OFFSPRING'S SEX COMPOSITION AND CHILDBIRTH TIMING IN THIRD CHILD TRANSITION AMONG INDIAN MOTHERS BORN BETWEEN 1966 AND 1985

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Abstract. India faces gender discrimination, leading to skewed sex ratios at birth and influencing family size and the sex composition of already-born offspring. Using the National Family Health Survey-4 (2015-2016), we first apply sequence analysis to investigate the sex composition, mothers' age at the first child, and childbirth timing for the first two children among Indian mothers born between 1966 and 1985, all of whom are under 30 years old. Second, using logistic regression, we analyze the determinants of the transition to a third child and examine whether the influence of sex composition, combined with timing, has changed over time. We find that education and wealth indices affect mothers' mean age at first child and the time interval between births. We also observe that women with two daughters are more likely to have a third child, even within younger birth cohorts, despite an overall reduction trend of declining fertility. Through sequence analysis, our study provides unique insights into gender discrimination in India and its implications for fertility across different mothers' birth cohorts. By identifying the trajectories of sex composition and childbirth timing among previously born offspring, we gain a deeper understanding of the role of male offspring in shaping the likelihood of having a third child while controlling for traditional covariates and mothers' birth cohorts.

1. Introduction and literature review

India faces severe discrimination against women, influenced by class, caste, state, religion, and education (Bhalotra *et al.*, 2020). The country ranks 127th out of 146 in the 2023 Global Gender Gap Index[1], with a score of 66.8%. The country has attained parity in enrolment across all levels of education, but it has reached only 36.7% parity on Economic Participation and Opportunity (World Economic Forum, 2023). Despite a general decline in under-five mortality (World Bank, 2022), Indian girls face higher mortality rates than boys (Kashyap & Behrman, 2020).

Cultural and social factors, such as a patrilineal family system and the economic burden of dowries, sustain son preference. Sons are valued for maintaining lineage,

[1] The global gender gap score is a composite index of four components: Economic Participation and Opportunity, Educational Attainment, Health and Survival, and Political Empowerment. In 2023, the gender gap closed by 96% in Health, 95.2% in Education, 60.1% in Economic Participation, and only 22.1% in Political Empowerment across 146 countries.

performing religious duties, and supporting elderly parents, while daughters are seen as a financial burden (Dyson & Moore, 1983). These factors also drive the use of prenatal sex-detection technologies (Anukirty *et al.*, 2016). As fertility rates decline to replacement levels (UNDP, 2022) gender bias intensifies, with families prioritizing sons within a smaller family size (Das Gupta & Mari Bhat, 1997; Chaudhuri, 2012; Farina & Terzera, 2015; Singh *et al.*, 2021; Saikia *et al.*, 2021).

The sex ratio at birth (SRB) reflects these biases, particularly the conditional SRB for second or higher birth orders, which depends on the sex of previous births (Saika et al. 2021). Son preference also manifests in differential stopping behavior (DSB), where couples continue having children until they have the desired number of sons, often resulting in larger families with more girls (Clark, 2000).

Families' socioeconomic factors, including wealth and education, intersect with these practices. While education can mitigate discrimination (Kaur *et al.*, 2016), highly educated women may be more likely to use sex selection (Das Gupta & Mari Bhat, 1997; Singh *et al.*, 2021). Religious beliefs, such as those in Hinduism and Islam, also play a role in son preference (Vlassoff, 1990; Murthy, 1996).

Parity progression analysis confirms parental intentions, showing that women with more sons than daughters are generally less likely to continue childbearing than those with more daughters than sons (Chaudhuri, 2012).

A recent article reports the association between SRB and birth order. Decisions on sex selection are likely to be sequential and depend on the sex of the children born, and such behavior may manifest after the sex of the first birth (UNFPA 2020). Nath (2023) extends this discussion by analyzing how the sex of the first two children affects the timing of the third birth, especially for cohorts born before 1990.

The misuse of prenatal diagnostic techniques (PNDT) also reflects the intentions of couples to control family composition, particularly at higher birth orders (Gellatly & Petrie, 2017).

Although there is extensive research on son preference in India, there is a gap in understanding birth spacing patterns and the combined effects of sex sequences of previous births.

This paper explores how maternal trajectories influence the transition to the third child, providing new insights into this area. Drawing from existing literature, we formulated two research hypotheses to frame our research:

H1: we expect mothers with two daughters to be more likely to have a third child, especially in younger cohorts, regardless of timing patterns.

H2: we expect mothers who give birth at a younger age and have shorter birth intervals to be more likely to have a third child, regardless of the sex composition of previous births.

2. Data and methods

We used the National Family Health Survey 4 (NFHS-4) conducted in 2015–2016, a nationally representative household survey covering all 29 states and seven union territories in India. The NFHS-4 employed a stratified two-stage sampling method[2]. Our analysis used the 'Woman's Questionnaire' for women aged 15–49 (N = 699,686 women), focusing on those born between 1966 and 1985 with at least two children (N = 250,280 women). For computational reasons, we ran the analysis on a stratified random sampling taking a 5% sample from each state, resulting in a subsample of 12,413 women[3]. Henceforth, all the comments and results refer to this subsample.

We used sequence analysis (Abbott & Tsay, 2000) to analyse the sex composition and childbirth timing of the first two children.

This method defines an ordered string of 'states' to represent women's childbearing history and has been used in the analysis of migrant working trajectories (e.g., Barbiano di Belgiojoso & Ortensi, 2019) and family formation among migrants (e.g., Barbiano di Belgioso & Terzera, 2018; Mikolai & Kulu, 2019). This method analyses sequences from a life-course perspective, considering two essential elements to define the sequence: the timing of events (period of observation) (Billari & Piccarreta, 2005) and the 'state space' (the set of all possible states, namely, 'sex sequences').

In the context of sex sequences in India, previous studies have examined offspring sex composition (e.g., Yadav *et al.*, 2020), but often neglect the timing of events, especially for mothers who gave birth before 1990 (Nath, 2023). Farina and Terzera (2015) were the first to apply sequence analysis to this topic.

Our analysis spans 15 years of observation, resulting in sequences that are 30 semesters long (a time unit), and covers women's fertility history from ages 15 to 30 across all birth cohorts. This approach accounts for the consistent mean age of mothers at the first (around 20) and third (almost 25) children, despite a decline in completed fertility over time.

The state-space was defined by self-declared childbirth and the child's sex, identifying seven states, coded as follows: no birth (coded 0); one son (S); one daughter (D); two sons (SS); two daughters (DD); first son then daughter (SD); and first daughter then son (DS). Children who died within the first year of life were not considered.

[2] For further details, see https://dhsprogram.com/pubs/pdf/FR339/FR339.pdf.
[3] Results are robust to different random sample extractions.

We use optimal matching analysis (OMA)[4] to compare sequences by creating a distance matrix[5] that displays the similarity in states' frequency, order, and location. The OMA functions transform one sequence into another by adding, removing, or replacing states, each with assigned 'costs'. The distance between two sequences represents the minimum total cost required for transformation (Billari, 2001; Gauthier *et al.*, 2009), with a lower distance value indicating a more remarkable similarity between the two sequences. By default, inserting or deleting a state incurs a cost of 1, whereas substitution costs 2. We adopted an ad-hoc substitution cost matrix, as in previous studies (Barbiano di Belgiojoso & Ortensi, 2019), to analyse sex sequences of previous births (Table 1).

Table 1 – *Substitution cost matrix for the sequence analysis.*

	0	S	D	DD	SD	DS	SS
0	0	1	0.50	0.75	1.50	1.50	2
S		0			0.50		1
D			0	0.75		1	
DD				0			
SD					0		
DS						0	
SS							0

Notes: 0 = no birth; S = son; D = daughter.

To categorise trajectories (Aassve *et al.*, 2007), we performed a cluster analysis on the OMA distance matrix using Ward's algorithm. We selected an eight-cluster solution based on the Duda and Caliński methods and cluster sizes to optimize classification informativeness (Halpin, 2016).

Finally, we used logistic regression models to examine how sex composition and childbirth timing of previous births affect the probability of having a third child and its determinants. The dependent variable analysed in the logistic regression is the 'transition to the third child', coded as 1 for women with a third child and 0 otherwise.

The primary explicative variable is the 'sex sequence of previous births,' a categorical variable with eight categories which align with the eight clusters obtained from the cluster analysis. We labelled these categories considering the sex composition of previous births, birth interval timing (a short, medium, or long time)[6],

[4] The sequence analysis was performed in Stata 16 using a package implemented by Kohler *et al.,* (2006).

[5] For further details, see Abbot and Tsay (2000), which is one of the available methods.

[6] We categorised the time intervals between births as follows: "short-time" for intervals of less than two and a half years; "medium-time" for intervals between two and a half years and just under three years;

and mothers' mean age at the first child[7]. The categories are 1 'SD, long time, 18-20 years, 2 'SD, long time, >20 years', 3 'SS, long time, >20 years', 4 'SS, medium time, <18 years', 5 'SS, long time, 18-20 years' –*reference*, 6 'DS, medium time, 18-20 years', 7 'DS, long time, >20 years', 8 'DD, long time, >20 years' (details in paragraph 4.2).

Independent variables included birth cohort (1' 1966–1970' –*reference*, 2' 1971–1975', 3' 1976–1980', 4' 1981–1985'); civil status (1 'currently unmarried' –*reference,* 2 'currently married'); educational level (1 'low,' i.e., no education and primary –*reference*, 2 'high,' i.e., secondary and tertiary); type of residence (1 'urban' –*reference*, 2 'rural'); religion (1 'Hinduism' –*reference*, 2 'Islam,' 3 'Christianity,' 4 'other religion'); wealth index (1 'poor' –*reference*, 2 'middle', 3 'rich'). Moreover, to control for infant mortality (i.e., if a woman had experienced the death of a child in the first year of life), we also included in the model the variable at least one child died (1 'no' –*reference*, 2 'yes'). Table 2 shows the characteristics of the sample.

Table 2 – *Percentage distribution of women's characteristics with at least two children.*

Variables	%	Variables	%	Variables	%
Birth cohort		Religion		Children died	
1966–1970	20.9	Hinduism	76.6	No	82.5
1971–1975	23.4	Islam	12.5	Unmet need	
1976–1980	27.5	Christianity	6.3	No	91.7
1981–1985	28.2	Other religion	4.6	Heard family planning	
Current civil status		Wealth index		No	42.7
Unmarried	6.2	Poor	42.3	Mean n. of children	(3.3)
Married	93.8	Middle	20.6	Age at 1st child	
Educational level		Rich	37.1	<20	42.7
Low	63.1	Type of residence		20-24	49.3
High	36.9	Urban	27.8	25-30	8.0
		Rural	72.2		
Number of women			12,413		

Note: The table shows percentages and should be read in columns.
Source: Authors' elaboration on NFHS-4 data (2015-2016).

and "long-time" for intervals greater than three years. These categories were determined through cluster analysis and represent the average time intervals between births, as shown in Table 3. The labels were chosen to ensure clarity when presenting the results.

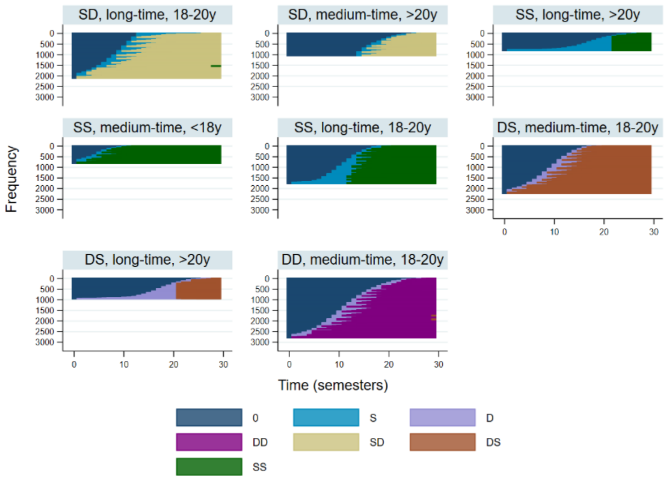
[7] We classified mothers into three groups based on their age at the start of childbearing: those who began before age 18 (<18y), those who started between 18 and 20 years (18-20y), and those who began after age 20 (>20y). These thresholds were determined through cluster analysis and represent the average age at which mothers had their first child.

3. Results

3.1. Sequence analysis and cluster analysis

Cluster analysis identifies eight distinct groups based on sex sequences and timing, labelled by sex composition, birth intervals, and mothers' mean age at the first birth (Fig. 1).

Figure 1 – *Sex sequences of the offspring already born over time and by cluster.*



Percentage distribution of the sample by cluster.

Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Tot
16.9%	8.3%	6.4%	6.5%	14.0%	17.9%	7.6%	22.4%	100.0%

Note: S = son; D = daughter.
Source: Authors' elaboration on NFSH-4 data (2015-2016).

Clusters 1 and 2 (25.2% of women) show a son-daughter (SD) pattern. Cluster 1 has a longer birth interval (three years) and a mean age of 18.3 years at first birth, while cluster 2 has a shorter interval (two years and six months) and a mean age at first child of 23.2 years old. Clusters 3, 4, and 5 (26.9% of women) consist of two sons. In cluster 3, women had their first son after age 20 (mean age 23.2) with a longer gap before the second (around age 26). Cluster 4 includes women who had their first son before age 18 (mean age 16.6) and their second around age 20. In cluster 5, women had their first son between 18 and 20 (mean age 20.0 years old) with a three year-gap between births). Clusters 6 and 7 (25.5% of women) involve a daughter followed by a son. In cluster 6, the birth interval is 2.5 years, with a mean age of 18.9 at first birth. In contrast, cluster 7 shows a longer time interval (on average, 3.3 years) and a mean age of 23.2 at first birth. Finally, cluster 8 (22.4% of women) consists of women with two daughters, with the first born at mean age of 20.0 and a 2.8-year birth interval.

3.2. Logistic model for the transition to the third child

Table 3 displays adjusted odds ratios (ORs) for the likelihood of having a third child, highlighting key determinants. Higher education and non-poor economic status decrease the likelihood of having a third child, while being married increases it. Younger birth cohorts are less likely to have a third child compared to the older ones (1966-1970), reflecting the decline in fertility among Indian women, though the average age at first two children remains unchanged. Christians and especially Muslims are more likely to have a third child than Hindus, while residence type has no significant effect. Women who have lost a child are more likely to have a child.

Table 3 – *Adjusted ORs for the probability of having the third child.*

	OR		OR
Clusters (ref. 5. SS, long-time, 18-20y)		Educational level (ref. Low)	
1. SD, long-time, 18-20y	1.64***	High	0.41***
2. SD, medium-time, >20y	0.61***	The type of residence (ref. Urban)	
3. SS, long-time, >20y	0.26***	Rural	0.97
4. SS, medium-time, <18y	1.68***	Religion (ref. Hinduism)	
6. DS, medium-time, 18-20y	1.84***	Islam	2.35***
7. DS, long-time, >20y	0.45***	Christianity	1.78***
8. DD, medium-time, 18-20y	2.78***	Other religion	0.93
Birth cohort (ref. 1966–1970)		Wealth index (ref. Poor)	
		Middle	0.69***
1971–1975	0.83***	Rich	0.48***
1976–1980	0.66***	At least one child died (ref. No)	
1981–1985	0.50***	Yes	1.22**
Current civil status (ref. Unmarried)			
Married	1.84***		
Number of women		12,413	

Note: S = son; D = daughter.
*Legend: *p < 0.05, **p < 0.01, ***p < 0.001*
Source: Authors' elaboration on NFSH-4 data (2015-2016).

All clusters differ from cluster 5. Clusters 1, 4, 6, and 8, where women had their first child at 20 years or younger, positively affect the likelihood of having a third child, with, cluster 8 showing the strongest effect. Conversely, clusters 2, 3, and 7, where women had their first child later and the birth interval exceeded two and a half years, negatively affect this likelihood, particularly when the first child is born after age 20. The interval exceeds three and a half years (cluster 3).

Finally, we ran a model with an interaction term between cluster and birth cohort to assess if the effect of the identified clusters varies across birth cohorts.

For the sake of brevity, we only report the results of the interaction terms; control variables remained consistent with the previous model. Table 4 shows that clusters 1–7 have a relatively uniform effect on the likelihood of having a third child across different birth cohorts, with no significant differences compared to the reference category (cluster 5: two sons, long time interval, first son born between ages 18-20, birth cohort 1966-1970). However, cluster 8 (two daughters, moderate time interval, first daughter born between ages 18-20) is linked to a higher likelihood of having a third child in more recent birth cohorts (from 1971 to 1985) compared to the oldest cohort (1966–1970). This may be due to changing fertility patterns in younger cohorts, where the desire for a son appears to be fulfilled at lower parities, unlike in older cohorts where childbearing extended beyond the third child.

Table 4 – *Adjusted ORs for the transition to the third child.*

	OR		OR
Cluster*Birth cohort		Cluster*Birth cohort	
1.*1971–1975	0.85	4.*1981–1985	0.73
1.*1976–1980	0.86	6.*1971–1975	0.95
1.*1981–1985	0.77	6.*1976–1980	0.95
2.*1971–1975	1.40	6.*1981–1985	0.70
2.*1976–1980	1.15	7.*1971–1975	1.10
2.*1981–1985	1.06	7.*1976–1980	1.37
3.*1971–1975	0.88	7.*1981–1985	0.81
3.*1976–1980	1.02	8.*1971–1975	1.51*
3.*1981–1985	1.06	8.*1976–1980	1.82**
4.*1971–1975	0.94	8.*1981–1985	1.50*
4.*1976–1980	1.05		
Number of women		12,413	

Notes: The model controls for civil status, education, type of residence, religion, wealth index, children died, unmet needs, and heard family planning. S = son; D = daughter.
Legend: *p < 0.05, **p < 0.01, ***p < 0.001.
Source: Authors' elaboration on NFSH-4 data *(2015-2016)*.

4. Discussion and conclusion

This study investigates two key aspects: the different combinations of sex composition of already-born offspring and childbirth timing (mothers' age at first child and the interval between births), and how these combinations influence the transition to a third child among Indian mothers born between 1966 and 1985.

Maternal birth trajectories appear to be shaped by personal strategies involving choices about the number and sex of children to welcome into the family.

Using sequence analysis, we identify distinct clusters based on the sex composition of already-born offspring and childbirth timing. Cluster 8 (DD) stands out with mothers who had two first-born daughters, typically becoming mothers between ages 18 and 20, with medium birth intervals and a high proportion of economically disadvantaged mothers (44.8%). In contrast, other clusters (SD, DS, SS) show more diverse patterns in maternal age at first childbirth and birth intervals.

The study findings underscore the significance of two elements in influencing the likelihood of having a third child: the sex composition of previous births (H1) and the timing of these events (H2). Mothers with two daughters are nearly three times more likely to have a third child than those with two sons, especially when they start motherhood between 18 and 20 and have longer birth intervals. Having at least one son is crucial for Indian parents across all birth cohorts, particularly for the youngest cohort (1981–1985, H1).

Our findings indicate an association between starting childbearing before age 20 and an increased likelihood of having higher-order births (H2). However, it is also possible that women who desire more children may choose to begin having them earlier. Conversely, women who start having children after age 20 tend to be less inclined to have a third child.

Furthermore, the results highlight the well-established influence of certain structural variables on the likelihood of transitioning to a third child. Higher education and wealth index reduced the likelihood of a third child. Religion as well emerges as a relevant factor: Hindu mothers are less likely to have a third child compared to others.

Our study has some limitations. First, we lack data on events before the first child. Second, the retrospective nature of self-assessed birth sequences information may lead to under-reporting of female births or sequencing bias, though we mitigated this by asking mothers to list births chronologically. Third, data on prenatal diagnostic technique (PNDT) and sex-selective abortions is missing, though laws and programs in India aim to address this issue. Finally, some explanatory variables (civil status, religion, type of residence, educational level and wealth index) used in the models are measured at the time of the interview due to data constraints.

Despite these limitations, our results provide valuable insights into gender discrimination in India, particularly its potential impact on gender imbalance and fertility.

Our findings highlight that the preference for son remains strong and persist even among younger birth cohorts with declining fertility. As India continues its fertility decline (World Bank Indicators, 2015), this preference may further exacerbate gender imbalances and pose unique challenges, as women aim to have fewer children but also aim to avoid being sonless (Aksan, 2021).

In conclusion, our study underscores the enduring preference for male offspring, which persists among younger generations in India.

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