechanisms. A woman's current age and her age at first birth are the strongest correlates, with older mothers typically having longer birth intervals, possibly because of less fertility, greater autonomy, and decision-making power over their reproductive choices, as well as reduced fertility with advancing age. Birth order analysis reveals an uneven pattern consistent with "fertility targeting," where the hazard of a short interval is highest for the second birth, suggesting households strategically accelerate childbearing to achieve a two-child norm quickly. Furthermore, extended breastfeeding-induced lactational amenorrhea is a key biological factor prolonging birth interval, just as extended postpartum abstinence has traditionally created long birth intervals in parts of sub-Saharan Africa (Caldwell et al., 1992). However, as Yeakey et al. (2009) demonstrated globally, contraceptive use lengthens the birth interval more significantly than changes in these postpartum behaviors. This underscores the critical gap in India, where a sterilization-centric program has failed to harness the spacing potential of reversible contraceptives (Singh et al., 2009).

Pronounced Unobserved Regional Heterogeneity

While a majority of the Northern, Southern, Western, and North-eastern states experienced birth intervals lengthening, several high-fertility states in the Central and Eastern regions such as Bihar, Madhya Pradesh, and Rajasthan, saw a contraction. This heterogeneous pattern resembles with global scenario, such as Rutstein's (2011), which found the longest birth intervals in South and Southeast Asia and the shortest in Central Asian states. The Southern region's consistently lower hazard of short birth intervals highlights the role of broader developmental contexts and potentially more effective family planning programs that emphasize spacing. This success story contrasts sharply with the lagging

regions and with Sub-Saharan Africa, which has seen the slowest pace of birth interval increase globally (Rutstein, 2011).

Overall, these findings reinforce that India's fertility transition is best understood as a decoupled process, where reductions in fertility levels have proceeded faster than changes in the timing and spacing of births.

9. Conclusion and Implications

This study concludes that India's demographic transition remains critically incomplete, particularly in terms of achieving optimal birth spacing, despite success in reducing fertility levels. Policy focus on reducing fertility, achieved primarily by female sterilization - successfully lowered the TFR to replacement level, this has not consistently translated into improvements in appropriate birth spacing. Worsening of spacing at higher birth orders reveals a limitation of a system designed for fertility limitation rather than holistic reproductive health and family welfare. Moreover, India's partial and uneven spacing transition is rooted in complex socio-economic and demographic behaviors that require targeted interventions beyond aggregate fertility reduction. The divergence between modest national trends and subnational state-level variation underscores the importance of examining subnational patterns when evaluating fertility transition and birth spacing dynamics. These findings highlight that policy responses must be explicitly aligned with the socio-economic, demographic, and regional determinants of birth spacing identified in this study.

Building on the empirical findings of this study, uneven and suboptimal birth spacing constitutes an urgent public health priority. Short intervals are strongly associated with adverse maternal and child health outcomes, undermining progress in child survival, nutrition, and development, while increasing maternal morbidity and mortality risks (Kundu et al., 2025). As a key pathway for achieving Reproductive, Maternal, Newborn, Child Health and Nutrition Sustainable Development Goals, this issue demands an immediate strategic shift in policy. Birth intervals serve as a key pathway for enhancing women's agency in reproductive health, reflecting not only biological recovery but also the autonomy to plan and space pregnancies. India's, which contrasts with nations that completed their fertility transitions alongside lower levels of infant and maternal mortality (Shekhar et al. 2024), underscores that healthier spacing is vital for realizing the full benefits of fertility decline (Rana & Goli, 2018). Comparable evidence from other transitioning contexts indicates that fertility decline does not necessarily translate into longer birth intervals (Casterline & Odden, 2016), particularly when family planning programs prioritize limiting births over promoting optimal spacing. Such international parallels suggest that India's uneven spacing transition reflects a wider structural challenge across LMICs, where fertility reduction has outpaced behavioral and programmatic shifts needed to support reproductive timing and agency (Carlson et al., 2024). Future program strategies must therefore integrate birth spacing as both a health and empowerment intervention central to reproductive rights and gender equity.

More specifically, the observed U-shaped relationship between wealth and short birth intervals indicates that higher socio-economic status does not necessarily ensure optimal spacing, even after accounting for key demographic factors such as age at marriage and first birth. This suggests that family planning interventions must extend beyond traditionally targeted poorer populations and also address spacing behaviour among wealthier groups. Similarly, the threshold effect for education highlights the importance of promoting secondary education for girls as a pathway to improved birth spacing outcomes. The pronounced regional heterogeneity further points to the need for decentralized and context-specific strategies, particularly in high-fertility states where birth intervals have contracted. Finally, the persistence of short birth intervals despite declining fertility levels indicates that current family planning efforts remain overly focused on limiting births rather than promoting optimal spacing.

To address this imbalance, a three-pronged approach aligned with these findings is essential. First, the persistence of short birth intervals and the limited role of spacing methods highlight the need to revitalize the family planning program by moving beyond sterilization dominance toward promoting reversible contraceptives and informed choice. Second, the strong regional disparities in birth interval

patterns call for targeted, region-specific interventions, particularly in lagging states such as those in Central and Eastern regions. Third, the observed socioeconomic and educational gradients emphasize the need to integrate spacing counselling into all maternal and child health programs, with a focus on both less-educated populations and socioeconomic groups experiencing compressed fertility patterns. Ultimately, reorienting policy toward optimal spacing, through targeted, region-specific interventions and a greater emphasis on reversible contraceptive use, is essential to translate India's demographic success into healthier, better-timed pregnancies and secure the next stage of its demographic and gender dividend.

10. References

- Ajayi, A. I., & Somefun, O. D. (2020). Patterns and Determinants of Short and Long Birth Intervals among Women in Selected sub-Saharan African Countries. *Medicine*, 99(19), e20118.
- Aleni, M., Mbalinda, S. N., & Muhindo, R. (2020). Birth Intervals and Associated Factors among Women Attending Young Child Clinic in Yumbe Hospital, Uganda. *International journal of reproductive medicine*, 2020(1), 1326596.
- Baschieri, Angela (2004). The Second Birth Interval in Egypt: The Role of Contraception (S3RI Applications and Policy Working Papers, A04/05) Southampton, GB. University of Southampton 51pp.
- Basu, A. M. (1993). Cultural Influences on the Timing of First Births in India: Large Differences that Add Upto Little Difference. *Population Studies*, 47(1), 85-95.
- Belachwe, Y. A., Komicha, M. A., Girsha, W. D., Getahun, M. S., Seifu, B. L., & Negussie, Y. M. (2024). Determinants of Suboptimal Birth Spacing among Reproductive-Age Women in Adama District, Ethiopia: A Community-Based Unmatched Case-Control Study. *BMC Women's Health*, 24(1), 580.
- Bhalotra, S., & Van Soest, A. (2008). Birth-Spacing, Fertility and Neonatal Mortality in India: Dynamics, Frailty, and Fecundity. *Journal of Econometrics*, 143(2), 274-290.
- Bongaarts, J. (1978). A Framework for Analyzing the Proximate Determinants of Fertility. *Population and development review*, 105-132.
- Bongaarts, J. (1999). The Fertility Impact of Changes in the Timing of Childbearing in the Developing World. *Population studies*, 53(3), 277-289.
- Caldwell, J. C., & Caldwell, P. (1987). The Cultural Context of High Fertility in Sub-Saharan Africa. *Population and development review*, 409-437.
- Caldwell, J. C., Orubuloye, I. O., & Caldwell, P. (1992). Fertility Decline in Africa: A New Type of Transition? *Population and development review*, 211-242.
- Carlson, L., Guzzo, K. B., & Wu, H. S. (2024). Birth Spacing and Working Mothers' Within-Organization Career Paths. *Socius*, 10, 23780231241230845.
- Casterline, J. B., & Odden, C. (2016). Trends in Inter-Birth Intervals in Developing Countries 1965-2014. *Population and Development Review*, 173-194.
- Cecatti, J. G., Correa-Silva, E. P., Milanez, H., Morais, S. S., & Souza, J. P. (2008). The Associations Between Inter-Pregnancy Interval and Maternal and Neonatal Outcomes in Brazil. *Maternal and child health journal*, 12, 275-281.
- Chowdhury, S., Singh, A., Kasemi, N., Chakrabarty, M., & Singh, S. (2023). Short Birth Interval and Associated Factors in Rural India: A Cross-Sectional Study. *Journal of Biosocial Science*, 55(4), 735-754.
- Conde-Agudelo, A., Rosas-Bermúdez, A., & Kafury-Goeta, A. C. (2007). Effects of Birth Spacing on Maternal Health: A Systematic Review. *American journal of obstetrics and gynecology*, 196(4), 297-308.

- Conde-Agudelo, A., Rosas-Bermudez, A., Castaño, F., & Norton, M. H. (2012). Effects of Birth Spacing on Maternal, Perinatal, Infant, and Child Health: A Systematic Review of Causal Mechanisms. *Studies in family planning*, 43(2), 93-114.
- Cox, D. R. (1972). Regression Models and Life-Tables. *Journal of the Royal Statistical Society: Series B (Methodological)*, 34(2), 187-202.
- Desai, S., Pramanik, S., & Chouhan, B. (2022). The Paradox of Declining Fertility and Declining Contraceptive Use in India: An Artefact of Survey Design? *SSM-Population Health*, 19.
- Dommaraju, P. (2009). Timing of First Birth in India. *Genus*, 65(1), 81-101.
- Gemmill, A., & Lindberg, L. D. (2013). Short Interpregnancy Intervals in the United States. *Obstetrics & Gynecology*, 122(1), 64-71.
- International Institute for Population Sciences (IIPS) and ICF. (2017). National Family Health Survey (NFHS - 4), 2015-16: India, Vol. I. IIPS.
- International Institute for Population Sciences (IIPS) Ministry of Health and Family Welfare. (2021). National Family Health Survey (NFHS - 5), 2019-21: India, Vol. I. IIPS.
- International Institute for Population Sciences (IIPS) ORC Macro International. (2007). National Family Health Survey (NFHS - 3), 2005-06: India, Vol. I. IIPS.
- International Institute for Population Sciences (IIPS) ORC Macro. (2000). National Family Health Survey (NFHS - 2), 1998-99: India. IIPS.
- International Institute for Population Sciences (IIPS). (1995). National Family Health Survey (NFHS -1), 1992-93: India. IIPS.
- Jadhav, A. (2014). Linkages among Fertility, Migration, and Aging in India. University of Pennsylvania.
- Jadhav, A., & Vala-Haynes, E. (2018). Informed Choice and Female Sterilization in South Asia and Latin America. *Journal of biosocial science*, 50(6), 823-839.
- Jadhav, A., Vala-Haynes, E., & Jadhav, A. (2016, April). Quality of Care and Female Sterilization: Measuring Informed Consent in 12 Countries. In *2016 Annual Meeting*. PAA.
- James, K. S., & Goli, S. (2016). Demographic changes in India: Is the country prepared for the challenge?. *Brown J. World Aff.*, 23, 169.
- Joshi, R., Khadilkar, S., & Patel, M. (2015). Global Trends in Use of Long-Acting Reversible and Permanent Methods of Contraception: Seeking a Balance. *International Journal of Gynecology & Obstetrics*, 131, S60-S63.
- Kannaujiya, A. K., Kumar, K., Upadhyay, A. K., McDougal, L., Raj, A., & Singh, A. (2020). Short Interpregnancy Interval and Low Birth Weight Births in India: Evidence from National Family Health Survey 2015-16. *SSM-Population Health*, 12, 100700.
- Karra, M., & Canning, D. (2024). Unwanted Family Planning Including Unwanted Sterilization: Preliminary Prevalence Estimates for India. *Studies in Family Planning*, 55(4), 349-359.
- Karra, M., Maggio, D., Guo, M., Ngwira, B., & Canning, D. (2022). The Causal Effect of a Family Planning Intervention on Women's Contraceptive Use and Birth Spacing. *Proceedings of the National Academy of Sciences*, 119(22), e2200279119.
- Kassie, S. Y., Ngusie, H. S., Demsash, A. W., & Alene, T. D. (2023). Spatial Distribution of Short Birth Interval and Associated Factors among Reproductive Age Women in Ethiopia: Spatial and Multilevel

- Analysis of 2019 Ethiopian Mini Demographic and Health Survey. *BMC Pregnancy and Childbirth*, 23(1), 275.
- Khan, J. R., Bari, W., & Latif, A. M. (2016). Trend of Determinants of Birth Interval Dynamics in Bangladesh. *BMC public health*, 16(1), 934.
- Khan, N., Mozumdar, A., & Kaur, S. (2020). Determinants of Low Birth Weight in India: An Investigation from The National Family Health Survey. *American Journal of Human Biology*, 32(3), e23355.
- Kundu RN, Borah J, Chatterjee A, Mukherjee K, Bharati S, Hossain MG, Bharati P. (2025). Short Birth Spacing and its Impact on Maternal and Child Health in India with Urban-Rural Variation: An Epidemiological Study Using the National Family Health Survey Data. *PLoS One*. Jun 27;20(6): e0325461.
- Long, J. S., and J. Freese. (2014). *Regression Models for Categorical Dependent Variables Using Stata*. 3rd ed. College Station, TX: Stata Press.
- Marston, C. (2006). Report of a Technical Consultation on Birth Spacing, Geneva, 13-15 June 2005.
- McNay, K., Arokiasamy, P., & Cassen, R. (2003). Why are Uneducated Women in India Using Contraception? A Multilevel Analysis. *Population Studies*, 57(1), 21-40.
- Miller, R., & Karra, M. (2020). Birth Spacing and Child Health Trajectories. *Population and Development Review*, 46(2), 347-371.
- Misra, S., Goli, S., Rana, M. J., Gautam, A., Datta, N., Nanda, P., & Verma, R. (2021). Family Welfare Expenditure, Contraceptive Use, Sources and Method-Mix in India. *Sustainability*, 13(17), 9562.
- Molitoris, J., Barclay, K., & Kolk, M. (2019). When and Where Birth Spacing Matters for Child Survival: An International Comparison Using The DHS. *Demography*, 56(4), 1349-1370.
- Nath, D. C., Leonetti, D. L., & Steele, M. S. (2000). Analysis of Birth Intervals in a Non-Contracepting Indian Population: An Evolutionary Ecological Approach. *Journal of Biosocial Science*, 32(3), 343-354.
- Nath, S. (2023). Explaining Third Birth Patterns in India: Causal Effects of Sibling Sex Composition. *Journal of Population Economics*, 36(4), 2169-2203.
- Padmadas, S. S., Hutter, I., & Willekens, F. (2004). Compression of Women's Reproductive Spans in Andhra Pradesh, India. *International Family Planning Perspectives*, 30 (1), 12-19.
- 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.
- Pörtner, C. C. (2022). Birth Spacing and Fertility in The Presence of Son Preference and Sex-Selective Abortions: India's Experience Over Four Decades. *Demography*, 59(1), 61-88.
- Prentice, R. L., & Gloeckler, L. A. (1978). Regression Analysis of Grouped Survival Data with Application to Breast Cancer Data. *Biometrics*, 57-67.
- Rabbi, A. M. F., Karmaker, S. C., Mallick, S. A., & Sharmin, S. (2013). Determinants of Birth Spacing and Effect of Birth Spacing on Fertility in Bangladesh. *Dhaka University Journal of Science*, 61(1), 105-110.
- Raj, A., Saggurthi, N., Balaiah, D., & Silverman, J. G. (2009). Prevalence of Child Marriage and Its Effect on Fertility and Fertility-Control Outcomes of Young Women in India: A Cross-Sectional, Observational Study. *The Lancet*, 373(9678), 1883-1889.
- Raj, A., Saggurthi, N., Winter, M., Labonte, A., Decker, M. R., Balaiah, D., & Silverman, J. G. (2010). The Effect of Maternal Child Marriage on Morbidity and Mortality of Children Under 5 in India: Cross Sectional Study of a Nationally Representative Sample. *BMJ*, 340.

- Rana, M. J., & Goli, S. (2018). Does Planning of Births Affect Childhood Undernutrition? Evidence from Demographic and Health Surveys of Selected South Asian Countries. *Nutrition*, 47, 90-96.
- Rana, M. J., & Goli, S. (2021). The Road from ICPD to SDGS: Health Returns of Reducing the Unmet Need for Family Planning in India. *Midwifery*, 103, Article 103107. <https://doi.org/10.1016/j.midw.2021.103107>
- Rana, M. J., & Jain, A. K. (2020). Do Indian Women Receive Adequate Information About Contraception? *Journal of Biosocial Science*, 52(3), 338-352.
- Rana, M. J., Gautam, A., Goli, S., Reja, T., Nanda, P., Datta, N., & Verma, R. (2019). Planning of Births and Maternal, Child Health, and Nutritional Outcomes: Recent Evidence from India. *Public Health*, 169, 14-25.
- Rutstein, S. O. (2005). Effects of Preceding Birth Intervals on Neonatal, Infant and Under-Five Years Mortality and Nutritional Status in Developing Countries: Evidence from the Demographic and Health Surveys. *International Journal of Gynecology & Obstetrics*, 89, S7-S24.
- Rutstein, S. O. (2011). Trends in Birth Spacing (No. 28). ICF Macro.
- Saha, U. R., & van Soest, A. (2013). Contraceptive Use, Birth Spacing, and Child Survival in Matlab, Bangladesh. *Studies in Family Planning*, 44(1), 45-66.
- Sahoo, H. (2013). Spacing Between Births in Odisha, India. *Marriage & Family Review*, 49(7), 585-605.
- Samari, G. (2017). Women's Agency and Fertility: Recent Evidence from Egypt. *Population Research and Policy Review*, 36(4), 561-582.
- Shachar, B. Z., & Lyell, D. J. (2012). Interpregnancy Interval and Obstetrical Complications. *Obstetrical & gynecological survey*, 67(9), 584-596.
- Shekhar C, Goli S, Mishra R. (2024). Fertility and Family Planning: Explaining Transition and Thinking about Post-Transitional Regimes. In: James KS, Sekher TV, eds. India Population Report. Cambridge University Press :46-109.
- Singh, S., Remez, L., Ram, U., Moore, A. M., & Audam, S. (2009). Barriers to Safe Motherhood in India. *New York: Guttmacher Institute*, 1-35.
- Singh, S., Shekhar, C., Bankole, A., Acharya, R., Audam, S., & Akinade, T. (2022). Key Drivers of Fertility Levels and Differentials in India, at the National, State and Population Subgroup Levels, 2015–2016: An Application of Bongaarts' Proximate Determinants Model. *Plos one*, 17(2), e0263532.
- Skjærven, R., Wilcox, A. J., & Lie, R. T. (2002). The Interval Between Pregnancies and the Risk of Preeclampsia. *New England Journal of Medicine*, 346(1), 33-38.
- Srinivasan, K. (2017). *Population Concerns in India: Shifting Trends, Policies, and Programs* (1st ed.). Sage.
- Van Wijk, D., & Billari, F. C. (2024). Fertility postponement, economic uncertainty, and the increasing income prerequisites of parenthood. *Population and Development Review*, 50(2), 287-322.
- Wegbom, A. I., Bademosi, A., Edet, C. K., Green, K. I., Sapira-Ordu, L., & Fagbamigbe, A. F. (2022). Rural-Urban Disparities in Birth Interval among Women of Reproductive Age in Nigeria. *Scientific reports*, 12(1), 17488.
- Wood, J. W. (2017). *Dynamics of Human Reproduction: Biology, Biometry, Demography*. Routledge.
- Yeakey, M. P., Muntifer, C. J., Ramachandran, D. V., Myint, Y., Creanga, A. A., & Tsui, A. O. (2009). How Contraceptive Use Affects Birth Intervals: Results of a Literature Review. *Studies in family planning*, 40(3), 205-214.

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