Indian Journal of Population and Development

Volume 5(1) January 2025 ISSN:2583-4827

INDIAN JOURNAL OF POPULATION AND DEVELOPMENT is an open access peer reviewed journal. It serves as a platform to discuss and debate the relationship between population issues and sustainable development in the context of human well-being. **INDIAN JOURNAL OF POPULATION AND DEVELOPMENT** publishes high quality research papers on different dimensions of population and development and their interrelationships in the contemporary context.

Journal Particulars

Title	Indian Journal of Population and Development
Frequency	Two times a year
ISSN	
Publisher	Mewalal Chaurasia Foundation
Chief Editor	Aalok Ranjan Chaurasia
Copyright	Mewalal Chaurasia Foundation
Starting year	2021
Subject	Multi-disciplinary subjects
Language	English
Publication format	Electronic (online)
Phone number	755-2927778
E-mail	ijpd@mlcfoundation.org.in
Mobile	9425017555
Website	www.mlcfoundation.org.in/research/IJPD
Address	Mewalal Chaurasia Foundation 51, Lake City Farms (Ganesh Puri) Kalkheda Road, Neelbad Bhopal, MP-462044 India

Research papers for publication in **INDIAN JOURNAL OF POPULATION AND DEVELOPMENT** may be submitted through e-mail to either Editor or Managing Editor with the understanding that they have not been published elsewhere and have not been submitted to any other journal for publication. Research papers must be in MS Word format. The first page of the paper must provide: 1) The Title of the paper; 2) Name and contact details of all authors; 3) Abstract in not more than 250 words; and 4) Three-four key words. The remaining part of the paper must not reveal identity of the author(s) to facilitate double-blind review process. Equations should be typed in the text using equation editor and should not be placed as a picture. Tables should be placed at the end of the paper in separate pages and should be appropriately referred to in the text. All tables must be in the table format and not in picture format. Figures should be placed at the end of the paper in jpg/jpeg format in separate pages and must also be provided as separate attachment in a spread sheet file to facilitate editing and formatting.

Publisher
Mewalal Chaurasia Foundation
51, Lake City Farms (Ganesh Puri)
Kalkheda Road, Neelbad
Bhopal, MP-462044
India

Editorial Board

Chander Shekhar
Professor,
Department of Fertility and Social Demography,
International Institute for Population Sciences, Mumbai, India
shekharc@iipsindia.ac.in

Kaushalendra K Singh
Professor,
Department of Statistics, Faculty of Science, Banaras
Hindu University, Varanasi, India kksingh@bhu.ac.in

Ravendra Singh
Former Additional Director General,
Ministry of Statistics and Programme Implementation,
Government of India, New Delhi
ravendra.singh@nic.in

Uttam Singh
Professor,
Department of Biostatistics and Health Informatics,
Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow, India
uttam@sgpgi.ac.in

Ravi BP Verma
Strategic Manager,
Statistics Canada, Ottawa, Canada
ravi2verma@yahoo.com

RC Yadav
Former Professor,
Department of Statistics,
Banaras Hindu University, Varanasi, India
rcyadava66@yahoo.com

INDIAN JOURNAL OF POPULATION AND DEVELOPMENT

VOLUME 5(1) JANUARY 2025 ISSN:2583-4827

Contributors

Moatula Ao
Department of Population Studies, Fakir Mohan University,
Balasore, Odisha, India
Jamirmoatula2@gmail.com

Joginder Singh Chauhan
Central University of South Bihar,
Gaya, Bihar, India
jschauhan@cusb.ac.in

Aalok R Chaurasia
MLC Foundation and ‘Shyam’ Institute,
Bhopal, India
aalok@mlcfoundation.org.in

Mriganka Dolui
Department of Geography, Central University of Karnataka,
Belagavi, India
mriganka.dolui@gmail.com

Adriza Dutta
Central University of South Bihar,
Gaya, Bihar, India
adrizadutta@cusb.ac.in

Frank Götmark
Department of Animal Ecology and Conservation Biology,
University of Gothenburg, Gothenburg, Sweden
frank.gotmark@bioenv.gu.se

Moslem Hussain
Department of Geography, School of Earth Sciences, Central University of Karnataka,
Kalaburagi, Karnataka 585367, India
moslemgeo@gmail.com

Chandan Kumar
‘Shyam’ Institute,
Bhopal, India

Archana Kujur,
Department of Fertility and Social Demography, International Institute for Population Sciences,
Mumbai, 400088, India
archanak@iipsindia.ac.in

Madhuri
Department of Geography, School of Earth Sciences, Central University of Karnataka,
Kalaburagi, Karnataka 585367, India
madhusp804@gmail.com

Grace Bahalen Mundu
Department of Population Studies, Fakir Mohan University,
Balasore, Odisha, India
grace.mundu@gmail.com

Rana Roy
Central University of South Bihar,
Gaya, Bihar, India

Sarda Prasad
Indira Gandhi National Open University,
New Delhi, India
sardaprasad@ignou.ac.in

Sanjit Sarkar
Department of Geography, Central University of Karnataka,
Belagavi, India
sanjitiips@gmail.com

Brijesh P Singh
Department of Statistics, Faculty of Science, Banaras Hindu University,
Varanasi, India
brijesh@bhu.ac.in

Kaushalendra K Singh
Department of Statistics, Faculty of Science, Banaras Hindu University,
Varanasi, India
kksingh@bhu.ac.in

Pappu Kumar Singh
Department of Statistics, Faculty of Science, Banaras Hindu University,
Varanasi, India
singhpppukumar63@gmail.com

Abhay Kumar Tiwari
Department of Statistics, Faculty of Science, Banaras Hindu University,
Varanasi, India
abhay.tiwari@ghu.ac.in

Nicola Turner
Dept of Biological and Environmental Sciences, University of Gothenburg,
Sweden

S Lima Kumba Warring
School of Economics, University of Hyderabad,
Hyderabad, Telangana, India
limawalling@uohyd.ac.in

INDIAN JOURNAL OF POPULATION AND DEVELOPMENT
ISSN: 2583-4827; Volume 5(1), January 2025: 1-45

Human Development Effects of Fertility in Districts of India

Aalok R Chaurasia
Chandan Kumar

Abstract

This paper analyses the relationship between human development and fertility across 707 districts in India using the classification and regression tree technique. The analysis reveals a statistically significant negative relationship between human development and total fertility rate (TFR), suggesting a positive role of human development in fertility transition, but inter-district variation in human development explains only a part of inter-district variation in TFR. The analysis suggests that there are factors beyond human development that influences the level of fertility in a district. The analysis also reveals regional variation in fertility and human development relationship. The southern region of the country shows advanced human development and lower fertility, while northern and eastern regions exhibit higher fertility with varying human development levels. The study also finds substantial intra-cluster and inter-district variation, emphasising the impact of unobserved factors on the variation in fertility across districts.

Introduction

The available evidence highlights persistent and pervasive variation in both demography and human development across the districts of India. In nearly half of the districts of the country, fertility now appears to have decreased below the replacement level, but it remains above the replacement level in other districts and exceptionally high in some districts. Similarly, the progress towards human development varies widely across districts (Chaurasia, 2023a) and, within district (Chaurasia, 2023b). These variations are expected because of the mesmerising social, cultural, and economic diversity of the country India. India is quite often christened as the country of countries from the perspective of both demography and development. This diversity also emphasises the need for a decentralised approach for planning and programming to meet the development and welfare needs of the people of the country.

The strong and persistent inter-district variation in both fertility and human development calls for examining the relationship between demographic dynamics and human development at the district level. Such an analysis may provide evidence for integrating demographic factors in planning and programming for human development activities at the local level. This integration ensures that the progress in human development leads to demographic transition while demographic transition contributes to accelerating human progress. Given the vastness and the diversity of the country India, it is neither feasible nor effective to adopt a universal approach to both fertility transition and human development in all districts. Instead, identifying uniformities or common patterns within this diversity can help to address local level challenges of both fertility transition and human development.

Attempts to explore how human development contributes to fertility transition has a long history (Luci and Thévenon, 2010). The demographic transition theory asserts that progress in the three core dimensions of human development - individual capacity, individual knowledge, and individual standard of living – are related to demographic transition, especially transition in fertility (Bryant, 2007; Notestein, 1945; Davis, 1945). This means fertility and human development are inversely related – the higher the human development the lower the fertility and vice versa. However, fertility and human development relationship is not linear. At low and medium levels, human development appears to promote fertility decline but at advanced levels of human development, the relationship is found to be weak (Wilson and Airey, 1999; Myrskylä et al, 2009; Fox et al, 2019), although the association between fertility and human development remains negative (Myrskylä et al, 2009; Furuoka, 2009; Myrskyläet al, 2011; Esping-Andersen and Billari, 2015; Goldscheider et al, 2015).

In India, both human development and fertility vary widely across the districts. For instance, some districts report fertility below the replacement level, while others still have more than four live births per woman (Chaurasia and Singh,). Similarly, human development varies from an advanced stage to unacceptably low level across districts (Chaurasia,). The variation in fertility and human development across districts offers an opportunity to examine the relationship between fertility and human development in the Indian context.

This paper examines the relationship between fertility and human development in India using district level data from the latest round of the National Family Health Survey (2019-21). The bivariate analysis regresses fertility (measured in terms of total fertility rate or TFR) on the surface measure of human development (HDS) - a composite index of human development capturing progress in individual capacity, knowledge, and standard of living (Chaurasia, 2023a). The multivariate analysis regresses TFR on the probability of survival in the first five years of life (HE), secondary school net attendance ratio (ED) and the proportion of households having at least the second wealth quintile of wealth index (SL). The classification or segmentation analysis further explores how human development influences fertility across the districts. Together, these analyses deepen understanding of fertility-human development dynamics within India.

Fertility and Human Development

The bivariate relationship between fertility and human development is presented in figure 1 in terms of the scatter plot of inter-district variation in total fertility rate (TFR) and inter-district variation in human development surface (HDS). The Figure suggests that human development and fertility are inversely related – the higher the level of human development the lower the fertility and vice versa. The relationship, however, is not strong as some districts exhibit high fertility despite advanced level of human development whereas some districts exhibit low or very low fertility despite low level of human development. More specifically, out of 144 districts in the country where human development is well advanced (HDS≥0.900), only 117 districts have TFR below the replacement level (TFR<2.1). In contrast, among 102 districts with either low or very low level of human development (HDS<0.600), the TFR is below the replacement level in 12 districts. The figure suggests that progress in human development contributes to fertility transition, but fertility transition is influenced by other factors also.

The ordinary least square regression of TFR on HDS also confirms the relatively weak relationship between inter-district variation in HDS and inter-district variation in TFR (Table 1). The regression coefficient is statistically significant and negative, reinforcing that human development promotes in fertility transition. However, inter-district variation in HDS explains less than 35 per cent of the inter-district variation in TFR. Notably, the TFR is not necessarily the lowest in the district with highest HDS; nor does the district with the lowest HDS have the highest TFR. The regression analysis confirms that confirms that fertility and human development are negatively associated, but human development is not the only determinant of fertility.

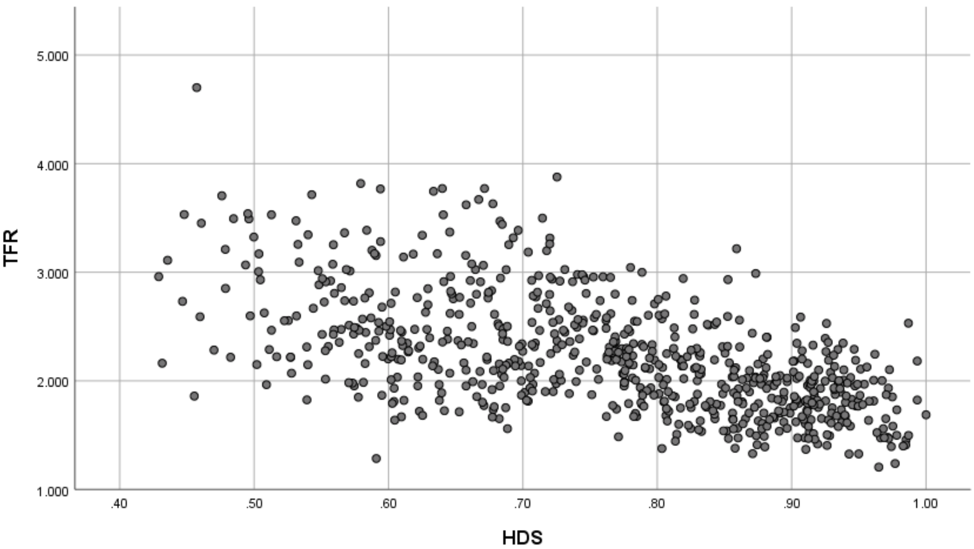


Figure 1: Association between the level of fertility (TFR) and human development (HDS) across 707 districts of India.
Source: Author.

The HDS is the composite measure of human development that encapsulates the probability of survival in the first five years of life (HE) reflecting individual capacity, secondary school net attendance ratio (ED) representing individual knowledge, and proportion of households having wealth index equal to or more than the second quintile of the inter-household distribution of wealth index (SL) indicating individual standard of living. Regression of TFR on HDS does not reveal the relative influence of the three dimensions of human development on TFR. Table 2 presents the regression results of TFR on HE, ED, and SL, the three constituents of HDS. The table suggests that inter-district variation in all the three dimensions of human development are statistically significantly and negatively associated with the inter-district variation in TFR. Among them, the individual knowledge dimension of human development has the highest influence on explaining the fertility variation, whereas the impact of individual capacity dimension on fertility is the weakest. Despite this, the relationship is not strong as three dimensions (HE, ED, and SL) explain only about 40 per cent of the inter-district variation in TFR, although it is still higher than the variation explained by HDS alone (Table 1).

Table 1: Regression of TFR on HDS based on district level estimates of TFR and HDS.

Independent variable	B	Std. Error	β	t	Sig.
Surface measure of human development (HDS)	-2.267	0.119	-0.584	-19.097	0.000
Constant	3.956	0.092		43.018	0.000
R^2					0.341
R^2 Adjusted					0.340
N					707

Source: Author

Table 2: Results of the regression of TFR on HE, ED, and SL based on district level data, 2019-2021.

Independent variables	B	Std. Error	β	t	Sig.
Probability of survival in the first five years of life (HE)	-4.240	0.792	-0.178	-5.353	0.000
Secondary school net attendance ratio (ED)	-1.575	0.174	-0.319	-9.054	0.000
Proportion of households having at least second quintile of wealth index distribution (SL)	-0.613	0.071	-0.296	-8.693	0.000
Constant	7.970	0.718		11.095	0.000
R^2					0.404
R^2 Adjusted					0.401
N					707

Source: Author

A comparison of Tables 1 and 2 indicates that inter-district variation in fertility is better explained when the three dimensions of human development are treated separately in the regression analysis. The explanatory power of human development in explaining fertility weakens when human development is measured through a composite index such as HDS. The reason is that aggregation of the three dimensions of human development into a single metric of human development results in some loss of information which is expected, as aggregating multiple indicators into a single scalar index often results in some loss of information. Table 2 supports the notion that analysing the relationship between fertility and human development is more revealing when different dimensions of human development are considered as the explanatory variable in the regression analysis rather than combining them into a single composite index. Treating the three dimensions of human development as separate explanatory variables also helps classifying districts in terms of human development and then examining how fertility varies across different clusters of districts.

Classification of Districts

The regression analysis suggests that fertility in a district is influenced by the progress in the three dimensions of human development – individual capacity, individual knowledge, and individual standard of living – and the influence of the progress in the three dimensions is not the same. On average, the influence of the individual knowledge on fertility is found to be relatively the highest whereas the influence of the individual capacity is found to be relatively the lowest. This means that the defining characteristics of human development within a district may also influence fertility in the district. Human development may be characterised in terms of the human development profile, which reflects the relative progress and inequality in progress across the three dimensions of human development (Chaurasia, 2023b). Human development can be characterised in eight human development profiles depending upon whether progress is relatively the most advanced in the individual capacity or the individual knowledge or the individual standard of living. Additionally, the inequality in human development or the difference in progress in the three dimensions of human development also varies widely across the districts. Any analysis of the relationship between inter-district variation in fertility and human development, therefore, must consider these characteristics.

To explore how fertility varies among districts with distinct human development characteristics, we have applied the classification modelling approach (Han et al, 2012; Tan et al, 2006). This approach classifies districts into mutually exclusive, yet exhaustive groups or clusters based on individual capacity (HE), individual knowledge (ED), individual standard of living (SL), human development profile (HDP) and human development inequality (HDE). There are various methods of classification available for the purpose. These include, among others, support vector machine (Urso et al, 2019), decision or classification tree (Liu et al, 2016), logistic regression (Leon, 1998), nearest neighbour (Parihari et al, 2023), imbalanced classification (Sun et al, 2009), random forest (Ho, 1998), multiclass classification (Venkatesan, 2016), and neural network (Muratbek and Bektemisova, 2024). The decision or classification tree method is a powerful statistical method that is very effective for the purpose of classification. It is a non-parametric, recursive partitioning method which does not require any assumption about the data distribution and is also robust to outliers. It is easy to interpret and understand and can be used even with heavily skewed data.

Several statistical techniques are available to construct a decision or classification tree. The popular ones are classification and regression trees (CART) (Brieman, et al. 1984), Chi-squared automatic interaction detection (CHAID) (Kass, 1980), and quick, unbiased, efficient, statistical tree (QUEST) (Loh and Shih, 1997). A comparison of these techniques can be found elsewhere (Song and Lu, 2015). This study employs CART technique to classify districts into mutually exclusive and exhaustive groups or clusters that maximize within-group homogeneity in fertility levels. A cluster or a group is termed as "pure," if the fertility level is the same for all districts in the cluster or group. If not, then the impurity in the cluster is measured using the Gini index.

One of the advantages of CART is that it can handle both categorical and continuous dependent variables. For a categorical variable, CART produces the classification tree (showing the proportionate distribution of data in different categories for each identified cluster), and for a continuous one, CART generates the regression tree (showing the estimates of arithmetic mean and standard deviation for each identified cluster). In the present case, the dependent variable TFR is a continuous variable. The CART, therefore, has generated the regression tree with estimates of mean fertility and associated standard deviation for each identified cluster.

The independent or the explanatory variables used in the classification modelling exercise represent the defining characteristics of human development in each district. Five indicators characterise human development are: 1) probability of survival in the first five years of life (HE); 2) secondary school net attendance ratio (ED); 3) Proportion of households having at least second quintile of intra-household wealth index distribution (SL); 4) human development profile (HDP); and 5) inequality in progress in the three dimensions of human development (HDE). The human development profile (HDP) and human development inequality (HDE) are derived from indices of individual capacity (H), individual knowledge (E) and individual standard of living (I), constructed from HE, ED, and SL respectively, as described in Chaurasia (2023b). Out of the five independent variables, four are continuous while HDP is a categorical variable. A key advantage of CART is that it can handle both continuous and categorical variables simultaneously.

Results of the classification modelling exercise are presented in the form of classification tree in Figure 2 and summarised in Table 3. The mean TFR across the 707 districts of the country is estimated to be 2.227 ± 0.526 births per woman of childbearing age (15-49 years). At the first stage of classification, the 707 districts of the country were classified into two groups or clusters (Node 1 and Node 2) based on the secondary school net attendance ratio (ED) as follows:

- Node 1 ($ED \leq 0.842$): 337 districts with a mean TFR of 2.507 ± 0.533.
- Node 2 ($ED > 0.842$): 370 districts with a lower mean TFR of 1.972 ± 0.365.

At the second stage, districts of Node 1 and Node 2 were further classified based on HE (the probability of survival in the first five years of life) and SL (the inter-household distribution of wealth index) respectively:

- Node 1 is split into:
    - Node 3 ($HE \leq 0.951$): 144 districts with a mean TFR of 2.712 ± 0.551.
    - Node 4 ($HE > 0.951$): 193 districts with a mean TFR of 2.353 ± 0.465.
- Node 2 is split into:
    - Node 5 ($SL \leq 0.687$): 186 districts with a mean TFR of 2.142 ± 0.386.
    - Node 6 ($SL > 0.687$): 204 districts with the lowest mean TFR of 1.834 ± 0.280.

At the third stage, districts (in Nodes 3, 4, 5 and 6) were further classified based on ED, SL, human development inequality (HDE), and human development profile (HDP). The classification process continued until 13 mutually exclusive and exhaustive clusters (nodes) were formed. Table 3 outlines the human development features of each cluster (Node) in terms of probability of survival in the first five years of life (HE), secondary school net attendance ratio (ED), and proportion of households having wealth index at least second quintile of inter-household distribution of wealth index (SL), human development profile (HDP) and human development inequality (HDE).

The average TFR varies across the 13 clusters. Key observations include:

- Highest Mean TFR (3.170±0.621) in Node 15 (25 districts):
  - HE ≤ 0.951, ED ≤ 0.751, and high HDE (>0.018), indicating significant disparities in human development.
- Lowest Mean TFR (1.714±0.258) in Node 14 (80 districts):
  - HE > 0.980, ED > 0.842, SL > 0.687, with fertility remaining low regardless of HDP and HDE.
- Low Mean TFR (1.734±0.280) in Node 24 (25 districts):
  - HE between 0.969–0.980, ED > 0.824, SL > 0.687, with the most progress in education.

The classification model also highlights the role of inequality in human development progress (HDE) and human development profile (HDP) in influencing fertility:

- Node 3 (HE ≤ 0.951, ED ≤ 0.842) further splits into:
  - Node 7 (HDE ≤ 0.018): 79 districts with a mean TFR of 2.657.
  - Node 8 (HDE > 0.018): 65 districts with a higher mean TFR of 2.865.

Districts with lower human development inequal tend to have lower fertility than those with higher inequality. The analysis confirms that education-led human development has the strongest negative association with fertility as compared to health-led or income-led human development. This observation reinforces previous findings that individual knowledge plays a crucial role in fertility transition.

Figure 3 shows the distribution of TFR across districts within each cluster identified through the classification modelling approach. The table illustrates that within each cluster fertility varies widely across the districts of the cluster and in some clusters, the within-cluster variation in fertility across districts is exceptionally high. The within-cluster, across districts, variation in fertility indicates that human development is not the sole determinant of the inter-district variation in fertility. There are other factors that are not captured by the three dimensions of human development which have a strong influence on fertility in the district. Figure 3 shows that the cluster with the lowest average TFR is not the cluster with the highest level of human development. Similarly, cluster with the highest average TFR is not the cluster with the lowest human development. Figure 3 further confirms that even at the cluster level, fertility is not inversely related to human development.

Additionally, Table 3 highlights that mean and median TFR in each cluster are not the same, which indicates that districts within each cluster are not statistically normally distributed in terms of TFR. All clusters (except clusters 15 and 17) exhibit a positively skewed distribution as the mean TFR is higher than the median TFR. It suggests that within these clusters, a few outlier districts with very high fertility rates increase the mean and have no impact on the median TFR of the cluster. This highlights the presence of outliers that influence overall cluster-level trend. In contrast, clusters 15 and 17 - having a negatively skewed distribution - show that more districts have relatively higher fertility levels than other districts within these clusters.

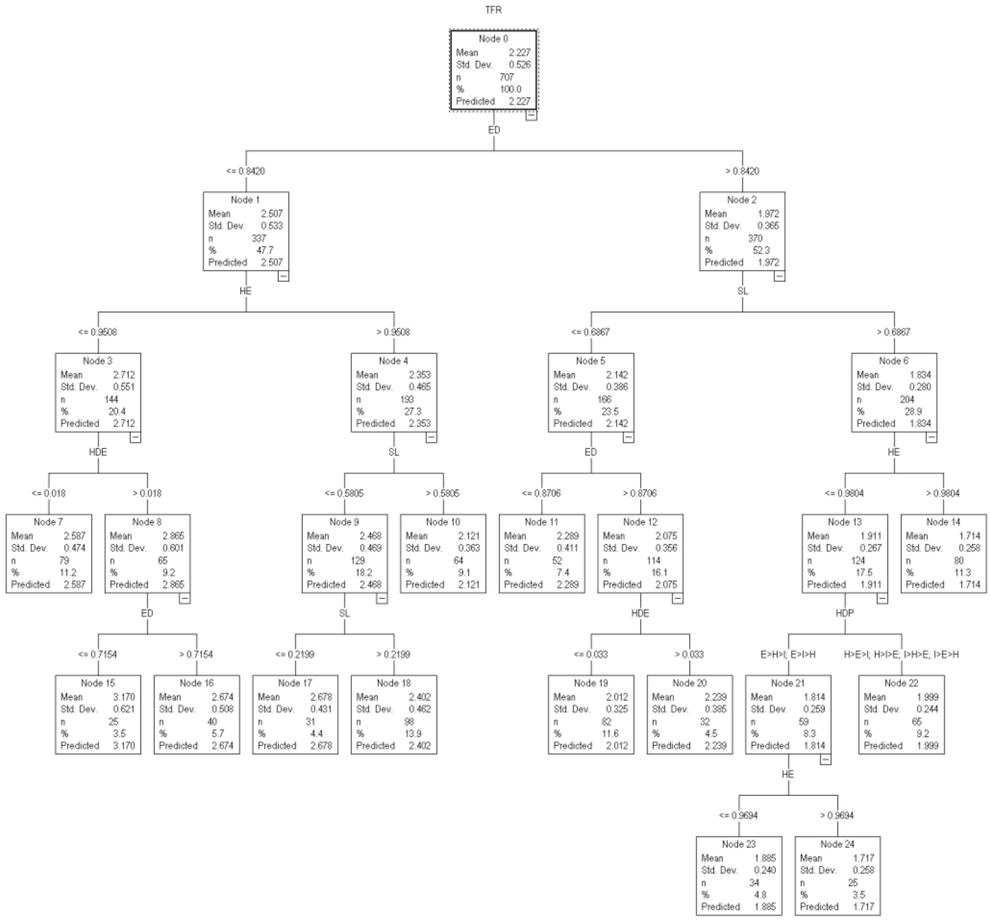


Figure 2: The classification tree showing the classification of districts in terms of level of fertility and characteristics of human development.
Source: Author

Table 3: Mean fertility (TFR) and characteristics of human development in mutually exclusive and exhaustive clusters of districts identified d through classification modelling exercise.

Node	Predictor variables					Total fertility rate (TFR)				Surface measure of human development (HDS)		Number of districts
	HE	ED	SL	HDP	HDE	Mean	SD	Median	IQR	Mean	SD	
15	≤0.951	≤0.715			>0.018	3.170	0.621	3.171	0.604	0.545	0.083	25
7	≤0.951	≤0.842			≤0.018	2.857	0.475	2.559	0.669	0.705	0.087	79
17	>0.951	≤0.842	≤0.220			2.678	0.431	2.734	0.717	0.521	0.045	31
16	≤0.951	0.715-0.842			>0.018	2.674	0.508	2.598	0.717	0.601	0.054	40
18	>0.951	≤0.842	0.220-0.581			2.402	0.462	2.352	0.528	0.666	0.058	98
11		0.824-0.871	≤0.687			2.289	0.411	2.286	0.577	0.718	0.071	52
20		>0.871	≤0.687		>0.033	2.239	0.385	2.186	0.385	0.678	0.065	32
10	>0.951	≤0.842	>0.581			2.121	0.363	2.092	0.503	0.821	0.048	64
19		>0.871	≤0.687		≤0.033	2.012	0.325	1.987	0.418	0.804	0.038	82
22	≤0.980	>0.842	>0.687	H>E>I H>I>E I>H>E I>E>H		1.999	0.244	1.982	0.327	0.917	0.029	65
23	≤0.969	>0.842	>0.687	E>I>H E>H>I		1.885	0.240	1.849	0.339	0.894	0.031	34
24	0.969-0.980	>0.842	>0.867	E>I>H E>H>I		1.717	0.258	1.712	0.379	0.898	0.025	25
14	>0.980	>0.842	>0.687			1.714	0.258	1.660	0.333	0.934	0.037	80

Source: Author.

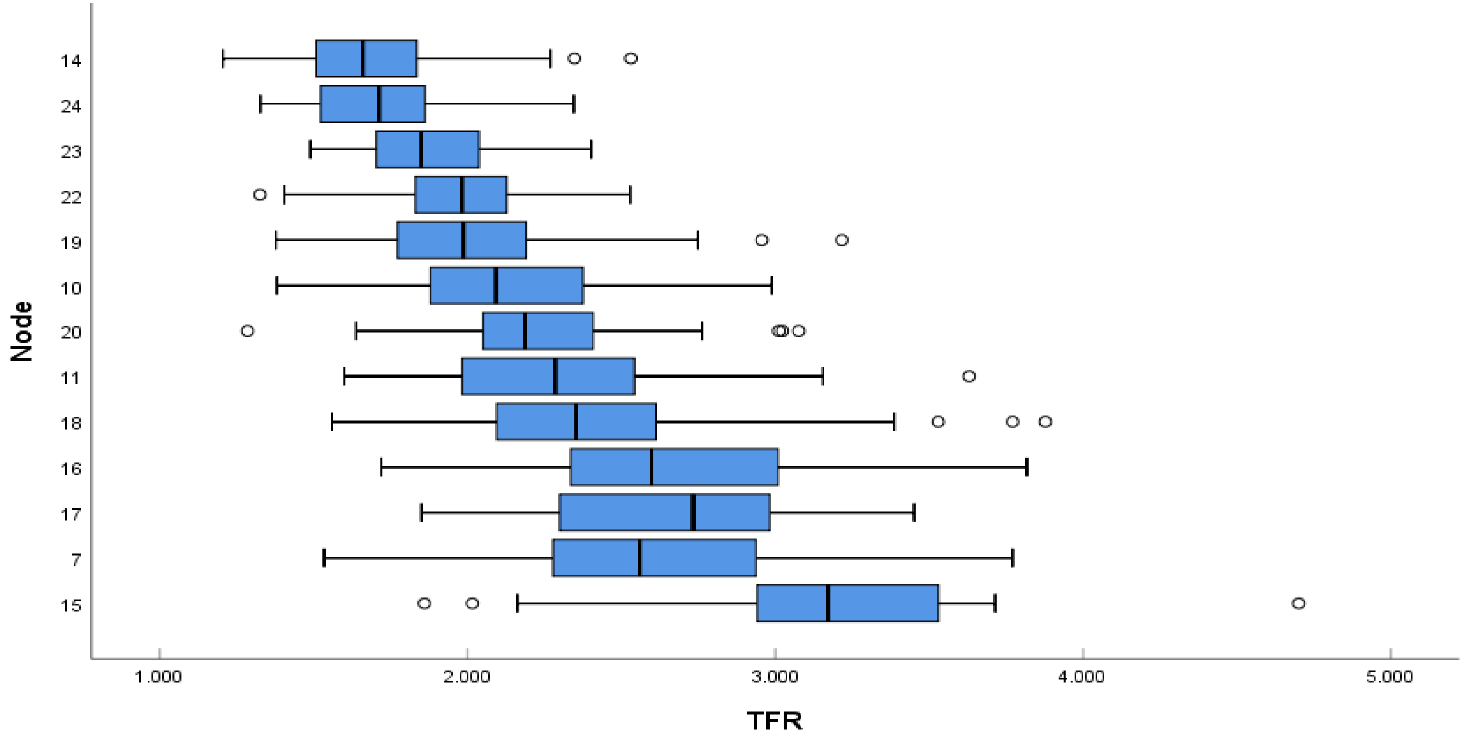


Figure 3: Distribution of districts by TFR in each cluster identified through classification modelling exercise. Clusters have been ordered by the median TFR in the cluster.
Source: Author

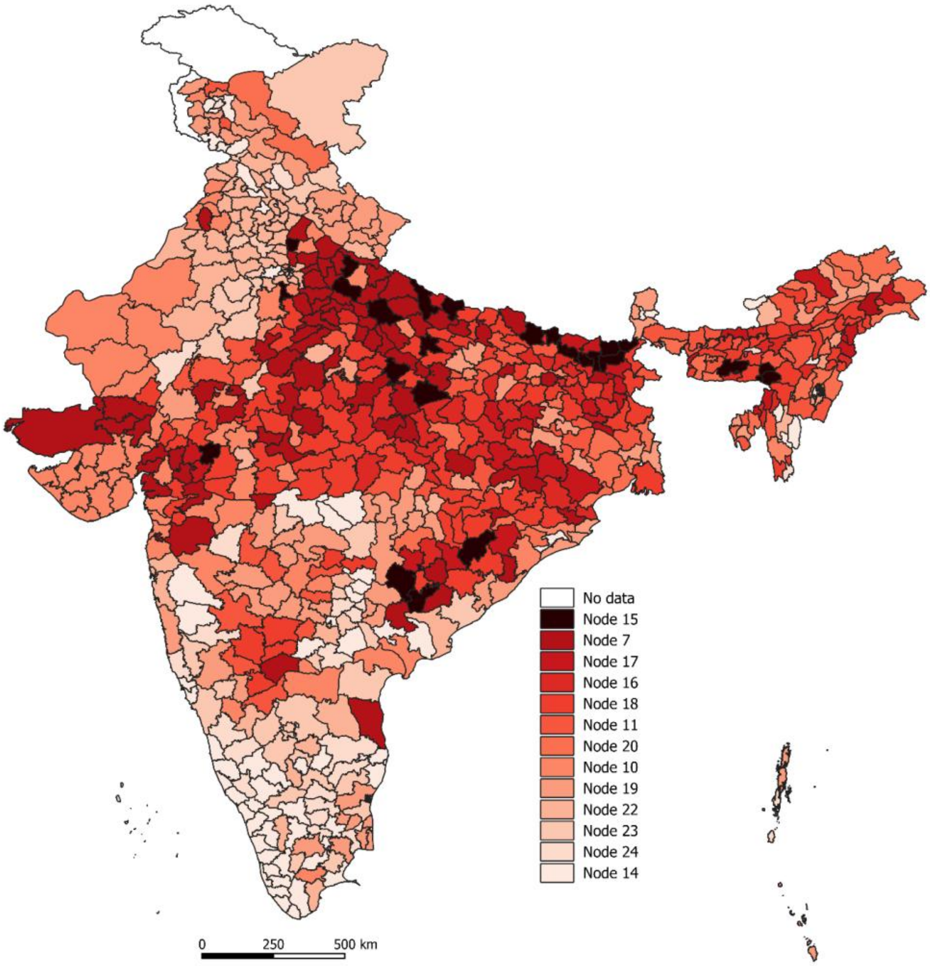


Figure 4: Fertility and human development in 707 districts of India, 2019-2021.
Source: Author.

The defining characteristics of human development also vary across clusters. Districts of Node 15 are characterised by low probability of survival in the first five years of life (HE), low secondary school net attendance ratio (ED), and a high level of human development inequality (HDE). In contrast, in districts of cluster 7, HE is low, ED is relatively high, but HDE is relatively low. Districts of cluster 14 have high HE, high ED which equals one in some districts, and high SL. This cluster has the lowest fertility, but TFR still varies from 1.206 in district South Goa (Goa) to 2.531 in Malappuram (Kerala). Interestingly, in Malappuram district, the probability of survival in the first five years of life is very high (0.995), almost 97 per cent of the households have wealth index at least second quintile of household distribution of wealth index and secondary school net attendance rate is 100 per cent. However, TFR is still very high, and exceeds more than 2.5. Conversely, in South Goa (Goa), all the three indicators - HE, ED, and SL, are lower than the corresponding indicators in Malappuram, yet the TFR in South Goa is less than half of that in Malappuram. It evidently suggests that fertility is influenced by factors beyond human development.

Table 4: Distribution of districts belonging to different Nodes across states and Union Territories of the country,

India/State/Union Territory	Nodes													Total
	15	7	17	16	18	11	20	10	19	22	23	24	14	
Andaman & Nicobar Islands	0	0	0	0	0	0	0	0	2	0	0	1	0	3
Andhra Pradesh	0	1	0	0	0	0	0	3	2	2	3	1	1	13
Arunachal Pradesh	0	0	2	0	4	2	6	0	4	1	0	0	1	20
Assam	0	1	4	5	12	8	2	0	0	0	0	1	0	33
Bihar	8	4	3	9	8	3	1	1	1	0	0	0	0	38
Chandigarh	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Chhattisgarh	2	2	2	4	6	2	2	0	5	2	0	0	0	27
Delhi	0	0	0	0	0	0	0	1	0	6	0	0	4	11
Dadra & Nagar Haveli and Daman & Diu	0	1	0	0	0	0	0	2	0	0	0	0	0	3
Goa	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Gujarat	0	8	1	0	5	0	0	19	0	0	0	0	0	33
Haryana	1	0	0	0	0	0	0	1	0	15	4	0	1	22
Himachal Pradesh	0	0	0	0	0	0	1	0	2	5	2	1	1	12
Jammu & Kashmir	0	0	0	0	0	2	0	2	8	0	0	1	7	20
Jharkhand	0	0	10	4	1	4	1	0	4	0	0	0	0	24
Karnataka	0	1	0	0	4	2	0	1	3	3	6	3	7	30
Kerala	0	0	0	0	0	0	0	0	0	0	0	0	14	14
Ladakh	0	0	0	0	0	0	1	0	0	0	1	0	0	2
Lakshadweep	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Madhya Pradesh	2	14	1	8	16	2	0	6	0	2	0	0	0	51
Maharashtra	0	2	0	0	0	3	0	4	11	3	3	4	6	36
Manipur	0	0	0	0	0	2	3	0	3	0	0	0	1	9
Meghalaya	3	0	0	1	3	1	3	0	0	0	0	0	0	11
Mizoram	0	0	0	0	1	1	0	1	0	1	0	1	3	8
Nagaland	0	0	3	2	2	0	1	0	2	0	0	0	1	11
Odisha	1	5	3	2	9	0	3	2	4	0	0	0	1	30
Puducherry	0	0	0	0	0	0	0	1	0	0	0	0	3	4
Punjab	0	1	0	0	0	0	0	5	0	12	1	0	3	22
Rajasthan	0	3	0	0	7	4	1	6	2	4	5	1	0	33
Sikkim	0	0	0	0	0	0	0	0	2	0	0	0	2	4
Tamil Nadu	0	0	0	0	0	0	0	1	6	2	5	7	11	32
Telangana	0	1	0	0	2	3	0	2	5	3	4	4	7	31
Tripura	0	0	1	1	0	2	2	0	2	0	0	0	0	8
Uttar Pradesh	8	33	1	4	13	7	0	4	3	2	0	0	0	75
Uttarakhand	0	1	0	0	0	0	0	1	8	2	0	0	1	13
West Bengal	0	1	0	0	5	4	5	1	3	0	0	0	1	20
India	25	79	31	40	98	52	32	64	82	65	34	25	80	707

Source: Author

Similarly, Node 15 has the highest average TFR, but it varies from just 1.860 in Bijapur (Chhattisgarh) to 4.701 in West Khasi Hills (Meghalaya). Bijapur has a very low human development - HE is only 0.917, ED is just 0.552, and less than 15 per cent households are in or above the second quintile of wealth index, despite this, fertility is well below the replacement level. Conversely, West Khasi Hills shows better HE and ED than Bijapur; however, the proportion of households in at least the second wealth quintile is lower than in Bijapur. Notably, the TFR in West Khasi Hills is more than twice that of Bijapur. These variations highlight that human development has a limited impact on fertility at the district level. Other sociocultural, economic, and behavioural factors are likely to exert a more significant influence on fertility rates.

The geographical distribution of districts across clusters is also uneven as may be seen from the Figure 4 and table 4. Key findings are as follows:

- Node 14 (high human development, low fertility) is mainly concentrated in southern India, with all districts of Goa and Kerala classified in this Node. Notably, 13 states/UTs have no districts in this category.
- Node 15 (low human development, high fertility) is primarily found in Uttar Pradesh (8), Bihar (8), and Meghalaya (3)—with 19 of its 25 districts concentrated in just these three states.
- Node 7 (moderate human development, mid-range fertility) is heavily concentrated in Uttar Pradesh (33), Madhya Pradesh (14), and Gujarat (8), with 55 of its 79 districts located in these three states.
- 18 states/UTs have no districts classified in either Node 15 or Node 7, further highlighting the regional variations in human development and fertility trends.

The appendix table gives the cluster membership of each of the 707 districts of the country along with the values of HE, ED, and SL, HDP, HDE and TFR.

Conclusions

The present analysis suggests that inter-district variation in human development, including inter-district variation in the three dimensions of human development, explains, only partly, inter-district in fertility in India, although progress in human development has a negative effect on fertility – the higher the level of human development the lower the fertility on average. The proximate determinants of fertility are well-known (Davis and Bruce, 1956; Bongaarts, 1972). Although, these proximate determinants of fertility are influenced by the level of human development, yet they are also influenced, often strongly, by a range of social and cultural factors which are not captured through the human development framework. For instance, districts like Malappuram in Kerala having very advanced level of human development may still have high fertility because of specific cultural, social, and other conditions or district like Bijapur in Chhattisgarh has low fertility despite of district-specific social, cultural, and other factors despite having low level of human development. The present study empirically illustrates these dynamics effectively by using the classification modelling approach. It emphasizes the need of understanding these nuances for better policy formulations aimed at both promoting human development and hastening fertility transition. Overall, the findings of the present analysis suggest that improving human development contributes substantially to reducing fertility but other factors such as cultural or social norms also play a critical role in deciding fertility at the local level in a country like India where diversity in almost all aspects of life is known for its strength and persistence. A decentralised, district-based approach of understanding the human development and fertility interrelationship is, therefore, crucial for both human development progress and fertility transition.

References

Bongaarts J (1972) A framework for analyzing the proximate determinants of fertility. *Population and Development Review* 4(1): 105-132

Breiman L, Friedman JH, Olshen RA, Stone CJ (1984) *Classification and Regression Trees*. Belmont, California: Wadsworth, Inc.

Bryant J (2007) Theories of fertility decline and the evidence from development indicators. *Population and Development Review* 33(1): 101–127.

Chaurasia AR (2023a) Human development in districts of India, 2019-2021. *Indian Journal of Human Development* 17(2): 1-34.

Chaurasia AR (2023b) Beyond HDI: a framework for characterising human development with application to India. Available at SSRN: https://ssrn.com/abstract=4919905 or http://dx.doi.org/10.2139/ssrn.4919905

Davis K, Blake J (1956) Social structure and fertility: an analytical framework. *Economic Development and Cultural Change* 4(3): 211-235

Esping-Andersen G, Billari FC (2015) Re-theorizing family demographics. *Population and Development Review* 41(1):1-31.

Fox J, Klüsener S, Myrskylä M (2019) Is a positive relationship between fertility and economic development emerging at the sub-national regional level? Theoretical considerations and evidence from Europe. *European Journal of Population* 35(3): 487–518.

Furuoka F (2009) Looking for a J-shaped development-fertility relationship: do advances in development really reverse fertility declines. *Economics Bulletin* 29(4): 3067–3074.

Goldscheider F, Bernhardt E, Lappegård T (2015) The gender revolution: a framework for understanding changing family and demographic behavior. *Population and Development Review* 41(2): 207–239.

Han J, Kamber M, Pei J (2012) *Data Mining: Concepts and Techniques*, 3rd ed. New York, Elsevier.

Harttgen K, Vollmer S (2014) A reversal in the relationship of human development with fertility? *Demography* 51(1):173-84.

Ho TK (1998) The random subspace method for constructing decision forests. *IEEE Transactions on Pattern Analysis and Machine Intelligence* 20 (8): 832–844.

Kass GV (1980) An exploratory technique for investigating large quantities of categorical data. *Applied Statistics* 29: 119-127.

Leon (AC) Descriptive and inferential statistics. In AS Bellack, M Hersen (Eds) *Comprehensive Clinical Psychology*. Pergamon.

Liu S, McGree J, Ge Z, Xie Y (2016) Classification methods. In S Liu, J McGree, Z Ge, Y Xie (Eds) *Computational and Statistical Methods for Analysing Big Data with Applications.* New York,

Loh W, Shih Y (1997) Split selection methods for classification trees. *Statistica Sinica* 7: 815-840.

Luci A, Thévenon O (2010) Does economic development drive the fertility rebound in OECD countries? Paper presented in the European Population Conference 2010 EPC2010, Vienna, Austria, September 1-4, 2010.

Muratbek BA, Bektemisova BU (2024) Using neural networks for demographic prediction. *Journal of Problems in Computer Science and Information Technologies* 1(2): 25-33.

Myrskylä M, Kohler HP, Billari FC (2009) Advances in development reverse fertility declines. *Nature* 460(7256): 741.

Myrskylä M, Kohler HP, Billari FC (2011) High development and fertility: fertility at older reproductive ages and gender equality explain the positive link. MPIDR Working Paper WP 2011–017.

Parihari S, Chatterjee ND, Das K, Bhattacharya RK (2023) Role of groundwater potentiality and soil nutrient status on agricultural productivity: A case study in Paschim Medinipur District, West Bengal, In P Shit, G Bhunia, P Adhikary (Eds) *Case Studies in Geospatial Applications to Groundwater Resources*. Elsevier: 39-66.

Song Y, Lu Y (2015) Decision tree methods: applications for classification and prediction. *Shanghai Archives of Psychiatry* 27(2): 130-135.

Sun Y, Wong, AKC, Kamel MS (2009) Classification of imbalanced data: a review. *International Journal of Pattern Recognition and Artificial Intelligence*: 687-719.

Tan P-N, Steinbach M, Karpatne A, Kumar V (2014) *Introduction to Data Mining*. Essex, Pearson.

Urso A, Fiannaca A, La Rosa M, Ravì V, Rizzo R (2019) Data Mining: Classification and Prediction. In S Ranganathan, M Gribskov, K Nakai, S Schönbach (Eds) *Encyclopedia of Bioinformatics and Computational Biology*. New York,

Venkatesan R, Meng J (2016) A novel progressive learning technique for multi-class classification. *Neurocomputing* 207: 310–321.

Venkatesh KA, Mohanasundaram K, Pothyachi V (2023) Regression tasks for machine learning. In T Goswami, GR Sinha (Eds) *Statistical Modeling in Machine Learning*, New York, Academic Press: 133-157,

Wilson C, Airey P (1999) How can a homeostatic perspective enhance demographic transition theory? *Population Studies* 53(2): 117–128.

Appendix Table:

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
Andaman & Nicobar Islands									
	Nicobars	1.377	0.959	1.000	0.523	E>H>I	0.026	0.803	19
	North & Middle Andaman	1.784	0.993	0.909	0.526	H>E>I	0.024	0.788	19
	South Andaman	1.327	0.979	0.952	0.919	E>I>H	0.000	0.950	24
Andhra Pradesh									
	Srikakulam	1.565	0.979	0.950	0.676	E>H>I	0.007	0.860	19
	Vizianagaram	1.852	0.960	0.941	0.583	E>H>I	0.012	0.813	19
	Visakhapatnam	1.540	0.961	0.870	0.735	E>H>I	0.001	0.852	23
	East Godavari	1.898	0.977	0.876	0.762	H>E>I	0.001	0.869	22
	West Godavari	1.793	0.981	0.871	0.867	H>I>E	0.001	0.905	14
	Krishna	1.650	0.958	0.825	0.755	I>E>H	0.000	0.843	10
	Guntur	1.652	0.976	0.817	0.811	H>I>E	0.002	0.866	10
	Prakasam	1.704	0.953	0.869	0.788	E>I>H	0.002	0.868	23
	Sri Potti Sriramulu Nellore	1.534	0.950	0.772	0.785	I>H>E	0.002	0.833	7
	Y.S.R.	1.985	0.928	0.872	0.864	I>E>H	0.017	0.888	22
	Kurnool	1.936	0.954	0.804	0.649	E>H>I	0.000	0.795	10
	Anantapur	1.774	0.969	0.878	0.711	E>H>I	0.001	0.847	23
	Chittoor	1.631	0.970	0.897	0.768	E>H>I	0.001	0.875	24
Arunachal Pradesh									
	Tawang	2.347	0.999	1.000	0.824	E>H>I	0.004	0.938	14
	West Kameng	1.703	0.973	0.857	0.850	I>H>E	0.000	0.892	22
	East Kameng	2.527	0.956	0.857	0.358	E>H>I	0.033	0.681	11
	Papum Pare	2.283	0.998	0.889	0.686	H>E>I	0.009	0.850	19
	Upper Subansiri	2.734	0.995	0.800	0.192	H>E>I	0.112	0.574	17
	Upper Siang	2.235	1.000	1.000	0.367	E=H>I	0.073	0.737	20

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Changlang	2.070	1.000	0.929	0.350	H>E>I	0.069	0.709	20
	Lower Subansiri	2.067	0.988	0.857	0.534	H>E>I	0.018	0.774	11
	Dibang Valley	2.013	0.982	1.000	0.412	E>H>I	0.051	0.756	20
	Lower Dibang Valley	2.114	1.000	1.000	0.550	E=H>I	0.031	0.828	19
	Anjaw	1.820	0.982	1.000	0.179	E>H>I	0.146	0.611	20
	East Siang	1.807	1.000	0.875	0.584	H>E>I	0.019	0.805	19
	Kra Daadi	2.294	0.974	1.000	0.443	E>H>I	0.041	0.770	20
	Kurung Kumey	2.347	0.991	0.833	0.239	H>E>I	0.090	0.614	18
	Longding	2.312	1.000	0.750	0.162	H>E>I	0.129	0.539	17
	Lohit	2.213	1.000	0.800	0.553	H>E>I	0.022	0.768	18
	Namsai	2.810	0.985	0.750	0.233	H>E>I	0.078	0.586	18
	Siang	2.506	0.987	1.000	0.279	E>H>I	0.097	0.682	20
	Tirap	2.477	0.964	0.800	0.394	H>E>I	0.024	0.685	18
	West Siang	2.150	0.977	0.875	0.540	H>E>I	0.014	0.779	19
Assam									
	Kokrajhar	1.953	0.961	0.866	0.308	E>H>I	0.048	0.658	11
	Goalpara	2.199	0.969	0.800	0.251	H>E>I	0.063	0.607	18
	Barpeta	2.475	0.972	0.840	0.252	H>E>I	0.070	0.619	18
	Morigaon	2.431	0.948	0.784	0.214	E>H>I	0.058	0.574	16
	Lakhimpur	1.889	0.976	0.840	0.283	H>E>I	0.062	0.640	18
	Dhemaji	2.372	0.976	0.913	0.181	E>H>I	0.120	0.591	20
	Tinsukia	1.715	0.937	0.781	0.354	E>H>I	0.018	0.653	7
	Dibrugarh	2.095	0.977	0.736	0.413	H>E>I	0.026	0.678	18
	Golaghat	2.193	0.971	0.785	0.261	H>E>I	0.059	0.609	18
	Dima Hasao	2.142	0.991	0.826	0.392	H>E>I	0.042	0.699	18
	Cachar	2.420	0.975	0.754	0.259	H>E>I	0.059	0.601	18

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Karimganj	2.474	0.954	0.741	0.216	H>E>I	0.055	0.565	17
	Hailakandi	2.428	0.898	0.768	0.203	E>H>I	0.042	0.551	16
	Bongaigaon	2.060	0.976	0.865	0.349	H>E>I	0.046	0.684	11
	Chirang	2.033	0.963	0.852	0.230	E>H>I	0.074	0.607	11
	Kamrup	1.968	0.982	0.831	0.411	H>E>I	0.033	0.707	18
	Kamrup Metropolitan	1.411	0.972	0.884	0.776	E>H>I	0.000	0.874	24
	Nalbari	1.773	0.987	0.847	0.329	H>E>I	0.057	0.671	11
	Baksa	1.850	0.971	0.840	0.190	H>E>I	0.097	0.578	17
	Darrang	2.457	0.974	0.788	0.232	H>E>I	0.072	0.593	18
	Udalguri	2.159	0.949	0.804	0.218	E>H>I	0.060	0.583	16
	Biswanath	2.201	0.929	0.808	0.251	E>H>I	0.041	0.600	16
	Charaideo	1.954	0.951	0.709	0.246	H>E>I	0.040	0.574	18
	Dhubri	2.763	0.962	0.802	0.214	H>E>I	0.072	0.582	17
	West Karbi Anglong	2.217	0.969	0.865	0.121	H>E>I	0.145	0.527	11
	Hojai	2.379	0.971	0.852	0.361	H>E>I	0.039	0.685	11
	Jorhat	1.882	0.943	0.867	0.466	E>H>I	0.015	0.735	11
	Karbi Anglong	2.370	0.968	0.867	0.294	E>H>I	0.057	0.652	11
	Majuli	2.445	0.958	0.895	0.183	E>H>I	0.101	0.583	20
	Nagaon	2.486	0.936	0.735	0.243	E>H>I	0.034	0.576	16
	Sivasagar	1.901	0.979	0.800	0.463	H>E>I	0.021	0.723	18
	Sonitpur	2.474	0.959	0.743	0.320	H>E>I	0.030	0.629	18
	South Salmara Mancachar	3.067	0.981	0.750	0.113	H>E>I	0.141	0.494	17
Bihar									
	Pashchim Champaran	3.256	0.906	0.658	0.220	E>H>I	0.017	0.533	7
	Purba Champaran	3.171	0.941	0.706	0.277	H>E>I	0.025	0.590	15
	Sheohar	3.253	0.936	0.757	0.207	E>H>I	0.048	0.559	16

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Sitamarhi	3.715	0.918	0.702	0.212	E>H>I	0.029	0.543	15
	Madhubani	3.363	0.955	0.740	0.220	H>E>I	0.055	0.567	17
	Supaul	2.959	0.957	0.639	0.081	H>E>I	0.118	0.429	17
	Araria	3.704	0.944	0.639	0.135	H>E>I	0.067	0.476	15
	Kishanganj	3.493	0.945	0.573	0.172	H>E>I	0.049	0.485	15
	Purnia	3.491	0.922	0.612	0.179	H>E>I	0.028	0.496	15
	Katihar	3.324	0.954	0.661	0.155	H>E>I	0.071	0.500	17
	Madhepura	3.532	0.947	0.643	0.101	H>E>I	0.091	0.448	15
	Saharsa	3.539	0.926	0.673	0.153	H>E>I	0.048	0.495	15
	Darbhanga	3.154	0.949	0.714	0.272	H>E>I	0.032	0.591	15
	Muzaffarpur	3.155	0.961	0.851	0.315	E>H>I	0.044	0.657	11
	Gopalganj	3.025	0.959	0.781	0.367	H>E>I	0.024	0.665	18
	Siwan	2.711	0.940	0.852	0.442	E>H>I	0.015	0.717	11
	Saran	2.923	0.940	0.800	0.358	E>H>I	0.020	0.661	16
	Vaishali	3.370	0.928	0.811	0.329	E>H>I	0.024	0.646	16
	Samastipur	3.345	0.942	0.768	0.174	E>H>I	0.067	0.540	16
	Begusarai	3.745	0.950	0.797	0.304	E>H>I	0.035	0.633	16
	Khagaria	3.817	0.950	0.726	0.247	H>E>I	0.041	0.579	16
	Bhagalpur	3.198	0.936	0.825	0.462	E>H>I	0.010	0.718	7
	Banka	3.282	0.960	0.787	0.239	H>E>I	0.058	0.594	18
	Munger	2.804	0.968	0.813	0.516	H>E>I	0.010	0.747	18
	Lakhisarai	3.771	0.962	0.783	0.377	H>E>I	0.024	0.671	18
	Sheikhpura	3.470	0.927	0.829	0.392	E>H>I	0.018	0.683	16
	Nalanda	3.254	0.950	0.745	0.446	H>E>I	0.008	0.690	7
	Patna	2.483	0.955	0.753	0.608	H>E>I	0.001	0.762	10
	Bhojpur	2.919	0.963	0.842	0.456	E>H>I	0.017	0.728	18

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Buxar	3.315	0.940	0.823	0.466	E>H>I	0.010	0.720	7
	Kaimur (Bhabua)	2.701	0.923	0.814	0.300	E>H>I	0.030	0.629	16
	Rohtas	2.956	0.906	0.885	0.518	E>I>H	0.030	0.752	19
	Aurangabad	3.318	0.953	0.842	0.390	E>H>I	0.024	0.693	18
	Gaya	3.529	0.962	0.766	0.328	H>E>I	0.032	0.641	18
	Nawada	3.386	0.971	0.815	0.404	H>E>I	0.027	0.696	18
	Jamui	3.202	0.926	0.751	0.258	E>H>I	0.029	0.588	16
	Jehanabad	3.024	0.952	0.882	0.358	E>H>I	0.035	0.688	20
	Arwal	2.913	0.925	0.855	0.301	E>H>I	0.037	0.641	11
Chandigarh									
	Chandigarh	1.675	0.983	0.873	0.967	I>H>E	0.002	0.940	14
Chhattisgarh									
	Koriya	2.086	0.883	0.890	0.352	E>I>H	0.068	0.668	20
	Jashpur	2.070	0.951	0.795	0.146	E>H>I	0.094	0.528	17
	Raigarh	1.893	0.908	0.854	0.425	E>I>H	0.025	0.701	11
	Korba	2.180	0.923	0.767	0.463	E>H>I	0.006	0.697	7
	Janjgir - Champa	1.872	0.970	0.909	0.460	E>H>I	0.025	0.751	19
	Kabeerdham	2.185	0.975	0.886	0.504	H>E>I	0.018	0.766	19
	Rajnandgaon	1.800	0.947	0.916	0.550	E>H>I	0.012	0.788	19
	Mahasamund	1.753	0.964	0.791	0.404	H>E>I	0.021	0.687	18
	Dhamtari	1.753	0.986	0.908	0.618	H>E>I	0.011	0.825	19
	Narayanpur	2.148	0.962	0.647	0.217	H>E>I	0.053	0.540	17
	Bijapur	1.860	0.917	0.552	0.148	H>E>I	0.028	0.455	15
	Balod	1.560	0.992	0.964	0.573	E>H>I	0.021	0.825	19
	Baloda Bazar	2.250	0.952	0.812	0.467	E>H>I	0.010	0.721	18
	Balrampur	2.466	0.937	0.748	0.146	E>H>I	0.073	0.513	16

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Bastar	2.316	0.925	0.621	0.269	H>E>I	0.013	0.555	7
	Uttar Bastar Kanker	1.868	0.978	0.932	0.342	E>H>I	0.058	0.699	20
	Bemetara	2.351	0.965	0.868	0.527	E>H>I	0.012	0.768	11
	Bilaspur	1.975	0.954	0.813	0.474	E>H>I	0.010	0.725	18
	Dantewada	1.985	0.952	0.721	0.252	H>E>I	0.041	0.581	18
	Durg	1.810	0.979	0.868	0.867	I>H>E	0.001	0.903	22
	Gariyaband	1.855	0.952	0.824	0.348	E>H>I	0.029	0.666	18
	Kodagaon	2.219	0.937	0.737	0.169	E>H>I	0.061	0.527	16
	Mungeli	2.831	0.944	0.830	0.370	E>H>I	0.023	0.677	16
	Raipur	2.036	0.978	0.843	0.757	H>E>I	0.001	0.856	22
	Sukma	2.163	0.929	0.625	0.092	H>E>I	0.073	0.432	15
	Surajpur	2.221	0.966	0.839	0.228	H>E>I	0.074	0.602	18
	Surguja	2.258	0.935	0.807	0.254	E>H>I	0.042	0.603	16
Delhi									
	Central	1.584	0.985	0.885	0.963	I>H>E	0.002	0.944	14
	East	1.831	0.959	0.914	0.961	I>E>H	0.005	0.945	22
	New Delhi	2.291	0.979	0.902	0.960	I>H>E	0.001	0.946	22
	North	2.587	0.969	0.827	0.928	I>H>E	0.004	0.907	10
	North East	2.108	0.970	0.897	0.990	I>E>H	0.004	0.951	22
	North West	2.002	0.984	0.931	0.987	I>E>H	0.001	0.967	14
	Shahdara	1.982	0.951	0.869	0.987	I>E>H	0.010	0.935	22
	South	2.127	0.948	0.932	0.989	I>E>H	0.013	0.956	22
	South East	1.815	0.985	0.927	0.972	I>H>E	0.001	0.961	14
	South West	1.559	0.990	0.934	0.981	I>H>E	0.001	0.968	14
	West	2.101	0.963	0.886	0.969	I>E>H	0.005	0.939	22

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
Dadra & Nagar Haveli and Daman & Diu									
	Diu	1.991	1.000	0.750	0.955	H>I>E	0.019	0.897	10
	Daman	2.036	0.958	0.800	0.867	I>H>E	0.004	0.873	10
	Dadra & Nagar Haveli	1.935	0.950	0.694	0.520	H>E>I	0.004	0.705	7
Goa									
	North Goa	1.239	1.000	0.965	0.966	H>I>E	0.000	0.977	14
	South Goa	1.206	0.984	0.940	0.971	I>E>H	0.001	0.965	14
Gujarat									
	Kachchh	2.336	0.962	0.613	0.821	I>H>E	0.029	0.789	10
	Banas Kantha	2.756	0.949	0.581	0.479	H>I>E	0.016	0.648	7
	Patan	2.369	0.910	0.641	0.648	I>E>H	0.011	0.725	7
	Mahesana	2.739	0.937	0.692	0.665	I>H>E	0.003	0.757	7
	Gandhinagar	2.255	0.957	0.785	0.816	I>H>E	0.002	0.850	10
	Porbandar	1.926	0.982	0.719	0.896	I>H>E	0.016	0.860	10
	Amreli	2.146	0.980	0.616	0.781	H>I>E	0.034	0.782	10
	Anand	2.229	0.935	0.676	0.697	I>H>E	0.006	0.763	7
	Dohad	2.931	0.973	0.594	0.184	H>E>I	0.076	0.505	17
	Narmada	2.225	0.954	0.667	0.305	H>E>I	0.026	0.596	18
	Bharuch	2.201	0.947	0.673	0.711	I>H>E	0.007	0.770	7
	The Dangs	2.555	0.975	0.571	0.227	H>E>I	0.067	0.526	18
	Navsari	1.679	0.982	0.727	0.729	H>I>E	0.010	0.806	10
	Valsad	1.550	0.977	0.805	0.725	H>I>E	0.003	0.831	10
	Surat	2.039	0.974	0.739	0.870	I>H>E	0.010	0.857	10
	Tapi	1.820	0.959	0.639	0.404	H>E>I	0.018	0.638	18
	Ahmadabad	1.983	0.961	0.733	0.934	I>H>E	0.013	0.872	10
	Aravali	2.613	0.961	0.687	0.458	H>E>I	0.012	0.679	18

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Bhavnagar	2.062	0.980	0.656	0.717	H>I>E	0.021	0.775	10
	Botad	2.549	0.980	0.596	0.810	H>I>E	0.042	0.783	10
	Chhota Udaipur	2.355	0.926	0.549	0.329	H>I>E	0.010	0.563	7
	Devbhumi Dwarka	2.538	0.971	0.450	0.776	H>I>E	0.121	0.707	10
	Gir Somnath	2.013	0.976	0.712	0.751	H>I>E	0.010	0.807	10
	Jamnagar	1.806	0.979	0.713	0.915	I>H>E	0.017	0.863	10
	Junagadh	2.002	0.961	0.724	0.817	I>H>E	0.008	0.830	10
	Kheda	2.195	0.934	0.577	0.555	H>I>E	0.011	0.673	7
	Mahisagar	2.383	0.970	0.664	0.394	H>E>I	0.025	0.644	18
	Morbi	1.811	0.989	0.653	0.868	H>I>E	0.033	0.828	10
	Panch Mahals	2.165	0.939	0.616	0.474	H>I>E	0.006	0.656	7
	Rajkot	2.161	0.980	0.827	0.934	I>H>E	0.004	0.912	10
	Sabar Kantha	2.170	0.968	0.626	0.587	H>I>E	0.018	0.713	10
	Surendranagar	2.363	0.967	0.646	0.721	H>I>E	0.017	0.769	10
	Vadodara	1.877	0.977	0.699	0.831	H>I>E	0.015	0.830	10
Haryana									
	Panchkula	2.190	0.960	0.915	0.968	I>E>H	0.005	0.948	22
	Ambala	1.755	0.932	0.889	0.939	I>E>H	0.019	0.920	22
	Yamunanagar	1.930	0.967	0.880	0.918	I>E>H	0.002	0.921	22
	Kurukshetra	1.958	0.958	0.865	0.914	I>E>H	0.004	0.912	22
	Kaithal	2.289	0.954	0.935	0.914	I>E>H	0.006	0.934	22
	Karnal	2.391	0.972	0.892	0.912	I>E>H	0.001	0.925	22
	Panipat	2.189	0.959	0.926	0.897	I>E>H	0.004	0.927	22
	Sonipat	1.953	0.965	0.937	0.940	I>E>H	0.003	0.947	22
	Jind	2.132	0.944	0.946	0.906	E>I>H	0.012	0.932	23
	Fatehabad	1.815	0.961	0.931	0.885	E>I>H	0.003	0.925	23

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Sirsa	2.182	0.958	0.870	0.879	I>E>H	0.003	0.902	22
	Hisar	2.028	0.971	0.910	0.910	I>E>H	0.001	0.930	22
	Rohtak	1.980	0.975	0.922	0.927	I>E>H	0.001	0.941	22
	Jhajjar	1.933	0.991	0.971	0.954	E>I>H	0.000	0.972	14
	Mahendragarh	2.355	0.965	0.970	0.851	E>I>H	0.004	0.927	23
	Rewari	2.030	0.969	0.936	0.926	I>E>H	0.002	0.944	22
	Gurgaon	2.007	0.966	0.911	0.940	I>E>H	0.003	0.939	22
	Mewat	3.621	0.941	0.526	0.561	H>I>E	0.028	0.658	15
	Faridabad	2.077	0.967	0.873	0.949	I>E>H	0.003	0.929	22
	Palwal	2.989	0.981	0.841	0.805	H>I>E	0.001	0.873	10
	Bhiwani	2.328	0.929	0.928	0.891	I>E>H	0.022	0.916	22
	Charkhi Dadri	2.245	0.967	0.984	0.935	E>I>H	0.004	0.962	23
Himachal Pradesh									
	Chamba	2.166	0.970	0.942	0.673	E>H>I	0.006	0.854	19
	Kangra	1.751	0.955	0.889	0.855	I>E>H	0.003	0.899	22
	Lahul & Spiti	2.111	0.996	1.000	0.481	E>H>I	0.041	0.794	20
	Kullu	1.890	0.984	0.957	0.661	E>H>I	0.009	0.857	19
	Mandi	1.972	0.979	0.947	0.820	E>H>I	0.001	0.913	24
	Hamirpur	2.007	0.972	0.900	0.872	I>E>H	0.000	0.914	22
	Una	2.099	0.980	0.882	0.900	I>H>E	0.001	0.920	22
	Bilaspur	1.998	0.992	0.886	0.899	H>I>E	0.001	0.925	14
	Solan	1.936	0.941	0.900	0.902	I>E>H	0.012	0.914	22
	Sirmaur	2.490	0.980	0.909	0.824	H>E>I	0.000	0.903	22
	Shimla	1.777	0.965	0.942	0.837	E>I>H	0.002	0.913	23
	Kinnaur	2.055	0.968	1.000	0.695	E>H>I	0.009	0.879	23

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
Jammu & Kashmir									
	Anantnag	2.270	1.000	0.953	0.830	H>E>I	0.003	0.926	14
	Bandipore	1.938	0.969	0.848	0.584	H>E>I	0.006	0.787	11
	Punch	2.137	0.972	0.949	0.581	E>H>I	0.014	0.818	19
	Rajouri	2.196	0.989	0.875	0.621	H>E>I	0.010	0.817	19
	Kishtwar	1.673	0.990	0.906	0.522	H>E>I	0.023	0.785	19
	Doda	1.952	0.981	0.897	0.514	H>E>I	0.020	0.775	19
	Baramula	1.882	0.976	0.805	0.648	H>E>I	0.004	0.801	10
	Srinagar	1.479	0.988	0.979	0.947	E>I>H	0.000	0.971	14
	Jammu	2.102	0.985	0.981	0.952	E>I>H	0.000	0.973	14
	Pulwama	1.752	0.974	0.950	0.869	E>I>H	0.001	0.930	24
	Shupiyan	2.083	1.000	0.909	0.803	H>E>I	0.004	0.901	14
	Badgam	1.841	0.995	0.925	0.773	H>E>I	0.004	0.894	14
	Kupwara	1.964	0.961	0.914	0.581	E>H>I	0.010	0.804	19
	Ganderbal	2.250	0.987	0.839	0.687	H>E>I	0.006	0.831	10
	Ramban	2.272	0.993	0.865	0.370	H>E>I	0.052	0.700	11
	Kulgam	1.868	0.983	0.926	0.542	E>H>I	0.019	0.797	19
	Udhampur	2.228	0.980	0.950	0.606	E>H>I	0.013	0.832	19
	Reasi	2.174	0.986	0.897	0.506	H>E>I	0.023	0.773	19
	Kathua	1.494	0.981	0.961	0.847	E>H>I	0.001	0.928	14
	Samba	1.894	0.991	0.946	0.876	H>E>I	0.000	0.937	14
Jharkhand									
	Garhwa	2.921	0.952	0.827	0.173	E>H>I	0.087	0.557	17
	Chatra	2.806	0.952	0.772	0.196	H>E>I	0.066	0.560	17
	Kodarma	2.645	0.963	0.912	0.399	E>H>I	0.034	0.720	20
	Giridih	2.612	0.956	0.806	0.331	H>E>I	0.032	0.653	18

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Deoghar	2.885	0.967	0.723	0.194	H>E>I	0.073	0.548	17
	Godda	2.726	0.930	0.723	0.213	E>H>I	0.037	0.552	16
	Sahibganj	3.169	0.969	0.648	0.161	H>E>I	0.082	0.504	17
	Pakur	2.590	0.959	0.623	0.117	H>E>I	0.092	0.460	17
	Dhanbad	2.300	0.976	0.847	0.555	H>E>I	0.011	0.777	11
	Bokaro	2.296	0.957	0.873	0.541	E>H>I	0.009	0.774	19
	Lohardaga	2.326	0.959	0.863	0.234	E>H>I	0.071	0.611	11
	Purbi Singhbhum	1.990	0.952	0.871	0.551	E>H>I	0.008	0.776	19
	Palamu	2.679	0.944	0.814	0.235	E>H>I	0.053	0.595	16
	Latehar	2.851	0.963	0.776	0.094	H>E>I	0.141	0.479	17
	Hazaribagh	2.563	0.954	0.883	0.434	E>H>I	0.022	0.727	19
	Ramgarh	2.959	0.959	0.861	0.484	E>H>I	0.014	0.745	11
	Dumka	2.668	0.941	0.785	0.173	E>H>I	0.070	0.544	16
	Jamtara	2.511	0.972	0.794	0.197	H>E>I	0.086	0.571	17
	Ranchi	2.027	0.958	0.891	0.546	E>H>I	0.010	0.782	19
	Khunti	2.217	0.961	0.725	0.112	H>E>I	0.113	0.482	17
	Gumla	2.599	0.933	0.822	0.108	E>H>I	0.111	0.497	16
	Simdega	2.288	0.964	0.813	0.119	H>E>I	0.130	0.511	17
	Pashchimi Singhbhum	2.284	0.955	0.760	0.091	H>E>I	0.131	0.470	17
	Saraikela-Kharsawan	1.965	0.929	0.844	0.298	E>H>I	0.036	0.638	11
Karnataka									
	Belgaum	2.193	0.975	0.907	0.670	E>H>I	0.005	0.843	19
	Bagalkot	2.197	0.972	0.857	0.533	H>E>I	0.012	0.769	11
	Bijapur	2.461	0.981	0.814	0.520	H>E>I	0.015	0.753	18
	Bidar	2.164	0.969	0.882	0.539	E>H>I	0.012	0.779	19
	Raichur	2.348	0.946	0.739	0.497	H>E>I	0.003	0.709	7

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Koppal	1.906	0.957	0.792	0.448	H>E>I	0.013	0.707	18
	Gadag	2.032	0.984	0.901	0.567	H>E>I	0.015	0.801	19
	Dharwad	1.489	0.960	0.927	0.762	E>I>H	0.003	0.880	23
	Uttara Kannada	1.608	0.963	0.892	0.786	E>I>H	0.001	0.878	23
	Haveri	1.790	0.965	0.827	0.582	H>E>I	0.005	0.779	10
	Bellary	1.813	0.932	0.862	0.643	E>I>H	0.007	0.805	11
	Chitradurga	1.693	0.957	0.887	0.700	E>H>I	0.002	0.843	23
	Davanagere	1.703	0.977	0.861	0.743	H>E>I	0.001	0.856	22
	Shimoga	1.476	0.979	0.922	0.833	E>H>I	0.000	0.910	24
	Udupi	1.503	0.985	0.963	0.837	E>H>I	0.001	0.926	14
	Chikmagalur	1.605	0.969	0.940	0.826	E>I>H	0.001	0.910	24
	Tumkur	1.729	0.926	0.991	0.823	E>I>H	0.029	0.911	23
	Bangalore	1.475	0.982	0.949	0.969	I>E>H	0.001	0.966	14
	Mandya	1.618	1.000	0.952	0.864	H>E>I	0.002	0.937	14
	Hassan	1.529	0.990	0.945	0.812	H>E>I	0.002	0.913	14
	Dakshina Kannada	1.768	0.992	0.950	0.903	H>E>I	0.000	0.948	14
	Kodagu	1.653	0.974	0.927	0.868	E>I>H	0.000	0.922	24
	Mysore	1.815	0.987	0.889	0.858	H>I>E	0.001	0.910	14
	Chamarajanagar	1.788	0.966	0.887	0.748	E>H>I	0.001	0.864	23
	Gulbarga	2.109	0.978	0.777	0.554	H>E>I	0.011	0.755	18
	Yadgir	2.196	0.958	0.735	0.458	H>E>I	0.010	0.694	18
	Kolar	1.802	0.988	0.942	0.892	H>E>I	0.000	0.940	14
	Chikkaballapura	1.810	0.978	0.856	0.849	H>I>E	0.001	0.893	22
	Bangalore Rural	1.703	0.969	0.931	0.891	E>I>H	0.001	0.930	23
	Ramanagara	1.641	0.941	0.901	0.901	I>E>H	0.011	0.914	22

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
Kerala									
	Kasaragod	2.006	0.995	0.974	0.916	H>E>I	0.000	0.961	14
	Kannur	1.733	1.000	0.967	0.968	H>I>E	0.000	0.978	14
	Wayanad	1.995	0.987	0.954	0.815	E>H>I	0.002	0.916	14
	Kozhikode	1.823	1.000	1.000	0.980	E=H>I	0.000	0.993	14
	Malappuram	2.531	0.995	1.000	0.966	E>H>I	0.000	0.987	14
	Palakkad	1.812	1.000	0.988	0.888	H>E>I	0.001	0.958	14
	Thrissur	1.410	1.000	0.984	0.971	H>E>I	0.000	0.985	14
	Ernakulam	1.498	0.989	0.990	0.982	E>I>H	0.000	0.987	14
	Idukki	1.640	0.989	0.967	0.832	E>H>I	0.001	0.927	14
	Kottayam	1.583	1.000	0.970	0.956	H>I>E	0.000	0.975	14
	Alappuzha	1.456	1.000	0.987	0.968	H>E>I	0.000	0.985	14
	Pathanamthitta	1.395	1.000	0.989	0.934	H>E>I	0.000	0.974	14
	Kollam	1.499	1.000	0.993	0.943	H>E>I	0.000	0.978	14
	Thiruvananthapuram	1.469	1.000	0.993	0.925	H>E>I	0.001	0.972	14
Ladakh									
	Leh(Ladakh)	1.934	0.969	0.900	0.742	E>H>I	0.001	0.866	23
	Kargil	2.098	0.975	1.000	0.388	E>H>I	0.054	0.742	20
Lakshadweep									
	Lakshadweep	2.182	1.000	1.000	0.981	E=H>I	0.000	0.993	14
Madhya Pradesh									
	Sheopur	2.502	0.934	0.658	0.323	H>E>I	0.011	0.598	7
	Morena	2.979	0.936	0.782	0.545	E>H>I	0.002	0.741	7
	Bhind	2.741	0.957	0.854	0.573	E>H>I	0.005	0.781	11
	Gwalior	2.402	0.972	0.851	0.828	I>H>E	0.000	0.882	22
	Datia	2.648	0.942	0.802	0.516	E>H>I	0.004	0.736	7

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Shivpuri	2.769	0.935	0.718	0.394	H>E>I	0.007	0.653	7
	Tikamgarh	2.538	0.960	0.798	0.476	H>E>I	0.011	0.722	18
	Chhatarpur	2.344	0.934	0.723	0.413	E>H>I	0.005	0.663	7
	Panna	2.469	0.901	0.725	0.234	E>H>I	0.026	0.559	16
	Sagar	2.925	0.961	0.830	0.421	E>H>I	0.020	0.707	18
	Damoh	2.766	0.941	0.758	0.307	E>H>I	0.025	0.621	16
	Satna	2.716	0.946	0.741	0.391	H>E>I	0.012	0.661	7
	Rewa	3.073	0.928	0.674	0.246	H>E>I	0.022	0.559	15
	Umaria	2.450	0.929	0.723	0.310	E>H>I	0.016	0.610	7
	Neemuch	2.250	0.963	0.823	0.657	H>E>I	0.001	0.807	10
	Mandsaur	2.273	0.940	0.824	0.576	E>H>I	0.003	0.768	7
	Ratlam	2.388	0.953	0.714	0.592	H>I>E	0.002	0.742	10
	Ujjain	2.404	0.976	0.818	0.667	H>E>I	0.003	0.813	10
	Dewas	2.310	0.952	0.802	0.575	E>H>I	0.002	0.764	18
	Dhar	2.031	0.973	0.731	0.478	H>E>I	0.016	0.706	18
	Indore	2.022	0.971	0.849	0.895	I>H>E	0.002	0.904	22
	Khargone (West Nimar)	2.199	0.959	0.708	0.647	H>I>E	0.004	0.763	10
	Barwani	2.471	0.968	0.572	0.371	H>I>E	0.036	0.601	18
	Rajgarh	2.359	0.957	0.794	0.350	H>E>I	0.028	0.659	18
	Vidisha	2.802	0.942	0.684	0.460	H>E>I	0.004	0.674	7
	Bhopal	1.791	0.984	0.799	0.850	H>I>E	0.005	0.875	10
	Sehore	2.913	0.940	0.835	0.495	E>H>I	0.009	0.737	7
	Jhabua	3.529	0.933	0.657	0.181	H>E>I	0.041	0.513	15
	Raisen	2.796	0.955	0.809	0.466	E>H>I	0.011	0.720	18
	Betul	1.952	0.965	0.797	0.391	H>E>I	0.024	0.683	18
	Harda	2.799	0.963	0.779	0.597	H>E>I	0.003	0.769	10

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Hoshangabad	2.680	0.952	0.765	0.531	H>E>I	0.003	0.734	18
	Katni	2.321	0.896	0.730	0.348	E>I>H	0.016	0.624	7
	Jabalpur	1.735	1.000	0.744	0.395	H>E>I	0.046	0.678	18
	Narsimhapur	2.163	0.976	0.735	0.438	H>E>I	0.022	0.689	18
	Dindori	2.554	0.945	0.779	0.146	E>H>I	0.086	0.523	16
	Mandla	2.105	0.956	0.818	0.297	E>H>I	0.042	0.637	18
	Chhindwara	1.813	0.951	0.766	0.462	H>E>I	0.008	0.704	18
	Seoni	2.036	0.950	0.755	0.305	H>E>I	0.029	0.622	16
	Balaghat	1.725	0.955	0.863	0.285	E>H>I	0.052	0.642	11
	Guna	2.797	0.950	0.695	0.428	H>E>I	0.009	0.665	7
	Ashoknagar	2.848	0.957	0.728	0.331	H>E>I	0.026	0.629	18
	Shahdol	1.932	0.909	0.778	0.280	E>H>I	0.027	0.604	16
	Anuppur	2.303	0.947	0.798	0.286	E>H>I	0.037	0.622	16
	Sidhi	2.859	0.931	0.723	0.232	E>H>I	0.033	0.565	16
	Singrauli	3.340	0.938	0.748	0.320	E>H>I	0.020	0.625	16
	Alirajpur	3.210	0.970	0.540	0.171	H>E>I	0.079	0.479	17
	Khandwa (East Nimar)	2.583	0.973	0.803	0.533	H>E>I	0.011	0.753	18
	Burhanpur	2.265	0.946	0.687	0.612	H>I>E	0.002	0.739	7
	Agar Malwa	2.558	0.981	0.787	0.522	H>E>I	0.015	0.745	18
	Shajapur	2.493	0.940	0.802	0.526	E>H>I	0.004	0.740	7
Maharashtra									
	Nandurbar	2.176	0.942	0.703	0.362	H>E>I	0.012	0.634	7
	Dhule	2.406	0.984	0.764	0.594	H>E>I	0.012	0.769	10
	Jalgaon	2.065	0.980	0.823	0.711	H>E>I	0.003	0.833	10
	Buldana	1.881	0.969	0.937	0.667	E>H>I	0.006	0.849	19
	Akola	2.026	0.969	0.883	0.776	E>H>I	0.000	0.873	23

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Washim	2.333	0.959	0.878	0.590	E>H>I	0.006	0.796	19
	Amravati	1.703	0.981	0.915	0.754	H>E>I	0.002	0.879	14
	Wardha	1.622	0.984	0.894	0.836	H>E>I	0.000	0.903	14
	Nagpur	1.636	0.990	0.951	0.932	I>H>E	0.000	0.957	14
	Bhandara	1.785	0.957	0.919	0.677	E>H>I	0.005	0.844	19
	Gondiya	1.786	0.946	0.958	0.607	E>H>I	0.014	0.824	19
	Gadchiroli	1.672	0.964	0.878	0.507	E>H>I	0.014	0.762	19
	Chandrapur	1.841	0.953	0.953	0.760	E>I>H	0.006	0.885	23
	Yavatmal	1.751	0.950	0.882	0.644	E>H>I	0.004	0.817	19
	Nanded	2.232	0.964	0.817	0.597	H>E>I	0.004	0.782	10
	Hingoli	2.123	0.965	0.873	0.608	E>H>I	0.005	0.804	19
	Parbhani	2.262	0.970	0.848	0.559	H>E>I	0.009	0.777	11
	Jalna	2.342	0.960	0.849	0.577	E>H>I	0.005	0.782	11
	Aurangabad	2.095	0.977	0.902	0.740	E>H>I	0.002	0.869	24
	Nashik	2.603	0.948	0.815	0.640	E>H>I	0.001	0.793	7
	Mumbai Suburban	1.326	0.886	0.966	0.979	I>E>H	0.118	0.943	22
	Mumbai	1.476	0.983	0.956	0.968	I>E>H	0.001	0.969	14
	Raigarh	2.202	0.980	0.848	0.814	H>I>E	0.001	0.879	22
	Pune	1.646	1.000	0.850	0.882	H>I>E	0.005	0.909	14
	Ahmadnagar	1.862	0.974	0.895	0.724	E>H>I	0.002	0.859	24
	Bid	2.190	0.980	0.881	0.577	H>E>I	0.011	0.798	19
	Latur	2.512	0.972	0.875	0.686	H>E>I	0.002	0.838	19
	Osmanabad	2.314	0.995	0.910	0.667	H>E>I	0.010	0.848	19
	Solapur	2.744	0.981	0.866	0.661	H>E>I	0.005	0.828	11
	Satara	2.154	1.000	0.883	0.755	H>E>I	0.006	0.875	14
	Ratnagiri	2.187	0.961	0.953	0.586	E>H>I	0.013	0.818	19

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Sindhudurg	1.330	0.977	0.975	0.687	E>H>I	0.008	0.871	24
	Kolhapur	1.795	0.967	0.958	0.817	E>I>H	0.003	0.912	23
	Sangli	1.369	0.971	0.955	0.813	E>I>H	0.002	0.911	24
	Palghar	1.863	0.988	0.793	0.675	H>E>I	0.008	0.811	10
	Thane	1.874	0.979	0.923	0.896	I>E>H	0.000	0.932	22
Manipur									
	Senapati	2.762	0.986	0.917	0.302	H>E>I	0.073	0.674	20
	Tamenglong	2.579	0.950	0.900	0.189	E>H>I	0.093	0.587	20
	Churachandpur	2.012	0.976	0.870	0.422	H>E>I	0.030	0.723	11
	Bishnupur	1.993	0.972	0.917	0.430	E>H>I	0.032	0.740	19
	Thoubal	2.004	0.971	0.894	0.422	E>H>I	0.031	0.728	19
	Imphal West	2.024	0.991	0.933	0.697	H>E>I	0.007	0.867	14
	Imphal East	1.900	0.957	0.907	0.597	E>H>I	0.008	0.808	19
	Ukhrul	3.012	0.966	0.900	0.164	E>H>I	0.119	0.571	20
	Chandel	2.772	0.962	0.857	0.410	E>H>I	0.025	0.710	11
Meghalaya									
	South West Garo Hills	2.071	0.973	0.826	0.301	H>E>I	0.053	0.646	18
	South Garo Hills	3.076	0.994	0.941	0.268	H>E>I	0.097	0.662	20
	North Garo Hills	2.098	0.974	0.923	0.277	E>H>I	0.075	0.658	20
	East Jantia Hills	2.314	0.947	0.696	0.274	H>E>I	0.029	0.586	15
	East Khasi Hills	3.877	1.000	0.780	0.472	H>E>I	0.033	0.725	18
	Ribhoi	1.867	0.964	0.739	0.261	H>E>I	0.048	0.595	18
	South West Khasi Hills	1.980	0.943	0.813	0.203	E>H>I	0.064	0.573	16
	East Garo Hills	3.630	0.991	0.867	0.330	H>E>I	0.061	0.678	11
	West Garo Hills	2.095	0.993	0.940	0.480	H>E>I	0.034	0.776	20
	West Jaintia Hills	3.474	0.951	0.587	0.236	H>E>I	0.037	0.531	15

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	West Khasi Hills	4.701	0.929	0.652	0.112	H>E>I	0.066	0.457	15
Mizoram									
	Mamit	2.224	0.980	0.857	0.655	H>E>I	0.005	0.822	11
	Kolasib	1.767	0.991	0.900	0.820	H>E>I	0.002	0.902	14
	Aizawl	1.677	0.970	0.896	0.935	I>E>H	0.002	0.933	22
	Champhai	1.702	0.990	0.900	0.813	H>E>I	0.002	0.899	14
	Serchhip	1.537	0.981	0.857	0.840	H>I>E	0.001	0.891	14
	Lunglei	1.380	1.000	0.833	0.754	H>I>E	0.008	0.858	10
	Lawngtlai	2.137	0.956	0.750	0.472	H>E>I	0.008	0.704	18
	Saiha	1.657	0.979	1.000	0.707	E>H>I	0.008	0.887	24
Nagaland									
	Mon	2.222	0.982	0.800	0.124	H>E>I	0.142	0.517	17
	Mokokchung	1.884	0.984	0.909	0.534	H>E>I	0.019	0.789	19
	Zunheboto	2.714	0.976	0.800	0.240	H>E>I	0.072	0.602	18
	Wokha	2.223	0.958	1.000	0.467	E>H>I	0.034	0.777	20
	Dimapur	1.830	0.986	0.939	0.794	H>E>I	0.002	0.904	14
	Phek	2.545	0.975	0.833	0.225	H>E>I	0.082	0.601	18
	Tuensang	3.015	0.967	0.739	0.187	H>E>I	0.079	0.548	17
	Longleng	3.006	0.953	0.750	0.130	H>E>I	0.098	0.503	17
	Kiphire	2.598	0.917	0.800	0.159	E>H>I	0.066	0.532	16
	Kohima	1.968	0.984	0.933	0.655	E>H>I	0.008	0.848	19
	Peren	2.457	0.900	0.800	0.345	E>I>H	0.026	0.644	16
Odisha									
	Bargarh	1.652	0.972	0.825	0.370	H>E>I	0.034	0.682	18
	Jharsuguda	1.773	0.940	0.911	0.511	E>H>I	0.016	0.767	19
	Sambalpur	1.559	0.966	0.833	0.380	H>E>I	0.030	0.689	18

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Debagarh	1.810	0.958	0.808	0.247	H>E>I	0.057	0.604	18
	Sundargarh	1.666	0.925	0.780	0.411	E>H>I	0.010	0.677	7
	Kendujhar	2.367	0.945	0.747	0.290	H>E>I	0.029	0.610	16
	Mayurbhanj	1.965	0.953	0.698	0.154	H>E>I	0.074	0.509	17
	Baleshwar	2.137	0.971	0.881	0.362	E>H>I	0.042	0.694	20
	Baudh	1.720	0.949	0.717	0.329	H>E>I	0.021	0.623	16
	Kendrapara	2.060	0.939	0.906	0.430	E>H>I	0.024	0.727	19
	Jagatsinghapur	1.740	0.972	0.884	0.515	E>H>I	0.016	0.770	19
	Cuttack	1.485	0.983	0.786	0.583	H>E>I	0.011	0.771	10
	Jajapur	2.143	0.941	0.798	0.412	E>H>I	0.013	0.687	7
	Dhenkanal	2.155	0.965	0.807	0.383	H>E>I	0.026	0.682	18
	Anugul	1.966	0.985	0.697	0.418	H>E>I	0.031	0.670	18
	Nayagarh	2.174	0.993	0.887	0.452	H>E>I	0.035	0.747	20
	Khordha	1.469	0.989	0.891	0.699	H>E>I	0.005	0.853	14
	Puri	1.720	0.979	0.926	0.570	E>H>I	0.015	0.809	19
	Ganjam	2.271	0.975	0.802	0.639	H>E>I	0.005	0.796	10
	Gajapati	1.983	0.936	0.636	0.283	H>E>I	0.017	0.570	7
	Kandhamal	2.428	0.952	0.745	0.206	H>E>I	0.058	0.559	17
	Bhadrak	2.032	0.957	0.903	0.343	E>H>I	0.043	0.686	20
	Subarnapur	1.820	0.941	0.814	0.433	E>H>I	0.012	0.703	7
	Balangir	1.993	0.959	0.783	0.362	H>E>I	0.025	0.663	18
	Nuapada	2.251	0.952	0.779	0.220	H>E>I	0.058	0.578	18
	Kalahandi	2.016	0.938	0.645	0.247	H>E>I	0.026	0.553	15
	Rayagada	2.278	0.962	0.604	0.260	H>E>I	0.042	0.553	18
	Nabarangapur	2.732	0.957	0.538	0.132	H>E>I	0.077	0.447	17
	Koraput	1.825	0.965	0.635	0.220	H>E>I	0.055	0.539	18

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Malkangiri	2.150	0.889	0.633	0.189	E>H>I	0.017	0.502	7
Puducherry									
	Yanam	1.671	0.959	0.800	0.972	I>H>E	0.009	0.908	10
	Puducherry	1.615	1.000	0.911	0.914	H>I>E	0.002	0.941	14
	Mahe	1.688	1.000	1.000	1.000	H=I=E	0.000	1.000	14
	Karaikal	1.475	0.986	0.893	0.839	H>I>E	0.001	0.904	14
Punjab									
	Kapurthala	1.862	0.969	0.905	0.949	I>E>H	0.002	0.941	22
	Jalandhar	1.968	0.968	0.911	0.985	I>E>H	0.004	0.954	22
	Hoshiarpur	1.852	0.989	0.971	0.964	I>E>H	0.000	0.975	14
	Shahid Bhagat Singh Nagar	1.652	0.997	0.949	0.965	H>I>E	0.000	0.970	14
	Fatehgarh Sahib	1.811	0.985	0.895	0.970	I>H>E	0.002	0.949	14
	Ludhiana	2.236	0.960	0.880	0.955	I>E>H	0.005	0.931	22
	Moga	1.825	0.966	0.843	0.929	I>H>E	0.004	0.911	22
	Muktsar	1.991	0.935	0.840	0.894	I>E>H	0.012	0.889	7
	Faridkot	1.969	0.956	0.783	0.901	I>H>E	0.007	0.877	10
	Bathinda	1.964	0.964	0.787	0.907	I>H>E	0.006	0.884	10
	Mansa	2.043	0.960	0.881	0.878	I>E>H	0.002	0.906	22
	Patiala	1.972	0.967	0.879	0.963	I>E>H	0.004	0.936	22
	Amritsar	1.918	0.975	0.867	0.956	I>H>E	0.003	0.932	22
	Tarn Taran	2.048	0.987	0.820	0.873	H>I>E	0.004	0.891	10
	Rupnagar	1.969	0.975	0.916	0.957	I>E>H	0.002	0.949	22
	Sahibzada Ajit Singh Nagar	1.767	0.937	0.944	0.967	I>E>H	0.020	0.949	22
	Sangrur	1.934	0.920	0.915	0.960	I>E>H	0.035	0.932	22
	Barnala	1.734	0.950	0.914	0.947	I>E>H	0.009	0.937	22
	Fazilka	2.120	0.951	0.809	0.820	I>E>H	0.003	0.858	10

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Firozpur	1.956	0.960	0.805	0.901	I>H>E	0.005	0.887	10
	Gurdaspur	1.778	0.959	0.940	0.937	I>E>H	0.005	0.945	22
	Pathankot	1.872	0.967	0.982	0.962	E>I>H	0.005	0.970	23
Rajasthan									
	Ganganagar	2.011	0.971	0.849	0.778	H>I>E	0.000	0.863	22
	Hanumangarh	2.439	0.975	0.858	0.786	H>I>E	0.000	0.871	22
	Bikaner	2.520	0.977	0.793	0.754	H>I>E	0.003	0.837	10
	Churu	2.518	0.971	0.875	0.700	H>E>I	0.002	0.843	22
	Jhunjhunun	2.180	0.967	0.905	0.835	E>I>H	0.001	0.901	23
	Alwar	2.781	0.960	0.803	0.675	H>E>I	0.000	0.806	10
	Bharatpur	2.958	0.975	0.777	0.568	H>E>I	0.009	0.760	18
	Dhaulpur	3.025	0.947	0.833	0.479	E>H>I	0.010	0.731	7
	Karauli	3.260	0.973	0.838	0.437	H>E>I	0.024	0.720	18
	Sawai Madhopur	2.977	0.928	0.826	0.525	E>I>H	0.008	0.744	7
	Dausa	2.749	0.968	0.915	0.567	E>H>I	0.012	0.801	19
	Jaipur	2.278	0.966	0.925	0.836	E>I>H	0.001	0.908	23
	Sikar	2.402	0.964	0.880	0.804	E>I>H	0.000	0.881	23
	Nagaur	2.312	0.959	0.852	0.780	I>E>H	0.000	0.861	22
	Jodhpur	2.260	0.974	0.793	0.743	H>I>E	0.002	0.832	10
	Jaisalmer	2.618	0.972	0.715	0.637	H>I>E	0.008	0.765	10
	Barmer	2.454	0.992	0.799	0.588	H>E>I	0.014	0.780	10
	Jalor	2.571	0.977	0.806	0.652	H>E>I	0.005	0.803	10
	Sirohi	2.927	0.960	0.759	0.560	H>E>I	0.004	0.746	18
	Pali	2.346	0.976	0.900	0.839	E>H>I	0.000	0.904	24
	Ajmer	2.121	0.939	0.886	0.821	E>I>H	0.009	0.881	23
	Tonk	2.558	0.953	0.851	0.532	E>H>I	0.008	0.762	11

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Bundi	2.467	0.945	0.854	0.513	E>H>I	0.009	0.752	11
	Bhilwara	2.709	0.960	0.862	0.605	E>H>I	0.004	0.798	11
	Rajsamand	2.137	0.969	0.862	0.652	H>E>I	0.003	0.820	11
	Dungarpur	2.340	0.988	0.886	0.361	H>E>I	0.053	0.699	20
	Banswara	2.266	0.952	0.774	0.282	H>E>I	0.038	0.615	18
	Chittaurgarh	2.358	0.939	0.802	0.592	E>H>I	0.002	0.767	7
	Kota	2.026	0.956	0.902	0.835	E>I>H	0.003	0.897	23
	Baran	2.264	0.959	0.836	0.544	E>H>I	0.007	0.764	18
	Jhalawar	2.314	0.952	0.811	0.441	E>H>I	0.013	0.708	18
	Udaipur	2.430	0.980	0.908	0.507	H>E>I	0.022	0.776	19
	Pratapgarh	2.631	0.953	0.810	0.286	E>H>I	0.042	0.628	18
Sikkim									
	North District	1.604	0.955	1.000	0.667	E>H>I	0.013	0.864	19
	West District	1.474	0.985	1.000	0.635	E>H>I	0.015	0.860	19
	South District	1.392	1.000	0.917	0.739	H>E>I	0.007	0.880	14
	East District	1.418	0.992	0.900	0.869	H>I>E	0.001	0.919	14
Tamil Nadu									
	Thiruvallur	1.685	0.981	0.931	0.908	I>E>H	0.000	0.940	14
	Chennai	1.400	1.000	0.974	0.976	H>I>E	0.000	0.983	14
	Kancheepuram	1.719	0.988	0.889	0.862	H>I>E	0.001	0.912	14
	Vellore	2.002	0.980	0.976	0.854	E>H>I	0.001	0.935	24
	Tiruvannamalai	1.647	0.958	0.932	0.698	E>H>I	0.005	0.856	23
	Viluppuram	2.103	0.958	0.922	0.644	E>H>I	0.006	0.832	19
	Salem	1.895	0.970	0.944	0.778	E>H>I	0.002	0.894	24
	Namakkal	1.462	0.971	0.938	0.846	E>I>H	0.001	0.917	24
	Erode	1.621	0.994	0.842	0.852	H>I>E	0.004	0.894	14

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	The Nilgiris	1.578	0.985	0.974	0.849	E>H>I	0.001	0.935	14
	Dindigul	1.758	0.960	0.907	0.666	E>H>I	0.004	0.837	19
	Karur	1.523	0.978	0.934	0.713	E>H>I	0.004	0.869	24
	Tiruchirappalli	1.669	0.991	0.944	0.739	H>E>I	0.005	0.886	14
	Perambalur	2.027	0.978	0.939	0.734	E>H>I	0.003	0.879	24
	Ariyalur	1.910	0.958	0.937	0.539	E>H>I	0.016	0.792	19
	Cuddalore	1.540	0.955	0.925	0.687	E>H>I	0.005	0.849	23
	Nagapattinam	1.630	0.985	0.901	0.581	H>E>I	0.014	0.807	19
	Thiruvarur	1.725	1.000	0.949	0.616	H>E>I	0.018	0.841	19
	Thanjavur	1.582	0.971	0.946	0.741	E>H>I	0.003	0.882	24
	Pudukkottai	2.005	0.953	0.884	0.560	E>H>I	0.008	0.784	19
	Sivaganga	1.559	0.966	0.923	0.756	E>H>I	0.002	0.878	23
	Madurai	1.513	1.000	0.877	0.876	H>I>E	0.003	0.916	14
	Theni	1.870	0.960	0.940	0.853	E>I>H	0.003	0.917	23
	Virudhunagar	1.557	1.000	0.820	0.763	H>I>E	0.009	0.857	10
	Ramanathapuram	1.723	0.991	0.943	0.751	H>E>I	0.004	0.890	14
	Thoothukkudi	1.900	0.973	0.907	0.871	I>E>H	0.000	0.916	22
	Tirunelveli	1.580	0.993	0.920	0.831	H>E>I	0.001	0.913	14
	Kanniyakumari	1.523	1.000	0.953	0.938	H>I>E	0.001	0.963	14
	Dharmapuri	1.712	0.972	0.965	0.759	E>H>I	0.004	0.894	24
	Krishnagiri	2.038	0.968	0.894	0.808	E>I>H	0.000	0.888	23
	Coimbatore	1.405	0.957	0.927	0.896	I>E>H	0.005	0.926	22
	Tiruppur	1.611	0.994	0.917	0.880	H>I>E	0.001	0.929	14
Telangana									
	Bhadradri Kothagudem	1.591	0.939	0.808	0.732	I>E>H	0.003	0.823	7
	Adilabad	2.433	0.971	0.662	0.579	H>I>E	0.014	0.724	18

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Hyderabad	1.782	0.975	0.904	0.981	I>E>H	0.002	0.953	22
	Jagitial	1.757	0.961	0.859	0.803	I>E>H	0.000	0.872	22
	Jangoan	1.821	0.977	0.976	0.812	E>H>I	0.002	0.919	24
	Jayashankar Bhupalapally	1.743	0.948	0.895	0.610	E>H>I	0.007	0.807	19
	Jogulamba Gadwal	2.150	0.978	0.745	0.701	H>I>E	0.007	0.801	10
	Kamareddy	1.766	0.971	0.864	0.576	H>E>I	0.008	0.790	11
	Karimnagar	1.469	0.992	0.891	0.859	H>I>E	0.001	0.912	14
	Khammam	1.643	0.989	0.853	0.815	H>I>E	0.002	0.883	14
	Komaram Bheem Asifabad	1.761	0.966	0.702	0.444	H>E>I	0.015	0.679	18
	Mahabubabad	1.631	0.992	0.902	0.634	H>E>I	0.011	0.832	19
	Mahabubnagar	2.098	0.982	0.887	0.719	H>E>I	0.003	0.857	14
	Mancherial	1.495	1.000	0.923	0.717	H>E>I	0.008	0.874	14
	Medak	1.984	0.954	0.925	0.512	E>H>I	0.017	0.776	19
	Medchal-Malkajgiri	1.866	0.981	0.909	0.963	I>H>E	0.001	0.951	14
	Nagarkurnool	1.809	0.971	0.900	0.724	E>H>I	0.002	0.860	24
	Nalgonda	1.784	0.991	0.963	0.816	E>H>I	0.002	0.921	14
	Nirmal	1.600	0.976	0.849	0.648	H>E>I	0.004	0.816	11
	Nizamabad	1.643	0.991	0.825	0.765	H>I>E	0.005	0.856	10
	Peddapalli	1.563	0.989	0.875	0.831	H>I>E	0.002	0.897	14
	Rajanna Sircilla	1.970	0.955	0.953	0.839	E>I>H	0.005	0.915	23
	Ranga Reddy	1.999	0.942	0.891	0.913	I>E>H	0.011	0.915	22
	Sangareddy	2.298	0.966	0.938	0.620	E>H>I	0.009	0.829	19
	Siddipet	1.827	0.974	0.929	0.775	E>H>I	0.001	0.890	24
	Suryapet	1.857	0.955	0.969	0.790	E>I>H	0.006	0.902	23
	Vikarabad	2.120	0.935	0.857	0.609	E>I>H	0.006	0.791	11
	Wanaparthy	1.930	0.936	0.951	0.767	E>I>H	0.014	0.881	23

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Warangal Rural	1.808	0.992	0.933	0.629	H>E>I	0.013	0.839	19
	Warangal Urban	1.778	0.973	0.917	0.862	E>I>H	0.000	0.916	24
	Yadadri Bhuvanagiri	1.798	0.948	0.938	0.862	E>I>H	0.008	0.915	23
Tripura									
	Dhalai	2.277	0.979	0.905	0.217	H>E>I	0.102	0.615	20
	Gomati	1.803	0.933	0.872	0.340	E>H>I	0.033	0.670	19
	Khowai	1.669	0.945	0.857	0.239	E>H>I	0.060	0.610	11
	North Tripura	1.919	0.932	0.833	0.375	E>H>I	0.021	0.677	16
	Sepahijala	2.220	0.964	0.879	0.328	E>H>I	0.047	0.673	20
	South Tripura	1.793	0.953	0.860	0.225	E>H>I	0.070	0.603	11
	Unakoti	2.465	0.958	0.778	0.219	H>E>I	0.062	0.578	17
	West Tripura	1.701	0.970	0.886	0.547	E>H>I	0.012	0.784	19
Uttar Pradesh									
	Saharanpur	2.210	0.938	0.677	0.783	I>H>E	0.011	0.794	7
	Bijnor	2.487	0.950	0.768	0.732	I>H>E	0.001	0.813	7
	Rampur	3.499	0.935	0.562	0.683	I>H>E	0.024	0.715	15
	Jyotiba Phule Nagar	3.044	0.943	0.706	0.709	I>H>E	0.003	0.780	7
	Meerut	2.932	0.943	0.739	0.886	I>H>E	0.011	0.853	7
	Baghpat	2.559	0.951	0.814	0.824	I>E>H	0.003	0.861	7
	Gautam Buddha Nagar	2.201	0.947	0.850	0.929	I>E>H	0.009	0.908	22
	Bulandshahr	2.612	0.939	0.786	0.765	I>E>H	0.004	0.827	7
	Aligarh	2.476	0.924	0.735	0.690	I>E>H	0.006	0.778	7
	Mahamaya Nagar	2.532	0.923	0.778	0.567	E>I>H	0.004	0.745	7
	Mathura	2.999	0.943	0.709	0.729	I>H>E	0.004	0.789	7
	Agra	2.942	0.939	0.718	0.812	I>H>E	0.009	0.819	7
	Firozabad	2.953	0.912	0.768	0.634	E>I>H	0.012	0.765	7

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Mainpuri	2.955	0.889	0.839	0.487	E>I>H	0.044	0.720	16
	Bareilly	2.935	0.961	0.565	0.679	H>I>E	0.034	0.722	10
	Pilibhit	2.621	0.930	0.596	0.472	H>I>E	0.005	0.646	7
	Shahjahanpur	3.670	0.900	0.669	0.481	E>I>H	0.006	0.667	7
	Kheri	2.738	0.904	0.643	0.288	E>H>I	0.006	0.567	7
	Sitapur	2.626	0.917	0.529	0.240	H>E>I	0.012	0.508	7
	Hardoi	3.093	0.931	0.579	0.252	H>E>I	0.018	0.533	15
	Unnao	2.396	0.945	0.659	0.382	H>E>I	0.011	0.631	7
	Lucknow	2.062	0.962	0.794	0.748	H>I>E	0.001	0.831	10
	Farrukhabad	2.969	0.927	0.726	0.524	E>I>H	0.001	0.712	7
	Kannauj	2.961	0.923	0.726	0.382	E>H>I	0.007	0.646	7
	Etawah	2.604	0.941	0.844	0.641	E>I>H	0.003	0.801	11
	Auraiya	2.946	0.931	0.796	0.410	E>H>I	0.012	0.683	7
	Kanpur Dehat	2.500	0.948	0.761	0.379	H>E>I	0.016	0.662	7
	Kanpur Nagar	2.282	0.946	0.827	0.714	E>I>H	0.001	0.825	7
	Jalaun	2.464	0.956	0.785	0.466	H>E>I	0.010	0.712	18
	Jhansi	2.314	0.966	0.872	0.574	E>H>I	0.008	0.790	19
	Lalitpur	3.171	0.929	0.790	0.323	E>H>I	0.022	0.636	16
	Hamirpur	2.501	0.946	0.827	0.393	E>H>I	0.020	0.688	16
	Mahoba	2.433	0.952	0.822	0.386	E>H>I	0.022	0.685	18
	Banda	2.941	0.932	0.669	0.234	H>E>I	0.026	0.551	15
	Chitrakoot	2.491	0.952	0.679	0.261	H>E>I	0.035	0.575	18
	Fatehpur	2.817	0.931	0.687	0.320	H>E>I	0.012	0.605	7
	Pratapgarh	2.816	0.956	0.834	0.430	E>H>I	0.018	0.711	18
	Kaushambi	3.767	0.933	0.677	0.305	H>E>I	0.014	0.594	7
	Prayagraj	3.186	0.935	0.771	0.468	E>H>I	0.005	0.704	7

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Bara Banki	3.025	0.930	0.557	0.333	H>I>E	0.011	0.569	7
	Faizabad	2.333	0.967	0.806	0.482	H>E>I	0.013	0.729	18
	Ambedkar Nagar	2.911	0.963	0.827	0.347	H>E>I	0.035	0.668	18
	Bahraich	3.110	0.936	0.395	0.192	H>I>E	0.082	0.436	15
	Shrawasti	3.452	0.955	0.449	0.195	H>I>E	0.073	0.461	17
	Balrampur	2.912	0.933	0.522	0.325	H>I>E	0.018	0.553	15
	Gonda	2.801	0.951	0.683	0.397	H>E>I	0.012	0.647	7
	Siddharthnagar	3.140	0.986	0.589	0.370	H>I>E	0.050	0.611	18
	Basti	2.318	0.949	0.754	0.457	H>E>I	0.007	0.697	7
	Sant Kabir Nagar	2.330	0.965	0.738	0.369	H>E>I	0.025	0.654	18
	Maharajganj	2.783	0.951	0.763	0.472	H>E>I	0.007	0.708	18
	Gorakhpur	2.612	0.942	0.813	0.550	E>H>I	0.003	0.755	7
	Kushinagar	2.364	0.965	0.746	0.435	H>E>I	0.016	0.689	18
	Deoria	2.124	0.985	0.864	0.570	H>E>I	0.013	0.791	11
	Azamgarh	2.296	0.933	0.875	0.448	E>H>I	0.018	0.725	19
	Mau	2.516	0.970	0.784	0.516	H>E>I	0.010	0.739	18
	Ballia	2.361	0.965	0.842	0.471	H>E>I	0.016	0.735	11
	Jaunpur	2.263	0.976	0.904	0.502	E>H>I	0.021	0.771	19
	Ghazipur	2.667	0.972	0.867	0.403	H>E>I	0.032	0.711	11
	Chandauli	2.447	0.944	0.852	0.468	E>H>I	0.013	0.731	11
	Varanasi	2.298	0.989	0.791	0.679	H>I>E	0.009	0.812	10
	Sant Ravidas Nagar (Bhadohi)	2.564	0.927	0.871	0.488	E>H>I	0.015	0.741	11
	Mirzapur	2.466	0.947	0.851	0.466	E>H>I	0.013	0.730	11
	Sonbhadra	2.569	0.960	0.706	0.254	H>E>I	0.045	0.581	18
	Etah	3.440	0.942	0.747	0.439	H>E>I	0.006	0.685	7
	Kanshiram Nagar	3.771	0.921	0.597	0.463	H>I>E	0.002	0.640	7

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Amethi	3.167	0.885	0.713	0.353	E>I>H	0.023	0.618	15
	Budaun	3.386	0.947	0.499	0.401	H>I>E	0.035	0.584	15
	Ghaziabad	2.529	0.970	0.844	0.968	I>H>E	0.005	0.926	22
	Hapur	2.593	0.930	0.777	0.856	I>E>H	0.013	0.852	7
	Moradabad	2.547	0.933	0.728	0.709	I>E>H	0.004	0.785	7
	Muzaffarnagar	2.479	0.981	0.695	0.822	H>I>E	0.017	0.826	10
	Rae Bareli	2.824	0.954	0.758	0.347	H>E>I	0.024	0.646	18
	Sambhal	2.814	0.931	0.598	0.540	I>H>E	0.006	0.674	7
	Shamli	2.582	0.944	0.594	0.779	I>H>E	0.026	0.762	15
	Sultanpur	3.064	0.950	0.817	0.362	E>H>I	0.024	0.671	16
Uttarakhand									
	Uttarkashi	2.125	0.952	0.972	0.604	E>H>I	0.014	0.829	19
	Chamoli	1.934	0.942	0.980	0.659	E>I>H	0.015	0.851	19
	Rudraprayag	2.317	0.969	0.964	0.654	E>H>I	0.009	0.852	19
	Tehri Garhwal	2.243	0.987	0.986	0.698	E>H>I	0.009	0.882	14
	Dehradun	1.928	0.967	0.892	0.950	I>E>H	0.003	0.936	22
	Garhwal	3.217	0.980	0.979	0.652	E>H>I	0.011	0.859	19
	Pithoragarh	2.106	0.939	0.971	0.624	E>I>H	0.017	0.833	19
	Bageshwar	2.020	0.983	0.969	0.564	E>H>I	0.020	0.820	19
	Almora	1.672	0.979	0.974	0.481	E>H>I	0.032	0.782	19
	Champawat	2.616	0.956	0.950	0.562	E>H>I	0.015	0.806	19
	Nainital	2.021	0.979	0.865	0.793	H>I>E	0.001	0.876	22
	Udham Singh Nagar	2.541	0.940	0.795	0.803	I>E>H	0.005	0.844	7
	Hardwar	2.227	1.000	0.656	0.812	H>I>E	0.035	0.814	10
West Bengal									
	Dakshin Dinajpur	1.681	0.986	0.850	0.252	H>E>I	0.082	0.625	11

State/ Union Territory	District	TFR	HE	ED	SL	HDP	HDE	HDS	Node
	Hugli	2.288	0.976	0.880	0.536	H>E>I	0.015	0.779	19
	Jalpaiguri	2.334	0.966	0.852	0.405	H>E>I	0.027	0.707	11
	Uttar Dinajpur	2.537	0.961	0.783	0.239	H>E>I	0.058	0.593	18
	Birbhum	1.954	0.974	0.770	0.287	H>E>I	0.051	0.622	18
	Maldah	2.357	0.970	0.799	0.306	H>E>I	0.046	0.640	18
	Murshidabad	2.138	0.955	0.826	0.287	E>H>I	0.045	0.633	18
	Bankura	2.198	0.965	0.903	0.238	E>H>I	0.081	0.625	20
	Nadia	1.901	0.977	0.911	0.386	E>H>I	0.043	0.717	20
	North Twenty Four Parganas	1.772	0.990	0.892	0.653	H>E>I	0.009	0.836	19
	Haora	1.444	0.990	0.821	0.655	H>E>I	0.009	0.813	10
	Kolkata	2.040	0.987	0.884	0.882	H>I>E	0.001	0.917	14
	Puruliya	2.464	0.969	0.865	0.227	H>E>I	0.082	0.609	11
	Darjiling	1.507	0.991	0.908	0.589	H>E>I	0.015	0.814	19
	Koch Bihar	1.285	0.956	0.875	0.201	E>H>I	0.086	0.591	20
	South Twenty Four Parganas	2.108	0.973	0.811	0.383	H>E>I	0.031	0.685	18
	Paschim Medinipur	2.010	0.978	0.874	0.210	H>E>I	0.098	0.602	20
	Purba Medinipur	1.639	0.984	0.882	0.209	H>E>I	0.106	0.605	20
	Paschim Barddhaman	1.867	0.945	0.809	0.636	E>I>H	0.001	0.789	7
	Purba Barddhaman	2.000	0.975	0.866	0.377	H>E>I	0.038	0.699	11

Source: Author

INDIAN JOURNAL OF POPULATION AND DEVELOPMENT
ISSN: 2583-4827; Volume 5(1), January 2025: 47-59

Religion Affects Birth Rate: An Overview of Religiosity, with Focus on Africa

Frank Götmark
Nicola Turner

Abstract

The global human population is projected to grow by more than 2 billion in the next 60 years, according to the latest population projections prepared by the United Nations. Birth rates are high in some parts of the world, leading to continued population growth. This paper argues that in Africa and parts of Asia, and within Muslim countries and communities, religiosity promotes high birth rates. However, this role of religion could potentially be reversed. In this paper, we discuss theories about religiosity and the role of Islam and other religions in the context of fertility and population growth in Africa and elsewhere.

Introduction

Religious immigrants to the West have high birth rates, the British political scientist Kaufmann (2010) concluded. Two years later, the psychologist Jonathan Haidt published a book on “The Righteous Mind” (Haidt, 2012). He and Kaufmann have argued that religion is hard to eliminate through rational arguments, as evolutionary biologist Richard Dawkins and many others have tried (Dawkins, 2006). According to Haidt, religiosity is part of inherited behaviour that reinforces social cooperation among competing groups of *Homo Sapiens*.

In this paper, religion refers to the belief in supernatural power, including spirituality and spirits that influence our attitudes and actions. Animism long dominated among hunters and gatherers via souls and spirits (deceased people, parts of nature, and the like). As agriculture evolved globally, larger hierarchical communities adopted gods who modelled forms of hierarchical leadership. Monotheism proved successful in building loyal followings and has branched into several religious traditions.

The American researcher Stephen Prothero attempted to characterise major religions of the world (Prothero, 2010). For Buddhism he suggests "the problem is suffering - the solution is awakening", for Christianity "the problem is sin, the solution is salvation", and for Islam "the problem is pride, the solution is submission". He found Confucianism and Hinduism harder to characterise. Prothero refers to them, respectively, as “the way of propriety” and “the way of devotion.”

Muslims Give Birth to More Children

In the 1960s and 1970s, many scholars in the Western world believed that religions would fade away and developing countries would become secular (Hekmatpour, 2020; Norris and Inglehart, 2011). This has, however, not happened. For example, the Gallup surveys carried out during 2005-2010 in Africa south of Sahara, and in Arab countries revealed that, on average, 90 per cent of the respondents answered "Yes" to the question, "Is religion an important part of everyday life?". Moreover, the Pew Research Center has reported that Islam is the fastest growing religion in the world and has forecasted that Muslims will give birth to more children than Christians by the year 2035 (Pew Research Center, 2017).

These observations are supported by the World Values Survey, carried out in 57 countries of the world. The survey showed that Muslims give birth to more children than other religions (Halimatusa'diyah and Toyibah, 2021). Immigrants to Europe from Muslim countries also appear to have higher birth rate than other immigrants and the host population (Blekesaune 2020). This is explained by higher religiosity in Muslims, and the Muslim family norms that favour large families (Berhman and Erman, 2019). This study also reported that differences in socioeconomic status and migration status are less important determinants of Muslim family sizes than religious preferences. In west and central Africa, it is found that girls aged 15-19 years having either incomplete primary or no formal education were three times more likely to have married, and twice as likely to have given birth compared with those having at least primary education (Sagalova et al, 2021). This study also found that the prevalence of adolescent marriage was higher among Muslims than all other religious groups.

Population growth is strong today in parts of Western Asia (for example, Indonesia, Pakistan, and Afghanistan) and in Africa, especially, Africa south of Sahara. The latest population projections prepared by the United Nations estimated that Africa's population is likely to increase dramatically, from 1.4 billion in 2024 to 3.8 billion in 2100 (United Nations, 2024). This massive increase in the population will be due to high birth rates and the momentum for growth built in the young age structure of the population, which means that large fractions of young age classes in the African countries will be forming families in the future. The total fertility rate in Africa is currently estimated to be around 4.2 children per woman of reproductive age (United Nations, 2024). The consequences of such a rapid population growth will be serious from the perspectives of economic development and environmental sustainability. For instance, the Food and Agricultural Organization of the United Nations has reported increased undernutrition in Africa and other parts of the world, (FAO et al, 2024).

Meanwhile, the popular media and environmental organisations are silent on the role of future population growth for social and economic development, and environmental sustainability, in Africa. Valuable studies attempting to compare the relative role of population growth and climate change for food security have not been reported by the popular media. One such global study has concluded that "although climate change scenarios had an effect on future crop yields, population growth appeared to be the dominant driver on the change in undernourishment" (Molotoks et al, 2020).

Is Religiosity Declining?

In recent years, there are reports that religiosity is decreasing around the world. This observation is based primarily on the analysis of the data available from the World Values Survey (Inglehart, 2021). Declining religiosity may be true for USA and some other countries but seems unlikely for Africa where the World Values Survey covered only a few countries. There is evidence that in many African countries, highly religious communities are rapidly growing (Pew Research Center, 2025).

It is also important to carefully interpret the meaning of the world "religious". Some respondents in the World Values Survey have indicated that they do not belong to a congregation or organised religion, and they are categorised as “none,” i.e., not belonging to any religion. A new survey conducted by the Pew Research Centre shows that the “none” response in the World Value Survey increased from 16 per cent to as high as 30 per cent in USA. Most of these respondents believed in a god or some higher power, even though very few of them regularly attended religious services (Pew Research Centre, 2024). They might therefore be classified as religious. In addition, concepts like spirituality and belief in spirits is difficult to capture in surveys like the World Values Survey.

The British African specialist Stephen Ellis and his Dutch colleague Gerrie ter Haar have described the importance of spirits in Africa (Ellis and ter Haar, 2004). The belief in spirits permeate culture and politics among the poor and the rich as well as in urban and in rural populations. They are omnipresent, even in communities that identify themselves as Christian or Muslim. Spiritual religious "mentors" often influence or control political leaders. President Kenneth Kaunda of Zambia, for example, was strongly influenced by two Indian gurus "who recognised him from his shamanistic journeys in the spiritual world," and they were given access to the power. Quite frequently, assassinations of political rivals are arranged with reference to spirits and gods. Some women who are seen as witches or women possessing evil spirits, have been found to be displaced and relegated to special villages. A recent book, *Religions in Contemporary Africa*, gives prominent place to the work of Ellis and ter Haar (Grillo et al, 2019).

African forms of religiosity have also been found to encourage fatalism. According to a BBC report from north-east Nigeria, in response to skyrocketing food prices, poverty and security concerns, the Governor of the region called for "divine intervention", and asked citizens to pray and fast (BBC, 2024). The Governor could, more usefully, have called for lowering birth rates so that there would be fewer mouths to feed but he preferred the spiritual route.

Spirits and minor gods still exist in close-to-nature animism, where much is considered animate. However, monotheism with a single, anthropomorphic ruling god (usually or often assumed to be male) predominates today also in Africa and in many other countries. How did we get there? The development can partly be explained by autocrats exploiting religion. An analysis of pre-modern societies and data from today has found that rulers with "divine legitimacy" contributed to religious laws. Societies that have followed this path are today more autocratic, and their populations are more religious than those in democratic societies (Bentzen and Gokmen, 2022).

The Dynamic Development of Congregations

How do individual churches and congregations develop? The sociologists Rodney Stark and Roger Finke and the economist Laurence Iannaconne have argued for a kind of economic market model where believing individuals act rationally based on inherent needs and choose congregations based on so-called *tension*, i.e., degree of "distinctiveness, separation, and antagonism" (Stark and Finke, 2000; Iannaconne, 1994). Stark and Finke have described their ideas in an original book, *Acts of Faith: Explaining the Human Side of Religion*. Strong faith and experiences in congregations (linked to high *tension*) give social cohesion, with more separated, contained congregations where the priest is financed by members who demand distinctive, strong experiences.

The social position of long-standing congregations and their priests can, however, be challenged by new congregations that provide alternative experiences. Christian charismatic churches (such as "speaking in tongues", ecstasy) are examples of rapidly increasing movements, at the expense of others, first in the United States, then, among other places in South America, and nowadays in parts of Africa (e.g., Grillo et al. 2019). This would be an example of the religious market in action, where the price extracted from members is rewarded by new intense experiences.

In traditional churches, belonging and faith are lower but cheaper. In highly secular Sweden, it costs little to remain in a congregation of the Church of Sweden, but religious beliefs are weak. In contrast, charismatic churches that provide high *tension* demand time and money and exclude free riders. There are studies from Africa that relate to ideas of religious market, but a recent one from Ghana gives some support (Yalley, 2025). Yalley has analysed factors influencing continued church membership, using a questionnaire in a range of denominational Christian groups, including Catholic, Protestant, Pentecostal, Charismatic, and “Others.” Charismatic leadership, religious experience, message credibility, and willingness to donate, contributed to continued church membership, among others. Corporate social responsibility has strengthened church membership. Among Christian, Pentecostal and Charismatic denominations are increasing in Ghana (Yalley, 2025).

Rodney Stark, who died in 2022, had argued that religion and religiosity were not going away (Stark, 1999). Some scholars are critical of the ideas of religious market and congregational dynamics. Additions to the model may be needed. For instance, in secularised countries, religiosity may, in general, be latent but may increase rapidly, because of crises such as wars (Henrich et al, 2019) and pandemics (Bentzen, 2021).

More surprisingly, a new study covering about 100 countries has suggested that three social conditions typical for modernity and secularity – high existential security, education and urbanicity – do not decrease religiosity (Roberts, 2024). The author studied the degree of religiosity during 1989-2020 and has reported that the three social conditions neither exert independent, negative effects on the religiosity in general, nor predict the decrease in religiosity. Roberts argues that when a country is facing extreme poverty and low levels of education, influences of religion on fertility may not be as strong as certain socioeconomic factors. When economic constraints and education levels are not as dire, religion may more strongly influence fertility.

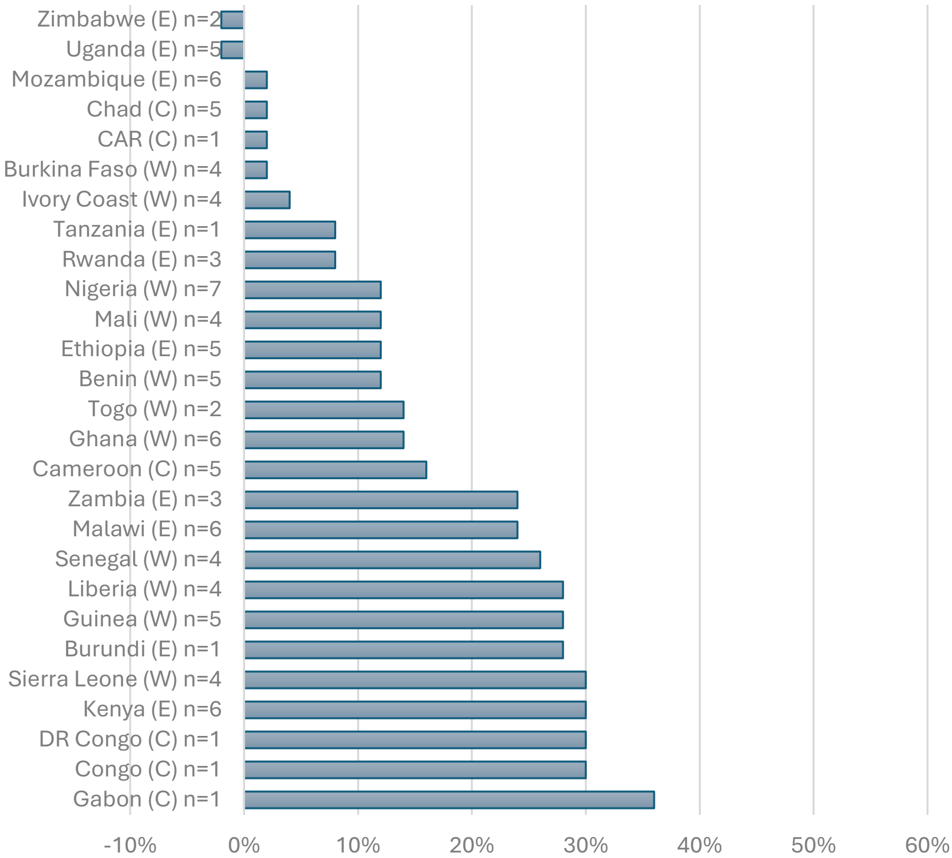


Figure 1: Mean fertility differences between Muslims and Christians in selected countries of Africs.
Remarks: Countries where Muslims had higher fertility than Christians is presented to the right; countries where Christians had higher fertility than Muslims is presented to the left.
Source: Turner and Götmark (2023), where original data for calculations can be found.

Different Religions have Different Family Size Norms

We have recently reviewed studies from sub-Saharan Africa to see if major religions in the region differ in birth rates and thus potentially in relative future population growth and population size (Turner and Götmark, 2023). We were surprised to find that so much information existed, including good research by many African scientists. Much of the valuable information was also found in various reports and low-ranked journals. Our study, and other studies (such as Westoff and Bietsch, 2015), suggest that, in general, high religiosity in Africa contributes to large family size, although other factors such as patriarchal culture also contribute to high fertility rates. Our findings are also consistent with a global study of fertility and religiosity, where fertility is positively associated with degree of religiosity in six world regions, and where the regions Sub-Saharan Africa and Arab States had highest religiosity (see Götmark and Andersson, 2020).

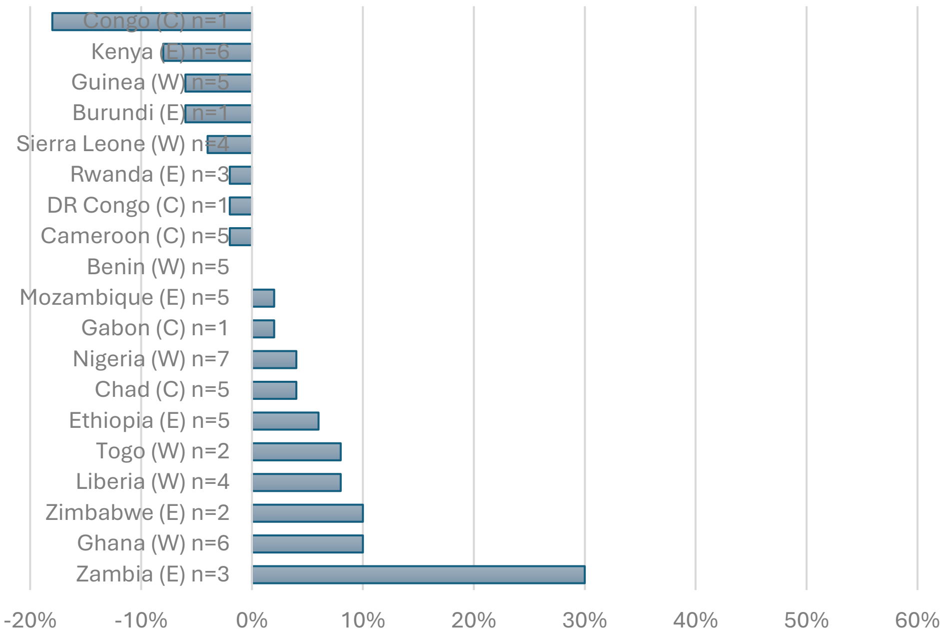


Figure 2: Fertility differences between Muslims and African Indigenous Religions (AIR)in selected African countries.
Remarks: Countries where AIR had higher fertility than Muslims is presented to the right; countries where Muslims had higher fertility than AIR is presented to the left.
Source: Turner and Götmark (2023), where original data for calculations can be found.

Turner and Götmark (2023) also found that Muslim families had birth rates 2–36 per cent higher than birth rates of Christian families, except in two countries, Zimbabwe and Uganda, where birth rate in Muslim families was around 2 per cent lower than that in Christian families. Although not significantly higher than Muslims, followers of older, Indigenous African religions had 4–58 per cent higher birth rates than those of Christian families, depending on the country (Turner and Götmark, 2023). Among Christians, Catholics and Protestants hardly differed in birth rate (their average birth rates were approximately similar across countries). Figures 1 through 3 show the results for individual countries in Sub-Saharan Africa.

Interestingly, there is evidence to suggest that Indigenous religions in Africa have higher paternity certainty than Islam and Christianity (Straussman et al, 2012), The Indigenous practices involved strong regulation of female sexuality. Such Indigenous religions, where followers identify as believers (without Christian or Muslim influences), were probably important for group cohesion and survival (Haidt, 2012). Currently, these religions are small minorities; monotheism with a single ruling god has largely "won" in Africa.

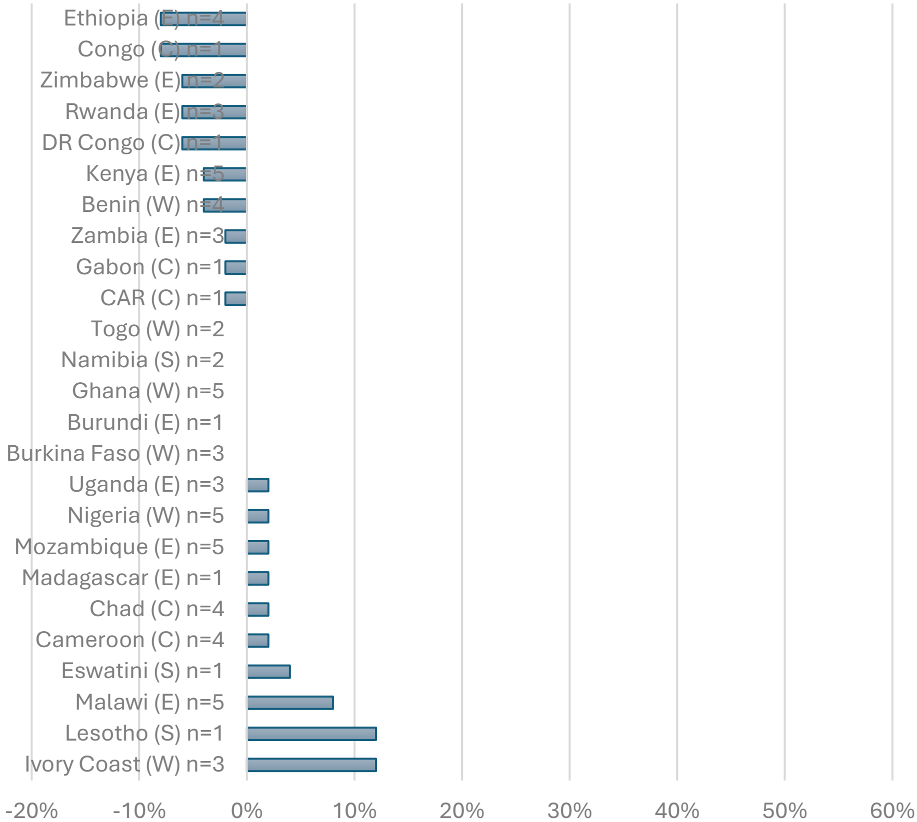


Figure 3. Fertility differences between Protestants and Catholics in selected African countries.
Remarks: Countries where Catholics had higher fertility than Protestants is presented to the right; countries where Protestants had higher fertility than Catholics is presented to the left.
Source: Turner and Götmark (2023), where original data for calculations can be found.

Beside religiosity, high fertility in Africa might be related to rural communities tending to have more traditional lifestyles, with low access to education, health services, and contraception. Yet, in focus group discussion and interview papers, the role of religion was often mentioned. The most frequent themes for "increasing fertility" were related to religion (11 cases) and polygamy (11), whereas the most frequent themes for "limiting births" were financial constraints (7) and quality of life (5) (Turner and Götmark, 2023).

Due to more rapid reproduction, Islam is now gaining ground in Africa. It is also expanding in other countries via migration, where Muslim migrants tend to have more children than the host community. In a survey of 15 European countries, immigration by Muslims was unpopular, irrespective of age, education, income, and political ideology of the respondents (Bansak et al, 2016). Covering clothing for women (Ahmed, 2012; Pazhoohi and Kingstone, 2020), gender segregation, Sharia law or sympathy for such, terrorist groups (Agbiboa, 2013; Choi, 2021), and high birth rates probably have contributed to make Islam unpopular in large parts of Europe. High birth rates contrast with the earlier history of Islam, with successful family planning programs in Muslim countries such as Indonesia, Iran, and Tunisia (The Overpopulation Project, 2025). Ahmed (2012) described how secular culture of Egypt changed through influence of the Muslim Brotherhood during late twentieth century.

Although not the focus of our overview, some studies have examined the relationships of Hinduism and Buddhism to fertility. One study compared cohort fertility among Hindu and Muslim women in India (Pasupuleti et al, 2017). Their results suggest higher fertility among Muslims – a gap of more than 1.3 children per woman between those Muslim and Hindu women who ended/will end their reproductive period in the calendar years 1993 to 2025. Socioeconomic differences, and higher demand for children among Muslims, were suggested as causes. On the other hand, Buddhism was reported to have negative or no association with childbearing, and Buddhist affiliation or devotion was unrelated to elevated fertility across diverse cultural settings (Skirbekk et al, 2015).

Possible Measures against Unsustainable Population Growth

It is often emphasised that more years of education can lower birth rates in developing countries, but the importance of the *content* of the education has not or rarely been investigated. Religious schools are common in Africa and supported through extensive international aid. Do these schools contribute to reducing the high birth rates in Africa, or do they maintain, or even encourage high fertility? Schoumaker and Sánches-Páez (2024) reviewed the stall in fertility in some African countries and called for more research on its causes in educational groups, especially less-educated women, to understand the stall.

In the early 1990s, the United States, a major donor, changed its policy to allow governmental aid to Africa through Christian organisations, which was supported by both Republicans and Democrats (Stambach, 2009). At the same time, many countries in Africa allowed private schools, paid for by e.g., the United States, Arab states, or other donors. Do these schools provide education in sexuality and family planning?

More international aid for family planning could favour people, the environment, and wildlife in Africa and elsewhere. Bongaarts and Hodgson (2022) stated that a major investment in voluntary family planning could halve the remaining population growth in Africa from 2 to 1 billion in the future. Aid to those countries in Africa which reported policy to lower fertility (United Nations, 2017), and those countries which invest in family planning out of their own resources, should be given a high priority.

Advocates for family planning point out that male allies are essential for women who wish to adopt modern contraception methods, and religious leaders, often men, are particularly valuable in this context (Gates, 2019). Priests have the potential to positively influence their congregation, media, and government policies. In Costa Rica (Dérer, 2019) and Indonesia, religious leaders positively influenced family planning uptake (Dodson, 2019). Today, total fertility rate is 1.5 in Costa Rica, and 2.1 in Indonesia. Political leaders in sub-Saharan Africa who advocate for family planning are relatively few, but those who advocate family planning need support. Turner and Götmark (2023) reviewed the evidence that outreach by Church leaders overcame barriers to the uptake of family planning, including opposition by male partners, and it was compatible with religious faith. This demonstrates the potentially strong influence of religious leaders on communities, and the possibilities to raise contraceptive prevalence and reduce fertility. In addition, the 'greening of religion,' taking environmental matters into the account, also offers some hope (Chaplin, 2016).

Religions and faith are present in many contexts, from terror to quiet prayer and wise advice. To slow population growth and address the many negative effects of rapid population growth in Africa and elsewhere, wise religious leaders should be supported as advocates for change. For an overview of African religious leaders that might be supported, by grants and or in other ways, see Turner and Götmark (2022).

Acknowledgements

We thank Malte Andersson, Philip Cafaro, and especially Jane O'Sullivan for helpful comments and suggestions on the manuscript. Part of this paper is based on the Master's Thesis by Nicola Turner (2021).

References

Agbiboa D (2013) The on-going campaign of terror in Nigeria: Boko Harem versus the State. *Stability: International Journal of Security and Development* 52: 1-18.

Ahmed L (2012) *A Quiet Revolution. The Veil's Resurgence, from the Middle East to America.* Yale University Press.

Bansak K, Hainmueller J, Hangartner D (2016) How economic, humanitarian, and religious concerns shape European attitudes toward asylum seekers. *Science* 354: 217-222.

BBC (2024) 'Divine intervention': Nigerians fast over steep food prices. 11 February. https://www.bbc.com/news/live/world-africa-68192925?ns_mchannel=socialandns_source=twitterandns_campaign=bbc_liveandns_linkname=65d314b157478648da6f9356%26%27Divine%20intervention%27%3A%20Nigerians%20fast%20over%20rocketing%20food%20prices%262024-02-19T10%3A24%

Behrman JA, Ehrman J (2019) An exploration of differences in ideal family size between Muslim and non-Muslim women in France. *Demographic Research* 41: 617-648.

Bentzen JS (2021) In crisis, we pray: religiosity and the COVID-19 pandemic. *Journal of Economic Behavior and Organisation* 192: 541-583.

Bentzen JS, Gokmen G (2022) The power of religion. *Journal of Economic Growth* 28: 45-78.

Blekesaune M (2020) The fertility of female immigrants to Europe from Christian and Muslim countries. *Journal of Religion and Demography* 7(2): 222-237.

Bongaarts J, Hodgson J (2022) *Fertility Transition in the Developing World*. New Yor, Springer.

Chaplin J (2016) The global greening of religion. *Palgrave Communications* 2: 16-47.

Choi S-W (2021) Terrorist campaigns and the growth of the Muslim population. *Japanese Journal of Political Science* 22: 40–56.

Dawkins R (2006) *The God Delusion*. Boston, MA: Houghton Mifflin Harcourt.

Dérer P (2019) Family planning for forests and people – the success story of Costa Rica. *The Overpopulation Project*. https://overpopulation-project.com/family-planning-for-forests-and-people-the-success-story-of-costa-rica/

Dodson J (2019) "Two Children Are Enough" – "Dua Anak Cukup". *The Overpopulation Project*, https://overpopulation-project.com/two-children-are-enough-dua-anak-cukup-indonesia-population-policy-case-study-1/

Ellis S, ter Haar G (2004) *Worlds of Power: Religious Thought and Political Practice in Africa*. London, Hurst, and Company.

FAO, IFAD, UNICEF, WFP and WHO (2024) *The State of Food Security and Nutrition in the World 2024. Financing to end hunger, food insecurity and malnutrition in all its forms.* Gates M (2019) *The Moment of Lift*: *How Empowering Women Changes the World.* Rome, Food and Agriculture Organization.

Gates M (2019) *The Moment of Lift*: *How Empowering Women Changes the World.* Flatiron Books, New York.

Götmark F, Andersson M (2020) Human fertility in relation to education, economy, religion, contraception, and family planning programs. *BMC Public Health*, Article number 265.

Grillo L, van Klinken A, Ndzovu HJ (2019) *Religions in Contemporary Africa*. Routledge, New York.

Haidt J (2012) *The Righteous Mind: Why Good People Are Divided by Politics and Religion*. New York, Pantheon Books.

Halimatusa'diyah I, Toyibah D (2021) Do religious people have more children? The effect of religious affiliation and religiosity on fertility. *Journal of Population and Social Studies* 29: 479-499.

Hekmatpour P (2020) Inequality and religiosity in a global context: different secularization paths for developed and developing nations. *International Journal of Sociology* 50(4): 286–309.

Henrich J, Bauer M, Cassar A, Chytilová J, Purzycki BG (2019). War increases religiosity. *Nature Human Behaviour* 3: 129-135.

Inglehart R (2021) *Religion's Sudden Decline*. Oxford, Oxford University Press.

Iannaccone LR (1994) Why strict churches are strong. *American Journal of Sociology* 99(5): 1180-1211.

Kaufmann E (2010) *Shall the Religious Inherit the Earth*? London, Profile Books.

Molotoks A (2020) Impacts of land use, population, and climate change on global food security. *Food and Energy Security* 10(1): e261.

Norris P, Inglehart R (2011) *Sacred and Secular: Religion and Politics Worldwide*. Cambridge, Cambridge University Press.

Pasupuleti SSR, Pathak P, Jatrana S (2017) Hindu-Muslim fertility differential in India: a cohort approach. *Journal of Biosocial Science* 49: 147–172.

Pazhoohi F, Kingstone A (2020) Sex difference on the importance of veiling: a cross-cultural investigation. *Cross-cultural Research* 54: 486–501.

Pew Research Center (2017) *The Changing Global Religious Landscape*. Washington, Pew Research Center. https://www.pewresearch.org/religion/2017/04/05/the-changing-global-religious-landscape/

Pew Research Center (2024) *Religious 'Nones' in America: Who They Are and What They Believe*. Washington, Pew Research Center. https://www.pewresearch.org/religion/2024/01/24/religious-nones-in-america-who-they-are-and-what-they-believe/

Pew Research Center (2025) *How the Global Religious Landscape Changed From 2010 to 2020*. Washington, Pew Research Center.

Prothero S (2010) *God is Not One*. San Francisco, HarperOne.

Roberts LL (2024) Do the three modern social conditions – high existential security, education, and urbanicity – really make people less religious? A worldwide analysis, 1989–2020. *Journal for the Scientific Study of Religion* 63(4):888–916.

Sagalova V, Garcia J, Kapeu AS, Ntambi J, Zagre NM, Vollmer S (2021) Socio-economic predictors of adolescent marriage and maternity in West and Central Africa between 1986 and 2017. *Journal of Global Health* 11: 13002.

Schoumaker BD, Sánches DA (2024) Disruptions in educational progress and fertility dynamics by educational level: unravelling the link between education and fertility stalls in Sub-Saharan Africa. *Population and Development Review* 50(1): 59-85.

Skirbekk V, Stonawski M, Fukuda S, Spoorenberg T, Hackett C, Muttarak R (2015) Is Buddhism the low fertility religion of Asia? *Demographic Research* 32: Article 1.

Stambach A (2009) *Faith in Schools. Religion, Education and American Evangelicals in East Africa*. Redwood City, CA, Stanford University Press.

Stark R, Finke R (2000) *Acts of Faith: Explaining the Human Side of Religion*. Oakland, CA, University of California Press.

Stark R (1999) Secularization, R.I.P. *Sociology of Religion* 60(3): 249–273.

Strassman BI, Kurapati NT, Hug BF, Burke EE, Gillespie BW, Karafet TM, Hammer MF (2012) Religion as a means to assure paternity. *PNAS* 109: 9781-9785.

The Overpopulation Project, 2025. Family planning success stories, https://overpopulation-project.com/family-planning-success-stories/

Turner N (2021) Influence of religion and religiosity on fertility and contraceptive use in continental Sub-Saharan Africa: A comprehensive review [Master thesis]. Göteborg, University of Gothenburg. https://thesiscommons.org/sezdq

Turner N, Götmark F (2022) Religion, fertility and contraceptive use in Sub-Saharan Africa, Part 6: progressive religious organisations. *The Overpopulation Project*. https://overpopulation-project.com/religion-fertility-contraceptive-use-sub-saharan-africa-6-progressive-religious-organisations/

Turner N, Götmark F (2023) Human fertility and religions in sub-Saharan Africa: a comprehensive review of publications and data, 2010-2020. *African Journal of Reproductive Health* 27: 119-171.

United Nations (2017) Governmental policies to raise or lower the fertility level. *UN Population Facts No. 2017/10.* New York, United Nations.

United Nations (2024). World Population Prospects. New York, United Nations, Department of Economic and Social Affairs, Population Division. https://population.un.org/wpp/

Yalley A (2025) Correlates of continued church membership intention: An empirical study of religion in Ghana. *Journal for the Scientific Study of Religion* 64(2): 123-147.

INDIAN JOURNAL OF POPULATION AND DEVELOPMENT
ISSN: 2583-4827; Volume 5(1), January 2025: 59-74

A Probability Model for the Analysis of Truncated Birth History

Brijesh P Singh
Kaushalendra K Singh

Abstract

Fecundability and sterility are two biological parameters that have attracted statistical demographers since 1960s. These parameters cannot be observed directly in the population but using of probability models for birth intervals and the number of births, it is possible to estimate these biological parameters. Fecundability is the monthly chance of conception and conception rate is yearly measure that can be obtain by multiplying 12 in fecundability. In this paper, we have used a probability model for inter-live birth interval to estimate these biological parameters and the probability of proceeding for the next birth. We have applied the model to two data sets which are almost one generation apart. The fitting of the model shows that the variability in the estimated parameters is very low indicates the consistency of the estimates. One of the interesting findings of the analysis is that parameters (rate of increase in conception rate and sterility) have increased over time however, the conception rate is slightly higher for younger age females and lower for the elder age females in the recent data than for the older data. To understand spatial pattern Uttar Pradesh, Bihar and Madhya Pradesh NFHS data have been used that indicates the fertility is higher in Bihar than other two states.

Introduction

The level of fertility is directly related to the proportion of females producing children and inversely related to the interval between successive live births. The study of the two aspects of fertility – spacing between births and parity progression ratio have been an interesting area of research for demographers to gain an insight of the fertility process which is a sequential time dependent process. Models for birth intervals are usually related to the timing of the first birth, inter-live birth interval (also known as closed birth interval) and open birth interval. Some other intervals like straddling, forward and interior birth intervals have also been of interest to researchers in the field of statistical demography. It is worthwhile to mention her is that the inter-live birth interval (the birth interval occurring during a specific period) is different than last or most recent closed birth interval.

For females of constant fecundability, a geometric distribution is used for the waiting time from marriage till conception, while for females of heterogeneous fecundability, the resulting distribution for the waiting time till conception is the beta geometric (Gini, 1924; Henery, 1958; Srinivasan, 1966; Singh et al, 2018). Singh (1964) has developed a probability model of waiting time up to the first conception by using the exponential distribution with a fecundability parameter following a Pearson type-III distribution.

Different mathematical models have been proposed to explain the nature of birth intervals and have been applied to the real time data to estimate fecundability and sterility (Bhattacharya, 1971; Sheps and Menken, 1973; Leridon, 1977; Mode, 1985). It is usually assumed in most these models that, all females are fecund at the time of marriage and fecundability is constant for a female till the first conception. These models also assume that fecundability may vary across females. However, these models, often, do not describe the data satisfactorily, especially when the age at the start of cohabitation is low (Singh 1964; Suchindran and Koo, 1999). Bhattacharya et al (1989) has described a model for the time of first birth which takes fecundability as the time dependent variable during the early period of married life and thus indirectly incorporates biological as well as socio-cultural factors responsible for low fecundability. Suchindran and Lachenbruch (1974) have also estimated parameters of a model for the first live birth interval. Sterility, which is biologically important, has also been studied using the birth interval data (Pathak and Prasad, 1977; Nair, 1983). Moreover, Singh et al (2002) have used the Singh (1968) model for the number of births and have obtained maximum likelihood estimate of fecundability and sterility over time and found that both are increasing.

Under the natural fertility conditions, usually, a closed birth interval is decomposed into some components viz. post-partum amenorrhea period, menstruating interval, time added by foetal wastages/temporary separation (due to short visit of the female to her maternal home) and gestational period and the distribution of the sum of these components is derived using the theory of semi-Markov process with stationary transition densities. The closed birth intervals are useful in studying the pattern of reproduction and estimation of certain parameters underlying the reproductive process of those females who continue to reproduce. Considerable attention has been paid towards the formulation of probability models for inter-live birth intervals under various sets of assumptions, especially for explaining data collected under different sampling frames. The details of this work till 1972 is given in Sheps and Menken (1973). An excellent survey and critical review of the work can also be found in Mode (1985). Braun (1977) extended D'Souza (1973, 1974) work and developed models for inter-live birth intervals capturing some salient features of the data for describing the whole reproduction process. Braun and Hoem (1979), Heckman and Singer (1982) proposed models incorporating co-variates information. George (1973) proposed a simple probability model and then generalized this (George and Mathai, 1975). Further, Bhattacharya et al (1986, 1988) derived a probability model for inter-live birth intervals which is applicable in situation where practice of abstinence following a child birth and taboos regulating coital frequency during the early part of the interval are widespread. Suchindran and Horne (1984) and Horne et al (1990) modelled some selected aspects of childbearing process and explained the parameters involved. Some probability models have also been developed considering various socio-demographic setups for the closed birth interval (Pandey et al, 1998; Mukherjee et al, 1991; Singh, 2002).

Several techniques are available in the literature for analysing the birth interval data from cross-sectional fertility surveys containing retrospective birth history of females of childbearing age. However, the completeness with which retrospective surveys collect information for the number and the timing of births is a controversial issue, even in case of fully designed surveys. Those children who were born many years in the past and have either died at an early age or living separately or working elsewhere for a long time (married daughters, son living separately or working elsewhere) are often under reported by the respondents. Thus, omission of events lengthens the birth interval and lowers the order of the subsequent birth interval. Further, error in dating of events that occurred deep in the past also influences the length of the birth interval.

In recent years, many retrospective fertility surveys have collected truncated birth histories (births in the last five years plus births earlier than five years and after the first birth) of females. The rationale for including a truncated birth history is based on economy and is preferable for areas where past demographic rates are well documented and where interest is in recent experience. There is, therefore, a need of modelling the truncated birth history data. In this paper, we apply a probability model that can be used to estimate biological parameters related to sterility and fecundability from the distribution of inter-live birth interval from the truncated birth history data. We also estimate the rate of change in conception rate as the chance of conception in a calendar year. The conception rate is different from fecundability which is the chance of conception during a lunar month. The model applied in this paper is a linear function of time. Mukherjee et al (1991) has analysed the conception in terms of polynomial of degree one and degree and as constant in the analysis of the last closed birth interval. The present approach is simple than the approach adopted by Mukherjee et al (1991) but the results are very similar. The information on number of females with no birth during the truncated period, distribution of females with exactly one birth during the truncated period by the time between start of the observation period and the birth, and the distribution of females with two or more births during the truncated period by length of the last closed interval have been used to obtain estimates. To test the suitability, the model has been applied to two real data sets having a gap of 25 years or almost one generation to explain the variation in the parameters over time. The R software has been used to obtain estimates of the parameters of the model.

The Model

This section gives a brief description of the model. Suppose married females of current age "b" are sampled at some time T_2 and the data of the two most recent births if they occurred during the preceding T years of the survey are recorded. The proportion of females with no birth during (T_1, T_2) where $T_1 = (T_2 - T)$, distribution of proportion of females with exactly one birth according to the time between T_1 and the birth, and distribution of proportion of females with two or more births during (T_1, T_2) according to the length of the closed interval are obtained under the following assumptions:

(i) T_1 is a distant point since marriage and the parameters of reproduction has been constant for the period considerably prior to female's age "a" so that the equilibrium is attained at T_1.

(ii) Let α is the probability that a female was fecund at T_1 so that $(1-\alpha)$ is the probability that a female was sterile at T_1 and remains sterile during the period (T_1, T_2).

(iii) After a live birth, the female proceeds to the next birth with probability β and for such a female, the probability that the next birth will occur on or before time t is $K(t)$.

Let us consider a female fecund at time T_1. Let $S_1, S_2, \ldots\ldots$ is the time of successive births after T_1, and let $X_1 = S_1$ and $X_i = S_i - S_{i-1} (i = 2,3 \ldots)$. Since the reproduction process was in equilibrium at time T_1, the probability density function of the time of the first live birth is

$$k^*(t) = \int_0^t \left[\frac{1-K(x)}{\mu}\right] dx \qquad (1)$$

where $K(x)$ is the distribution function of inter-live birth interval for a female who proceeds to the next birth and μ is the mean length of the inter-live birth interval and is given by

$$\mu = \int_0^\infty [1 - K(y)] dy \qquad (2)$$

$X_2, X_3 \ldots$ are identically and independently distributed random variables each having distribution function $\beta K(x)$.

The proportion of couples with no birth during (T_1, T_2) is given by

$$B_0^*(T) = (1-\alpha) + \alpha[1 - k^*(T)] \qquad (3)$$

The proportion of females fecund at T_1 and will deliver exactly one birth during (T_1, T_2) which will occur during $(t, t+dt), (T_1 < t < T_2)$ is

$$B_1^*(t)dt = \alpha P[t < S_1 < t + dt, S_2 > T]$$
$$= \alpha P[t < S_1 < t + dt, X_2 > T - t]$$
$$= \alpha k^*(t)[1 - \beta K(T-t)]dt \qquad (4)$$

The inter-live birth interval within the period (T_1, T_2) could be observed only for those females who have given two or more live births during the period. The proportion of couples fecund at T_1 and who have given exactly $i (i \geq 2)$ births during (T_1,T_2) and the length of the interval between $(i-1)^{th}$ and i^{th} which is smaller or equal to t is

$$\alpha\beta^i P[(X_i \leq t) \cap (S_1 \leq T) \cap (S_{i+1} \leq T)] + \alpha\beta^{i-1}(1-\alpha)P[(X_i \leq t) \cap (S_i \leq T))]$$

Thus, the proportion of couples fecund at T_1 with the length of the inter-live interval lying between t and $(t + dt)$ is

$$B_2^*(t)dt = \sum_{i\geq 2} \{\alpha\beta^i P[(S_{i-1} \leq T - t) \cap (S_{i-1} + X_{i+1} > T - t)]k(t)dt$$
$$+\alpha\beta^{i-1}(1-\alpha)P[S_{i-1} \leq T - t]k(t)dt\}$$
$$= \sum_{i\geq 2} \left\{ \begin{matrix} \alpha\beta^i [K^* \$ K^{(i-2)}(T-t) - [K^* \$ K^{(i-1)}(T-t)]k(t)dt + \\ \alpha\beta^{i-1}(1-\alpha)K^* \$ K^{(i-2)}(T-t)k(t)dt \end{matrix} \right\}$$
$$= \alpha\beta K(T-t)k(t)dt \qquad (5)$$

where $K^{(i-1)}(t)$ is the *n*-fold convolution of $K(t)$ with itself and the symbol $ stands for the convolution and $k(t)$ is the density function of closed birth interval $K(t)$.

Bhattacharya et al (1988) proposed a probability model for inter-live birth interval which is applicable in situations where practice of abstinences following a child birth and taboos regulating coital frequency during the early part of interval are widespread. The model assumes that coitus starts after abstinence and increases with time up to a certain point and then it becomes constant till the next birth. The distribution, *K(t)* of the length of the inter-live birth interval is derived under the following assumptions:

(1) The duration of post-partum amenorrhea (PPA), say U, and the period of sexual abstinence, say V, following a live birth are independently distributed, non-negative random variables with corresponding distribution functions $G_1(t)$ and $G_2(t)$ respectively. The distribution of the non-susceptible period say, Z, associated with a live birth is given by $Z = max(U, V)$

(2) For a female with $Z = z$ and $V = v$, the conditional instantaneous risk of conception following a live birth after time t is

$m(t|v); t > z$ and $m_0 = \lim_{t\to\infty}[m(t|v)]$; for all v

Since coitus resumes after the period of abstinence, its frequency and consequently $m(t|v)$ is assumed to depend on the duration of the postpartum abstinence and t, until a conception occurs or the normal level is attained, whichever is earlier.

(3) θ is the probability that a conception results in a foetal loss, $0 \leq \theta < 1$.

(4) The length of the non-susceptible period comprising the duration of pregnancy and PPA associated with foetal loss is an exponentially distributed random variable with mean $\frac{1}{c}, c > 0$. Where *c* is the parameter of the exponential distribution.

(5) The conditional instantaneous risk of conception following the termination of the non-susceptible period following a foetal loss is m_0. Functional forms of $G_1(t)$,$G_2(t)$,$m(t|v)$ and constants involved therein and the parameters θ and *c* do not change with age and parity in the interval (T_1, T_2).

Under the assumption (1), model given by equation (5) can further be formulated as follows:

The duration of postpartum abstinence will be the period of non-susceptibility when PPA is less than or equal to the period of abstinence. In this case the probability that Z will lie in the interval $(z, z + dz)$ is $G_1(z)dG_2(z)$.

Again, the duration of non-susceptibility will be the duration of PPA when the period of abstinence is less than the duration of PPA. Thus, the probability that Z and V will lie in the interval $(z, z + dz)$ and $(v, v + dv)$ respectively $(0 < v < z)$ is $dG_1(z)dG_2(v)$.

Therefore, the proportion of females with two or more live births with the length of inter-live interval lying between t and $(t + dt)$ is

$$B_2^*(t)dt = \int_{[0,t)} G1(z)dG2(z)\{\alpha\beta K*(T-t|z,z)k(t|z,z)dt\}$$
$$+\int_{[0,t]} dG1(z)\int_{[0,t]} dG2(v)\{\alpha\beta K*(T-t|v,z)k(t|v,z)dt\} \qquad (6)$$

The proportion of females with exactly one live birth which occurred during t and $(t+dt)$ is

$$B_1^*(t)dt = \int_{[0,t)} G1(z)dG1(z)\{\alpha k*(t|z,z)[1-\beta K(T-t|z,z)]dt\}$$
$$+\int_{[0,t]} dG1(z)\int_{[0,z)} dG2(v)\{\alpha k*(t|v,z)[1-\beta K(T-t|v,z)]dt\} \qquad (7)$$

The proportion of females in the population with no birth during (T_1,T_2) is

$$B_0^*(T) = \left\{1-\int_{(0,T]}\int_{[0,t)} \alpha G1(z)\, dG2(z)k*(t|z,z)dt\right\}$$
$$+\left\{1-\int_{[0,T]}\int_{[0,t)} \alpha dG1(z)\int_{[0,z)} dG2(v)\, k*(t|v,z)dt\right\} \qquad (8)$$

The proportion of females with exactly one live birth during (T_1, T_2) and time between T_1 and time of the birth smaller than or equal to t, say $B_1(t)$, the proportion of females with two or more live births during (T_1, T_2), and length of inter-live birth interval smaller than t, say $B_2(t)$, are given by

$$\left.\begin{aligned} &B_1(t) = \int_0^t B_1^*(t)\,dt, 0<t<T \\ &B_2(t) = \int_0^t B_2^*(t)dt\,, 0<t<T \\ &\text{and } B_0(T)+B_1(T)+B_2(T) = 1 \end{aligned}\right\} \qquad (9)$$

Illustration

We have applied the above model to analyse the temporal and regional variation in selected indicators of reproductivity. The analysis of the temporal variation is based on two datasets available from two surveys carried out in district Varanasi of Uttar Pradesh. The first dataset is based on the survey "Status of Women and Fertility in Eastern Uttar Pradesh" which was conducted in 1996 (Singh, 1998). This survey covered 1432 eligible females aged 15-49 years in district Varanasi of Uttar Pradesh, India. The second dataset is based on the data available from the fifth round of the National Family Health Survey (NFHS-5) which is a large-scale, multi-round survey conducted across India that provides essential information on population, health, and nutrition indicators (Government of India, 2022). This survey covered 1403 eligible females aged 15-49 years in district Varanasi.

The regional analysis, on the other hand is based on the data available from NFHS-5 for three states of India – Bihar, Madhya Pradesh, and Uttar Pradesh – which are among the high fertility states of the country. A comparison of the results from the temporal perspective based on the two surveys about 25 years apart and from the regional perspective helps in understanding the change and the variation in fecundability and sterility among females.

The analysis is confined to females aged 25-45 years with an effective marriage duration of at least 12 years who did not produce a live birth during the interval (T_1, T_2), women who produced exactly one live birth during the interval (T_1, T_2), and women who produced two or more live births during the interval (T_1, T_2). Only those females who had at least 12 years of effective marriage duration (married for five years or more, 7 years preceding the survey) were considered because the reproductive process may be assumed to have attained equilibrium by that time. Among the eligible female, only those who or whose husband did not adopt any terminal method of family planning program and who were the usual residents of the village were included in the study. Information on the current reproductive status of females (menstruating, pregnant, amenorrhoeic, menopaused) on the reference date of the survey was collected and those females who had reached menopause were excluded.

The model requires information on the distribution of PPA the period of abstinence τ (the time beyond abstinence during which coital frequency depends on time), θ, the incidence of foetal loss. The mean duration of the non-susceptible period associated with the foetal loss was taken as 3 months and 0.15 is the incidence of foetal loss. Analysis of the data on PPA from surveys in Eastern Uttar Pradesh and in rural areas of India and Bangladesh, where extended breastfeeding is the norm reveals that the distribution of PPA has two modes, one within few months after birth and other many months latter (Misra et al, 2021). I have, therefore, considered two groups of females whose PPA takes two values t_1 and t_2 with probability p_1 and p_2 respectively, $0 < p_1 \leq 1$, $p_1 + p_2 = 1$. Empirical data available from the survey suggests t_1=0.1 years and t_2=1.00 year and the values of p_1 are taken as 0.60, 0.50 and 0.45 for females aged 25-30 years, 30-35 years, and 35-45 years, respectively.

Now let us consider that –

1. The duration of postpartum abstinence is same for all females, and its length is τ_1.
2. The conception rate $m(t|\tau_1)$ is a polynomial of degree r in t for $\tau_1 < t \leq \tau_2, (\tau_2 = \tau_1 + \tau)$ and constant thereafter and is of the form

$$m(t|\tau_1) = \begin{cases} \sum_{j=0}^{r} q_j (t-\tau_1)^j & for\ z < t \leq \tau_2 \\ \sum_{j=0}^{r} q_j \tau^j & for\ t > \tau_2 \end{cases} \tag{10}$$

When we assume the conception rate $m(t|\tau_1)$ to be constant then the distribution involves only one parameter q_0 (conception rate at the start of cohabitation). When we assume the conception rate $m(t|\tau_1)$ to be a polynomial of degree one, then the distribution involves two parameters q_0 (conception rate at the start of cohabitation) and q_1 (a measure of rate of increase).

Under these assumptions the expressions for $B_2^*(t)dt, B_1^*(t)dt$ and $B_0^*(T)$ in (6), (7) and (8) reduce to

$$B_2^*(t)dt = \sum_{i=1}^{2} p_i [\alpha\beta K * (T-t|i) k(t|i) dt] \tag{11}$$

$$B_1^*(t)dt = \sum_{i=1}^{2} p_i\{\alpha k*(t|i)[1-\beta K(T-t|i)dt]\} \quad (12)$$

and $B_0^*(t)dt = p_i\{1-\int_0^T \alpha k*(t|i)dt\}$ (13)

where $K*(t|i)$ and $K(t|i)$ are the distribution function of time of first recording and between successive recordings of births for a female with $V=\tau_1$and $U=t_i (i=1,2)$. $k*(t|i)$ and $k(t|i)$ are the corresponding density function of $K*(t|i)$ and $K(t|i)$ where

$$K(t|i) = \sum_{j=0}^{2} A_j\, K_j(t|i) \quad (14)$$

Denote by $M(t|i) = \int_{z_i}^{t-g} m(x|\tau_1)dx, z_i = max(t_i, \tau_1)(0 \le z_i < t-g)$

$h_i = t_i + g, i = 1,2$ and $h' = \tau_1 + g$ then

$$K_0(t|i) = 1 - exp\{-M(t|i)\} \quad (15)$$

The function $M(t|i)$ reduces to the following for $h' \ge hi$

$$M(t|i) = \begin{cases} \varphi(t) & ;\ if\ h' < t \le h'+\tau \\ \varphi(\tau+h') + \sum_{j=0}^{r}(q_j\tau^j)\,(t-h'-\tau) & ;\ if\ t > h'+\tau \end{cases} \quad (16)$$

For $h' < h \le h' + \tau$

$$M(t|i) = \begin{cases} \varphi(t) - \varphi(h_i) & ;\ if\ h' < t \le h'+\tau \\ \varphi(\tau+h') - \varphi(h_i) + \sum_{j=0}^{r}(q_j\tau^j)\,(t-h'-\tau) & ;\ if\ t > h'+\tau \end{cases} \quad (17)$$

For $h_i > h' + \tau$

$$M(t|i) = \sum_{j=0}^{r} q_j\, \tau^j (t-h_i) if t > h_i$$

and $\varphi(t) = \sum_{j=0}^{r} \frac{q_j}{j+1}(t-h')^{j+1}$ (18)

Similarly, $K_j(t|i), (j = 1,2)$ can be obtained. Scoring method was used to obtain maximum likelihood estimates of the parameters of the model (11, 12 and 13) (Singh, 2002). In the estimation of parameters, it was assumed that θ=0.15, $\frac{1}{c}$=0.5 years, τ=0.25 years and τ=2 years. When $m(t|\tau_1)$ is linear, the distribution involves four parameters q_0, q_1, α and β. The initial value of the q_0, q_1 can be obtained by equating the observed mean of the inter-live birth interval of females with two or more births to its theoretical values. The initial estimates of β and α were obtained as a solution of the equation (11, 12 and 13)

$$\hat{\beta} = \frac{1-\frac{(N-n-n')}{N}}{1-[1-\hat{K}*(T)]} = \frac{n+n'}{N\hat{K}*(T)} \quad (19)$$

and $$\hat{\alpha} = \frac{\beta\left(1-\frac{(N-n-n')}{N}-\frac{n'}{N}\right)}{1-[1-\hat{K}*(T)]-\int_0^T \hat{B}_1(t)dt} = \frac{\beta n}{N[\hat{K}*(T)-\int_0^T \hat{B}_1(t)dt]} \quad (20)$$

where N, n and $n'$are respectively the total number of females under study, number of females with two or more births, and number of females with exactly one birth during (T_1, T_2).

Table 1: Distribution of the females according to zero birth, exactly one birth and two or more births during 7 years preceding the survey date by current age (1996)

Number of births	Intervals (in years)	Current age of females in years whose effective marriage duration is ≥ 12											
		25-30		30-35		35-45		25-30		30-35		35-45	
		O	E	O	E	O	E	O	E	O	E	O	E
		1996 Survey						2021 Survey					
Females with zero birth	-	9	9.4	35	35.7	140	141.2	7	6.8	31	33.9	128	126.4
Females with one birth	Interval between T_1 and first birth during 7 years before T_2												
	0.0 – 2.50	6	6.2	21	20.7	32	31.6	5	5.7	19	17.2	27	25.1
	2.50 – 4.50	5		14		15	13.8	4		12		11	8.1
	4.50 – 7.00	1	5.8	3	15.2	8	6.6	1	4.7	2	14.7	5	5.4
Females with two or more births	Inter-live birth interval												
	0.0 – 1.25	5	6.3	14	9.4	9	6.4	5	5.2	14	15.3	8	6.9
	1.25 – 1.75	7	8.5	12	17.6	12	13.3	7	7.3	10	9.1	12	10.1
	1.75 – 2.50	45	46.6	69	62.7	54	49.6	37	35.2	61	59.2	48	55.3
	2.50 – 3.25	33	30.7	33	36.5	29	32.4	29	30.7	28	30.1	27	33.6
	3.25 – 4.00	11	8.8	17	19.3	16	18.7	9	8.2	13	11.2	14	10.7
	4.00 – 4.75	3		5		9	11.1	3		5		7	
	4.75 – 7.00	2	4.7	3	8.9	6	5.3	1	4.2	2	6.3	4	9.4
	Total	127	127.0	226	226.0	330	330.0	108	108.0	197	197.0	291	291.0
	χ^2	1.36		5.60		3.23		0.405		1.238		5.315	
	df	4		4		6		4		4		5	
	p-value	0.851		0.231		0.779		0.982		0.871		0.379	

O-Observed; E-Expected

Source: Authors

Table 2: Estimates of the parameters of the model, variance, and correlation coefficients between estimates of the parameters (1996)

Particulars	Current age of those females whose marriage duration is ≥12 years (years)					
	25-30	30-35	35-45	25-30	30-35	35-45
	1996 Survey			2021 Survey		
q_0 (Conception rate)	0.453	0.344	0.294	0.461	0.338	0.285
q_1 (Measure of rate of increase in conception rate)	0.161	0.173	0.178	0.169	0.180	0.183
α (Probability that a female is fecund)	0.998	0.950	0.623	0.986	0.889	0.568
1-α (Probability that a female is sterile)	0.002	0.050	0.377	0.014	0.111	0.432
β (Probability that female proceeds for next birth)	0.985	0.974	0.811	0.980	0.949	0.782
Variance(q_0)	1.145	3.545	3.751	1.991	1.823	3.201
Variance(q_1)	0.743	1.094	2.133	0.736	0.948	1.661
Variance(α)	0.144	0.253	0.296	0.133	0.223	0.329
Variance(β)	0.193	0.304	0.585	0.203	0.281	0.419
Correlation$(q_0, q_1)(\times -1)$	0.943	0.875	0.799	0.911	0.880	0.734
Correlation$(q_0, \alpha)(\times -1)$	0.744	0.741	0.394	0.711	0.745	0.350
Correlation(q_0, β)	0.065	0.085	0.007	0.051	0.087	0.006
Correlation(q_1, α)	0.641	0.632	0.298	0.668	0.684	0.272
Correlation$(q_1, \beta)(\times -1)$	0.393	0.561	0.317	0.363	0.589	0.297
Correlation(α, β)	0.049	0.038	0.013	0.041	0.036	0.010

Source: Authors

Table 3: Estimates of the parameters, variances, and correlation coefficient between estimators for Uttar Pradesh, Bihar, and Madhya Pradesh NFHS-V data.

Particulars	Current age of those females whose marriage duration is ≥12 years (years)								
	Uttar Pradesh			Bihar			Madhya Pradesh		
	25-30	30-35	35-45	25-30	30-35	35-45	25-30	30-35	35-45
q_0 (Conception rate)	0.452	0.323	0.281	0.473	0.343	0.289	0.443	0.321	0.273
q_1 (Measure of rate of increase in conception rate)	0.163	0.179	0.183	0.171	0.183	0.186	0.159	0.176	0.178
α (Probability that a female is fecund)	0.987	0.891	0.564	0.991	0.902	0.582	0.985	0.889	0.553
1-α (Probability that a female is sterile)	0.013	0.109	0.436	0.009	0.098	0.418	0.015	0.111	0.447
β (Probability that female proceeds for next birth)	0.983	0.939	0.751	0.988	0.953	0.797	0.981	0.929	0.722
Variance(q_0)	1.691	1.859	3.413	1.892	1.823	3.226	2.012	1.623	3.221
Variance(q_1)	0.735	0.941	1.653	0.783	0.938	1.651	0.766	0.938	1.631
Variance(α)	0.130	0.233	0.341	0.131	0.203	0.349	0.123	0.212	0.301
Variance(β)	0.201	0.281	0.423	0.223	0.261	0.439	0.198	0.241	0.403
Correlation$(q_0, q_1)(\times -1)$	0.911	0.883	0.727	0.901	0.877	0.714	0.901	0.892	0.763
Correlation$(q_0, \alpha)(\times -1)$	0.701	0.748	0.359	0.722	0.741	0.355	0.704	0.739	0.353
Correlation(q_0, β)	0.051	0.081	0.005	0.058	0.078	0.003	0.053	0.091	0.005
Correlation(q_1, α)	0.661	0.696	0.263	0.643	0.681	0.252	0.666	0.666	0.261
Correlation$(q_1, \beta)(\times -1)$	0.343	0.581	0.291	0.323	0.566	0.293	0.367	0.579	0.281
Correlation(α, β)	0.038	0.033	0.009	0.042	0.031	0.011	0.048	0.037	0.013

Source: Authors

Discussion and Conclusion

The constant form of the hazard function gave a poor fit (using χ^2test) for all datasets so the results of the model are not presented here. However, the linear form of the hazard function $m(t|\tau_1)$ gave an adequate fit (using χ^2 test) for all age-groups in both 1996 survey and 2011 survey. The expected number of females with zero live birth, one live birth and two or more live births obtained from the model are presented in table 1 along with the observed number of women with zero live birth, one live birth and two and more live births. The difference between the observed and the estimated number of women has been found to be statistically insignificant as may be seen from the table.

On the other hand, estimates of the parameters of the model are presented in table 2. It can be observed from the table the estimate of conception rate at the start of cohabitation, $\hat{q}_0$, is the highest for females whose current age is 25-30 years while $\hat{q}_1$, a measure of the rate of increase in the conception rate, is the lowest. Thus, the age group 25-30 shows high conception rate in the beginning of the interval and subsequently with time, falls below the other two groups. Rate of increase of conception rate $\hat{q}_1$ increases with the increase in the age of the female. This pattern is observed in both the surveys. The values of $\hat{q}_0$ and $\hat{q}_1$ is, however, found to be higher in 2021 compared to those in 1996 in females aged 25-30 years but lower in females of other age groups. This may be due to the fact that females are delaying the birth and, are attaining maximum fecundability in the age group 25-30 years and after that due to increase in secondary sterility, lower sexual activity and use of contraceptive, the low value of estimates of $\hat{q}_0$ and $\hat{q}_1$ are observed in age group 30-35 and 35-45. The instantaneous risk of pregnancy following the previous live birth is assumed to increase during (τ_1, τ_2) and attains a plateau thereafter. In fact, both τ_1 and τ_2 may depend on the survival status of the child, breastfeeding practices, other demographic characteristics (such as age, marital duration, parity number of surviving children, and their age and sex) and cultural characteristics and they may vary from female to female. The variation in $m(t|\tau_1)$ may be incorporated in the present model in a manner similar to that discussed in Bhattacharya et al (1988). The measure of sterility $(1-\alpha)$ is observed more in all age groups in 2021 in comparison of 1996 due to the increasing behaviour of contraceptive use. The probability that the female proceeds for the next birth (β) is found lower in 2021 than in 1996 for all females due to voluntary sterility (vasectomy, tubectomy and other contraceptive use) and aversion of more child. The variance of all parameters in both datasets is quite low which indicates the consistency and the efficiency of the model. The correlation coefficient between $\hat{q}_0$ and $\hat{q}_1$ is very high and negative but decreases with the increase in the age of the female. It is observed that at the elder age the risk of conception is lower in comparison to the younger age. Similar pattern has been observed for correlation between conception rate and probability of sterility. The correlation between α and β is positive but very low for females of all ages in both surveys which means that females with higher fecundability proceed for the next birth.

We have also fitted the model to the data for Bihar, Madhya Pradesh, and Uttar Pradesh for the year 2021 based on the data available from NFHS-5. Table 3 presents the estimates of the parameter of the model for the three states. Among the three states, the conception rate, $\hat{q}_0$, and the rate of increase in the conception rate, $\hat{q}_1$, is found to be the highest in Bihar followed by Uttar Pradesh and Madhya Pradesh. The data available from

NFHS-5 also reveals that the fertility (measured in terms of the total fertility rate) is also the highest in Bihar (2.98 births per woman of childbearing age). followed by Uttar Pradesh (2.35 births per woman of child bearing age) and Madhya Pradesh (1.99 births per woman of childbearing age) (Government of India, 2022). The fecundability is also higher in Bihar compared to Uttar Pradesh and Madhya Pradesh in women of all age groups. It appears that relatively high fecundability thus high conception rate, along with relatively higher rate of increase in the conception rate with the increase in age in Bihar, are contributing factors to high current fertility in Bihar relative to Uttar Pradesh and Madhya Pradesh. The probability of proceeding to the next birth after a birth is also relatively higher in Bihar than that in Uttar Pradesh and Madhya Pradesh.

Factors that influence fecundability of women include demographic factors such as age, life style choices such as smoking and use of alcohol, health and nutritional status, particularly, sexually transmitted infections and hormonal imbalances, and a host of social and cultural factors such as the desire or the demand for children, social support system, and religious beliefs and cultural traditions. A discussion on how these and many other factors influence fecundability differentially in Bihar, Uttar Pradesh and Madhya Pradesh is out of the scope of this paper. However, understanding the determinants of fecundability in the three states may provide an insight about the variation in the current fertility across the three states.

On the other hand, the probability of a woman being sterile is estimated to be, the highest in Madhya Pradesh but the lowest in Bihar. Sterility in women can be classified into primary and secondary sterility and an important factor in secondary sterility is the sickle cell disease which has comparatively high prevalence in Madhya Pradesh. The prevalence of sickle cell disease is particularly high in the tribal population and the proportion of the tribal population to the total population is the highest in Madhya Pradesh among the three states. Madhya Pradesh has the highest proportion of the tribal population.

The fitting of the model reveals that cross-sectional (across states) data have shown a decrease in the conception rate with the increase in the age of the female. The decrease in the conception rate may be attributed to various biosocial factors including age dependent infertility, use of contraceptive methods to regulate fertility and temporary separation between the partners which are normally absent during the early stages of the reproductive life. Conception rate depends upon fecundability which is affected by the coital frequency, and which varies from female to female, being a matter of individual choice and because of various other factors. Traditional intercourse taboos of one form or the other that vary in the degree of restriction affect the coital frequency. In the joint family system in which there is a custom of occupying a separate physical space by the partners even in the night and meeting each other only when the situation permits such as when small kids and elders in the family are sleeping seriously compromises coital frequency. There is also, shortage of space in the house necessary for the privacy of the intimate act. Postpartum taboos on sexual activity to avoid pregnancy to prolong the duration of breast-feeding and other taboos also force couples to abstain from intimate relationship for a substantial period of time. Abstaining from the intimate act in the presence of a daughter-in-law or grown-up children in the family, and also possibly due to the poor nutritional status also has a telling impact on coital frequency. A comparison of the conception rate estimated from the data from 1996 survey with the data from 2021 survey suggests that conception rate in younger women has increased but has decreased in older women. Further, it is observed that temporal data reveals the measure of rate of increase in conception rate and sterility are increasing over time for all age groups due to the weakening of social taboos, increasing protected coital frequency. In any case, this is an issue which needs to be investigated further.

The analysis also reveals difference in fecundability and sterility across the three high fertility states of India. All the three states are from the same social and cultural zone of India and are amongst the poorest states of the country. There is a need to investigate the reasons behind the variation in the fecundability and sterility across the three states as both fecundability and sterility influences the level of fertility.

References

Bhattacharya BN (1971) On Some Stochastic Models for Couple Fertility. Unpublished Ph.D. Thesis, Banaras Hindu University, Varanasi, India.

Bhattacharya BN, Singh KK (1986) A probability model for interior birth interval and its application. *Canadian Studies in Population* 13(2): 167-180.

Bhattacharya BN, Pandey CM, Singh KK (1988) Model for interlive birth interval and some social factors. *Janasamkhya* 6(1): 57-77.

Bhattacharya BN, Singh KK, Singh U, Pandey CM (1989) An extension of model for first birth interval and some social factors. *Sankhya*, *Series B* 51: 115-124.

Braun HI (1977) Stochastic model for birth histories with application to the study of fertility patterns. Princeton, New Jersey, USA, Princeton University, Department of Statistics, Technical Report No. 124, Series 2.

Braun HI, Hoem JM (1979) Modeling cohabitation birth intervals in the current Danish population. Copenhagen, University of Copenhagen, Laboratory of Actuarial Mathematics. Working paper No. 24.

D'Souza S (1973) Interlive birth intervals of non-contraceptive population: A data analytic study. *Social Action* 23: 404-425.

D'Souza S (1974) *Closed Birth Intervals – A Data Analytic Study*. New Delhi, Sterling Publishers Private Limited.

George A (1973) A probability model for inter-birth interval. *The Canadian Journal of Statistics, Section C: Applications* 1(2): 201-209.

George A, Mathai AM (1975) A generalized distribution for interlive birth interval. *Sankhya, Series B* 37: 332-342.

Gini C (1924) First investigations on the fecundability of a woman. In *Proceedings of the International Mathematics Congress, Toronto* 2: 889-892.

Government of India (2022) *National Family Health Survey (NFHS-5) 2019-2021. India*. Mumbai, International Institute for Population Sciences.

Heckman JJ, Singer B (1982) Population heterogeneity in demographic models. In KC Land, A Rogers (Eds) *Multidimensional Mathematical Demography*, New York, Academic Press.

Henry L (1958) Intervals between confinements in the absence of birth control. *Eugenics Quarterly* 5(4): 200-211.

Horne AD, El-Khorazaty MN, Suchindran CM (1990) Statistical modeling of selected aspects of the childbearing process with application to World Fertility Survey countries. *Mathematical Population Studies* 2(3): 183-207.

Leridon H (1977) *Human fertility – The Basic Components*. Chicago, University of Chicago Press.

Mishra R, Singh KK, Singh Brijesh P (2021) Duration of post-partum amenorrhoea: a model-based approach. *Indian Journal of Population and Development* 1(1): 41-50.

Mode CJ (1985) *Stochastic Processes in Demography and their Computer Implementation*. Berlin, Springer-Verlog.

Mukherjee S, Singh KK, Suchindran CM, Bhattacharya BN (1991) A probability distribution for last closed birth interval. *Demography India* 20(2): 259-272.

Nair NU (1983) A stochastic model for estimating adolescent sterility. *Biometrical Journal* 25(6): 557-561.

Pandey A, Dwivedi SN, Mishra RN (1998) A stochastic model for the study of last closed birth interval with some biosocial components. *Mathematical Population Studies* 7(1): 1-27.

Pathak KB, Prasad CVS (1977) A model for estimating adolescent sterility among married women. *Demography* 14: 103-104.

Singh Brijesh P (2002) Fertility Analysis Through Application of Models. Unpublished Ph.D. Thesis, Banaras Hindu University, Varanasi, India.

Singh Brijesh P, Singh G, Singh KK (2018) On the number of menstrual cycles required for first conception: An insight of chance mechanism. *Demography India* 47(2): 01-15.

Singh KK (1998) Status of Women and Fertility in Eastern Uttar Pradesh. Report of a Research Project. Varanasi, Banaras Hindu University.

Singh KK, Singh Brijesh P, Singh U, Singh K (2002) Trends in fecundability and sterility over time. *Progress of Mathematics* 36(1 and 2): 111-129.

Singh SN (1964) On the time of first birth. *Sankhya* 26(1 and 2) B: 95-102.

Singh SN (1968) A chance mechanism of variation in number of births per couple. *Journal of American Statistical Association* 63: 209-213.

Sheps MC, Menken JA (1973) *Mathematical Models of Conceptions and Birth*. Chicago, University of Chicago Press.

Srinivasan K (1966) An application of a probability model to the study of interlive birth intervals. *Sankhya, Series B* 28: 175-182.

Suchindran CM, Lachenbruch PA (1974) Estimates of parameters in a probability model for first live birth interval. *Journal of American Statistical Association* 69: 507-513.

Suchindran CM, Horne AD (1984) Some statistical approaches to the modelling of selected fertility events. *Proceedings of American Statistical Association (Social Statistics Section)* Washington, DC, 629-634.

Suchindran CM, Koo HP (1999) Statistical models for human reproduction. In CR Rao, PK Sen (Eds) *Handbook in Statistics: Environmental and Public Health Statistics*. New York, Elsevier.

INDIAN JOURNAL OF POPULATION AND DEVELOPMENT
ISSN: 2583-4827; Volume 5(1), January 2025: 75-97

Intimate Partner Violence during Pregnancy and Adverse Birth Outcomes in India: Findings from the National Family Health Survey

Sanjit Sarkar
Archana Kujur
Madhuri
Moslem Hossain
Mriganka Dolui

Abstract

This study has examined how intimate partner violence (IPV) during pregnancy has affected adverse birth outcomes (ABO) in India using the data available from the National Family Health Survey, 2019-2021 (NFHS-5). The study reveals that the risk of IPV is strongly associated with adverse birth outcomes along with the effect of education of women, standard of living, place of residence, alcohol consumption by the partner. The study highlights the importance of prioritising follow-up care to women after delivery and improving their socio-economic conditions. The study also suggests that involving women in reproductive health decision-making processes is crucial for preventing adverse birth outcomes. The findings underscore the need of comprehensive policy interventions to support vulnerable women. Addressing socio-economic factors and empowering women to participate in healthcare decision-making can mitigate both prevalence of IPV and risk of ABO in India.

Introduction

Adverse birth outcomes are a significant public health concern with wide-ranging implications for the health and well-being of both mothers and infants. These outcomes not only affect the health and well-being of the mother but also have profound effects on the morbidity and mortality of the foetus (Adane et al, 2014; Silasi et al, 2015; Abdo et al, 2016; Mirzakhani et al, 2020). Maternal complications during pregnancy and delivery can also significantly cause high mortality among adolescent girls aged 15-19 years. In many developing countries, adolescents face higher risk of complications during pregnancy and delivery due to various factors, including intimate partner violence (Stöckl et al, 2014; Cha and Masho, 2014; Huber-Krum et al, 2023). The association between intimate partner violence (IPV) and adverse birth outcomes (ABO) has been well-established (Janssen et al, 2003; Mahapatro et al, 2011; Sarkar, 2013). Previous studies have shown that spousal violence is linked with an increased risk of life-threatening complications for both mother and child, such as miscarriage, abortion, preterm birth, stillbirth, and low birth weight (Campbell, 2002; Kelly et al, 2008; Moylan et al, 2010; Han and Stewart, 2014; Alhusen et al, 2015). A study based on in-depth interview of women suggests that spousal violence is associated with unintended pregnancies and pregnancy outcomes (Straus et al, 1990). According to the World Health Organization (WHO, 2021a), nearly one-third women aged 15-49 years worldwide have experienced IPV, which includes physical or sexual violence perpetrated by their intimate partner. IPV can manifest in various forms, including physical, sexual, and emotional abuse. It can occur in both heterosexual and same-sex relationships. The consequences of IPV are far-reaching and can have severe physical, psychological, and social impacts on the survivor. Globally, the prevalence of IPV is estimated to be the highest in central Sub-Saharan Africa (32 per cent) followed by Oceana (29 per cent), rest of Sub-Saharan Africa (24 per cent) and South Asia (19 per cent) (Sardinha et al, 2022). The literature has also highlighted the adverse implications of IPV the mother and the developing foetus (Alhusen et al, 2015; Chambliss, 2008; Afiaz et al, 2020; WHO, 2021; Garg et al, 2020). Pregnant women who experience IPV can encounter multiple challenges affecting their reproductive health, including high rates of stress, and less likelihood of receiving prenatal care. They may also carry out self-managed abortion (Alhusen et al, 2015; Goemans et al, 2021). Studies suggest that abused women are more likely to have preterm deliveries than non-abused women (Ping-Hsin Chen et al, 2017; Bramhankar and Reshmi, 2021). A meta-analysis of 39 studies conducted across different regions of the world has reported that pregnancy of approximately half of those pregnant women who were affected by IPV during pregnancy resulted in preterm birth (Pastor-Moreno et al, 2020). Additionally, one-third of women who experienced IPV during pregnancy, reported miscarriages. Studies from Peru, Uganda, and Ethiopia show strong relationship between intimate partner violence (IPV) during pregnancy and miscarriage (Medrano et al, 2022; Gubi et al, 2020; Tiruye et al, 2020). The study conducted by Abrahams et al (2023) highlights the association between exposure to trauma resulting from intimate partner violence (IPV) and rape and its impact on women's health outcomes, specifically hypertension and body mass index (BMI). The study suggests that such health issues can have implications for pregnancy outcomes, including the risk of miscarriage. Other studies suggest that women exposed to spousal violence have higher preterm birth rates (Curry et al, 1998; Martin et al,2001). A study in Bangladesh shows a significant association between intimate partner violence and adverse birth outcomes (Afiaz et al, 2020). Besides, IPV directly threatens women's physical and mental health and has significant implications for pregnancy and childbirth (Abrahams et al, 2023). According to the report, women who have experienced IPV are 16 per cent more likely to suffer a miscarriage compared to those who have not experienced IPV (WHO, 2021).

Prevalence of IPV in India is alarmingly high. Aa earlier study has revealed that one in every three women in India is likely to have experienced IPV in her lifetime, either in terms of physical violence or in terms of emotional abuse (Krishnamoorthy et al, 2020). The latest round of the National Family Health Survey conducted during 2019-2021 reports that around 32 per cent of ever-married women aged 18-49 years had experienced either physical, or sexual, or emotional spousal violence. The most common type of spousal violence is reported to be physical violence (28 per cent), followed by emotional violence

(14 per cent), while 6 per cent of ever-married women aged 18-49 have experienced spousal sexual violence (Government of India, 2022).

Reducing maternal and foetal deaths has explicitly been expressed as one of the objectives of the United Sustainable Development Agenda (United Nations, 2015). The target 3.1 of the Sustainable Development Goal 3 (SDG 3) specifically aims at reducing maternal mortality ratio while target 3.2 aims at eliminating preventable deaths of newborns and children below five years of age. However, both maternal mortality ratio and neonatal and under-five mortality in India remains well above the international standards (Government of India, 2025a Government of India, 2025b). Reducing maternal and child mortality remains a major public health challenge in India.

At the global level, especially in the developing countries, there is evidence of different forms of adverse birth outcomes, but, in India, the evidence is limited. There are studies that have investigated socio-economic, demographic, and accessibility-related risk factors associated with the adverse birth outcomes, but the impact of spousal violence on women during pregnancy has received limited attention (Mahapatro et al, 2011; Mondal and Paul, 2020; Paul and Mondal, 2021). The Indian Penal Code (IPC) Section 498-A, introduced in 1983, criminalises certain acts of cruelty by the husband and his relatives on the spouse. However, it was not until the enactment of the Protection of Women from Domestic Violence Act 2005 (PWDVA) that a comprehensive legal framework could be established to address domestic violence against women. The PWDVA recognises domestic violence as a distinct offence and provides a wide range of protections and remedies for women who experience violence within marital or domestic relationships. However, spousal violence against women remains challenging and threatens the empowerment and autonomy of women (Gupta and Yesudian, 2006; Gangoli et al, 2011; Krishnan et al, 2012).

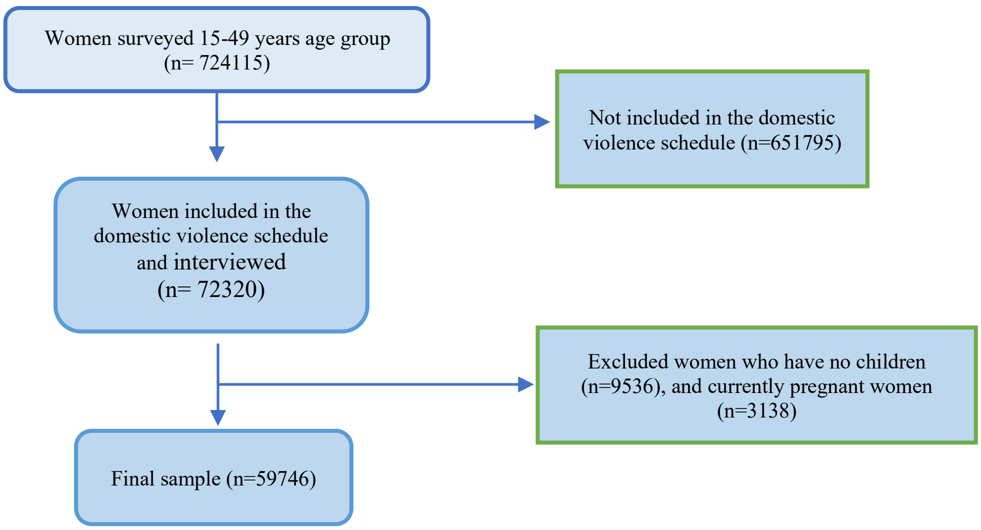
This paper explores the association between intimate partner violence (IPV) and adverse birth outcomes in India to provide a better understanding of the impact of IPV on adverse birth outcomes. The study adds to the growing body of research on adverse birth outcomes in India and may be useful for developing policies and programs to battle the high incidence of adverse birth outcomes in the country. The study also provides a new perspective on designing policy interventions to meet the maternal health care needs of the country. The study is based on the most recent data available from the nationally representative, cross-sectional survey.

Data source

The study is based on the data available from the National Family Health Survey (NFHS-5), 2019-2021 which aims to provide reliable estimates on various aspects of reproductive health, including birth outcomes, miscarriage, abortion, stillbirth, terminated pregnancy, birth weight, and spousal violence against females aged 15-49 years. The survey collected information from approximately 610,000 households in India, covering a sample size of 724,115 women and 101,839 men for India, each state/union territory (UT), and for 707 districts as of March 31, 2017 (Government of India, 2022). All relevant information about the NFHS survey is publicly available.

Study population

This study has used the women data file (IR file), which include data from 724,115 women aged 15-49 years interviewed during the survey. However, specific exclusions were made before the analysis to ensure that the sample was aligned with the study's objectives. First, 651,795 women were excluded from the analysis as they were not covered in the domestic violence schedule. Second, women who were not having child at the time of the survey and women who were pregnant at the time of the survey were also excluded. The final sample size for the present study, therefore, is 59,746 women aged 15-49 years. The flow chart of the sample selection is shown below.



The definition of the terms used in the present analysis are given below:

Adverse birth outcome: at least one of the following conditions during the in the last birth pregnancies experiences- miscarriage, abortion, stillbirth, and terminated pregnancy.

Miscarriage: unexpected loss of foetus before 22 completed weeks of pregnancy.

Abortion: intentional cessation or initiation of termination of gestation before 28 weeks of pregnancy or when the foetal weight is less than 1 kg.

Stillbirth: demise of the foetus in the uterus before delivery, occurring at or after 28 completed weeks of gestational age. A stillbirth is diagnosed when the foetus shows no signs of life upon delivery.

Pregnancy termination: loss of pregnancy before 37 completed gestational weeks or more irregular than 259 days since the woman's last menstrual period. This category includes any pregnancy that does not progress to the full term of 37 weeks or more, regardless of the specific cause or timing of the loss.

Table 1. Covariates used in the analysis.

Covariates	Description	Coding
Age	Age was grouped into 15–24 years, 25–39 years, and 40–49 years.	15–24 (0) 25-39 (1) 40-49 (2).
Educational Status	Educational status was classified as no education, primary education, secondary and higher.	No education (0) Primary (1), secondary (2) Higher (3)
Wealth status	The wealth status of the households was classified as poorest, poorer, middle, richer, and richest.	Poorest (0) Poorer (1) Middle (2) Richer (3) Richest (4)
Working Status	The respondents were asked whether they were currently working or not during the survey. Based on their responses, this variable was coded as no or yes.	No (0) Yes (1)
Occupation	The occupation was categorised as no occupation, agricultural, service, skilled and unskilled manual, and others.	Agricultural (0) Skilled & unskilled manual (1) Household & domestic work (2) Professional, technical, others (3)
Place of residence	The place of residence was coded as rural and urban.	Urban (0) Rural (1).
Religion	The households' religious beliefs were coded as the Hindu, Muslim, Christian, and others.	Hindu (0) Muslim (1) Christian (2) Others (3)
Social Group	The households' social group was classified as scheduled caste, scheduled tribe, other backward class, and 'others.	Scheduled Castes (0) Scheduled Tribes (1) Other Backward Class (2) General (3)
Partner Alcohol Consumption	The respondent whose husband consumption of alcohol was coded as yes or no.	No (0) Yes (1)
Household Size	The respondent's household size was coded as follows.	1-3 (0) 4-6 (1) >6 (2)

Dependent variable. The dependent variable of the present study is Adverse Birth Outcome" (ABO) which has been dichotomised into two binary groups: 'yes' and 'no'. This variable aims to determine whether a mother has experienced any of the adverse birth outcomes mentioned above. If a mother has reported experiencing any of these outcomes, ABO is coded '1' meaning that the woman has experienced an adverse birth outcome. Otherwise, ABO is coded '0'.

Explanatory variables. The study considered physical violence as an explanatory variable. This variable was determined based on a set of seven questions asked in the National Family Health Survey (NFHS-5) regarding spousal violence against women. The questions assessed various forms of physical violence experienced by women at the hands of their husbands. The specific questions were: whether the woman had ever been pushed, shook, or had something thrown by her husband, whether the woman had ever been slapped by her husband, whether the woman had ever had her arm twisted or hair pulled by her husband, whether the woman had ever been punched with a fist or hit by something harmful by her husband, whether the woman had ever been kicked or dragged by her husband, whether the woman had ever been strangled or burnt by her husband, whether the woman had ever been threatened with a knife/gun or other weapons by her husband. Based on the responses to these questions, a binary variable was developed to indicate whether the women reported being exposed to physical violence by their husbands.

Covariates. The study included a comprehensive range of socio-demographic factors that may be influencing the outcome of the birth in addition to intimate partner violence as control variables. These covariates or explanatory variables were selected through a review of previous research on the association between spousal violence and maternal health. The covariates or the explanatory variables used in the present analysis has been described in table 1.

Statistical analysis. To analyse the prevalence and the determinants of domestic violence, various statistical analysis techniques were adopted at every stage of the research depending upon the need of the study. The background characteristics of the study participants were presented as per centages, providing a descriptive overview of the sample. At the first stage, bivariate analysis was carried out and the $\chi 2$ test was used to test the association between adverse birth outcome (ABO) and the explanatory variables or covariates at $p=0.05$ level of significance.

At the second stage of the analysis, binary logistic regression analysis was carried out to explore how the variation in different covariates or the explanatory variables influenced the dependent variable or the probability of experiencing IPV during pregnancy. The results of the binary logistic regression analysis are presented as adjusted odds ratios (ORs) along with 95 per cent confidence interval (CIs). The adjusted odds ratios give an idea about how the change in a covariate induces a change in the dependent variables when the effect of other covariates or explanatory variables is controlled. estimates of the effect of each explanatory variable on the odds of experiencing adverse birth outcomes while controlling for other variables in the model. All the statistical analyses were done using STATA software version 14.1 (Stata 14; Stata Corp LP, 2015).

Results

The distribution of the sample is shown in table 2. The age distribution shows the highest percentage of women in the group 25-39 at 56 per cent, followed by 32.2 per cent in the age group 40-49. Nearly 46 per cent of women have completed secondary education, but 29.6 per cent have not received any education. Nearly 70 per cent of women were currently not working. The occupation pattern of respondent partners shows that nearly 33.5 per cent are engaged in agriculture, followed by 31 per cent in skilled and unskilled manual labour. Nearly 24 per cent of the respondents informed that their partners consumed alcohol. Nearly 60.2 per cent of respondents had a household size of 4-6. Two third respondents reside in rural areas, and 80 per cent of respondents belong to the Hindu religion. Moreover, 42 per cent of respondents belong to the OBC caste category, followed by 21 per cent in both SC and General caste categories. Nearly 20 per cent of respondents belong to the poorest wealth index, and 17 per cent belong to the richest wealth index.

Table 3 shows the prevalence of IPV among women during pregnancy. The prevalence was the highest in women aged 40-49 years and in women having primary education followed by women without any education. The prevalence of IPV during pregnancy has been found to be higher in working women as compared to that in non-working women. Consuming of alcohol by the partner is found to have a direct impact on IPV during pregnancy as almost 8 per cent of the women whose partner was alcoholic reported experiencing of IPV during pregnancy compared to less than 2 per cent in women whose partner was not alcoholic. The prevalence of IPV during pregnancy is found to be high in rural women, in women of Christian religion, in Scheduled Castes and in Scheduled Tribes women. The prevalence of IPV during pregnancy has been found to be inversely related to the living standard of the household of the women – the prevalence is found to be the highest in the poorest households but the lowest in the richest households. The prevalence of IPV during pregnancy has, however, not been found to be associated with the household size.

Table 4 shows the determinant of prevalence of IPV during pregnancy. The odds of experiencing IPV during pregnancy is found to be statistically significantly higher in working women as compared to non-working women. The odds of experiencing IPV during pregnancy has also been found to be statistically significantly high in women whose partner was alcoholic as compared to women whose partner was not alcoholic. Compared to Hindu women, the odds of experiencing IPV during pregnancy was statistically significantly higher in Muslim women but statistically significantly lower in women of religions other than Hindu, Muslim and Christian. Similarly, compared to Scheduled Castes women, the odds of experiencing IPV during pregnancy was statistically significantly higher in Scheduled Tribes women and in women of general social class but not in women belonging to other backward classes (OBC). There was no statistically significant difference in the odds of experiencing IPV during pregnancy in poorest women and in poor women or women of middle income group but the odds of experiencing IPV during pregnancy was statistically significantly lower in women belonging to rich and the richest income groups. The age of the woman and the occupation of the partner of the woman have not been found to be having any statistically significant association on the prevalence of IPV during pregnancy among the women surveyed.

Table 2: Distribution of women by their background characteristics.

Background characteristics	%	N
Age		
15-24	11.90	6295
25-39	55.90	36185
40-49	32.20	17266
Level of Education		
No education	29.60	18097
Primary	14.30	8897
Secondary	45.80	26867
Higher	10.20	5885
Working Status		
No	69.40	41711
Yes	30.60	18035
Type of Partner's Occupation		
Agriculture	33.50	22511
SUM#	30.80	17282
HSW@	9.30	5254
Others*	26.30	14633
Partner’s Alcohol Consumption		
No	75.60	42799
Yes	24.20	16870
Household Size		
1-3	18.80	12616
4-6	60.20	37677
> 6	21.00	9453
Place of Residence		
Urban	30.70	14449
Rural	69.30	45297
Religion		
Hindu	79.20	45376
Muslim	16.00	7088
Christian	2.60	4313
Others	2.20	2969
Social Group		
SC	21.00	11392
ST	8.80	11437
OBC	42.00	23043
General	21.20	10981
Wealth Index		
Poorest	19.60	13348
Poorer	21.30	13596
Middle	21.40	12435
Richer	20.40	11012
Richest	17.40	9355
Total		59746

#SUM=Skilled and unskilled manual; @HSW=Household and service work; *Others= Professional / technical / management/clerical/ sales/ other / don’t know; SC= Scheduled Caste, ST= Scheduled Tribes, OBC= Other Backward Class.
Source: Authors.

Table 3: Prevalence of IPV during pregnancy by background characteristics of women

Background Characteristics	IPV During Pregnancy		
	%	χ^2, df, p	N
Age			
15-24	2.80	2.536, 2, 0.281	6295
25-39	3.10		36185
40-49	3.20		17266
Level of Education			
No education	3.90	171.870, 3, 0.000	18097
Primary	4.50		8897
Secondary	2.60		26867
Higher	1.40		5885
Working Status			
No	2.40	239.182, 1, 0.000	41711
Yes	4.80		18035
Type of Partner's Occupation			
Agriculture	3.70	46.631, 3, 0.000	22511
SUM#	3.20		17282
HSW@	2.40		5254
Others*	2.60		14633
Partners Alcohol Consumption			
No	1.70	1327.444, 1, 0.000	42799
Yes	7.70		16870
Household Size			
1-3	3.30	3.074, 2, 0.215	12616
4-6	3.20		37677
> 6	2.90		9453
Place of Residence			
Urban	2.60	22.271, 1, 0.000	14449
Rural	3.40		45297
Religion			
Hindu	3.10	3.751, 3, 0.290	45376
Muslim	3.30		7088
Christian	3.40		4313
Others	2.70		2969
Caste			
SC	3.60	30.347, 3, 0.000	11392
ST	3.70		11437
OBC	3.20		23043
General	2.60		13874
Wealth Index			
Poorest	4.30	164.030, 4, 0.000	13348
Poorer	3.60		13596
Middle	3.60		12435
Richer	2.40		11012
Richest	1.60		9355
Total	3.13		59746

#SUM=Skilled and unskilled manual; @HSW=Household and service work; *Others= Professional / technical / management/clerical/ sales/others/don't know; SC= Scheduled Castes, ST= Scheduled Tribes, OBC= Other Backward Classes.
Source: Authors.

Table 4: Determinants of IPV During Pregnancy of women in India

Background Characteristics	IPV during Pregnancy	
	OR [CI: 95%]	p-value
Age		
15-24	1	
25-39	0.915 [0.772-1.084]	0.306
40-49	1 [0.829-1.207]	0.998
Level of Education		
No education	1	
Primary	0.939 [0.81-1.087]	0.399
Secondary	0.877 [0.773-0.996]	0.042
Higher	0.783 [0.609-1.006]	0.055
Working Status		
No	1	
Yes	1.66 [1.497-1.842]	0.000
Type of Partner's Occupation		
Agriculture	1	
SUM#	1.036 [0.917-1.171]	0.568
HSW@	0.996 [0.816-1.216]	0.970
Others*	1.034 [0.891-1.199]	0.661
Partners Alcohol Consumption		
No	1	
Yes	4.537 [4.077-5.05]	0.000
Household Size		
1-3	1	
4-6	0.851 [0.702-1.031]	0.100
> 6	0.862 [0.711-1.044]	0.129
Place of Residence		
Urban	1	
Rural	0.891[0.789-01.006]	0.042
Religion		
Hindu	1	
Muslim	1.748 [1.481-2.062]	0.000
Christian	0.946 [0.703-1.273]	0.716
Others	0.731 [0.605-0.884]	0.001
Caste		
SC	1	
ST	1.494 [1.272-1.755]	0.000
OBC	1.086 [0.914-1.290]	0.349
General	1.238 [1.068-1.434]	0.005
Wealth Index		
Poorest	1	
Poorer	0.943 [0.822-1.082]	0.404
Middle	0.862 [0.741-1.002]	0.054
Richer	0.707 [0.591-0.846]	0.000
Richest	0.536 [0.424-0.678]	0.000
Constant	0.022 [0.016-0.031]	0.000
Pseudo r-squared	0.077	

OR= Odds Ratio; CI= Confidence Interval at 95% confidence level; #SUM=Skilled and unskilled manual; @HSW=Household and service work; *Others= Professional / technical / management/clerical/ sales/ other / don't know; SC= Scheduled Caste, ST= Scheduled Tribes, OBC= Other Backward Class.
Source: Authors.

The prevalence of adverse birth outcome (ABO) has been found to be statistically significantly higher in women exposed to IPV during pregnancy (25.1 per cent) as compared to the prevalence of ABO in women who are not exposed to IPV during pregnancy (16.7 per cent) ($z=9.010$, $p<0.001$). Among different adverse birth outcomes (ABO) the difference in the prevalence between women exposed to IPV and women not exposed to IPV during pregnancy has been found to be statistically significant in case of abortion (2.3 per cent and 1.6 per cent respectively, $z=2.037$, $p<0.05$)) but not in case of miscarriage (4.4 per cent and 3.9 per cent respectively, $z=0.913$, $p\geq0.05$) and still birth (0.6 per cent and 0.5 per cent respectively, $z=0.555$, $p\geq0$)).

Table 5 shows the association of the prevalence of adverse birth outcomes (ABO) in women exposed to and not exposed to IPV during pregnancy by their background characteristics. The difference in the prevalence of adverse birth outcomes between women exposed to and women not exposed to IPV during pregnancy has been found to statistically significantly associated with the age, level of education, work status, alcohol consumption by the partner, place of residence, social class and wealth index but not with the type of occupation of the partner and the household size.

Results of the bivariate logistic regression analysis of the prevalence of adverse birth outcomes on the explanatory variables are presented in table 7. The chance of having an adverse birth outcome is found to be more than 47 per cent higher in women exposed to IPV during pregnancy relative to the change of having adverse birth outcome in women not exposed to IPV during pregnancy even after controlling the explanatory variables. The chance of having adverse birth outcome has also been found to be statistically significantly higher in women aged 25-29 years relative to women aged 15-24 years; in women having at least secondary level education relative to illiterate women; in working women relative to non-working women; in women whose partner is in non-agriculture occupation relative to women whose partner is in agriculture occupation; in women whose partner consumes alcohol relative to women whose partner does not consume alcohol; in women belonging to households with at least 4 household members relative to women belonging to households having less than 4 household members; in women of Christian and other religions relative to Hindu women; and in women belonging to OBC and general social classes relative to Scheduled Castes women. On the other hand, women living in rural areas have lower chance of an adverse birth outcome relative to women living in urban areas. Similarly, women having at least middle level wealth index is found to be statistically significant lower change of having an adverse birth outcome relative to women having the lowest wealth index. The table also shows that there is no statistically significant difference in the chance of having adverse birth outcome in aged 40-49 years relative to women aged 15-19 years; in women having primary level education relative to women having no education; and in Muslim women relative to Hindu women. Table 6 shows that the impact of IPV during pregnancy in terms of adverse birth outcomes is different in different women having different social, economic and demographic characteristics. An intervention directed towards mitigating the risk of adverse birth outcomes resulting from IPV during pregnancy, therefore, should also take into consideration the social, economic and demographic characteristics of women as these factors also have a telling impact on the risk of adverse birth outcome emanating from IPV during pregnancy.

Table 5: Prevalence of adverse birth outcomes due to exposure to IPV during pregnancy by background characteristics of women in India.

	Exposed to IPV during pregnancy				χ^2	df	p
	Yes		No				
	Prevalence of ABO	N	Prevalence of ABO	N			
Age							
15-24	15.90	161	16.60	6134	7.282	2	0.026
25-39	27.30	963	17.80	35222			
40-49	22.40	530	15.70	16736			
Level of Education							
No education	21.40	639	15.30	17458	45.760	3	0.000
Primary	32.30	276	16.00	8621			
Secondary	23.80	648	18.20	26219			
Higher	18.90	91	17.30	5794			
Working Status							
No	23.60	907	16.90	40804	57.748	1	0.000
Yes	25.40	747	17.20	17228			
Type of Partner's Occupation							
Agriculture	22.70	666	14.00	21845	6.947	3	0.074
SUM#	22.60	536	19.40	16746			
HSW@	30.90	126	19.60	5128			
Others*	28.20	322	17.00	14311			
Partners Alcohol Consumption							
No	24.50	613	15.7	42186	172.207	1	0.000
Yes	24.40	1037	19.2	15833			
Household Size							
1-3	20.10	403	18.70	12213	7.791	2	0.408
4-6	25.50	999	16.80	36678			
> 6	25.40	252	16.00	9201			
Place of Residence							
Urban	23.60	364	18.60	14085	6.065	1	0.014
Rural	24.70	1290	16.30	44007			
Religion							
Hindu	23.10	1304	17.00	44075	19.312	3	0.000
Muslim	30.60	204	17.40	6884			
Christian	17.60	82	15.10	4231			
Others	7.20	67	16.10	2902			
Caste							
SC	24.40	391	16.20	11001	18.433	3	0.000
ST	24.20	291	13.60	11146			
OBC	25.90	656	17.00	22387			
General	22.00	316	18.50	13558			
Wealth Index							
Poorest	26.90	475	16.10	12873	41.615	4	0.000
Poorer	22.80	429	16.60	13167			
Middle	23.70	363	17.10	12072			
Richer	24.80	248	17.30	10764			
Richest	23.10	139	17.80	9216			
Total	24.45	1654	16.97	58092			

#SUM=Skilled and unskilled manual; @HSW=Household and service work; *Others= Professional / technical / management/clerical/ sales/ other / don't know; SC= Scheduled Caste, ST= Scheduled Tribes, OBC= Other Backward Class.
Source: Authors.

Table 6: Determinants of adverse birth outcomes due to exposure to IPV during pregnancy among women in India

Background Characteristics	Adverse Birth Outcomes	
	OR [CI: 95 %]	p-value
Domestic Violence during Pregnancy		
Non-exposed	1	
Exposed	1.472 [1.312-1.651]	0.000
Age		
15-24	1	
25-39	1.095 [1.016-1.181]	0.017
40-49	0.934 [0.859-1.017]	0.116
Level of Education		
No education	1	
Primary	1.036 [0.961-1.116]	0.358
Secondary	1.178 [1.109-1.252]	0.000
Higher	1.109 [1.008-1.221]	0.034
Working Status		
No	1	
Yes	1.059 [1.007-1.113]	0.025
Type of Partner's Occupation		
Agriculture	1	
SUM#	1.439 [1.356-1.527]	0.000
HSW@	1.466 [1.347-1.595]	0.000
Others*	1.211 [1.132-1.294]	0.000
Partners Alcohol Consumption		
No	1	
Yes	1.301 [1.235-1.371]	0.000
Household Size		
1-3	1	
4-6	0.779 [0.703-0.864]	0.000
> 6	0.73 [0.659-0.808]	0.000
Place of Residence		
Urban	1	
Rural	0.941 [0.888-0.997]	0.040
Religion		
Hindu		
Muslim	1.062 [0.991-1.138]	0.090
Christian	0.858 [0.738-0.998]	0.047
Others	0.806 [0.682-0.953]	0.012
Caste		
SC	1	
ST	0.844 [0.767-0.928]	0.000
OBC	1.075 [1.011-1.142]	0.020
General	1.275 [1.189-1.368]	0.000
Wealth Index		

Background Characteristics	Adverse Birth Outcomes	
	OR [CI: 95 %]	p-value
Poorest	1	
Poorer	0.93 [0.864-1.001]	0.052
Middle	0.9 [0.835-0.971]	0.006
Richer	0.871 [0.802-0.945]	0.001
Richest	0.886 [0.806-0.975]	0.013
Constant	0.189 [0.162-0.221]	0.000
Pseudo r-squared	0.013	

OR= Odds Ratio; CI= Confidence Interval at 95% confidence level; #SUM=Skilled and unskilled manual; @HSW=Household and service work; *Others= Professional / technical / management/clerical/ sales/ other / don't know; SC= Scheduled Caste, ST= Scheduled Tribes, OBC= Other Backward Class.

Inter-state Variation

Figure 2 shows prevalence of IPV during pregnancy across states/Union Territories. The prevalence varies ranges from 0 per cent in Chandigarh and Lakshadweep to almost 6 per cent in Karnataka. The prevalence is also estimated to be high in Dadra and Nagar Haveli and Telangana. There are 12 states/Union Territories where prevalence of IPV during pregnancy is estimated to be more than 3 per cent whereas, in 6 states/Union Territories, it is less than 1 per cent. The most noticeable of these states/Union Territories is Kerala where the prevalence of IPV during pregnancy is estimated to be around 0.3 per cent.

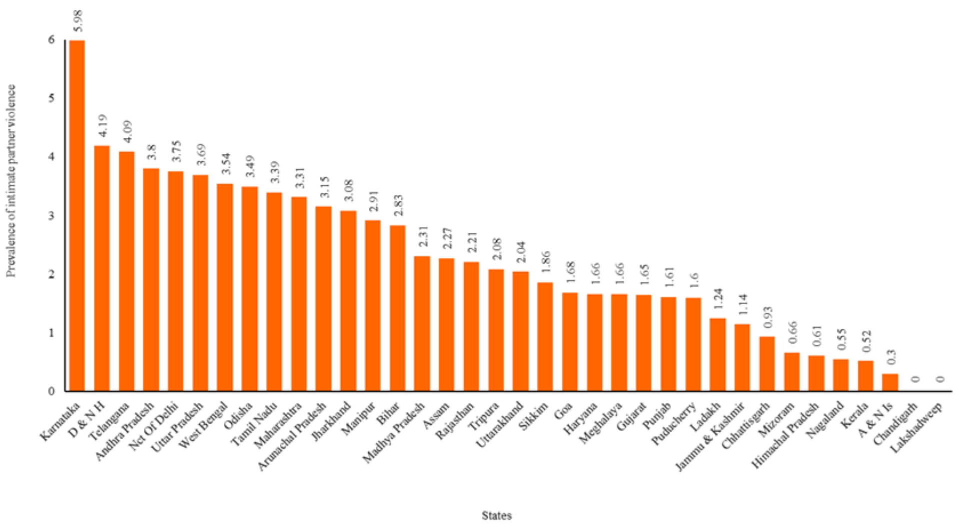


Figure 2: State-level Prevalence of intimate partner violence during pregnancy among women in India, 2019-21.
Source: Authors

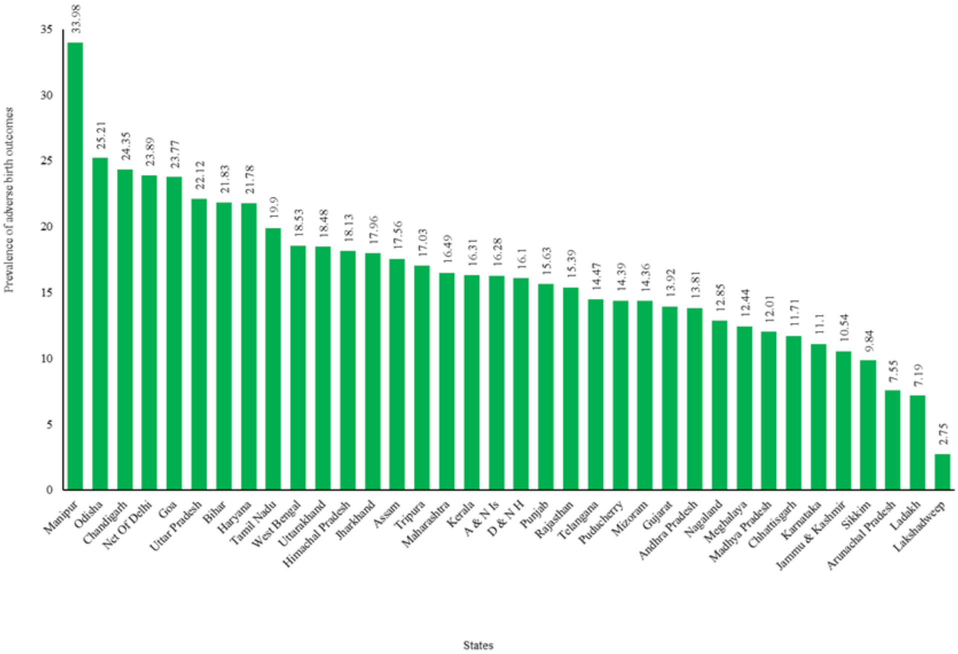


Figure 3: State-level Prevalence of adverse birth outcomes among women in India, 2019-2021.
Source: Authors

Figure 3 depicts the variation in the prevalence of adverse birth outcomes (ABO) across states/Union Territories. The prevalence of adverse birth outcome is estimated to be remarkably high in Manipur where the prevalence of adverse birth outcome is estimated to be almost 34 per cent. By contrast the prevalence of adverse birth outcome is estimated to be less than 3 per cent in Lakshadweep. There are only four states/Union Territories – Sikkim, Arunachal Pradesh, Ladakh, and Lakshadweep where prevalence of adverse birth outcome is estimated to be less than 10 per cent. On the other hand, there are 8 states/Union Territories where the prevalence of adverse birth outcome is estimated to be at least 20 per cent.

Figure 4 depicts inter-district variation in the prevalence of IPV during pregnancy and prevalence of ABO in India. The prevalence of IPV during pregnancy is estimated to be relatively high in districts of Karnataka, Andhra Pradesh, Tamil Nadu, and Maharashtra and in some districts of Odisha, West Bengal, Delhi and Rajasthan. On the other hand, the prevalence of ABO is found to be relatively high in districts of northern and eastern India, especially, in districts of Odisha, Uttar Pradesh, Delhi, Bihar and Andhra Pradesh. The prevalence of adverse birth outcomes has also been found to be relatively high in some districts of hilly states. By comparison, prevalence is estimated to be low in districts of central India.

Prevalence of IPV during pregnancy Prevalence of adverse birth outcome

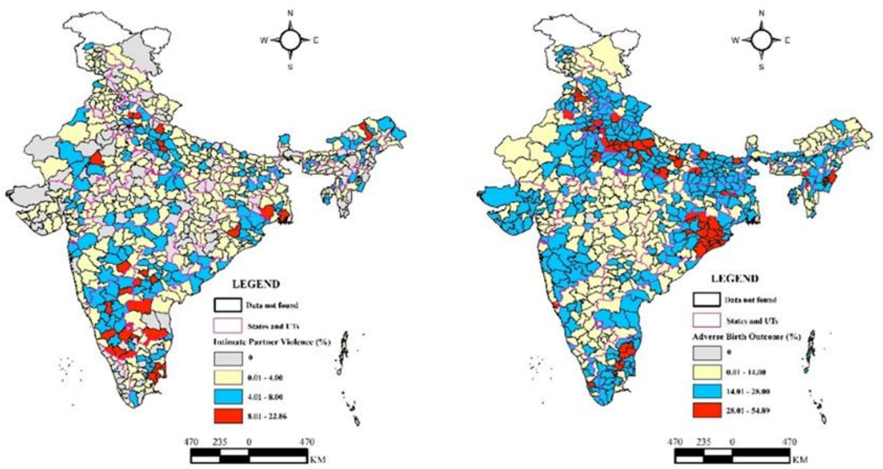


Figure 4: Inter-district variation in the prevalence of IPV during pregnancy and adverse birth outcome among women in India, 2019-21.
Source: Authors

Discussion

This study has synthesized the association between intimate partner violence (IPV) during pregnancy and adverse birth outcomes (ABO) in women of India. The findings confirm that adverse effects of IPV during pregnancy are significantly driven by demographic and socioeconomic characteristics of women. Other studies have also found that socio-economic characteristics of the women leave them susceptible to IPV during pregnancy which can lead to adverse birth outcomes including miscarriage, abortion, stillbirth and pregnancy termination (Donovan et al, 2016; Han and Stewart, 2014). Consistence with earlier studies, the study finds that social behaviour such as alcohol consumption by the partner and no education are two important factors in IPV during pregnancy (Garg et al, 2021; Gustafsson et al, 2016). The linkage between women's education and IPV during pregnancy in India is associated with economic disadvantage. Education can provide women with knowledge and skills to enhance their ability to reduce economic instability and financial dependence, thereby decrease the risk of IPV during pregnancy (Ackerson et al, 2008; Krishnan, 2005; Koenig et al, 2006; Martin et al, 1999). The study shows that the chance of a woman experiencing IPV during pregnancy reduces with the increase in her education and family income. Higher family income has been found to protect women from IPV during pregnancy in other studies also (Babu and Kar, 2010). On the other hand, the relationship between alcohol consumption by the partner with IPV is well-established globally (Ferrer et al, 2004; Foran and Leary, 2008; Foran et al, 2012). Studies also show that partners who consumed alcohol were more likely to be violent toward their wives and partners (Bryant., 2021; Curtis et al, 2019; Babu and Kar, 2010; Indu et al, 2018). A study by Curtis et al (2019) also shows that one-third of violent incidents experienced by women were alcohol-induced. This was especially true for women from poorer socio-economic background (Bryant., 2021; Mondal and Paul., 2021). Earlier studies have found that low economic status creates financial stress, which is linked with marital conflicts (Parke et al, 2004; Thompson et al, 2006). According to the family stress model, lack of money or increased expenditure induces frequent emotional outbursts and conflicts among family members, including conflict between spouses (Parke et al, 2004). Similarly, Muslim women have been found to be more likely to experience this situation has been observed in studies carried out in Bangladesh (Silverman et al,2007; Dalal et al, 2012). Similarly, the observation that working women are more likely to experience IPV compared to women who were not working has also been reported in other studies (Ram, 2019; Barnett, 2023; Ghatak and Dutta, 2023). The prevalence of abortion in women who were exposed to IPV obtained in the present study is also similar to that observed in other studies (Gard et al, 2021).

The present study reveals that the prevalence of adverse birth outcome is very high in women who are exposed to IPV relative to women who are not exposed to IPV during their pregnancy even after controlling the variation in socio-economic and demographic characteristics of women. Other studies in India have reported similar findings (Bramhankar and Reshmi, 2021; Dhar, 2018; Showalter, 2020). A study by Ahmed et al (2006) has revealed that the risk of perinatal mortality and neonatal mortality is higher in women who had experienced IPV than women who had not experienced IPV during pregnancy. The IPV experienced by the women during pregnancy may be because of various reasons including the fact that IPV may be common in their families and IPV is accepted as usual (Ghoshal et al, 2022), due to differential power equations in marital relationship and attitudes towards IPV (Mondal and Paul, 2021; and because the material power of women threatens patriarchal norms (Ghatak, 2023) and, therefore, the response is IPV (Weitzman, 2014).

Nevertheless, the study reveals that the prevalence of adverse birth outcome in women exposed to IPV can be reduced by improving the educational status of women (Cantarutti et al, 2017). There is, however, studies that show that higher educational status of women increases the frequency of several outcomes including low-weight birth, miscarriage, abortion, stillbirth and termination of pregnancy (Cantarutti et al, 2017). The present studies shows that consumption of alcohol by the partner is a major factor in adverse birth outcome in women exposed to IPV. Similar findings have been reported in other studies also (Raatikainen et al, 2006; Ouyang et al, 2013). It is argued that alcohol consumption by the partner rigorously strikes the health the woman including adverse birth outcome (Luan et al, 2022; Haber et al, 2005; Haber et al, 1987; Godbole et al, 2020). A study by Dasgupta (2019) shows a high transmission rate of attitude towards wife beating from one generation to the other. Studies show that a family-focused, women empowerment–based approach may address this malaise (Krishnan, 2012). A study in Iran shows how women cope with IPV through passive or neutral behaviour, and through seeking help (Barez, 2022). Improving woman autonomy and increasing awareness about interventions to reduce IPV such as a screening tool to identify IPV early in the pregnancy can prevent adverse birth outcomes (Garg et al, 2020; Alhusen et al,2015).

Conclusion

The study concludes that the risk factors for of exposure to IPV during pregnancy and associated adverse birth outcome were deeply associated with the underlying socio-economic factors such as poverty, education, and alcohol consumption by the partner, which emphasises the need for prioritising education for all women, alleviating poverty, promoting gender equity and including IPV reduction messaging in programming and mass media. Those women who experience IPV during pregnancy but who are unable to reach out for help may be screened and identified by health workers so that the required help is directed to them to break the vicious cycle of IPV during pregnancy and adverse birth outcome. There is also a need to involve women in reproductive health decision-making within the family and in the community.

References

Abdo RAET, Endalemaw T, Tesso F (2016) Prevalence and associated factors of adverse birth outcomes among women attended maternity ward at Negest Elene Mohammed Memorial General Hospital in Hosanna Town, SNNPR, Ethiopia. *Journal of Women's Health Care* 5(4): 324-.

Abrahams N, Chirwa E, Mhlongo S, Seedat S, Myers B, Peer N., ... and Jewkes, R. (2023). Pathways to adverse pregnancy outcomes: exploring the mediating role of intimate partner violenceand depression: results from a South African rape cohort study. *Archives of Women's Mental Health* 1-11.

Ackerson LK, Kawachi I, Barbeau E M, Subramanian SV (2008) Effects of individual and proximate educational context on intimate partner violence: a population-based study of women in India. *American Journal of Public Health* 98(3): 507–514.

Adane AA, Ayele TA, Ararsa LG, Bitew BD, Zeleke BM (2014) Adverse birth outcomes among deliveries at Gondar University hospital, Northwest Ethiopia. *BMC Pregnancy and Childbirth* 14: 1-8.

Afiaz, A., Biswas, R. K., Shamma, R., and Ananna, N. (2020). Intimate partner violence (IPV) with miscarriages, stillbirths and abortions: Identifying vulnerable households for women in Bangladesh. PLoS One, 15(7), e0236670.

Ahmed, S., Koenig, M. A., and Stephenson, R. (2006). Effects of domestic violence on perinatal and early-childhood mortality: evidence from north India. American journal of public health, 96(8), 1423-1428.

Alhusen, J. L., Ray, E., Sharps, P., and Bullock, L. (2015). Intimate partner violence during pregnancy: maternal and neonatal outcomes. Journal of women's health, 24(1), 100-106.

Amel Barez, M., Babazadeh, R., Latifnejad Roudsari, R., Mousavi Bazaz, M., and Mirzaii Najmabadi, K. (2022). Women's strategies for managing domestic violence during pregnancy: a qualitative study in Iran. Reproductive health, 19(1), 58.

Babu, B. V., and Kar, S. K. (2010). Domestic violence in Eastern India: factors associated with victimization and perpetration. Public health, 124(3), 136-148.

Barnett, J. P., and Maticka-Tyndale, E. (2023). 'Money is what makes you to be called a man.': The interaction of resource access and gender norms in shaping intimate partner violence in urban slums. Journal of International Development.

Bramhankar, M., and Reshmi, R. S. (2021). Spousal violence against women and its consequences on pregnancy outcomes and reproductive health of women in India. BMC women's health, 21, 1-9.

Bryant, L., and Lightowlers, C. (2021). The socioeconomic distribution of alcohol-related violence in England and Wales. PLoS one, 16(2), e0243206.

Campbell, J. C. (2002). Health consequences of intimate partner violence. The lancet, 359(9314), 1331-1336.

Cantarutti, A., Franchi, M., Monzio Compagnoni, M. et al Mother's education and the risk of several neonatal outcomes: an evidence from an Italian population-based study. BMC Pregnancy Childbirth 17, 221 (2017).

Cha, S., and Masho, S. W. (2014). Intimate partner violence and utilization of prenatal care in the United States. Journal of Interpersonal Violence, 29(5), 911-927.

Chambliss, L. R. (2008). Intimate partner violence and its implication for pregnancy. Clinical Obstetrics and Gynecology, 51(2), 385–397.

Curry, M., Perrin, N., and Wall, E. (1998). Effects of abuse on maternal complications and birth weight in adult and adolescent women. Obstetrics and gynecology, 92(4), 530-534.

Curtis, A., Vandenberg, B., Mayshak, R., Coomber, K., Hyder, S., Walker, A., ... and Miller, P. G. (2019). Alcohol use in family, domestic and other violence: Findings from a cross-sectional survey of the Australian population. Drug and alcohol review, 38(4), 349-358.

Dalal, K., Andrews, J., and Dawad, S. (2012). Contraception use and associations with intimate partner violence among women in Bangladesh. Journal of biosocial science, 44(1), 83-94.

Dasgupta, S. (2019). Attitudes about wife-beating and incidence of violence in India: An instrumental variables analysis. Journal of Family and Economic Issues, 40, 647-657.

Dhar, D., McDougal, L., Hay, K., Atmavilas, Y., Silverman, J., Triplett, D., and Raj, A. (2018). Associations between intimate partner violence and reproductive and maternal health outcomes in Bihar, India: a cross-sectional study. Reproductive health, 15, 1-14.

Donovan, BM, Spracklen, CN, Schweizer, ML, Ryckman, KK, Saftlas, AF. Intimate partner violence during pregnancy and the risk for adverse infant outcomes: a systematic review and meta-analysis. BJOG 2016; 123: 1289– 1299.

Ferrer, V., Bosch, E., Garcia, E., Manassero, M. A., and Gili, M. (2004). Meta-analytic study of differential characteristics between batterers and non-batterers: The case of psychopathology and consumption of alcohol and drugs. Psykhe, 13(1), 141-156.

Foran, H. M., and O'Leary, K. D. (2008). Alcohol and intimate partner violence: a meta-analytic review. Clinical psychology review, 28(7), 1222–1234.

Foran, H. M., Heyman, R. E., Smith Slep, A. M., Snarr, J. D., and United States Air Force Family Advocacy Research Program (2012). Hazardous alcohol use and intimate partner violence in the military: understanding protective factors. Psychology of addictive behaviors: journal of the Society of Psychologists in Addictive Behaviors, 26(3), 471–483.

Gangoli, G., and Rew, M. (2011, September). Mothers-in-law against daughters-in-law: Domestic violence and legal discourses around mother-in-law violence against daughters-in-law in India. In Women's Studies International Forum (Vol. 34, No. 5, pp. 420-429). Pergamon.

Garg, P., Das, M., Goyal, L.D. et al Trends and correlates of intimate partner violence experienced by ever-married women of India: results from National Family Health Survey round III and IV. BMC Public Health 21, (2021).

Garg, S., Rustagi, R., Singh, M. M., and Engtipi, K. (2020). Effect of intimate partner violence on maternal and birth outcomes of pregnancy among antenatal clinic attendees in Delhi: a prospective observational study. Indian Journal of Community Medicine: Official Publication of Indian Association of Preventive and Social Medicine, 45(4), 501.

Ghatak, S., and Dutta, M. (2023). Negotiating Autonomy: The Linkages between Intimate Partner violence, Women's Paid Work Status and Birth Outcomes. Administrative Sciences, 13(3), 82.

Ghoshal, R., Douard, A. C., Sikder, S., Roy, N., and Saulnier, D. (2022). Risk and Protective Factors for IPV in Low-and Middle-Income Countries: A Systematic Review. Journal of Aggression, Maltreatment and Trauma, 1-18.

Goemans, S. L., Singh, A., Yadav, A. K., McDougal, L., Raj, A., and Averbach, S. H. (2021). The association between intimate partner violence and recent self-managed abortion in India. AJOG global reports, 1(4), 100029.

Godbole, N. B., Moberg, M. S., Patel, P., Kosambiya, J., Salihu, H. M., Campos, E. A., Menezes, L., Verma, R., and Wilson, R. (2020). Paternal Involvement and Adverse Birth Outcomes in South Gujarat, India. International journal of MCH and AIDS, 9(1), 161–166.

Gubi, D., Nansubuga, E., and Wandera, S. O. (2020). Correlates of intimate partner violence among married women in Uganda: a cross-sectional survey. BMC public health, 20, 1-11.

Gupta, K., and Yesudian, P. P. (2006). Evidence of women's empowerment in India: A study of socio-spatial disparities. GeoJournal, 65, 365-380.

Gustafsson, H.C., Cox, M.J. and the Family Life Project Key Investigators. Intimate Partner Violence in Rural Low-Income Families: Correlates and Change in Prevalence Over the First 5 Years of a Child's Life. J Fam Viol 31, 49–60 (2016).

Haber, J. R., Jacob, T., and Heath, A. C. (2005). Paternal alcoholism and offspring conduct disorder: evidence for the 'common genes' hypothesis. Twin research and human genetics : the official journal of the International Society for Twin Studies, 8(2), 120–131.

Han, A., and Stewart, D. E. (2014). Maternal and fetal outcomes of intimate partner violence associated with pregnancy in the Latin American and Caribbean region. International Journal of Gynecology and Obstetrics, 124(1), 6-11.

Huber-Krum, S., Miedema, S. S., Shortt, J. W., Villaveces, A., and Kress, H. (2023). Path Analysis of Adverse Childhood Experiences, Early Marriage, Early Pregnancy, and Exposure to Intimate Partner Violence Among Young Women in Honduras. Journal of Family Violence, 1-18.

Indu, P. V., Jinu, C. R., Pallikkal, N. R., Sampathkumar, R., and Joy, J. (2018). Experience of Domestic Violence and psychological morbidity in spouses of alcohol-dependent males. Indian journal of psychological medicine, 40(4), 322-327.

International Institute for Population Sciences (IIPS) and ICF. 2021. National Family Health Survey (NFHS-5), 2019-21: India. Mumbai: IIPS

Janssen, P. A., Holt, V. L., Sugg, N. K., Emanuel, I., Critchlow, C. M., and Henderson, A. D. (2003). Intimate partner violence and adverse pregnancy outcomes: a population-based study. American journal of obstetrics and gynecology, 188(5), 1341-1347.

Kelly, J. B., and Johnson, M. P. (2008). Differentiation among types of intimate partner violence: Research update and implications for interventions. Family court review, 46(3), 476-499.

Koenig, M. A., Stephenson, R., Ahmed, S., Jejeebhoy, S. J., and Campbell, J. (2006). Individual and contextual determinants of domestic violence in North India. American journal of public health, 96(1), 132–138.

Krishnamoorthy Y, Ganesh K, Vijayakumar K. Physical, emotional and sexual violence faced by spouses in India: evidence on determinants and help-seeking behaviour from a nationally representative survey. J Epidemiol Community Health 2020;74:732-740.

Krishnan, S., Subbiah, K., Khanum, S., Chandra, P. S., and Padian, N. S. (2012). An intergenerational women's empowerment intervention to mitigate domestic violence: results of a pilot study in Bengaluru, India. Violence against women, 18(3), 346-370.

Little, R. E., and Sing, C. F. (1987). Father's drinking and infant birth weight: report of an association. Teratology, 36(1), 59–65.

Luan, M., Zhang, X., Fang, G. et al Preconceptional paternal alcohol consumption and the risk of child behavioral problems: a prospective cohort study. Sci Rep 12, 1508 (2022).

Mahapatro, M., Gupta, R. N., Gupta, V., and Kundu, A. S. (2011). Domestic violence during pregnancy in India. Journal of interpersonal violence, 26(15), 2973-2990.

Martin, S. L., Tsui, A. O., Maitra, K., and Marinshaw, R. (1999). Domestic violence in northern India. American journal of epidemiology, 150(4), 417–426.

Martin, S. L., Mackie, L., Kupper, L. L., Buescher, P. A., and Moracco, K. E. (2001). Physical abuse of women before, during, and after pregnancy. Jama, 285(12), 1581-1584.

Medrano, L. V. P., Loarte, M. A. G., Visconti-Lopez, F. J., Azañedo, D., and Vargas-Fernández, R. (2022, December). Physical IPV during pregnancy and its implications at birth: analysis of a population survey, 2019. In Healthcare (Vol. 11, No. 1, p. 33). MDPI.

Mirzakhani, K., Ebadi, A., Faridhosseini, F., and Khadivzadeh, T. (2020). Well-being in high-risk pregnancy: an integrative review. BMC Pregnancy and Childbirth, 20, 1-14.

Mondal, D., and Paul, P. (2020). Association between intimate partner violence and child nutrition in India: Findings from recent National Family Health Survey. Children and Youth Services Review, 119, 105493.

Mondal, D., and Paul, P. (2021). Associations of power relations, wife-beating attitudes, and controlling behavior of husband with domestic violence against women in India: Insights from the National Family Health Survey–4. IPV against women, 27(14), 2530-2551.

Moylan, C. A., Herrenkohl, T. I., Sousa, C., Tajima, E. A., Herrenkohl, R. C., and Russo, M. J. (2010). The effects of child abuse and exposure to domestic violence on adolescent internalizing and externalizing behavior problems. Journal of family Violence, 25, 53-63.

Ouyang, F., Zhang, J., Betrán, A. P., Yang, Z., Souza, J. P., and Merialdi, M. (2013). Recurrence of adverse perinatal outcomes in developing countries. Bulletin of the World Health Organization, 91(5), 357–367.

Parke, R.D., Coltrane, S., Duffy, S., Buriel, R., Dennis, J., Powers, J., French, S. and Widaman, K.F. (2004), Economic Stress, Parenting, and Child Adjustment in Mexican American and European American Families. Child Development, 75: 1632-1656.

Pastor-Moreno, G., Ruiz-Pérez, I., Henares-Montiel, J., Escribà-Agüir, V., Higueras-Callejón, C., and Ricci-Cabello, I. (2020). Intimate partner violence and perinatal health: a systematic review. BJOG: An International Journal of Obstetrics and Gynaecology, 127(5), 537-547.

Ping-Hsin Chen, Sue Rovi, Marielos L. Vega, Theodore Barrett, Ko-Yu Pan, Mark S. Johnson, Birth Outcomes in Relation to Intimate Partner Violence, Journal of the National Medical Association, Volume 109, Issue 4, 2017, Pages 238-245.

Raatikainen, K., Heiskanen, N., and Heinonen, S. (2006). Does unemployment in family affect pregnancy outcome in conditions of high quality maternity care?. BMC public health, 6, 46.

Ram, A., Victor, C. P., Christy, H., Hembrom, S., Cherian, A. G., and Mohan, V. R. (2019). Domestic Violence and its determinants among 15–49-year-old women in a rural block in South India. Indian journal of community medicine: official publication of Indian Association of Preventive and Social Medicine, 44(4), 362.

Sardinha, L., Maheu-Giroux, M., Stöckl, H., Meyer, S. R., and García-Moreno, C. (2022). Global, regional, and national prevalence estimates of physical or sexual, or both, intimate partner violence against women in 2018. The Lancet, 399(10327), 803-813.

Sarkar, N. N. (2013). The cause and consequence of domestic violence on pregnant women in India. Journal of Obstetrics and Gynaecology, 33(3), 250-253.

Showalter, K., Mengo, C., and Choi, M. S. (2020). Intimate partner violence in India: Abuse in India's empowered action group states. IPV against women, 26(9), 972-986.

Silasi, M., Cardenas, I., Kwon, J. Y., Racicot, K., Aldo, P., and Mor, G. (2015). Viral infections during pregnancy. American journal of reproductive immunology, 73(3), 199-213.

Silverman, J. G., Gupta, J., Decker, M. R., Kapur, N., and Raj, A. (2007). Intimate partner violence and unwanted pregnancy, miscarriage, induced abortion, and stillbirth among a national sample of Bangladeshi women. BJOG: An International Journal of Obstetrics and Gynaecology, 114(10), 1246-1252.

Stöckl, H., March, L., Pallitto, C., and Garcia-Moreno, C. (2014). Intimate partner violence among adolescents and young women: prevalence and associated factors in nine countries: a cross-sectional study. BMC public health, 14, 1-14.

Straus, M. A., Gelles, R. J., and Asplund, L. M. (1990). Physical violence in American families: Risk factors and adaptations to violence in 8,145 families.

Thompson RS, Bonomi AE, Anderson M, Reid RJ, Dimer JA, Carrell D, et al Intimate partner violence. Prevalence, types, and chronicity in adult women. Am J Prev Med. 2006;30(6):447–57.

Tiruye, T. Y., Chojenta, C., Harris, M. L., Holliday, E., and Loxton, D. (2020). Intimate partner violence against women and its association with pregnancy loss in Ethiopia: evidence from a national survey. BMC women's health, 20, 1-11.

Weitzman, A. (2014). Women's and men's relative status and intimate partner IPV in India. Population and Development Review, 40(1), 55-75.

WHO (2021) Violence against women. (https://www.who.int/news-room/fact sheets/detail/IPV-against-women) (Accessed on 19.04.2023).

INDIAN JOURNAL OF POPULATION AND DEVELOPMENT
ISSN: 2583-4827; Volume 5(1), January 2025: 99-114

Gender Disparity in Literacy in North Indian States

Adriza Dutta
Jogindar Singh Chauhan
Rana Roy
Sarda Prasad

Abstract

This paper analyses trend and variation in gender disparity in the north Indian states of Uttar Pradesh, Rajasthan, Haryana, Punjab, Chandigarh, Himachal Pradesh, Jammu and Kashmir, and Uttarakhand based on the data available from the 1991, 2001, 2011 population censuses and the Periodic Labour Force Survey (PLFS) 2023-2024. Data available from different population censuses indicate a marked decrease in gender disparity in literacy in north India during the period 1991-2011, but PLFS, 2023-24 data reveal that gender disparity in literacy remains quite pervasive in some of the states in this part of the country. The share of females in the population having at least secondary level education is less than that of males in all states and Union Territories, but in some states, females have a higher share than males in the population having up to primary level education. Uttar Pradesh, Uttarakhand, and Rajasthan record the highest gender disparity in literacy rate, where Chandigarh is the lowest and maintains gender parity, but most states still reflect persistent gender gaps.

Introduction

Gender disparity in literacy is an important dimension of gender inequality. It is contingent upon a range of social, cultural, and economic factors. Literacy is globally used to reflect the level of education of the population, and universal literacy is one of the development goals. UNESCO defines literacy rate as the proportion of the population of a given age group that can read and write. Literacy rate is typically measured according to the ability to comprehend a short, simple statement on everyday life, usually encompassing numeracy. According to UNESCO, a high literacy rate indicates the existence of an effective primary education system and/or literacy programmes that have enabled a large proportion of the population to acquire the ability to use the written word and make simple arithmetic calculations in daily life. UNESCO, however, emphasises that literacy should be distinguished from functional literacy, which is more comprehensive than literacy, which is assessed on a continuum in which multiple proficiency levels are determined. Literacy should also be distinguished from educational attainment, which refers to the formal level of schooling completed, although both are crucial indicators of social development and quality of life, influencing economic progress, health, and social participation. Literacy, however, is universally recognised as the fundamental measure of social development.

In India, literacy rate is measured following the definition of a literate person adopted at the population census. Since the 1991 population census, a person aged at least 6 years of age is classified as literate if she or he can read and write with understanding. Following this definition of a literate person, the literacy rate is defined as the proportion of the population aged at least 6 years who can read and write with understanding. The same definition has also been adopted under the Periodic Labour Force Survey (PLFS), that is conducted by the Government of India for the calculation of the literacy rate so that literacy rate obtained from the PLFS can be compared with the literacy rate obtained from the population census.

Gender disparity in literacy, or the difference between female and male literacy rates, is well-known and is a universally used indicator to highlight discrimination against females in the society and the economy. Eliminating gender disparity in literacy through accelerated improvement in female literacy is important, as female literacy is a force multiplier for social development. Illiteracy retards the development of both the individual and the society. However, despite all efforts being made at the level of the government, gender disparity in literacy continues to persist in the Indian society, which has implications for the social and economic development of the country. The Constitution of India gives equal civil rights to both men and women in all aspects of life. However, males still dominate their counterparts in the society, although this dominance is not the same throughout the country (Pathak and Gupta, 2013). In the northern region of the country, the male dominance over females in all aspects of the society and the economy has been found to be particularly strong.

In this paper, we analyse trend and variation in gender disparity in literacy across the states of north India. The available evidence suggests that general disparity in literacy in the northern states of India remains pervasive, and performance in reducing gender disparity in literacy remains poor. In the past, the lack of proper and adequate infrastructural facilities for girls, the lack of vision in designing school curriculum appropriate to the needs of girl children and introducing a uniform pattern of formal structure of education without considering the needs of specific areas or groups were other factors influencing the participation (Ghosh 2007). This article aims to examine the spatio-temporal variation in gender disparity in the literacy rate during the period 1991-2024. The states and Union Territories of India that have been covered in the present study include Jammu and Kashmir, Himachal Pradesh, Haryana, Punjab, Delhi, Chandigarh, Uttarakhand, Uttar Pradesh, and Rajasthan.

The literacy rate in India has improved significantly, from 18.3 per cent in 1951 to more than 74.0 per cent in 2011 (Census of India, 2011). According to the latest PLFS, the literacy rate in India has now crossed the 80 per cent mark. However, the survey reveals that literacy rate varies widely across the states and Union Territories of the country, with Mizoram topping the list with a literacy rate of more than 98 per cent, while Rajasthan has the lowest literacy rate in the country. Among the nine states and Union Territories of India covered in the present analysis, the total literacy rate is estimated to be the highest in Chandigarh, 93 per cent, but the lowest in Rajasthan, 71.4 per cent, according to the PLFS. The gender gap in the literacy rate also varies widely across these nine states and Union Territories.

Data Source and Methodology

The present study is the data from the 1991, 2001, and 2011 population censuses of India and the Periodic Labour Force Survey (PLFS) conducted during 2023-2024. The data available from these sources permits to calculation of literacy rate for males and females separately to analyse the gender disparity in literacy. We have first calculated the average annual change per year in male and female literacy rate during the period 1991-2023 for each of the nine states/Union Territories included in the present analysis. Let L_2 denote the literacy rate in the year t_2 and L_1 denote the literacy rate in the year t_1 ($T_2 > t_1$). Then the annual rate of change in the literacy rate between t_1 and t_2 is calculated as

$$\partial_{2,1} = \frac{(L_2 - L_1)}{L_1 \times (t_2 - t_1)} \times 100$$

The average annual rate of change during the period 1991-2023 is calculated as the weighted sum of the annual rate of change during the period 1991-2001, 2001-2011, and 2011, 2023 where weights are equal to the proportionate length of the three time-segments.

On the other hand, for measuring the gender disparity or inequality in the literacy rate, we have proceeded as follows: let L_m denotes the literacy rate for males and L_f denotes the literacy rates for females. The odds that a male is literate is then defined as

$$O_m = \frac{L_m}{100 - L_m}$$

Similarly, the odds that a female is literate is defined as

$$O_f = \frac{L_f}{100 - L_f}$$

The ratio of the odds that a male is literate and the odds that a female is literate, or the odds ratio, is then calculated as

$$\frac{O_m}{O_f} = \frac{\left(\frac{L_m}{100 - L_m}\right)}{\left(\frac{L_f}{100 - L_f}\right)} = \frac{L_M}{L_f} \times \frac{100 - L_f}{100 - L_m}$$

An index of the gender disparity in the literacy rate may now be calculated as

$$D_s = Log\left(\frac{O_m}{O_f}\right) = Log\left(\frac{L_M}{L_f}\right) + Log\left(\frac{100 - L_f}{100 - L_m}\right)$$

where *Log* is the logarithm to the base 10. This index is the Sopher's index of inequality or disparity (Sopher, 1974). When there is no disparity or when the odds of a male being literate is the same as the odds of a female being literate, the index is equal to zero and the higher the index the higher the gender disparity. The problem of this index, however, is that it fails to satisfy the principle of additive monotonicity which means that if a constant number is added to all observations in a non-negative series, ceteris paribus, the inequality index must decrease. To overcome this limitation, Kundu and Rao (1983) modified it as follows:

$$D = Log\left(\frac{L_m}{L_f}\right) + Log\left(\frac{(200-L_F)}{(200-L_m)}\right)$$

It may be noted that when $L_m > L_f$, $D > 0$, but when $L_m < L_f$, $D < 0$. However, there is no change in the magnitude of the index. Male literacy does not always need to be higher than female literacy, which means that the index D can take both positive and negative values. However, the magnitude of the index remains the same. In the present paper, we have used the index D to measure the gender disparity in literacy rate in the north Indian states and Union Territories of the country.

Finally, the choropleth maps have been constructed to visualise the spatial variation in gender disparity in the literacy rate. A choropleth map is a popular thematic mapping method that represents statistical data through various shading patterns or symbols on predetermined geographic areas, states, and Union Territories in the present case. Collectively, these tools provide an analytical framework to uncover and interpret literacy trends and gender disparity in literacy rates across states and Union Territories.

Findings and Discussions

Trend in male and female literacy rate. Table 1 presents the literacy rate for the total population and for males and females in the nine states/Union Territories for the period 1991-2023-2024. In 1991 literacy rate was the highest in Delhi but the lowest in Rajasthan. In 2023-2024, however, literacy was the highest in the Union Territory of Chandigarh, although it remained the lowest among the nine states/Union Territories in Rajasthan. Chandigarh is the only state/Union Territory among the nine states/Union Territories where the literacy rate was more than 90 per cent according to PLFS 2023-2024. On the other hand, Rajasthan and Uttar Pradesh are the only two states where the literacy rate was less than 75 per cent even in 2023-2024.

In all states and Union Territories, the female literacy rate has always been lower than the male literacy rate. In Chandigarh, Delhi, Haryana and Himachal Pradesh, male literacy was more than 90 per cent in 2023-2024, but there is no state/Union Territory where female literacy was more than 90 per cent. In 2023-204, the male literacy rate ranged from around 83 per cent in Uttar Pradesh and Rajasthan to more than 96 per cent in Chandigarh, whereas female literacy ranged from less than 60 per cent in Rajasthan to almost 90 per cent in Chandigarh. Rajasthan is the only state/Union Territory where the female literacy rate was less than 60 per cent in 2023-2024.

Estimates of literacy for rural and urban areas of the nine states/Union Territories are not available from PLFS, 2023-2024. However, data available from the 2011 population census indicates that female literacy has always been lower than the male literacy rate in all nine states/Union Territories. In the rural areas, the female literacy rate was the lowest in Rajasthan, whereas in the urban areas, it was the lowest in Uttar Pradesh. On the other hand, in both rural and urban areas, the female literacy rate was the highest in Himachal Pradesh. There is, however, no state where the female literacy rate was more than 75 per cent in the rural areas, whereas in three states – Himachal Pradesh, Chandigarh, and Delhi – the female literacy rate was more than 80 per cent at the 2011 population census.

Table 1: Literacy rates in 9 states/Union Territories of north India as estimated from the data available from the population census and Periodic Labour Force Survey.

State/Union Territory		Literacy rate						
		Total			Rural		Urban	
		Total	Male	Female	Male	Female	Male	Female
Chandigarh	1991	77.8	82.5	72.2	72.1	53.1	83.2	73.6
	2001	81.9	86.1	77.5	83.9	58.9	89.9	77.2
	2011	86.0	90.0	81.2	85.8	73.2	90.1	81.4
	2023	93.0	96.3	89.4	Na	Na	Na	Na
Delhi	1991	77.9	84.7	70.9	74.4	48.7	83.2	68.9
	2001	81.7	87.3	75.0	80.3	57.1	89.6	79.9
	2011	86.2	90.9	80.8	89.4	73.1	91.0	80.9
	2023	85.3	90.9	78.7	Na	Na	Na	Na
Haryana	1991	55.9	68.1	42.5	64.6	38.5	78.2	61.3
	2001	67.9	78.5	55.7	74.9	47.2	87.8	75.2
	2011	75.6	84.1	65.9	81.6	60.0	88.6	76.9
	2023	82.4	90.1	74.1	Na	Na	Na	Na
Himachal Pradesh	1991	63.9	75.4	52.1	72.9	47.7	86.9	74.2
	2001	76.5	85.4	67.4	83.3	58.0	91.7	80.1
	2011	82.8	89.5	75.9	89.1	74.6	93.4	88.4
	2023	87.3	93.9	81.1	Na	Na	Na	Na
Jammu & Kashmir	1991	Na	Na	Na	Na	Na	Na	Na
	2001	55.2	66.6	43.0	63.8	35.7	85.2	65.7
	2011	67.2	76.8	56.4	73.8	51.6	83.9	69.0
	2023	79.0	88.0	78.7	Na	Na	Na	Na
Punjab	1991	58.5	65.7	50.4	60.9	44.9	78.0	65.9
	2001	69.7	77.1	60.7	74.6	53.2	86.4	73.4
	2011	75.8	80.4	70.7	76.6	65.7	86.7	79.2
	2023	81.2	85.4	77.0	Na	Na	Na	Na
Rajasthan	1991	38.6	55.0	20.4	49.3	13.4	75.5	44.8
	2001	60.4	75.7	44.3	71.9	38.1	86.6	70.6
	2011	66.1	79.2	52.1	76.2	45.8	87.9	70.7
	2023	71.4	83.3	59.9	Na	Na	Na	Na
Uttar Pradesh	1991	41.6	55.7	25.3	52.4	19.2	73.9	48.6
	2001	56.3	70.2	41.6	66.9	34.2	82.9	60.7
	2011	67.7	77.3	57.2	76.3	53.7	80.4	69.2
	2023	73.9	83.2	64.7	Na	Na	Na	Na
Uttarakhand	1991	57.8	70.1	44.6	67.3	40.5	84.9	66.9
	2001	71.6	83.3	59.6	80.2	50.6	90.9	77.0
	2011	78.8	87.4	70.0	86.6	66.2	89.1	79.3
	2023	81.3	88.6	74.2	Na	Na	Na	Na

Remarks: Literacy rate is calculated as the proportion of the population aged 7 years and above who can read and write with understanding.

Source: Estimated by the authors from the data available from population censuses 1991, 2001 and 2011, and the periodic labour force survey 2023-2024.

Table 2: Gender disparity index (*D*) in states and Union Territories of north India during the period 1991-2024.

State/Union Territory	Year	Gender disparity index (Index *D*)		
		Total	Rural	Urban
Chandigarh	1991	0.095	0.193	0.087
	2001	0.077	0.239	0.113
	2011	0.078	0.114	0.077
	2023	0.060	Na	Na
Delhi	1991	0.126	0.265	0.132
	2001	0.111	0.225	0.086
	2011	0.090	0.147	0.090
	2023	0.109	Na	Na
Haryana	1991	0.281	0.302	0.162
	2001	0.223	0.288	0.114
	2011	0.169	0.206	0.105
	2023	0.144	Na	Na
Himachal Pradesh	1991	0.234	0.263	0.115
	2001	0.166	0.242	0.102
	2011	0.122	0.131	0.044
	2023	0.113	Na	Na
Jammu & Kashmir	1991	Na	Na	Na
	2001	0.261	0.335	0.182
	2011	0.201	0.226	0.137
	2023	0.083	Na	Na
Punjab	1991	0.161	0.179	0.114
	2001	0.158	0.215	0.118
	2011	0.090	0.103	0.067
	2023	0.076	Na	Na
Rajasthan	1991	0.523	0.659	0.322
	2001	0.330	0.378	0.146
	2011	0.270	0.316	0.157
	2023	0.223	Na	Na
Uttar Pradesh	1991	0.426	0.523	0.262
	2001	0.314	0.388	0.210
	2011	0.197	0.225	0.104
	2023	0.173	Na	Na
Uttarakhand	1991	0.275	0.300	0.167
	2001	0.225	0.296	0.125
	2011	0.159	0.189	0.087
	2023	0.130	Na	Na

Remarks: Na - Not available
There was no population census in Jammu and Kashmir in 1991.
Source: Authors' calculations based on data presented in Table 1.

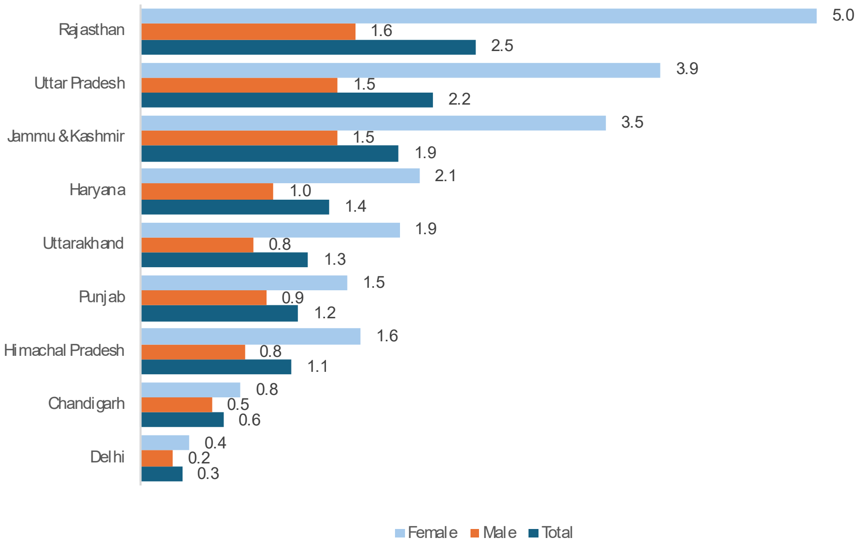


Figure 1: Average annual increase in literacy rate in different states/Union Territories of north India during 1991-2023-2024.
Source: Authors based on data given in Table 1.

Although the female literacy rate has always remained lower than the male literacy rate in all the 9 states/Union Territories, the average annual increase in the female literacy rate has always been faster in female literacy rate as compared to the male literacy rate during the period 1991-2024, as may be seen from Figure 1. In Rajasthan, female literacy rate increased at an average annual rate of around 5 per cent per year during this period, whereas the increase in Delhi has been just around 0.4 per cent per year. Rajasthan had the lowest female literacy rate among the nine states and Union Territories, whereas Delhi had the highest. The increase in female literacy has been associated with the level effects – the lower the female literacy in 1991, the higher the increase in it during the period 1991-2024.

Gender Disparity in Literacy. Table 1 shows an overall summary of the changing positions of North Indian states in gender disparity in literacy rates for three decades. If the gender disparity rate is divided into three stages, high, medium, and low, it can be seen that Rajasthan is consistent in high disparity from 1991 to 2024, and on the other hand, Chandigarh is acquiring the lowest disparity at the same time. Delhi, Himachal Pradesh, and Punjab are developing. Figures 2 through 5 highlight the variation in gender disparity in literacy across north Indian states and union territories. Chandigarh consistently maintained one of the lowest disparities, with an index of 0.09 in 1991, reducing slightly to 0.08 by 2011 and stagnant at the same percentage by 2023-24, demonstrating near gender parity in literacy. Similarly, Delhi shows progressive improvement, with the index *D* decreasing from 0.13 in 1991 to 0.09 in 2011, but recently, in 2024, disparity has increased in literacy rate to 0.11, reflecting its continued focus on equal educational opportunities, but some socio-economic factors are still lagging. Haryana reduced the gender disparity significantly during 1991-2024, marking substantial progress. Himachal Pradesh achieved remarkable improvements, lowering its disparity from 0.23 in 1991 to just 0.12 in 2011 and 0.11 in 2024. In Jammu and Kashmir, the index *D* decreased from 0.26 in 2001 to 0.20 in 2011 and 0.08 in 2023-24, showing steady improvement despite political challenges. Punjab also demonstrated consistent progress, but gender disparity increased after 2011. In Rajasthan, the index *D* decreased from 0.52 in 1991 to 0.27 in 2011 and 0.22 in 2023-24, whereas Uttarakhand showed consistent improvement, with the index *D* decreasing from 0.28 in 1991 to 0.16 in 2011 and 0.13 in 2023-24. Uttar Pradesh also exhibited considerable progress as the index *D* decreased from 0.43 in 1991 to 0.20 in 2011, and to 0.17 in 2023-24. However, gender disparity in female literacy remains the highest in the state among all north Indian states and Union Territories.

Table 2 also shows that the gender disparity in literacy rates is substantially higher in rural areas compared to urban areas in all nine states and Union Territories. According to the data available from the 2011 population census, among the 9 states/Union Territories, gender disparity in literacy rate was the highest in Rajasthan in both rural and urban areas, whereas it was the lowest in the rural areas of Chandigarh and in the urban areas of Himachal Pradesh. In Chandigarh, Delhi, Haryana, Punjab, and Uttarakhand, the difference between rural and urban gender disparities in literacy rates increased in 2001 relative to the rural-urban difference in gender disparities in literacy in 1991. However, the rural-urban difference in gender disparity in literacy decreased in all states/Union Territories between 2001 and 2011. Overall, results reveal a clear trend of declining gender disparity in literacy across all states/Union Territories. In Himachal Pradesh, gender disparity in literacy in the urban areas is now marginal if the evidence from the 2011 population census is any indication. In the urban areas of Chandigarh, Delhi, Punjab, and Uttarakhand, gender disparity in literacy appears to have reached very low levels. In Rajasthan and Uttar Pradesh, however, gender disparity in literacy remains quite substantial even in the urban areas. In the rural areas of all the nine states/Union Territories, on the other hand, gender disparity in literacy remains quite substantial relative to the gender disparity in literacy in the urban areas.

Table 3: Change in gender disparity in literacy in states and Union Territories.

Disparity	1991	2001	2011	2023-24
High	Haryana Uttarakhand Uttar Pradesh Rajasthan Himachal Pradesh	Jammu & Kashmir Haryana Uttarakhand Uttar Pradesh Rajasthan	Rajasthan	Rajasthan
Medium	Punjab Delhi	Himachal Pradesh Punjab Delhi	Jammu & Kashmir Haryana Uttarakhand Uttar Pradesh Himachal Pradesh	Delhi Uttar Pradesh Himachal Pradesh Uttarakhand Haryana
Low	Chandigarh	Chandigarh	Punjab Delhi Chandigarh	Chandigarh Punjab Jammu & Kashmir

Source: Authors

Figure 2: Gender disparity (Index D) in literacy rate in north India, 1991.
Source: Authors, based on data from Table 2.

Figure 3: Gender disparity in literacy rate (Index D) in north India, 2001.
Source: Authors, based on data from table 2.

Figure 4: Gender disparity (Index D) in literacy rate in north India, 2011.
Source: Authors, based on data from Table 2.

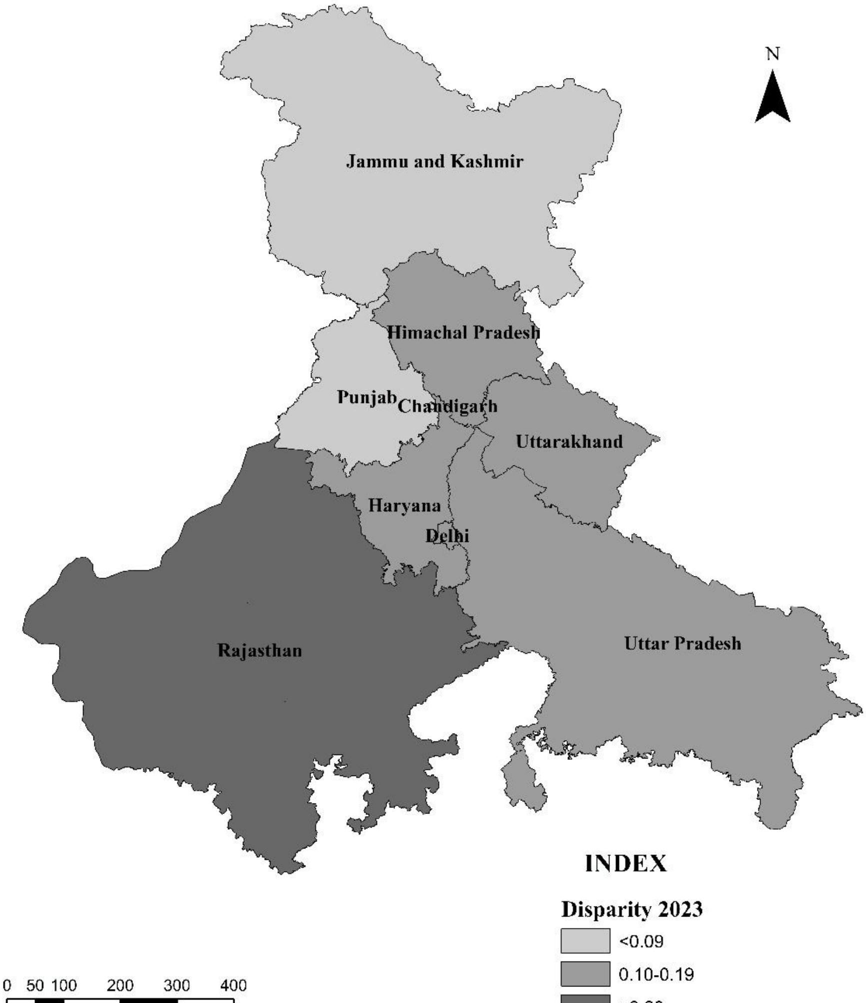


Figure 5: Gender disparity (Index D) in literacy rate in north India, 2023-2024.
Source: Authors, based on data from Table 2.

Table 3 depicts how gender disparity in literacy has changed from high to low in different states and Union Territories. The gender disparity is classified as high if $D>0.20$; medium if $0.10\leq D\leq 0.19$, and low if $D<0.09$. The most remarkable decrease in gender disparity in literacy has been observed in Haryana and Uttarakhand, where gender disparity in literacy was high in 1991 and 2001 but decreased to medium in 2023-2024. In Himachal Pradesh, gender disparity in literacy was medium in 2001 and decreased at a slow rate, remaining in the same position in 2023-2024. On the other hand, in Uttar Pradesh and Uttarakhand, gender disparity in literacy appears to have remained high between 1991 to 2001 but decreased in medium from 2011 to 2023-2024. Rajasthan also had high gender disparity in literacy during the 40 years between 1991 and 2011, but there has been a rapid decrease in gender disparity in literacy between 2011 and 2023-2024, but it is still in a high level of disparity in 2023-24. On the other hand, gender disparity in literacy was low in Delhi in 2011, but it appears to have increased between 2011 and 2023-2024.

Table 4: Proportion (per cent) of population aged 7 years and above having different levels of education in north Indian states/Union Territories.

State	Primary			Middle			Secondary and above		
	Person	Male	Female	Person	Male	Female	Person	Male	Female
Chandigarh	10.3	9.9	10.8	10.5	11.9	9.1	72.1	74.6	69.5
Delhi	12.4	12.7	12.1	17.9	18.3	17.3	55.5	59.9	49.3
Haryana	13.8	13.3	14.5	15.5	17.1	13.8	53.1	59.7	45.9
Himachal Pradesh	17.1	15.7	18.5	13.6	15.3	12.0	56.6	63.0	50.6
Jammu & Kashmir	9.6	9.6	12.1	24.9	27.2	17.3	44.4	51.2	49.3
Punjab	15.8	16.2	15.4	15.5	17.2	13.7	50.0	52.0	47.9
Rajasthan	15.8	17.1	14.4	18.5	21.9	15.2	37.2	44.2	30.4
Uttar Pradesh	12.5	12.9	12.1	20.7	23.7	17.8	40.7	46.6	34.7
Uttarakhand	12.5	11.3	13.7	17.8	19.2	16.4	50.9	58.1	44.1

Source: Government of India (2024)

Table 4 presents the level of education of the literate population as revealed through the PLFS 2023-2024. In Rajasthan, only around 37 per cent of the population aged 7 years and above had at least secondary level education, whereas this proportion was more than 72 per cent in Chandigarh. In Jammu and Kashmir and Uttar Pradesh also, less than 50 per cent of the population aged 7 years and above had at least secondary level education, whereas Chandigarh in the only state/Union Territory in north India where more than 70 per cent of the population aged 7 years and above had at least secondary level education. On the other hand, the proportion of the population having up to the primary level education only was the highest in Himachal Pradesh, but the lowest in Jammu and Kashmir, whereas Jammu and Kashmir and Uttar Pradesh are the only two states where at least one-fifth of the population aged 7 years and above had middle-level education according to the PLFS 2023-2024. In Chandigarh, Haryana, Himachal Pradesh, Jammu and Kashmir, and Uttarakhand, the of females aged 7 years and above and having up to primary level education is higher than that in males. The gender disparity index (index D) in primary level education, in these states and Union Territories, is, therefore, negative and reflects a higher proportion of females than males aged 7 years and above having up to primary level education (Figure 6). However, there is no state/Union Territory where the proportion of females aged 7 years and above and having at least secondary level education is higher than the proportion of males aged 7 years and above and having at least secondary level education, so that the gender disparity index (index *D*) is positive in all states and Union Territories.

It may also be seen from Figure 6 that the gender disparity is the highest in the population having at least secondary level education in Delhi, Haryana, Himachal Pradesh, Rajasthan, Uttar Pradesh, and Uttarakhand. However, in Chandigarh, Jammu and Kashmir and Punjab, the gender disparity is higher in the population having middle-level education than in the population having at least secondary-level education.

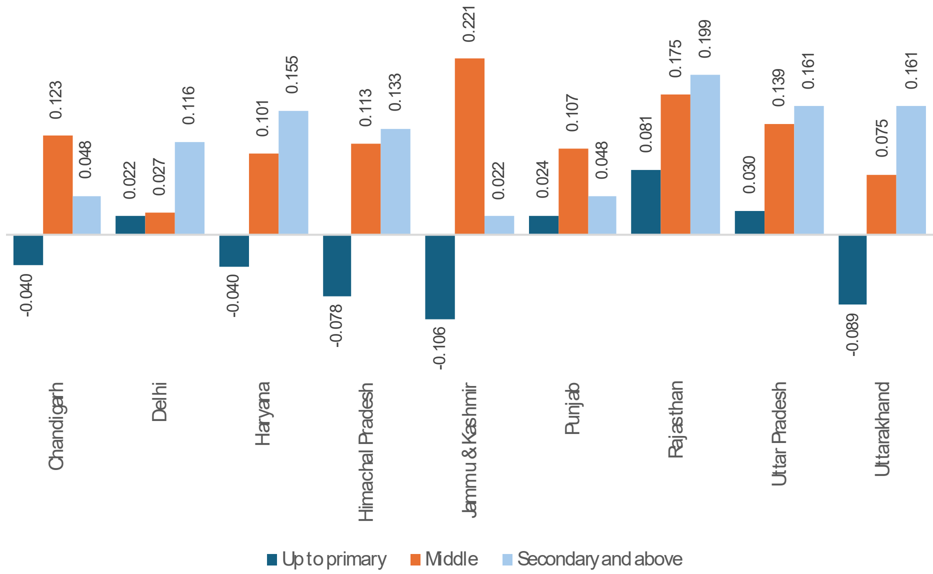


Figure 6: Gender disparity by the level of education in states/Union Territories of north India, 2023-2024.
Source: Authors based on data of Table 4.

Conclusion

In this paper, we have conducted an empirical investigation of the gender disparity in literacy across the states/Union Territories of North India. The level of literacy varies widely across these states and Union Territories, and the male-female difference in literacy may be a reason behind this variation. The analysis reveals that since 1991, the gender gap in literacy has been steadily decreasing in all states and Union Territories of North India. This study shows that Rajasthan, Uttar Pradesh, and Uttarakhand have emerged with the maximum gender disparity in literacy rate between males and females. Meanwhile, Punjab, Chandigarh, and Delhi have the lowest gender disparity in rural areas, and Chandigarh has the lowest disparity in urban areas, indicating that Chandigarh is on track to achieve gender parity, though female illiteracy is still there in 2023-24. The article concludes that there is an inverse relationship between literacy and gender disparity; when female literacy increases, gender disparity decreases, which means that all state and Union Territories in this part of India are on the way to gaining gender parity, but no state in India has a better female literacy rate than males but female illiteracy always surpasses male illiteracy which clearly defines the lack of opportunity in women education in North India. It also reveals more gender disparity in rural areas than in urban areas. Consequently, there is an urgent need to focus on female literacy in all areas, particularly rural areas, to address the issue of gender disparity.

References

Arora M (2023) Disparity in microenvironment in urban areas of India. *International Journal for Multidisciplinary Research* 5(1): 1-7.

Bano S (2023) Gender disparity in literacy in Uttar Pradesh: A spatial analysis. *Humanities and Social Sciences Communications* 10(962).

Bano S (2017) Spatiotemporal variation of male-female disparity in literacy: a geographical analysis of Awadh Region, U.P, India. *IOSR Journal of Humanities and Social Sciences* 22(8): 26–31.

Busse M, Nunnenkamp P (2009) Gender disparity in education and the international competition for foreign direct investment. *Feminist Economics* 15 (3): 61-90.

Chakrabarti S, Mehta S (2019) The urban-rural disparity in education in India. *International Journal of Research in Social Sciences* 9(6): 639-650.

Dutta S, Sivaramakrishnan L (2013) Disparity in the literacy level among the scheduled and non-scheduled population: Indian scenario in the 21st century. *Transactions* 35(2): 185-200.

De J (2015) Gender disparity in literacy: a macro level spatio-temporal account of India. *IOSR Journal of Humanities and Social Science* 21(10): 52-59.

Ghosh AK (2007) The gender gap in literacy and education among the scheduled tribes in Jharkhand and West Bengal. *Sociological Bulletin* 56(1): 109-125.

Government of India (1991) Census of India 1991. State-wise Literacy Rate. (http://censusindia.gov.in/) (Accessed on 10.08.2025).

Government of India (2001) Census of India 2001. State-wise Literacy Rate. (http://censusindia.gov.in/) (Accessed on 10.08.2025).

Government of India (2011) Census of India 2011. State-wise Literacy Rate. (http://censusindia.gov.in/) (Accessed on 10.08.2025).

Government of India (2024) *Annual Report. Periodic Labour Force Survey (PLFS) (Juny 2023-June 2024)*. New Delhi, Ministry of Statistics and Programme Implementation. National Statistics Office.

Islam MM, Mustaquim M (2015) Gender gap in literacy: a study of Indian scenario. In MD Ismail, Asarful Alam (Ed) *Life and Living Through Newer Spectrum of Geography*. Mohit Publications: 188 - 201.

Katiyar SP (2016) Gender disparity in literacy in India. *Social Change* 46(1): 46-69.

Kumar N, Kumar N, Rani R (2016) Gender disparity in literacy: district level evidence from selected states of India. *Educational Quest-An International Journal of Education and Applied Social Sciences* 7(3): 243-254.

Kundu A, Shariff A, Ghosh PK (2002) Indexing Human Development in India: Indicators, Scaling, and Composition. *National Council of Applied Economic Research* 83.

Pathak S, Gupta A (2013) Status of women in India with particular reference to gap in male-female literacy rate in India. *International Journal of Environmental Engineering and Management* 4(6): 549-552.

Roy D, Mondal A (2015) The rural-urban disparity of literacy in Murshidabad District, WB, India. *International Research Journal of Social Sciences* 4(7): 19-23.

Sarkar CS, Chakraborty A (2021) Comparative study of male-female disparity in literacy of Purulia and North 24 Parganas district in West Bengal. *Psychology and Education* 58(2): 44-55.

Sharma M, Kumar S (2020) Geographical appraisal of gender disparity and progress in literacy of Haryana, India. *Indonesian Journal of Geography* 52(2): 280-289.

Skinder S, Shah SA, Dar SN (2022) Analysis of educational disparities in border areas of India: a study of Gurez Valley. *Geo Journal* 87(4):1-14.

Singh S (2022) Gender disparity in education and health in India: a comprehensive analysis. *International Journal of English Literature and Social Sciences* 7(1): 373-379.

Sopher DE (1974) A measure of disparity. *The Professional Geographer* 26(4): 389-392.

INDIAN JOURNAL OF POPULATION AND DEVELOPMENT
ISSN: 2583-4827; Volume 5(1), January 2025: 115-128

Impact of the Sex of the First Child on Second Birth Interval in Uttar Pradesh: A Non-Parametric and Semi-Parametric Approach

Abhay Kumar Tiwari
Pappu Kumar Singh

Abstract

The interval between a woman's first and second birth, known as second birth interval (SBI), is a crucial indicator of reproductive behaviour, with implications for maternal and child health and population policy. This paper has analysed SBI among ever-married women of reproductive age in Uttar Pradesh, India, using data from the fifth round of the National Family Health Survey (NFHS-5), 2019–21. Non-parametric Kaplan–Meier (KM) and semi-parametric Cox proportional hazard (CPH) survival analysis techniques have been employed to estimate SBI and identify its predictors. The tri-mean of SBI is estimated to be 34.25 months. The CPH model revealed that age at first birth, religion, education, caste, place of residence, wealth index, foetal loss/stillbirth, and sex of the first child have significant influence on the timing of the second birth. In particular, women whose first child is female have a 4.2 per cent higher likelihood of progressing to the second birth compared to those whose first child is male. The analysis underscores role of gender preference in shaping reproductive behaviour. The paper provides valuable insights for designing targeted reproductive health interventions and informing family planning policies.

Introduction

The timing between two successive births, known as the birth interval, and the time between the first and the second birth known as the second birth interval (SBI), play a vital role in shaping fertility trends, affecting both maternal and child health outcomes and informing population policies (Marini and Hodsdon, 1981; Conde-Agudelo et al, 2006; Afolabi and Palamuleni, 2022). SBI measures how first two births are spaced and reflects the underlying reproductive behaviour including how well family planning works in regulating fertility (Nath et al, 2000; Ahammed et al, 2019). The World Health Organization (WHO) has recommended a spacing of at least 24 months between two successive live births to reduce health risks and recommends a span of 3-5 years as ideal. Too short or too long birth interval can lead to increased chances of maternal health complications, low birth weight, premature deliveries, and even infant mortality (WHO, 2007).

In demographic research globally, much attention has been paid to patterns of SBI in Africa and parts of the Middle East (Moultrie et al, 2012; Fallahzadeh et al, 2013). However, the scenario in India, particularly in Uttar Pradesh, remains underexplored in this regard. Uttar Pradesh is the most populous state of India and fertility in the state is high relative to other states of the country and female marriage at an early age is quite common. According to the latest National Family Health Survey (NFHS-5), Uttar Pradesh continues to demonstrate wide variation in fertility and reproductive behaviour across socio-economic and regional lines, contributing significantly to national demographic scenario (Government of India, 2022).

Understanding the determinants of SBI in Uttar Pradesh is vital for two reasons. First, Uttar Pradesh is central to India's demographic transition, and its reproductive patterns significantly influence national fertility trends. Second, the state exhibits significant diversity in socio-demographic characteristics such as education, wealth, urban-rural divide, religion, and access to healthcare, all of which are known to influence fertility decisions and birth intervals (Singh et al, 1993; Nath et al, 2000; Halli et al, 2019; Singh and Rai, 2025). Educational attainment, in particular, has emerged as a powerful determinant of reproductive behaviour. Studies have consistently shown that higher levels of maternal education are associated with delayed childbearing, greater autonomy in fertility decisions, and better use of contraceptive methods (Ní Bhrolcháin and Beaujouan, 2012).

There is evidence to suggest that the practice of family planning for spacing births, particularly, spacing between the first and the second birth remains inconsistent across Uttar Pradesh (Santhya et al, 2007). While the desire for at least two children remains strong in many Indian communities, the timing of the second birth is increasingly seen as a strategic decision influenced by education, economic opportunities, and access to reproductive healthcare (Rajan et al, 2018; Halli et al, 2019). SBI, therefore, represents a vital mechanism through which policy efforts can promote replacement-level fertility and better maternal and child health outcomes. A particularly important factor influencing the timing of the second birth in India is the sex of the first child. Son preference has historically been strong in many parts of the country, including Uttar Pradesh, where cultural, social, and economic values attached to a son plays a decisive role in fertility decisions. Couples whose first child is a female are found to be often more likely to reduce the period between the first birth and the second birth or SBI in the hope that the second child would be male, couples whose first child in male may delay or space their second birth more strategically (Shukla et al, 2018). This gender-driven fertility behaviour is closely linked to patriarchal norms, inheritance practices, and expectations regarding old-age security, all of which reinforce the desire for sons.

Despite the significance of SBI, empirical studies using robust statistical frameworks like the non-parametric and semi-parametric model remain limited in Uttar Pradesh, and nearly absent for SBI. Survival analysis methods, particularly the CPH regression, allow for the estimation of time-to-event data while accommodating censored observations (Cox, 1972), an essential feature for analysing birth intervals where not all women may experience a second birth during the study period. Non-parametric and semi-parametric models have been effectively employed in various contexts to analyse inter-birth intervals and waiting time of conceptions (Nair, 1996; Nath et al, 2000; Mahmood et al, 2013; Singh et al, 2016), offering insights into the relative risks associated with different socio-demographic and behavioural covariates.

In the above context, the present study aims to analyse SBI among ever-married women of reproductive age in Uttar Pradesh using survival analysis techniques (non-parametric and semi-parametric). The study also examines the role of socio-demographic, economic, and behavioural factors influencing SBI.

Methods

Data Source. This study uses data from the National Family Health Survey (NFHS-5) for Uttar Pradesh, India. The survey provides detailed information on demographic and reproductive health characteristics of ever-married women of reproductive age (15–49 years). It was conducted the Government of India, Ministry of Health and Family Welfare and was coordinated by the International Institute for Population Sciences (IIPS), Mumbai. The survey employed a stratified two-stage sampling design that ensured representativeness at national, state/union territory, and district levels. In the first stage, primary sampling units (PSUs) were selected using the village and town list of the 2011 population census as sampling frame. In the rural areas, PSUs were villages, while in the urban areas they were census enumeration blocks (CEBs). In the second stage of sample selection, a systematic random sample of 22 households was drawn from each PSU based on the newly created household list. All ever-married women of reproductive age residing in these selected households were surveyed (Government of India, 2022).

Study Design and Setting. The present study is limited to only those ever-married women of reproductive age who had given at least one live birth at the time of the survey. Women who reported that their second birth occurred within 12 months of the first birth were excluded from the analysis to ensure biological plausibility and avoid postpartum bias as it is biologically uncommon to conceive and give birth within that period due to the typical 9 months gestation period and approximately 2–3 months of the duration of postpartum amenorrhea (PPA) (Bongaarts and Potter, 1983; Yadava et al, 2025). Additionally, to minimise the influence of extreme values and reduce potential censoring bias, we restricted the analysis to ever-married women whose second birth or censoring occur within 120 months (10 years) from the survey date. After applying these criteria and excluding women with missing or implausible dates and negative intervals, the final sample for the analysis consisted of 22616 ever-married women of reproductive age. For women who had a second birth (i.e., event), the SBI was calculated by subtracting the date of the first birth from the date of the second birth. Among these women, 8070 (35.72 per cent) women did not give birth to a second child by the survey date and, therefore, they were considered as censored.

Study Variables. SBI, defined as the duration (in months) between a woman's first and second live birth, is treated as the response variable in the present analysis. On the other hand, the explanatory variables included a range of socio-economic, demographic, and reproductive health variables. Several predictors have been identified in previous studies that influence birth interval (Nath et al, 2000; Singh et al, 2016; Seyedtabib et al, 2020; Afolabi & Palamuleni, 2022; Zambwe, 2023). We have considered age at first birth, religion, women education, place of residence, wealth index, social class, ever had terminated pregnancy due to foetal loss or still birth, sex of the first child, and mass media exposure as explanatory variables.

Statistical analysis. Survival analysis techniques have been employed to examine the timing of the second birth. For women who have experienced a second birth, the event time was defined as the SBI. Women who did not have the second birth by the time of the survey are treated as censored, with the censoring time defined as the time between the first birth and the date of the interview.

Let T be a continuous random variable representing the survival time (here, the time between the first and second birth), t be a specific time point, and $f(t)$ be the probability density function of T. Then the survival function $S(t)$ gives the probability that a woman does not have a second birth by time t and is defined as:

$$S(t) = P(T > t) = 1 - P(T \leq t) = 1 - F(t) \qquad (1)$$

where $F(t)$, gives the probability of the second birth before time t, and is defined as:

$$F(t) = P(T < t) = \int_0^t f(v)dv\,; t \geq 0 \qquad (2)$$

The hazard function $h(t) \geq 0$, represents the instantaneous risk of a second birth at time t, given that the woman does not have a second birth until that time and is given by

$$h(t) = \lim_{\Delta t \to 0} \frac{P(t<T<t+\Delta t|T>t)}{\Delta t} = \frac{f(t)}{1-F(t)} = \frac{f(t)}{S(t)} \qquad (3)$$

In this study, both non-parametric and semi-parametric methods were employed to analyse the time between the first birth and the second birth (SBI). The Kaplan–Meier (KM) estimator, developed by Kaplan and Meier (1958), has been used to describe the survival function or the probability that a woman does not have a second birth by the given time. Let the sample consists of n independent observations denoted by (t_i, c_i), where t_i is the observed time and c_i is the censoring indicator and $m \leq n$ is the number of women who have second birth. Let $t_{(1)} \leq t_{(2)} \leq \cdots \leq t_{(m)}$ be the ordered event times, n_i be the number of women at risk just before $t_{(i)}$, and d_i the number of second births at time $t_{(i)}$. Then, the Kaplan–Meier estimate of the survival function is given as

$$\hat{S}(t) = \prod_{t_{(i)} \leq t} \left(\frac{n_i - d_i}{n_i}\right) \qquad (4)$$

and $\hat{S}(t) = 1$ if $t < t_{(1)}$.

The log-rank test (Wellek, 1993) has been used to test the statistical significance of the difference in SBI across different categories of women by explanatory variables while the frequency distribution, tri-mean, and spread has been used as descriptive statistics to describe the variation. The tri-mean (*TM*) is a robust measure of central tendency compared to mean in case of non-normal data (Páez and Boisjoly, 2022) and can be calculated as

$$TM = \frac{Q_1+Q_3+2Q_2}{4} \quad (5)$$

The spread is measured in terms of semi-interquartile range (SIQR), which is a robust measure of spread (Wilcox, 2012) and is given by

$$SIQR = \frac{Q_3-Q_1}{2} \quad (6)$$

Finally, the Cox proportional hazard (CPH) model has been applied to assess the net effect of explanatory variables on the timing of the second birth. CPH is a semi-parametric regression technique (Cox, 1972) and is given by

$$h_i(t) = h_0(t)\exp(\beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_p x_{pi}) \quad (7)$$

where $h_0(t)$ is the baseline hazard function; x_{ji} is a vector of covariates and β_j is a vector of parameters for fixed effects. Equation (7) can be written as

$$log\left(\frac{h_i(t)}{h_0(t)}\right) = \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_p x_{pi} \quad (8)$$

The sign of the regression coefficients in equation (8) indicates the direction of the effect of the covariate on the hazard ratio (HR). The HR, obtained by exponentiating the regression coefficient, reflects the relative risk of experiencing the event. HR>1 suggests a higher likelihood of the second birth occurring sooner (a shorter SBI), while HR<1 indicates higher likelihood of a longer SBI. HR=1 implies no effect of the covariate on the timing of the second birth. The statistical significance of these effects was evaluated at the 5 per cent level (p-value < 0.05).

Results

Table 1 presents summary measures of distribution and log-rank test for median SBI in Uttar Pradesh according to the explanatory variables included in the analysis. The tri-mean of SBI among ever married women is estimated to be 34.25 months. The spread shows considerable variation across population subgroups, reflecting differences in the interval between the first and the second birth (SBI). The table indicates that women who had first birth before 20 years of age had a shorter SBI with a tri-mean of 31.75 months and spread 11.5 months, compared to women who had first birth after 20 years of age (Tri-mean 35.25 months, spread 14.5 months) and the difference is statistically significant (p = 0.000). This indicates that age at first birth is associated with SBI. On the other hand, Hindu women had a longer SBI (tri-mean 34.25 months, spread 13.5 months) compared to Muslim women (tri-mean 31 months, spread = 12 months), and the difference is statistically significant (p = 0.000) which shows that religious affiliation has a bearing on SBI. Similarly, the level of education of the woman has a strong positive association with SBI – the higher the level of education of the woman the longer the SBI and vice versa. Women without any education had a shorter SBI (Tri-mean 30.75 months, spread 10.5 months) while women having higher education had the longest SBI (Tri-mean 45 months, spread 21 months. The upward gradient with education is found to be statistically significant (p = 0.000), highlighting education as a major determinant of SBI.

Table 1: Summary measures of log rank test for median of second birth interval of Uttar Pradesh according to socio-demography characteristics.

Characteristic	Number	Per cent	Tri-mean (months)	Spread	Log rank test for median (*p*-value)
Age at first birth					
≤20 years	5,880	26.00	31.75	11.5	0.000
>20 years	16,736	74.00	35.25	14.5	
Religion					
Hindu	19,181	84.81	34.25	13.5	0.000
Muslims	3,435	15.19	31.00	12.0	
Education					
No Education	4,946	21.87	30.75	10.5	0.000
Primary	2,758	12.19	30.25	10.5	
Secondary	10,216	45.17	33.00	13.0	
Higher	4,696	20.76	45.00	21.0	
Place of residence					
Urban	3,999	17.68	40.50	20.0	0.000
Rural	18,617	82.32	32.75	12.5	
Sex of first child					
Male	12,503	55.28	34.25	13.5	0.001
Female	10,113	44.72	34.00	13.0	
Wealth index					
Poorest	4,999	22.10	30.75	10.5	0.000
Poorer	5,833	25.79	32.00	12.0	
Middle	4,386	19.39	33.00	13.0	
Richer	3,793	16.77	36.00	15.0	
Richest	3,605	15.94	44.25	22.5	
Social Class					
SC/ST	6,016	26.60	32.00	12.0	0.000
OBC	12,368	54.69	34.00	13.0	
Others	4,232	18.71	38.00	18.0	
Ever had Foetal Loss/ Still Birth					
No	18,346	81.12	34.00	13.0	0.000
Yes	4,270	18.88	35.50	15.0	
Mass Media Exposure					
Not exposed	7,360	32.54	31.50	11.0	0.000
Exposed	15,256	67.46	34.25	14.5	
Total	22,616	100.00	34.25	13.5	

Remarks: SC: Scheduled Castes; ST: Scheduled Tribes; OBC: Other Backwards Classes.
Source: Authors

Place of residence also matters. Urban women have a longer SBI (tri-mean 40.5 months, spread 20 months), compared to rural women (tri-mean 32.75 months, spread 12.5 months) and the difference is statistically significant. The reason for this difference may be traced to better access to healthcare and family planning services in the urban areas. The sex of the first child also influences SBI. Women whose first child is male have a longer SBI (tri-mean 34.25 months, spread 13.5 months compared to women whose first child is female (tri-mean 34 months, spread 13 months). Although the tri-mean is nearly identical in the two groups of women, yet the log-rank test shows that the difference is statistically significant difference ($p = 0.001$) which means that the sex of the first child does have an impact on SBI.

Table 1 also shows that the SBI is also influenced by such covariates as the living standard of women as measured through the household wealth index, social class, and exposure to mass media. The history of foetal loss or stillbirth also has an impact of SBI as women having the history of foetal loss or still birth have a longer SBI (tri-mean 35.5 months, spread 15 months) compared to SBI in women who had no history of foetal loss and still birth (tri-mean 34 months, spread 13 months) and the difference is statistically significant ($p=0.000$) which suggests that adverse reproductive experience may have an impact on SBI. Figure 1 presents KM survival curves which show the probability that a woman does not have the second birth within the given time since the first birth, by various socio-demographic and reproductive characteristics of women. Each curves compares survival functions across different categories of women.

We have applied the Cox proportional hazard (CPH) model to identify the predictors of the time to second birth given that the woman already has a child and the results of the fitting of the model are presented in Table 2. The table suggests that the age at first birth, religion, level of education, place of residence, standard of living, social class, and the history of foetal loss or still birth are significant predictors of the time to second birth from the time of the first birth (SBI). A hazard ratio (HR)>1 indicates an increased probability of the second birth within a given time which implies a shorter SBI) while an HR <1 implies a reduced probability of the second birth within the given time period or delayed progression to the second birth, leading to a longer SBI. Two models are fitted. The first model excludes the sex of the first child as predictor while the second model includes the sex of the first child as predictor of SBI. A comparison of the two models highlights the impact of the sex of the first child on SBI.

Model 1 indicates that women whose age at first birth exceeds 20 years have around 8 per cent lower chance of progressing to a second birth compared to women whose age at first birth is less than or equal to 20 years. Similarly, Muslim women have 15 per cent chance of progressing to second birth compared to Hindu women. Women having primary education have around 4 per cent higher chance of progressing to second birth compared to women with no education but the difference is not statistically significant. On the other hand, women having secondary education have around 5 per cent lower chance of progressing to second birth compared to women with not education and the difference is statistically significant. By comparison, women having higher education have almost 30 per cent lower chance of progressing to the second birth relative to women with no education. Women living in the rural areas also have almost 16 per cent higher chance of progressing to the second birth within the given time period compared to the women living in the urban areas and this ratio is found to be statistically significant which indicates that the residence of woman is a strong predictor of SBI.

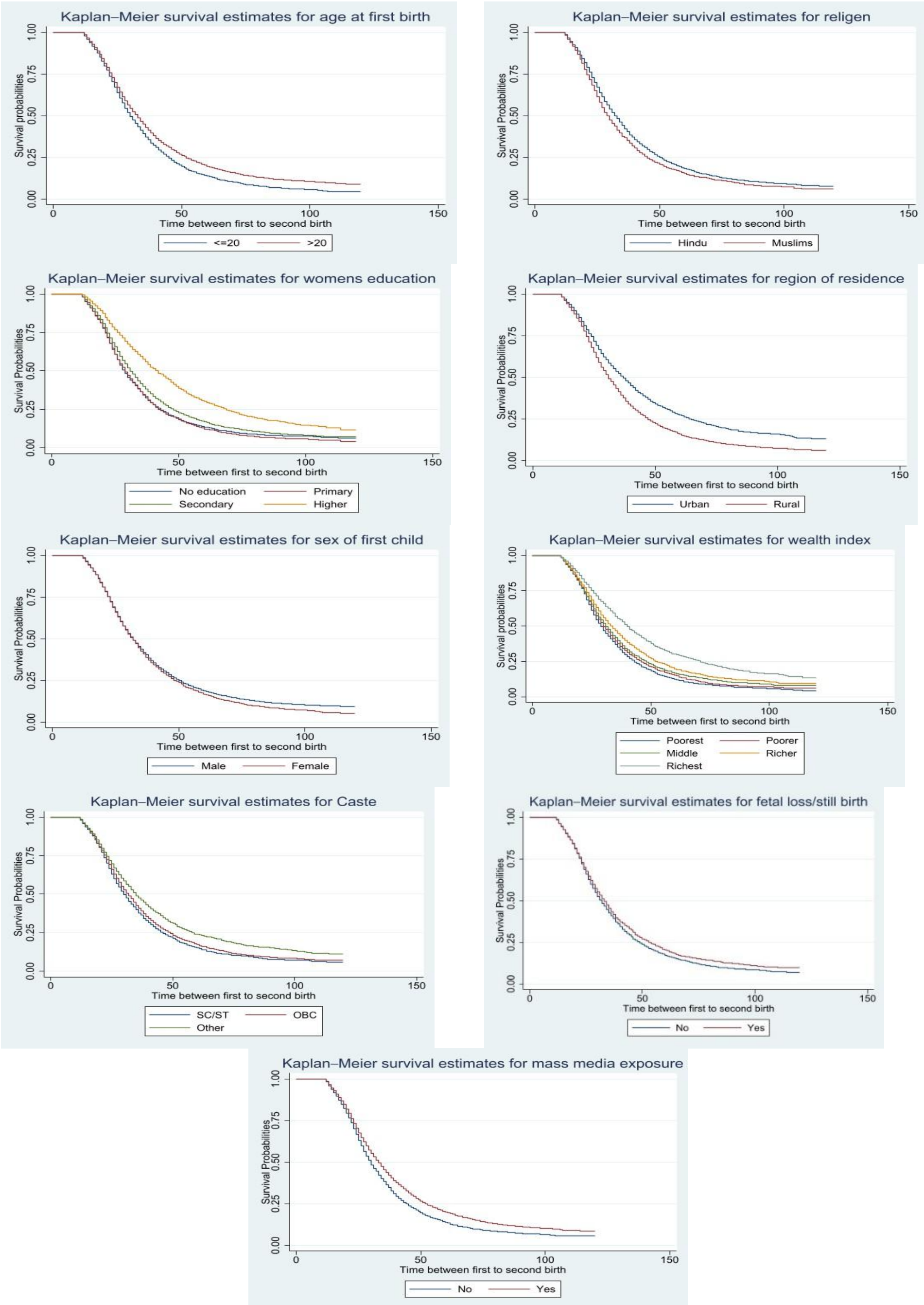


Figure 1: Kaplan-Meier curve of progression to second birth by time according to different characteristics of women.
Source: Authors.

Table 2: Results of fitting the Cox proportional hazard model.

Characteristics	Model 1			Model 2		
	HR	Z	*p*-value	HR	Z	*p*-value
Age at First Birth						
≤20 years$						
>20 years	0.922	-4.40	0.000	0.922	-4.41	0.000
Religion						
Hindu$						
Muslim	1.156	5.95	0.000	1.155	5.90	0.000
Education						
No Education$						
Primary	1.043	1.50	0.135	1.042	1.48	0.139
Secondary	0.951	-2.26	0.024	0.952	-2.22	0.026
Higher	0.707	-11.45	0.000	0.708	-11.41	0.000
Place of Residence						
Urban$						
Rural	1.158	5.66	0.000	1.158	5.67	0.000
Wealth Index						
Poorest$						
Poorer	0.968	-1.37	0.170	0.968	-1.34	0.179
Middle	0.959	-1.54	0.124	0.959	-1.53	0.125
Richer	0.919	-2.75	0.006	0.920	-2.72	0.007
Richest	0.799	-6.20	0.000	0.800	-6.17	0.000
Social Class						
SC/ST$						
OBC	0.958	-2.13	0.033	0.959	-2.11	0.035
Others	0.875	-4.93	0.000	0.876	-4.91	0.000
Ever had Foetal Loss/ Still Birth						
No$						
Yes	0.933	-3.35	0.001	0.932	-3.37	0.001
Mass Media Exposure						
Not exposed$						
Exposed	0.985	-0.78	0.437	0.984	-0.80	0.422
Sex of first child						
Male						
Female				1.042	2.47	0.014
-2log-Likelyhood	263118.94			263112.86		

$Reference category
Remarks: SC: Scheduled Castes; ST: Scheduled Tribes; OBC: Other Backwards Classes.
Source: Authors

The table also reveals a clear socioeconomic gradient in the progression to second birth. Compared to women having the poorest living standard, there is no statistically significant difference in time to second birth in women having poor and middle level of standard of living. However, the probability of progression to second birth is statistically significantly lower in women with richer and the richest standard of living. Women with the richest standard of living has more than 20 per cent lower probability of progressing to second birth compared to women having the poorest standard of living. Social class differences in the probability of progression to second birth with a given time are also apparent from the table.

The table also shows statistically significant impact of the history of foetal loss or still birth on the progression to second birth. It may, however, be recognised that the interval between two successive live births also includes the interval between the time of the first birth and the time of foetal loss or still birth. This means that the experience of foetal loss or still birth leads to the increase in the interval between two successive live births. At the same time, it may also lead to a decrease in the time of progress to the next live birth after foetal loss or still birth as there is impetus for the next birth after a foetal loss or still birth.

Model 2 includes the sex of the first child as predictor of the probability of progression to the second child and it is evident that the sex of the first child has a statistically significant impact on the probability of progression to the second child even after controlling other predictor variables. The probability of progression to the second child in a given time is found to be more than 4 per cent higher in women whose first child is female as compared to women whose first child is male. It may also be seen from the table that the -2log-likelihood of Model 2 is smaller than the -2log-likelihood of Model 1 which indicates that the inclusion of the sex of the first child as the predictor variable increases the explanatory power of the Model.

Discussions

This study provides critical insights into the dynamics of SBI among ever-married women in UP, India, using non-parametric KM and semi-parametric CPH survival analysis techniques. The analysis not only describes the median timing of second birth but also identifies key socio-demographic and behavioural factors influencing the SBI. The study shows the median SBI is 32 months. Our findings align with previous state-level analyses which reported, interval between subsequent birth approximately 32 months and significant variation across socioeconomic and educational groups (Singh et al, 1993). The average second birth interval estimated in our study is also close to the WHO recommended birth interval of 24-33 months (WHO, 2007). The analysis shows that SBI varies by different socioeconomic, and other characteristics of women in Uttar Pradesh.

The analysis confirms that the age of woman at first birth is a significant predictor of the SBI, with women initiating childbearing after age 20 having longer SBI. This aligns with previous studies, which show delayed first births are often associated with higher autonomy and more deliberate fertility planning (Ní Bhrolcháin and Beaujouan, 2012).

Religious affiliation emerged as a strong predictor of SBI. Muslim women have shorter birth intervals compared to Hindu. This could reflect distinct cultural norms around family size, contraceptive acceptance, and reproductive decision-making. This finding is almost consistent with other studies (Bhalotra and Van Soest, 2008).

This study shows there exists an inverse relationship between educational attainment and the hazard of second birth in Uttar Pradesh, India. The study reveals that women with secondary or higher education experienced significantly longer SBI than women having less than secondary education. Education is likely to enhance the awareness and knowledge of women about contraceptive options and improves their decision-making capacity leading to the delays in the first birth, and creating conditions for longer birth spacing. Similar findings have also been reported by Singh (1993), who has observed that higher educational attainment of women is associated with longer birth intervals in Uttar Pradesh. On the other hand, the impact of the standard of living, measured in terms of the household wealth index index has been found to be low uniformly across all categories, but women from the richest households are found to have a significantly lower hazard of a second birth which suggests longer duration between the time of the first live birth and the time of the second live birth, possibly through better access to healthcare, education, and family planning services.

The study has also found that that women residing in rural areas of the state face a significantly higher risk of having second live birth in a short interval compared to urban women. This disparity may be attributed to limited access to reproductive health services, lower educational attainment, and the prevalence of pronatalist norms that encourage early and closely spaced childbearing in rural areas (Stephenson et al, 2007). In contrast, urban women often benefit from greater exposure to health information, improved healthcare infrastructure, and enhanced social and economic mobility, all of which contribute to delayed and better-spaced births. Social class also appears to influence birth spacing. Women from OBC and other social classes had marginally longer SBI compared to SC/ST and the findings align with the results of earlier studies (Singh, 1993). These differences are statistically significant. Women who experienced terminated pregnancies (either miscarriage, stillbirth, or abortion) have longer SBI. This could reflect physical or emotional recovery periods following a pregnancy loss, or more cautious fertility planning thereafter (Abebe and Yohannis, 1996). These findings emphasise the need for improved postpartum counselling and mental health support to mitigate the adverse effects of pregnancy loss on future reproductive behaviour.

The sex of the first child has been found to have statistically significant influence on the time of the second live birth. The study reflects the influence of prevailing son preference in many societies, where parents, particularly in the context in which strong cultural or economic values are placed on the male offspring, often accelerate subsequent childbearing when the first child is a female in the expectation that the next child will be a son. Consequently, the length of the second birth interval is influenced by the sex of the first child highlighting the continuing impact of gender preferences on reproductive behaviour.

The findings of this study have important implications for public health policy and planning for reproductive health services in Uttar Pradesh. Investing in the education of women, especially, secondary, and higher education can be a powerful lever to delay and better space births. Programmes should focus on rural women, Muslim population, and those with lower education levels, who are more likely to have shorter SBI. Postpartum family planning initiatives must emphasise the timing and purpose of contraceptive use, not just access. Media campaigns and community-level interventions must consider religious and cultural beliefs to effectively influence birth spacing behaviour. Women who experience pregnancy loss need targeted reproductive and psychological health interventions to support informed future fertility decisions.

Conclusion

This study highlights the importance of socio-economic, cultural, and demographic factors that affect the progression from first birth to second birth in Uttar Pradesh. The use of non-parametric and semi-parametric survival analysis provides a deep understanding about the determinants of SBI, with key insights into how various factor influence the progression from first to second birth. The findings highlight the critical role of education, delayed first births, and wealth in achieving longer birth intervals, and further emphasize the need for targeted family planning strategies tailored to the unique needs of different population segments. These insights can inform more responsive and equitable reproductive health policies that align with both health outcomes and fertility reduction goals in the most populous state of India.

References

Abebe GM, Yohannis A (1996) Birth interval and pregnancy outcome. *East African Medical Journal* 73(8): 552-555.

Afolabi RF, Palamuleni ME (2022) Influence of maternal education on second childbirth interval among women in South Africa: rural-urban differential using survival analysis. *SAGE Open* 12(1):1-14.

Ahammed B, Kabir MR, Abedin MM, Ali M, Islam MA (2019) Determinants of different birth intervals of ever married women: Evidence from Bangladesh. *Clinical Epidemiology and Global Health* 7(3): 450-456.

Al-Rumhi AAS, Arulappan J, Al-Hashmi I (2023) Short interpregnancy interval and adverse pregnancy outcomes among women in a Middle Eastern country. *British Journal of Midwifery* 31(6): 325-335.

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 (1997) Trends in unwanted childbearing in the developing world. *Studies in Family Planning* 28(4): 267–277.

Bongaarts J, Potter RG (1983) *Fertility, Biology, and Behaviour: An Analysis of the Proximate Determinants*, New York, Elsevier.

Casterline JB, Odden C (2016) Trends in inter-birth intervals in developing countries 1965-2014. *Population and Development Review* 42(2): 173–194.

Conde-Agudelo A, Rosas-Bermúdez A, Kafury-Goeta AC (2006) Birth spacing and risk of adverse perinatal outcomes: a meta-analysis. *JAMA* 295(15): 1809–1823.

Cox DR (1972) Regression models and life-tables. *Journal of the Royal Statistical Society: Series B* 34(2): 187-202.

Fallahzadeh H, Farajpour Z, Emam Z (2013) Duration and determinants of birth interval in Yazd, Iran: a population study. *Iranian Journal of Reproductive Medicine* 11(5): 379–384.

Halli SS, Ashwini D, Dehury B, Isac S, Joseph A, Anand P, Gothalwal V, Prakash R, Ramesh BM, Blanchard J, Boerma T (2019) Fertility and family planning in Uttar Pradesh, India: major progress and persistent gaps. *Reproductive Health* 16(1): 1-12.

Hutcheon JA, Nelson HD, Stidd R, Moskosky S, Ahrens KA (2019) Short interpregnancy intervals and adverse maternal outcomes in high-resource settings: an updated systematic review. *Paediatric and Perinatal Epidemiology* 33(1): 48–59.

Government of India (2022) *National Family Health Survey (NFHS-5)*, 2019-21: India. New Delhi, Ministry of Health and Family Welfare, International Institute for Population Sciences, and ICF.

Kaplan EL, Meier P (1958) Nonparametric estimation from incomplete observations. *Journal of the American Statistical Association* 53(282): 457–481.

Mahmood S, Zainab B, Latif AHMM (2013) Frailty modeling for clustered survival data: an application to birth interval in Bangladesh. *Journal of Applied Statistics* 40(12): 2670–2680.

Marini MM, Hodsdon PJ (1981) Effects of the timing of marriage and first birth on the spacing of subsequent births. *Demography* 18(4): 529–548.

Moultrie TA, Sayi TS, Timæus IM (2012) Birth intervals, postponement, and fertility decline in Africa: a new type of transition? *Population Studies* 66(3): 241–258.

Mowa Z (2023) Determinants of second child birth interval among women of Lusaka Province: a Cox regression model. https://doi.org/10.1101/2023.02.15.23285966

Nair SN (1996) Determinants of birth intervals in Kerala: an application of Cox's hazard model. *Genus* 52(3/4): 47–65.

Nath DC, Leonetti DL, Steele MS (2000) Analysis of birth intervals in a non-contracepting Indian population: an evolutionary ecological approach. *Journal of Biosocial Science* 32(3): 343-354.

Ní Bhrolcháin M, Beaujouan É (2012) Fertility postponement is largely due to rising educational enrolment. *Population Studies* 66(3): 311–327.

Páez A, Boisjoly G (2022) Exploratory data analysis. In R Gentleman, K Hornik, P Giovanni (Eds) *Discrete Choice Analysis with R*. Springer.

Rajan S, Nanda P, Calhoun LM, Speizer IS (2018) Sex composition and its impact on future childbearing: a longitudinal study from urban Uttar Pradesh. *Reproductive Health* 15(1): 35.

Rindfuss RR, Bumpass LL, Palmore JA (1987) Analysing fertility histories: do restrictions bias results? *Demography* 24(1): 113–122.

Santhya KG, Jejeebhoy SJ, Ghosh S, Haberland N (2007) Addressing the sexual and reproductive health needs of young people: perspectives and experiences of stakeholders from the health and non-health sectors. Research update. New Delhi: Population Council. https://doi.org/10.31899/pgy17.1020

Seyedtabib M, Moghimbeigi A, Mahmoudi M, Majdzadeh R, Mahjub H (2020) Pattern and determinant factors of birth intervals among Iranian women: a semi-parametric multilevel survival model. *Journal of Biosocial Science* 52(4): 534–546.

Shukla AK, Yadava RC, Tiwari AK (2018) Measuring son preference through number of children born. *Demography India* 47(2): 67-82.

Singh BP, Rai H (2025) Analysing menstruating interval to the first conception: an application of CPH and AFT Models. *Journal of Population and Social Studies* 34(1): 199–216.

Singh BP, Singh G, Singh KK (2016) Heterogeneity in waiting time to first conception in Uttar Pradesh: a parametric regression analysis. *Demography India* 45(1-2): 77-88.

Singh KK, Suchindran CM, Singh V, Ramakumar R (1993) Analysis of birth intervals in India's Uttar Pradesh and Kerala States. *Journal of Biosocial Science* 25(2): 143–153.

Stephenson R, Baschieri A, Clements S, Hennink M, Madise N (2007) Contextual influences on modern contraceptive use in sub-Saharan Africa. *American Journal of Public Health* 97(7): 1233–1240.

Trussell J, Menken J (1978) Early childbearing and subsequent fertility. *Family Planning Perspectives* 10(4): 209–218.

Wellek S (1993) A log-rank test for equivalence of two survivor functions. *Biometrics* 49(3): 877–881.

Wilcox RR (2011) *Introduction to Robust Estimation and Hypothesis Testing*, 3rd ed. New York, Elsevier.

World Health Organization (2007) Report of a WHO Technical Consultation on Birth Spacing. Geneva, World Health Organization.

Yadava RC, Tiwari AK, Singh PK (2025) A parity-dependent model for number of births and its applications: some more insights. *Mathematical Population Studies*, 1–23.

INDIAN JOURNAL OF POPULATION AND DEVELOPMENT
ISSN: 2583-4827; Volume 5(1), January 2025: 129-145

Navigating the Trajectories of Female Migration in India

Grace Bahalen Mundu
Moatula Ao
S. Limakumba Walling

Abstract

This paper examines determinants of female out migration for education and employment and explores trajectories of female migrants in India. The paper reveals that most of the northeastern states of the country show higher female out migration for education and employment compared to other states. Mizoram has the highest female out migration for employment followed by Nagaland whereas, Nagaland has the highest female out migration for education. Intra-state and intra-district out migration for education and employment is found to be high but inter-state out migration has been found to be low. The female out migration for education and employment is found to be associated with female mean age at marriage and female work participation rate. The paper concludes that increasing female age at marriage can act as a tool to pursue females for higher studies and contribute to economic activity rather than just as migrating as an associate of their husband.

Introduction

Migration is one of the most important components of population change, as it can lead to a dramatic increase or decrease in the population of any region or country. There are many reasons for migration, including economic, social, political, and climatic conditions etc., but most people migrate for economic reasons. According to the United Nations, India had the largest diaspora in the year 2020, with 18 million Indians living outside the country (United Nations, 2020). India also has a large number of internal migrants, and this was reflected during the COVID-19 pandemic as it created a severe mobility crisis due to large number of return migrants (Rajan et al, 2020). There is evidence to suggest that movement of the people within the country is increasing over the decades. According to the 1991 population census, there were 220 million internal migrants in India which increased to 315 million at the 2001 population census and 454 million according to the 2011 population census (Government of India, 2017a). The latest estimates suggest that the migration rate – the proportion of migrant population in the total population - was almost 29 per cent in the country – around 27 per cent in the rural areas and almost 35 per cent in the urban areas (Government of India, 2022). The migration rate was higher in females (47.9 per cent) compared to males (15 per cent). The female migration rate was nearly the same in rural and urban areas, but the male migration rate was substantially lower in rural areas as compared to urban areas (Government of India, 2022). The higher migration rate in female has primarily been due to marriage-migration. Between 1991 and 2001, an increase in marriage and family-migration accounted for around 72 per cent of the increase in the number of female migrants in this country. This proportion increased to almost 75 per cent between 2001 and 2011. Between the marriage-related migration and family-related migration, however, the share of marriage-related migration has decreased but the share of family-related migration has increased (Government of India, 2017a).

In the national context, female migrants are generally classified into three distinct categories. The first category comprises of autonomous female migrants. These migrants usually move out from their native place for better education and employment opportunities and belong primarily to middle and upper middle-class families. The second category of female migrants are those female migrants who move out of their native place to work as domestic help to augment family income. Finally, the third category of female internal migrants are those female migrants who move with their husband who migrated in search of employment and livelihood opportunities (Fawcett et al, 1984).

Female migrants are generally termed as the vulnerable group of population as they are often faced with low wages, discrimination, and exploitation at their place of destination, threatening their health and health of their children (Bhan et al, 2020). Female migrants are also at higher risk of sexual harassment and exploitation (Saradamoni, 1995; Teerink, 1995). The vulnerability of female migrants is reflected in the post pandemic situations where there has been an increase in household responsibilities and caring of children (Chauhan, 2022) which resulted in a disproportionate increase in the burden on women, leading to worsening of mental health and well-being (Bau et al, 2022). It is in the above context that this paper attempts to analyse the pattern and the trend in female internal migration in India and examines social and economic factors that contribute to female internal migration in the country.

Female Internal Migration in India

The Periodic Labour Force Survey, 2020-21 has estimated that the migration rate for females was 47.9 per cent. The main reason for female migration was marriage (Government of India, 2022). The survey revealed that around 91 per cent of rural female migrants and 61 per cent of urban female migrants migrated because of marriage. Other studies have also found that marriage is the dominant reason for female migration in India (UNICEF, 2020; Bhagat and Kesari, 2020). The Economic Survey of India, 2017, on the other hand, estimated that inter-state migration in the country was around 9 million annually during the period 2011-2016 (Government of India, 2017b). According to the 2011 population census, Uttar Pradesh and Bihar are the leading states for out-migration, followed by Madhya Pradesh, Punjab, Rajasthan, Uttarakhand, Jammu and Kashmir, and West Bengal. The major destination states are Delhi, Maharashtra, Tamil Nadu, Gujarat, Andhra Pradesh, and Kerala (Sharma, 2017).

The trend and pattern of internal migration in India during the period 1971-2001 show that women dominate both short- and long-distance migration. There is an increasing trend in the number of women migrating due to marriages or moving with their family/household members. It has also been observed that the rate of migration is higher among better-off sections of the society compared to the poor and the disadvantaged population groups (Bhagat, 2009). Education and age have also been found to be major factors in migration, as educated females and younger women become an asset for the economy and the family (Das, 2018). The migration rate peaks at age 20 years for females and at age 25 years for males (Bhagat and Kesari, 2020). It has also been observed that female migration rate for work/employment is increasing over time, although migration for work/employment in females remains substantially lower than male migration rate (Vivek, 2017). It is observed that females are migrating for work/job even after they have migrated due to marriage (Deshingkar and Akter, 2009). During the COVID-19 pandemic, the country witnessed very heavy return migration. However, after the pandemic, female out migration was slower than male out migration. It is argued that the slower female out migration has resulted lower economic benefits to women compared to men, which has impacted their well-being and making them more vulnerable (Allard et al, 2022).

There are studies that have investigated the linkages between husband migration and autonomy of left-behind women, educational qualification and the effect of their age on the decision to migrate, and trends and patterns of internal migration (Das, 2018; Shattuck et al, 2019; Bhagat, 2009; Rajan and Sumeetha, 2019). However, studies related to the social and economic determinants of female migration and the place of destination of female migrants are sparse.

Data and Methods

The paper is based on the data available from 2011 population census and Periodic Labour Force Survey 2020-2021. The population census in India has been collecting data on migration since 1872, but it was only after 1961 population census that data on the rural and urban status of the place of birth and the duration of stay at the place of enumeration were collected. In the 1971 population census, additional information on the place of last residence in relation to the place of birth was also collected while a question on the reason for migration was asked for the first time at the 1981 population census. Since then, the data on migration collected at the decennial population censuses have remained the same with the exception of the 2001 population census in which rural-urban status of the place of birth was not collected and natural calamities as one of the reasons for migration was not asked whereas moved at birth was included as the reason for migration. The migration status of an individual in the decennial population census is asserted on the basis of the place of last residence and the place of enumeration and the place of birth and place of enumeration. When a person is enumerated at a place different from the place of birth, that person is classified as a migrant by the place of birth. A person is also classified as a migrant if the place of the last residence of the person is different from the place of enumeration. In the present study, an individual is classified as a migrant if the place of enumeration of the individual is different from the place of last residence of the individual.

Findings

The total population of India at the 2011 census was enumerated to be 1210 million out of which 456 million or about 38 per cent of the population was classified as migrant in the sense that the place of enumeration of was different from the place of the last residence. Among females, the proportion of the migrant population was almost 53 per cent. The sex ratio of the migrant population was heavily favourable to females, as there were 212 female migrants for every 100 male migrants during the 2011 census. On the other hand, the Periodic Labour Force Survey (PLFS) conducted by the Government of India during 2020-2021 has estimated that there were around 318 million migrants in the country out of which 256 million or more than 81 per cent were females (Government of India, 2022).

The share of the female migrants in the total migrant population has, however, decreased over time. At the 1991 population census female migrants constituted more than 72 per cent of the total migrant population. This proportion decreased to around 70 per cent at the 2001 population census and to less than 68 per cent at the 2011 population census. According to the PLFS 2020-2021, female migrants accounted for more than 78 per cent of the total migrants surveyed. The growth of female migrants has also been slower than the growth of male migrants, according to the data available from population censuses. Between 1991 and 2001, female migrants in the country increased at an average annual rate of around 2.8 per cent per year, whereas male migrants increased at an average annual rate of 3.7 per cent per year. Between 2001 and 2011, female migrants increased, on average, at 3.4 per cent per year whereas male migrants increased at an average annual rate of almost 4.5 per cent per year. There has been no population census in the country since 2011 to estimate the growth of female migrants as compared to the growth of male migrants.

Table 1: Migrants in India by reason of migration, 2011

Reason for migration	Number		Per cent	
	Males	Females	Males	Females
Work/Employment	3,50,16,700	64,06,217	24.0	2.1
Business	26,83,144	9,07,343	1.8	0.3
Education	32,96,340	21,61,216	2.3	0.7
Marriage	53,46,733	20,58,39,698	3.7	66.5
Moved after birth	2,00,78,947	1,37,76,918	13.7	4.4
Moved with HH	2,96,79,662	3,62,80,253	20.3	11.7
Other	5,00,44,441	4,42,70,009	34.2	14.3
Total migrants	14,61,45,967	30,96,41,654	100.0	100.0
Migrant rate (per cent)	12.07	25.57		

Source: Census of India 2011

The reasons for migration are contrastingly different in females as compared to males. The PLFS 2020-2021 suggests that for almost 87 per cent of female migrants, the reason for migration was marriage, whereas for almost half of the male migrants, the reason for migration was livelihood-related factors. Only about 1.7 per cent of the female migrants reported at the time of PLFS 2020-2021 that they migrated for livelihood-related factors, whereas around 7 per cent reported that they migrated because the family migrated. On the other hand, data available from the 2011 population census suggests that the reason for migration for more than two-third of the female migrants was marriage. The 2011 population census also reveals that only around 2 per cent of the female migrants migrated because of livelihood related factors.

Migration of female because of marriage may be termed as trivial as this migration is not governed by the push and pull theory of migration. If marriage migration of females is excluded, then the number of female migrants in the country decreases sharply. The 2011 population census suggests that when marriage migration is excluded, there were 737 female migrants for every 1000 male migrants in the country, whereas PLFS 2020-2021 suggests 562 female migrants for every 1000 male migrants. However, when marriage migration is included, there were almost 2119 female migrants for every 1000 male migrants according to 2011 population census and 3580 female migrants for every 1000 male migrants according to PLFS 2020-2021.

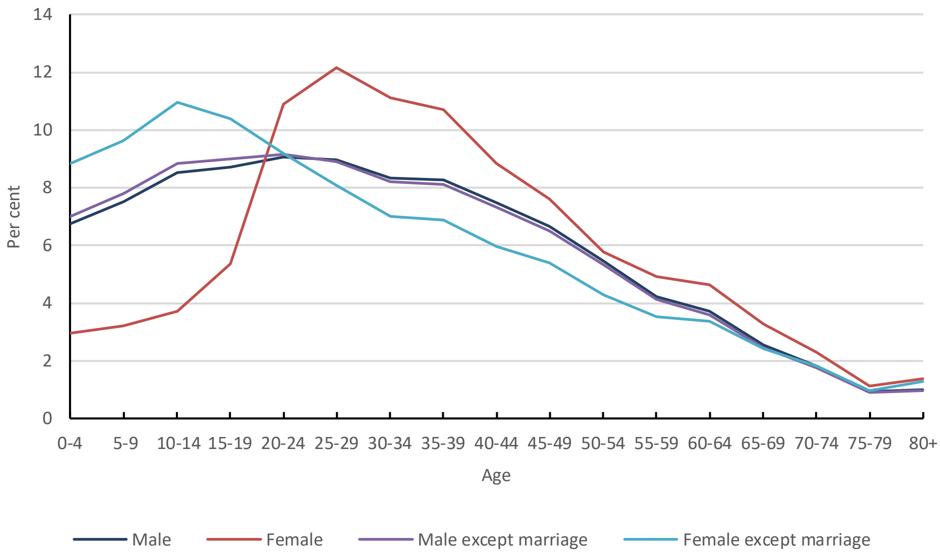


Figure 1: Age composition of male and female migrants in India as compared to that of male migrants and female migrants migrated except marriage.
Source: Authors, based on data from the 2011 population census.

Characteristics of Female Migrants. Since migration of females due to marriage may be termed as trivial, which is not governed by the push and pull theory of migration, it should have been more appropriate that females who migrated due to marriage are excluded from the analysis. However, limited data are available for carrying out such an analysis. As such, the analysis is carried out for all female migrants, including females who migrated due to marriage when data by reasons of marriage are not available.

Figure 1 shows the age composition of all female migrants and female migrants who migrated because of reasons other than marriage, along with all male migrants and male migrants who migrated for reasons other than marriage, as obtained from the 2011 population census. There is little change in the age-composition of male migrants when marriage migration is excluded but the age composition of female migrants changes drastically when marriage migration is excluded. Since marriage migration is not associated with push-pull factors of migration, excluding marriage migration gives the correct picture of the age composition of female migrants.

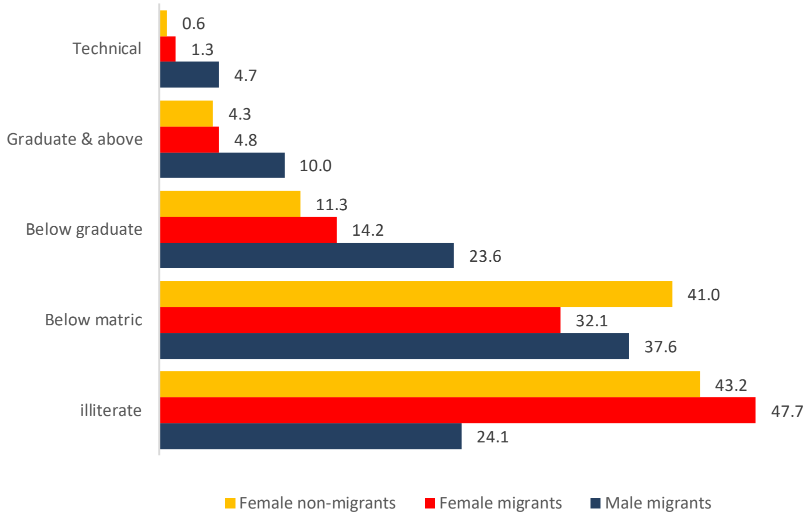


Figure 2: Educational status of female migrants as compared to that of male migrants and female non-migrants in India.
Source: Authors based on 2011 population census.

The educational status of female migrants has also been found to be different from that of male migrants. The primary reason for the migration of males is for livelihood opportunities, and the level of education plays an important role in the quest for better living opportunities. This is not the case with female migrants, as the primary reason for female migration is marriage in which the level of education of the female plays no role in marriage migration. According to the 2011 population census, almost half of the female migrants were illiterate, whereas the proportion of male migrants who were illiterate was only 24 per cent. Because education has little relevance for most of female migrants, the level of education is always lower than the level of education of male migrants as may be seen from the figure 2.

The work participation rate (WPR) has been found to be higher in female migrants (39.6 per cent) as compared to female non-migrants (33.0 per cent) according to the 2011 population census (Figure 3). The difference between WPR of migrant and non-migrant females, however, is not large as majority of females migrate due to marriage and not for livelihood opportunities and other factors. The composition of migrant female workers has, however been found to be radically different from the composition of non-migrant female workers. Among the migrant female workers, more than 50 per cent were main workers, or they worked for at least 6 months during the year prior to the 2011 population census whereas this proportion was less than 30 per cent for female non-migrant workers. The proportion of migrant female workers who worked for less than 3 months during the year prior to the 2011 population census was substantially lower than that among non-migrant workers.

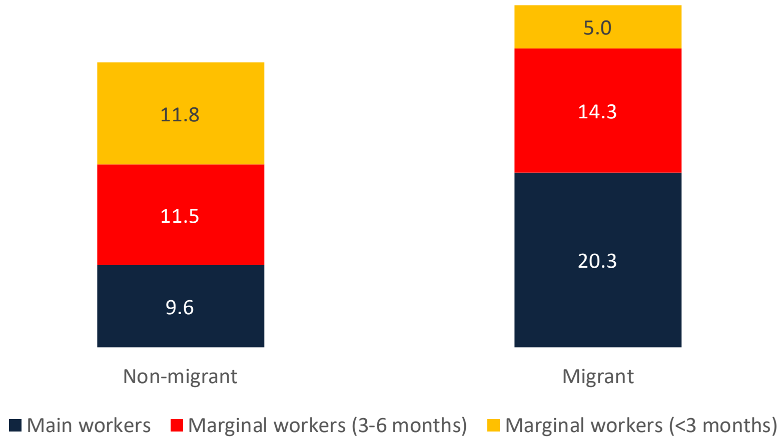


Figure 3: Work participation rate in migrant and non-migrant females in India.
Source: Authors, based on data from 2011 population census.

Regional pattern of female migrants for education and livelihood opportunities. In India, only about 0.7 per cent of female migrants reported at the 2011 population census that they migrated for education, while less than 2.4 per cent reported that they migrated for livelihood opportunities. This proportion, however, varies widely across states and Union Territories, as may be seen from the figure 4. More than 7 per cent of female migrants in Nagaland reported that they migrated for education. This proportion was only about 0.2 per cent in Bihar and West Bengal. In most of the states and Union Territories, less than 1 per cent of the female migrants reported that they migrated for education. There are only two states and Union Territories – Arunachal Pradesh and Puducherry – in addition to Nagaland where more than 4 per cent of the female migrants migrated for education.

As regards migration for livelihood, more than 10 per cent of the female migrants in Mizoram reported that they migrated for livelihood opportunities. This proportion was less than 1 per cent in Bihar. There are six states/Union Territories, in addition to Mizoram, where more than 5 per cent of the female migrants reported that they migrated in search of livelihood opportunities. In contrast, there are 7 states/Union Territories, in addition to Bihar, where less than 2 per cent of the female migrants reported that the search for better livelihood opportunities was the reason for migration. A higher proportion of female migrants reporting migration in search of livelihood opportunities implies that there were limited livelihood opportunities for females at the place from where they had migrated any time before the 2011 population census. Regional pattern in the migration of females for education and for livelihood opportunities may also be seen from the figure.

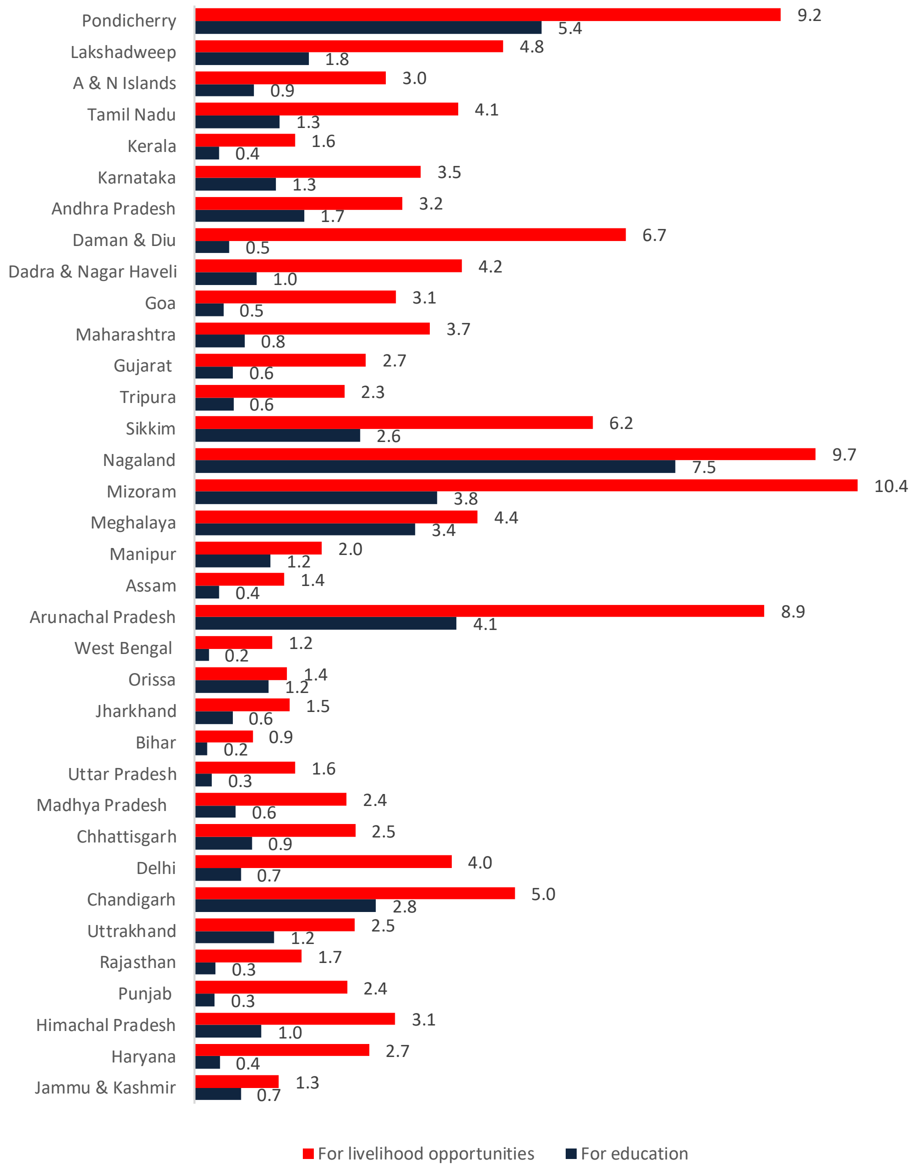


Figure 4: Variation across states/Union Territories in the proportion of female migrants reporting education and livelihood opportunities as reason for migration.
Source: Authors based on data from 2011 population census

Streams of female migration. The movement of the population can be classified as movement within the same district, movement across districts within the same state, and movement across states. In each of the three types of movement, migration can be further classified as movement from rural to rural areas (rural-to-rural), movement from rural to urban areas (rural-to-urban), movement from urban to rural areas (urban-to-rural), and movement from urban to urban areas (urban-to-urban). Table 2 provides the two-way classification of female migrants in the country as revealed through the 2011 population census. It may be seen from the table that within-district migration was the most common among female migrants, while inter-state migration was the least common. Almost two-third of the female migrants migrated within the same district while around 28 per cent migrated across districts within the same state. On the other hand, only about 10 per cent of the female migrants migrated across states/Union Territories of the country. In case of within-district and between-district movement of females, rural-to-rural migration was the most common, but in case of inter-state movement, rural-to-rural, rural-to-urban, and urban-to-urban movement of females was found to be almost equally important. The dominance of rural-to-rural migration among females is because marriage is the main reason for migration.

Table 2: Streams of female migration in India, 2011.

Stream		Intra-district		Inter-district		Inter-state	
		Number	Per cent	Number	Per cent	Number	Per cent
Rural	Rural	12,76,09,690	73.40	4,02,76,694	52.43	90,31,125	31.36
Rural	Urban	1,98,98,698	11.44	1,40,78,484	18.33	88,51,526	30.73
Urban	Rural	95,83,261	5.51	54,60,684	7.11	17,93,554	6.23
Urban	Urban	1,67,73,385	9.65	1,70,04,954	22.14	91,25,243	31.68
Total		173865034		76820816		28801448	

Source: Authors based on data from 2011 population census.

Flow of Female Migrants

Table 3 and figure 4 shows the number of female in-migrants in a state/Union Territory at the 2011 population census along with the state/Union Territory accounting for the largest share of female in-migrants. In all states/Union Territories, majority of female in-migration were from the adjacent states/Union Territories. This is expected as marriage is the main reason for female migration females, and cross-border marriages are quite common in. Almost 88 per cent of female in-migrants in Puducherry were from Tamil Nadu only. Similarly, more than 81 per cent of the female in-migrants in Daman and Diu were from Gujarat only while almost two-third of female in-migrants in Sikkim were from West Bengal. On the other hand, the largest proportion of in-migrants in Manipur were from Nagaland but the proportion of in-migrants from Nagaland constituted less than 20 per cent of the total in-grants in Manipur which means that in-migration in Manipur has not been dominated by any single state/Union Territory. Similar scenario prevails in Rajasthan, Uttar Pradesh, and Bihar where the state/Union Territory accounting for the largest share of the in-migrants in the state/Union Territory accounted for less than 25 per cent of the total in-migrants in the state.

Table 3: Total number of female in-migrants from states/Union Territories in a state/Union Territory and states/Union Territories with the largest share of female in-migrants in the state/Union Territory, 2011.

State	Total female in-migrants from all states/UTs	State/UT which accounting for largest share of female in-migrants	Female migrants from the state	
			Number	Per cent
Jammu & Kashmir	163275	Punjab	47671	29.2
Himachal Pradesh	303789	Punjab	136453	44.9
Punjab	1066081	Haryana	376536	35.3
Chandigarh	136232	Punjab	74955	55.0
Uttarakhand	591149	Uttar Pradesh	296211	50.1
Haryana	1592214	Rajasthan	446005	28.0
NCT of Delhi	926839	Uttar Pradesh	337581	36.4
Rajasthan	2246796	Haryana	484513	21.6
Uttar Pradesh	6067612	Delhi	1338274	22.1
Bihar	3602243	Jharkhand	803314	22.3
Sikkim	13023	West Bengal	8542	65.6
Arunachal Pradesh	19871	Assam	12019	60.5
Nagaland	24689	Assam	13546	54.9
Manipur	38298	Nagaland	7402	19.3
Mizoram	15526	Tripura	9167	59.0
Tripura	46235	Assam	24611	53.2
Meghalaya	39849	Assam	24678	61.9
Assam	339293	West Bengal	97497	28.7
West Bengal	1451881	Jharkhand	388600	26.8
Jharkhand	1132846	Bihar	387878	34.2
Odisha	669621	Chhattisgarh	171516	25.6
Chhattisgarh	443445	Madhya Pradesh	112283	25.3
Madhya Pradesh	1981543	Uttar Pradesh	586859	29.6
Gujarat	886352	Maharashtra	528701	59.6
Daman and Diu	12076	Gujarat	9805	81.2
Dadra & Nagar Haveli	12267	Gujarat	8163	66.5
Maharashtra	1854139	Gujarat	521546	28.1
Andhra Pradesh	1195536	Karnataka	532446	44.5
Karnataka	1516952	Maharashtra	806985	53.2
Goa	61732	Maharashtra	40972	66.4
Lakshadweep	7114	Bihar	1831	25.7
Kerala	696031	Tamil Nadu	258993	37.2
Tamil Nadu	1061732	Karnataka	377345	35.5
Puducherry	167367	Tamil Nadu	146945	87.8
Andaman & Nicobar Islands	11289	Tamil Nadu	3335	29.5

Source: Authors based on the data from the 2011 population census.

Figure 5: Outflow of females from different states/Union Territories to different states/Union Territories in India, 2011.
Source: Authors based on the data from 2011 population census.

Table 4: Total number of female out-migrants from different states/Union Territories and the state/Union Territory where the largest share of female out-migration moved.

State	Total females out-migrants from the state/UT	State/UT where the largest share of out-migrants moved	Female out-migrants from the state	
			Number	Per cent
Jammu & Kashmir	87678	Punjab	31620	36.1
Himachal Pradesh	207448	Punjab	91605	44.2
Punjab	1373637	Haryana	391365	28.5
Chandigarh	296905	Punjab	80170	27.0
Uttarakhand	700622	Uttar Pradesh	521277	74.4
Haryana	2234428	Uttar Pradesh	627065	28.1
NCT of Delhi	3022073	Uttar Pradesh	1338274	44.3
Rajasthan	1829343	Haryana	446005	24.4
Uttar Pradesh	2971302	Bihar	779471	26.2
Bihar	947626	Jharkhand	387878	40.9
Sikkim	29331	West Bengal	18658	63.6
Arunachal Pradesh	60106	Assam	41539	69.1
Nagaland	46342	Assam	22246	48.0
Manipur	10868	Assam	4974	45.8
Mizoram	17242	Manipur	5908	34.3
Tripura	46658	Assam	19719	42.3
Meghalaya	55418	Assam	33274	60.0
Assam	257360	West Bengal	61054	23.7
West Bengal	1288453	Bihar	525291	40.8
Jharkhand	1434794	Bihar	803314	56.0
Odisha	519521	Jharkhand	113777	21.9
Chhattisgarh	729044	Odisha	171516	23.5
Madhya Pradesh	1876743	Uttar Pradesh	776738	41.4
Gujarat	1725863	Maharashtra	521546	30.2
Daman and Diu	38513	Gujarat	13031	33.8
Dadra & Nagar Haveli	53778	Gujarat	18087	33.6
Maharashtra	4194564	Uttar Pradesh	995456	23.7
Andhra Pradesh	984021	Karnataka	345006	35.1
Karnataka	1749106	Andhra Pradesh	532446	30.4
Goa	129232	Karnataka	59765	46.2
Lakshadweep	1676	Kerala	1446	86.3
Kerala	313095	Tamil Nadu	158137	50.5
Tamil Nadu	921633	Kerala	258993	28.1
Puducherry	203739	Tamil Nadu	165616	81.3
Andaman & Nicobar Islands	36775	Tamil Nadu	8783	23.9

Source: Authors based on the data from the 2011 population census.

Figure 5 shows the magnitude of the outflow of females from a particular state/Union Territory to other states and Union Territories of the country as revealed through the 2011 population census. The majority of the females of Jammu and Kashmir who migrated out of the state moved to Punjab. Similarly, most of the females who migrated out of Himachal Pradesh also moved to Punjab for various reasons including migration due to marriage. Punjab has also been a favourable destination for females who migrated out of Chandigarh. On the other hand, majority of females who migrated out of Punjab moved to the adjacent Haryana. Most of this out-migration is because of the marriage of females. The proportion of females who migrated out of the state/Union Territory because of marriage, however, varies across states and Union Territories. Likewise, the majority of the female in-migrants in a state/Union Territory abe been from the states/Union Territories adjecent to the state/Union Territory (Table 4).

Discussion

Globally, efforts have been made to raise the status of women and empower them through education and gainful employment. The evidence available from the decennial population census and from the Periodic Labour Force Survey conducted by the Government of India suggests that the primary reason for the migration of females in the country is marriage, which may be termed as trivial as females in India move to their in-laws house after marriage, irrespective of any social, economic or other factors. The marriage migration of females cannot be attributed to either the push or the pull factors that have commonly been identified as responsible for the movement of population away from either the place of their birth or the place of their last residence. In any analysis of female migration, especially in India, it is therefore important that marriage migration is excluded.

The present analysis reveals that female migration in India is substantially higher than the male migration in the country. However, when marriage migration is excluded, female migration is substantially lower than the male migration. Excluding the marriage migration is necessary to understand the true dynamics of female migration in the context of social and economic development.

There are several issues and debates on the migration of females that focus on the context of development, both at the international and national level such as international laws and labour migration, as many females are either trafficked or exploited (Sil, 2008). The focus on women studies gained prominence after the United Nations declared the year 1975 as the 'International Women's Year', after which studies on female migration received global attention. The concept of ‘feminisation of work’ and ‘feminisation of migration’ evolved due to the increase in female migration for employment and increase in the mobility of females (Deshingkar and Grimm, 2005). Our study revealed that there are regional variations in the pattern of movement of females for education and employment/business. Females migrating for education and livelihood is found to be higher the north-eastern region of the country than females of other regions. The north-eastern region of the country is dominated by the tribal population. In the tribal communities, female work participation rates are higher than in other population groups.

The analysis also reveals that the age composition of female migrants is different when marriage migration is included and when marriage migration is excluded from the analysis. When marriage migration is included, the marriage migration is very high in the age group 20-30 years as nearly all marriages take place in this age group. However, when marriage migration is excluded from the analysis, the age composition changes.

The present analysis reveals that the level of education is lower in female migrants as compared to female non-migrants. However, the work participation rate is higher in female migrants. This may be because of higher educational levels and feminisation of the work force. The higher work participation rate in female non-migrants is because of higher proportion of marginal workers. The proportion of main workers in female migrants is substantially higher than that in female non-migrants.

Among different streams of migration, the rural-to-rural migration is found to be the most common one among intra-district and inter-district within-state female migrants, but not among inter-state female migrants. This difference may again be attributed to the dominance of marriage migration in the intra-district and inter-district movement of females. The present analysis corroborates with other similar studies (Singh and Biradar, 2022). Most of the seasonal female migrants are mainly engaged in brick-kiln industry, construction, crop-cutting, domestic help, and wage labour (Saraswati et al, 2015; Sil, 2008; Government of India, 2010). The analysis has also revealed that among the inter-state migration, the majority of females migrate to neighbouring states only, which refer as short distance migrants (Vijay, 2005). The cross-border marriages may be one of the reasons.

Understanding the context of female migration requires separating female migration from marriage from female migration due to economic, social, and other reasons. Other studies have observed that better availability of employment opportunities is the most important pull factor for migration (Saraswati et al, 2015). Many women, especially from the north-eastern reason of the country migrate to other parts of the country as this reason is dominated by the tribal population and also development is quite low in this part of the country. Similar findings have been observed in other studies, which revealed that migrants from poorer villages migrate to richer or more urbanised areas (Rajan and Sumeetha, 2020; Kundu, 2003).

Conclusions

The study found that rural to rural migration is found to be dominant with short-distance migration. As majority of the female migrants were migrating to neighbouring states, only a small proportion of the female migrants were migrating to long distance migration. The intra-district and inter-district migrants of rural-to-rural area is found highest which could be due to marriage related reasons, while inter-state migration of rural to urban migration is found highest and this maybe for employment related reasons. There is a significant link between male and female migration patterns. Often, women migrate with their husbands or male partners after marriage, which can have economic implications. Notably, women who migrate tend to have high workforce participation rates, contributing to the economic dynamics of their destination locations. And if one looks at the economic status among the female migrants, it is relatively higher compared to female non-migrants, both as a main worker or marginal worker. Moreover, the data also revealed that the educational level of female migrants was mostly matric, but the higher educational level were among the female migrant compared to female non-migrant.

Finally, although the data available from the population census and from other sources reveal that the most prominent reason for female migration in India is the marriage, yet the economic contribution of migrant females needs to be highlighted. Therefore, delaying the age at marriage of girls and encouraging girls to go for higher education may help in reducing migration of females either as a marginal worker or as an associational migrant.

References

Allard J, Jagnani M, Neggers Y, Pande R, Schaner S, Moore CT (2022) Indian female migrants face greater barriers to post-covid recovery than males: evidences from a panel study. *EclinicalMedicine* 101631.

Bau N, Khanna G, Low C, Shah M, Sharmin S, Voena A (2022) Women's well-being during a pandemic and its containment. *Journal of Development Economics* 156: 102839.

Bhan G, Surie A, Horwood C, Dobson R, Alfers L, Portela A, Rollins N (2020). Informal work and maternal and child health: a blind spot in public health and research. *Bulletin of the World Health Organization* 98: 219–221.

Bhagat RB (2009) Internal migration in India: are the underclass more mobile? Paper presented in the 26th IUSSP General Population Conference, Marrakech, Morrocco.

Bhagat RB, Keshri K (2020) Internal migration in India. In M Bell, A Bernard, E Charles-Edwards, Y Zhu (Eds) *Internal Migration in the Countries of Asia*. Springer.

Chauhan P (2021) Gendering COVID-19: impact of the pandemic on women's burden of unpaid work in India. *Gender Issues* 38(4): 395-419.

Das P (2018). Education and age as the determinants of internal female migration in India: an analysis of secondary data. *International Journal of Recent Scientific Research* 9(3): 25052-25056.

Deshingkar P, Grimm S (2005) Internal migration and development: A global perspective. Geneva, International Organization for Migration. IOM Migration Research series No.19.

Deshingkar P, Akter S (2009) Migration and Human Development in India. New York, United Nations Development Programme. Human Development Research Paper 2009/13.

Fawcett JT, Khoo S, Smith PC (1984) *Women in the Cities of Asia: Migration and Urban Adaptation*. New York, Routledge.

Government of India (2010) *Migration in India, 2007-2008*. New Delhi, Ministry of Statistics and Programme Implementation, National Sample Survey Office.

Government of India (2017a) *Report of the Working Group on Migration*. New Delhi, Ministry of Housing and Urban Poverty Alleviation.

Government of India (2017b) *Economic Survey 2016-17*. New Delhi, Ministry of Finance Department of Economic Affairs, Economics Division.

Government of India (2022) *Migration in India 2020-21*. New Delhi, Ministry of Statistics and Programme Implementation. National Statistics Office. Periodic Labour Force Survey (PLFS).

Kundu A (2003) Urbanisation and urban governance, search for a perspective beyond neo-liberalism. *Economic and Political Weekly* 38(29): 3079-98.

Rajan SI, Sumeetha M (Eds) (2020) Handbook of Internal Migration in India. New Delhi, Sage.

Rajan SI, Sivakumar P, Srinivasan A (2020) The COVID-19 pandemic and internal labour migration in India: a crisis of mobility. *The Indian Journal of Labor Economics* 63: 1021-1039.

Sharma K (2017) India has 139 million internal migrants. They must not be forgotten. World Economic Forum. https://www. weforum.org/agenda/2017/10/india-has-139-million-internal-migrants-we-must-not-forget-them/

Singh DP, Biradar R (2022) Migration in India: trends and characteristics. *Demography India* 51(1): 160-175.

Shattuck D, Wasti SP, Limbu N, Chipant NS, Riley C (2019) Men on the move and the wives left behind: the impact of migration on family planning in Nepal. *Sexual and Reproductive Health Matters* 27(1): 248-261.

Saraswati LR, Sharma V, Sarna A (2015) *Female Migrants in India*. New Delhi, Population Council.

Saradamoni K (1995). Crisis in the fishing industry and women's migration: the case of Kerala. In S Sandbergen (Ed) *Women and Seasonal Labour Migration*. New Delhi, Sage.

Sil M (2008) Women migration in India: an overview. Munich Personal RePEc Archive. Paper No. 47746. https://mpra.ub.uni muenchen.de/47746/

Teerink R (1995) Migration and its impact on Khandeshi Women in the sugarcane harvest. In S Sandbergen (Ed) *Women and Seasonal Labour Migration*. New Delhi, Sage.

United Nations (2009) Human Development Report 2009. Overcoming Barriers: Human Mobility and Development. New York, United Nations Development Program.

United Nations (2020) International Migration 2020 Highlights. New York, Department of Economic and Social Affairs, Population Division (ST/ESA/SER.A/452).

United Nations Children's Fund (2020) Understanding child migration in India. New Delhi, United Nations Children's Fund.

Vivek V (2017) In India, women migrate for work at double the rate than men do. *Hindustan Times*: https://www.hindustantimes.com/india-news/in-india-women-migrate-for-work-at-double-the-rate-than-men-do/story-HjQdnG4ePPJErN4yQ8hqlO.html

Vijay G (2005) Migration, vulnerability and insecurity in new industrial labour markets. *Economic and Political Weekly* 40(22/23): 2304-2312.

INDIAN JOURNAL OF POPULATION AND DEVELOPMENT
ISSN: 2583-4827; Volume 5(1), January 2025: 147-149

Book Review

Statistical Learning with R

Dibyajyoti Bora and Sahana Bhattacharjee

Kalyani Publishers, 2025, India, ISBN: 978-93-6440-364-1

Brijesh P Singh

Statistical Learning with R by Dibyajyoti Bora and Sahana Bhattacharjee is a cornerstone text for those entering the field of Statistics and data science. The book provides a practical and accessible introduction to statistical learning techniques, emphasising their implementation in R. The book covers a wide array of topics including logistic/linear regression, classification, clustering, non-parametric methods, time series analysis, and survival analysis in addition to descriptive statistics. Each chapter includes theoretical explanations, real-world examples, and R-based tutorials for hands-on learning.

The R software and its code play a key role in data analysis and statistical modelling. The book is an accessible and comprehensive guide for beginners in statistical computing and data analysis using R. The book is structured across 23 well-organised chapters, starting from the foundational concepts of R programming and extending to advanced statistical methodologies. The progression of topics is instructionally effective, making it suitable for self-learners, undergraduate students and early-stage researchers in statistics and data science.

Chapters 1 to 6 introduce readers to R programming environment, particularly R Studio, and cover essential concepts such as mathematical operations, construction of different types of vectors (numeric, character, logical, categorical), sequences, lists, matrices, determinants, and data frames. These chapters serve as a solid grounding in R, presented in simple language that avoids overwhelming the reader.

Chapters 7 and 8 shift focus to data summarisation through tabular formats (one-way, two-way, and multi-way tables), and graphical representation techniques including bar diagrams, box plots, pie charts, histograms, frequency polygons, and ogives. These visual tools are important for effective data communication, and the inclusion of formatting options in R enhances the practical utility of these chapters. Chapter 9 explores descriptive statistics, such as measures of central tendency (mean, median, mode) and dispersion (range, variance, standard deviation), with clear R implementation, helping readers to perform basic statistical analysis with confidence.

Chapter 10 introduces probability distributions including all discreate distributions such as Bernoulli, Binomial, Poisson, Hyper-geometric, Geometric, Negative Binomial as well as continuous distributions such as Normal, Uniform, Exponential, Weibull, Multinomial distributions and many more. The inclusion of R code to demonstrate each distribution makes theoretical concepts more approachable and application oriented.

Chapters 11 to 13 delve into fundamentals of statistical inference. Key topics covered include hypothesis testing, types of errors, test statistics for both small and large samples, and application of Student's t and F distributions in hypothesis testing scenarios, again supported with ample R code.

Chapter 14 covers correlation and regression analysis including scatter plots, correlation coefficient, and regression equations. The examples are clearly explained, making complex concepts understandable for beginners. Chapter 15 is devoted to ANOVA (Analysis of Variance) and the Design of Experiments. Topics such as one-way and two-way ANOVA, randomised block design, Latin square design, factorial experiments, split-plot designs, and incomplete block designs are covered comprehensively. The examples provided with R syntax ensure a practical understanding of these experimental methods.

Chapters 16 and 17 focus on non-parametric tests and Chi-square test including one-sample, two-sample, and k-sample tests. These chapters are especially useful for scenarios where data assumptions are not met, and the corresponding R code enhances comprehension. Chapter 18 introduces time series analysis, covering data transformation, trend, and seasonal variation analysis, and forecasting techniques using ARMA, ARIMA and SARIMA models. The application of R for time series forecasting is particularly well-explained and practically oriented.

Chapter 19 discusses survival analysis, including survival and hazard functions, different types of censoring, and both parametric and non-parametric approaches. The inclusion of the Cox proportional hazard model shows the intent of authors to extend the reach of the book to health sciences and related fields. Chapters 20 and 21 provide concise but effective coverage of logistic regression, principal component analysis (PCA), and factor analysis which are the key tools in multivariate statistical analysis under the environment of R. Finally, Chapters 22 and 23 offer a hands-on guide to writing user-defined functions and creating loops in R (for, while, and repeat), rounding off the understanding of the reader with essential programming constructs.

I would like to mention here the strengths of the book in terms of following points:

1. Accessibility: The book assumes only a basic understanding of statistical tools, making it approachable for readers without advanced mathematical backgrounds. The authors prioritise intuition over rigor, using clear explanations and visualisations to demystify complex concepts.
2. Practical Focus: Each chapter concludes with R labs that guide readers through implementing techniques using real datasets. These tutorials are praised for their clarity and relevance, bridging theory and application.
3. Engaging Visuals: Colour graphics enhance understanding, and datasets used in variety of examples make the material relatable across disciplines.

Apart from the above strengths, the book has some limitations. It does not cover inflated, truncated, size and length biased distributions and various kinds of censoring schemes. Other kinds of correlations should have also been discussed to enhance the readability of the book.

Overall, *Statistical Learning with R* is a commendable introductory text that balances theoretical explanation with hands-on coding in R. The book stands out in its clarity of presentation and breadth of topics. By incorporating practical examples and structured R scripts for each concept, authors have successfully created a learning resource that is both informative and appealing. It is particularly useful for beginners in R and statistical analysis and can also serve as a supplementary text in undergraduate courses in statistics, data science, and related disciplines. The book is highly recommended for students, early-career researchers and professionals who wish to build a solid foundation in statistical learning using R. The best feature of the book is its choice of examples, which are outstanding and should appeal especially to the readers. Its accessibility and comprehensive scope make it a valuable addition to any academic or personal library.

Brijesh Pratap Singh
Banaras Hindu University
Varanasi