Abstract

Background: Around 810 women dye daily due to APO events, predominantly in low- and middle-income countries. In India, despite advances in maternal health initiatives, the prevalence of pregnancy loss rate remains high. This study aims to analyze the determinants, prevalence and spatial distribution of pregnancy loss in India.

Study Design: A cross-sectional study.

Methods: Using data from the National Family Health Survey (NFHS-5, 2019-2021), the study analyzes 255,385 pregnancies to assess the prevalence of PL. The analysis includes socio-demographic variables and spatial factors affecting PL rates.

Results: The national PL prevalence is 11.1%, with miscarriages at 7.3%, abortions at 2.9%, and stillbirths at 0.9%. Higher PL rates correlate with older maternal age, urban residence, higher wealth index, and tobacco use. The spatial analysis identifies 84 districts as hot spots for PL, primarily located in Northern and Eastern India, while 89 cold spots are found in Central and North-Eastern regions. Multilevel logistic regression reveals that older woman 35-49 years old (aOR=3.8, 95% CI=1.26-1.63) and women who used tobacco (aOR: 1.28, 95% CI: 1.09-1.49) were significantly at higher risk of pregnancy wastage than in comparison to younger women (< 20 years) and women not using tobacco respectively.

Conclusion: The study highlights the need for further research to elucidate the underlying causes of pregnancy losses and recommends strengthening the health system in hotspot districts. This can be achieved through targeted interventions that address regional disparities and socio-economic determinants, ultimately aiming to improve maternal health outcomes.

Keywords: Pregnancy, Stillbirths, Miscarriages, Abortions, Spatial Analysis, India

Introduction

Pregnancy is the most crucial phase in any woman's life, which requires utmost care and attention. Failure to do so leads to a greater risk of Adverse Pregnancy Outcomes (APO). APO encompasses a wide range of health problem that affects the mother, the child or both during pregnancy, labor, delivery or during the postpartum phase. These problems include stillbirth, low birth weight, hypertensive disorders during pregnancy, obstructed labor, and antepartum/postpartum hemorrhage.[1]

Miscarriage and stillbirth are the most common natural pregnancy losses (PL), which affects the mother's physical and psychosocial well-being.[2] With India being one of the six countries to share half the global burden of stillbirth, for one-third of cases causes still remain unexplained.[3,4] The American College of Obstetricians and Gynecologists gave an estimate of abortion to be 26% which is the most common pregnancy loss followed by miscarriages contributing up to 10% in the clinically perceived pregnancies.[5]

As per the World Health Organization, nearly 810 women die due to APO every day. [6] Of these deaths, 94% occur in low- and middle-income countries (LMICs), 66% in Sub-Saharan Africa and 20% in South Asia. Developing countries like India observe approximately 44,000 deaths from adverse pregnancy related outcome each year. [6] Though APO occurs frequently in developing countries, it is a matter of public health concern for both developed and developing countries.[7]

Existing literature identifies, a plethora of factors that influence the occurrence of PL. These include; maternal age [8-10] wealth index [8,10,11], excessive work [8,11], place of residence, education level of the mother, religion, Body Mass Index (BMI), anemia level [8], spousal violence [12], consumption of alcohol or liquor during pregnancy [8,13], lack of antenatal care (ANC) visits. [14] Gestational diabetes mellitus (GDM) is an increasingly prevalent clinical complication that adversely impacts pregnancy.[15]

Although PL is widely studied in both developed and developing countries,[16,17]; research on its trends and pattern has been scarce considering the Indian perspective. Literature has presented the prevalence of PL to be higher in India due to higher APOs[7,8,10]. APO poses a threat to the life of both the mother and child therefore is a serious public health issue. In recent years, India has made remarkable strides to improve Reproductive, Maternal, Neonatal, Child and Adolescent (RMNCH+A) health. Some of these maternal and child health (MCH) interventions include Janani Suraksha Yojana (2005), Pradhan Mantri Surakshit Matritva Abhiyan (2016), Pradhan Mantri Matru Vandana Yojna (2017), and LaQshya (2017). These programs aim to provide good quality, free antenatal check-ups and care during delivery, identify high-risk pregnancies, and offer cash incentives.[18, 19]

Despite the availability of such intervention, there exist challenges in the uptake of available services the underprivileged and sociocultural varying populations have poor utilization of the maternal health services.[11] These gaps are evident due to the urban-rural divide and worsen further in the case of tribal population.[11] Therefore, it is crucial to understand the determinants and spatial distribution of PLs in India. The spatial analysis is the technique to explore the spatial variability and spatial dependence in the relationship between individual-level factors, contextual factors, and pregnancy loss in India. So, the paper aims to identify the determinants, prevalence, and spatial distribution of pregnancy loss (PL) in India using data from the National Family Health Survey (NFHS-5) conducted in 2019-21, which is the latest round of the Indian Demographic Health Survey. This approach enables us to examine how neighboring geographic units may influence the observed associations and to assess the variability of these associations across different geographic regions. Spatial models will help in identifying areas where policies and interventions can be prioritized to improve health outcomes, particularly in relation to pregnancy loss.

Methods

Study Design and Participants

The fifth round of National Family Health Survey (NFHS-5) conducted in 2019-21 is the latest round of the Indian Demographic Health Survey. NFHS is a cross-sectional survey collecting information from a large sample of ever-married women aged 15-49 across India, covering various health and demographic aspects. The survey is a nationally representative sample covering all states and union territories of India. Data was collected from 724,115 ever-married women and 636,699 households. [20] The NFHS fourth round with similar design and methodology was conducted during 2015-16. Detailed information about the NFHS survey, including its sample design and data collection methods, can be found in the NFHS Report.[20]

The NFHS survey also collects calendar data on key life events of the respondents. This calendar data records information on various activities and important events in the respondents' lives, such as births, pregnancies, terminations, and contraceptive use. The survey provides a comprehensive history of women's reproduction and contraceptive use for the 5 to 7 years prior to the survey. The calendar data consists of a matrix of rows and columns that contains the history of events in women's lives.[20] In this study, we used the calendar data from the women's file and birth history file to examine the relationship between individual and community risk factors and PL.

Procedures

Calendar data from the NFHS survey was used to calculate the rate of PL such as stillbirth, abortion, and miscarriage. The analysis was restricted to pregnancies among women aged 15-49 during the five years prior to the survey. The total sample of the study includes 255,385 pregnancies of which 228,788 are live births and 26,597 are PL (including stillbirths, miscarriages, and abortions) among ever-married women during the five years preceding the survey.

Outcome Variable

The primary dependent variable in this study is pregnancy loss, which refers to pregnancies ending in non-live births. It is defined as the loss of a fetus within the five years preceding the survey, due to adverse events such as stillbirth, miscarriage, or abortion. Stillbirth refers to the late pregnancy loss that occurs after seven months of gestation. Miscarriage is the sudden loss of a pregnancy before 20 weeks of gestation. Abortion refers to the voluntary termination of a pregnancy, whether it occurs spontaneously or is induced.[21] For this analysis, we recoded the pregnancy loss variable into a binary format, with "1" assigned for pregnancy loss due to any adverse event such as stillbirth, miscarriage, or abortion and "0" is assigned for live births.

Independent Variable

The individual and household-level factors include woman's age at the end of pregnancy, which is re-coded in three categories (i.e. <20, 20-34, and 35-49 years), parity (one, two and three or more) place of residence (rural/urban), occupation (currently working is categorized into yes/no), wealth status with three categories (poor, middle, rich) and behavioral risk factors such as smoking and alcohol use (yes/no). The wealth index is calculated based on information regarding the household's amenities and assets by the household respondents, including factors such as the main source of drinking water, type of water facility, fuel used for cooking, source of lighting, type of household structure, land ownership status, and possession of various household assets. Using this data, a wealth index was constructed. Each question's response was assigned a weight, which was determined through Principal Component Analysis (PCA). The score is further converted into percentiles and divided into five categories, with each group representing a 20% segment of the distribution. The lowest two quintiles (poorest and poorer) are grouped and labeled as "poor," the middle quintile is designated as "middle," and the top two quintiles (richer and richest) are categorized as "rich."

Contextual factors include exposure to mass media, measured by the frequency of watching television, reading newspapers or magazines, and listening to the radio. This exposure is categorized into three levels: no exposure, partial exposure, and full exposure. The community factors considered were, community education, the Ethnic Fractionalization Index, and the Religious Fractionalization Index.

Community-level education is indicated by the proportion of women in the community with secondary and higher education, categorized as high or low. The Ethnic and Religious Fractionalization Indices measure the ethnic and religious diversity within the community. The index was calculated as EFL = 1- Σi (proportion of ethno-linguistic group/religious group 'i' in the population). The homogenous category shows there was no diversity and not homogenous category shows complete diversity. The detailed calculations are provided elsewhere.[22]

Prevalence of Pregnancy Loss (PL)

The prevalence of PL across different districts and various background characteristics is measured and presented as percentages. To determine the association between predictor variables and PL, the Chi-square test is conducted at a 5% level of significance.

Spatial pattern of Pregnancy Loss (PL)

The present study aimed to examine the spatial patterns and clustering of PL across districts in India. To investigate spatial autocorrelation and heterogeneity in the prevalence of PL, geospatial techniques such as Moran's I and the Local Indicator of Spatial Association (LISA) were utilized. Moran's I is a useful measure to quantify spatial autocorrelation within a dataset across a geographical area. Its values range from -1 to +1, with positive values close to +1 indicating spatial clustering, a value of zero indicating spatial randomness, and values close to -1 suggesting dispersion.[23, 24]

Additionally, the Univariate Local Indicator of Spatial Association (LISA) was employed to assess spatial autocorrelation between specific geographical units and their neighbors, thereby identifying the spatial distribution of PL in India in terms of hot spots and cold spots. Spatial autocorrelation occurs when values for a random variable cluster together, whereas negative spatial autocorrelation is observed when a region is surrounded by neighbors with markedly different values.[23, 24] The queen contiguity method, based on shared vertices and boundaries, was employed to identify neighbors. A weight matrix was created using this method, assigning values of 1 to neighbors and 0 to non-neighbors, respectively**.**[24] Further details on the spatial analysis methodology can be found elsewhere.

In this study, we used two types of spatial maps to illustrate the distribution of PL: the cluster map and the significance map.

Cluster Map: This map shows the clustering or geographical variation in the prevalence of PL, identifying hot spots and cold spots.

High-High Category (Hot Spots): Districts with a high prevalence of PL, surrounded by neighboring districts with similarly high prevalence.

Low-Low Category (Cold Spots): Districts with a low prevalence of PL, surrounded by neighboring districts with similarly low prevalence.

High-Low Category: Districts with a high prevalence of PL, surrounded by neighboring districts with low prevalence.

Low-High Category: Districts with a low prevalence of PL, surrounded by neighboring districts with high prevalence.

Significance Map: This map shows Moran's I statistics in terms of LISA (Local Indicator of Spatial Association) significance. Districts with significant spatial autocorrelation are shaded in green, with different colours in the cluster map highlighting these significant districts.

Both the cluster map and the significance map illustrate the spatial prevalence of PL at a 5% level of significance.

Multilevel analysis

We employed two-level mixed-effect multilevel logistic regression analyses to identify risk factors for PL in India. The fixed part of the model measured risk factors at two levels: individual, and district. The random part of the model assessed the random effects or clustering at the district level. Two separate multilevel logistic regression models were constructed:

Empty Model: This model contained no exposure variables and focused solely on decomposing the total variance into district levels, which helps to measure the extent of cluster variation in the prevalence of PL.

Adjusted Model: This model included individual and contextual variables.

The results for the fixed effects model are presented as adjusted odds ratios (aOR) with 95% confidence intervals after controlling all factors mentioned in the independent variable section. The advantage of multilevel logistic regressions is its ability to partition the variation in the dependent variable measured at the individual level and attribute it to differences among individuals, and districts in terms of variance partition coefficient (VPC). Further details on the spatial analysis methodology can be found elsewhere.[22, 25] All statistical analyses for this study were performed using STATA, while spatial analyses were conducted using ArcGIS and GeoDa software.

Results

Percentage Distribution of Study Sample

The distribution of the sample according to socio-demographic characteristics is shown in [Table 1]. About 83.6% of the women belonged to the age group of 20 to 30 years. Around 39% of the women had two children (parity). A significant proportion, 72.6%, came from rural areas, and 78% were not currently working. More than two-thirds of the women belonged to the low economic wealth status group. Approximately 65% had partial exposure to mass media. Around 3% of the women consume tobacco. About 28% of the women belonged to the central region of India. Additionally, 74% of the women had high community-level education. Ethnically, 81.7% belonged to heterogeneous ethnic groups, while 65% belonged to completely homogeneous religious groups.

Prevalence of Pregnancy Loss (PLs) in India over two time periods

Figure 1 Depicts the prevalence of PL from NFHS-4 to NFHS-5. In the NFHS-5 (2019-21) survey period, 11.1% of women aged 15-49 at the national level reported experiencing PL, including stillbirth, miscarriage, and abortion. This represents a slight increase compared to the NFHS-4 survey period (2015-16), indicating a marginal rise in the prevalence of PLs over time.

Prevalence of PLs by district and states

The national prevalence of PLs in India is 11.1%, including 7.3% miscarriages, 2.9% abortions, and 0.9% stillbirths. Figure 2 shows the state-wise prevalence of pregnancy loss (PL) in India. In the legend, the green color represents states where the prevalence of PL is less than 10%. Yellow indicates states with a PL prevalence between 10% and 13%, orange shows states with a prevalence between 13% and 15%, and red represents states where the prevalence of PL is greater than 15%. This prevalence varies across the country, ranging from 6.0% in Lakshadweep to 22.9% in Manipur. The highest rates of PLs are found in Manipur, followed by Delhi, Pondicherry, and Goa, while the lowest rates are observed in Lakshadweep, Meghalaya, and Arunachal Pradesh [Fig. 2]. Similarly, the prevalence of PLs varies by district, ranging from 1.6% in Kra Daadi district of Arunachal Pradesh to 31.4% in the Bishnupur district of Manipur [Fig. 3].

Prevalence of PL by selected exposure variables

Table 2 shows the prevalence of PL by the socio-demographic characteristics of the respondents. The study found a significant positive association between the prevalence of PL and various socio-demographic factors, including women's age, place of residence, occupation, mass media exposure, tobacco use, region, community education, and the Ethnic Fractionalization Index, with a statistical significance at ($\chi 2$ p-value = 0.001).

Women aged 35-49 have a higher prevalence of PL (19.2%) compared to younger women. The prevalence of PLs also varies with the number of children women have, with those having only one child experiencing a higher rate of PL (13.7%) than other groups. There is a significant urban-rural difference in PL prevalence, with 13.1% in urban areas and 10.1% in rural areas. Working women experience more PLs than non-working women, and wealthier women have a higher prevalence of PL (13%) compared to middle-class (11.9%) and poor women (9.3%).

Exposure to mass media is also associated with PL. Women with partial (12%) and full (11.7%) mass media exposure are more likely to experience PL than those with no media exposure (8.7%). Additionally, the prevalence of PL is higher among tobacco users (12.9%) and alcohol users (12.4%). The prevalence of pregnancy losses (PL) varies by region, with higher rates observed in the North, North-East, and Central parts of India compared to other regions. Community education is significantly associated with PL prevalence, with higher levels of maternal education correlating with higher rates of PL. The Ethnic Fractionalization Index indicates that higher levels of ethnic and religious diversity may slightly increase the prevalence of PL.

Spatial Pattern of Pregnancy Loss

The univariate Moran's I index value for pregnancy loss, which was 0.56, indicates a substantial degree of spatial autocorrelation across the districts in India. Univariate LISA cluster map for PLs in Figure 4 illustrates the spatial clustering of pregnancy losses (PLs) by district in India, while Figure 5 shows the significance map, with areas significant at the 5% level. In the map legend, five colors are used: the white color indicates districts that were not significant, the red color represents districts with high-high values, which are hotspots (Districts with above-average prevalence of PLs, which share boundaries with neighboring districts that also have above-average values), and the blue color indicates districts with low-low values, which are cold spots. In Fig. 4 we identified 84 districts with significant hot spots, indicating a high prevalence of PLs, primarily located in Delhi, Uttar Pradesh, Manipur, Odisha, Haryana, Rajasthan, and some districts of Tamil Nadu, Pondicherry, Goa Maharashtra. Conversely, 89 districts were identified as cold spots, showing lower prevalence of PL, in regions such as Madhya Pradesh, Rajasthan, Chhattisgarh, Maharashtra, Arunachal Pradesh, Jammu and Kashmir and Mizoram. Additionally, six districts exhibited a high prevalence of PL despite being surrounded by districts with low prevalence. Nine districts with a low-high pattern were identified, characterized by a low prevalence of PL surrounded by districts with high prevalence. These can be considered positive deviant districts.

Risk Factors of Pregnancy Loss

Fixed effect Model:

Table 3 presents the results from multilevel models examining the association between various exposure variables and pregnancy loss. Significant positive associations were found for women's age, parity, working status, place of residence, mass media exposure, wealth status, tobacco use, region, and ethnic fractionalization index with PL.

Women aged 35-49 years were 3.8 times more likely to experience PLs compared to younger women under 20 years of age (aOR=3.8, 95% CI=1.26-1.63). Parity was negatively associated with PLs, indicating that women with more than one child had a lower risk of experiencing these outcomes. Urban women had a 1.2 times higher risk of PLs (aOR: 1.2, 95% CI: 1.04-1.26) compared to those in rural areas.

Working women were 1.2 times more likely to have PLs (aOR: 1.17, 95% CI: 1.07-1.27). Women from the rich (aOR: 1.20, 95% CI: 1.08-1.33) and middle-class (aOR: 1.20, 95% CI: 1.08-1.34) categories had a significantly higher risk compared to poor women. Partial media exposure was associated with a higher risk of pregnancy wastage (aOR: 1.19, 95% CI: 1.02-1.38). Additionally, women who used tobacco had a higher risk of pregnancy wastage (aOR: 1.28, 95% CI: 1.09-1.49). Women aged 35-49 years were 3.8 times more likely to experience PLs compared to younger women under 20 years of age (aOR=3.8, 95% CI=1.26-1.63)

Regionally, women from the North (aOR: 1.20, 95% CI: 1.03-1.40), East (aOR: 1.56, 95% CI: 1.32-1.83), and Central (aOR: 1.26, 95% CI: 1.08-1.47) regions had a higher risk of PL compared to their counterparts. Although community education was not significantly associated with PL, higher odds were observed for more educated women. The ethnic fractionalization index was positively associated with PL, with lower community-level ethnic and religious concentration significantly increasing the likelihood of these wastage among women.

Random effect Model

The null model, or empty model, does not include any exposure variables and is used to decompose the total variance at the district level (not shown in table). This helps determine the extent to which individual-level variation is attributed to the district level. The variance partition coefficient (VPC) of the null model was 5.1%, indicating that approximately 5.1% of the variation in pregnancy wastage, is due to the clustering effect at the district level. After adjusting the model for individual and contextual factor, the VPC value decreased to 2.8% suggesting the remaining variation in pregnancy loss is attributed to differences among respondents at the individual, household, and other unknown factors. A high VPC value signifies a significant clustering of pregnancy wastages across districts and a strong neighborhood effect on individual risk.

Additionally, the proportion change in variance (PCV) value in the full model was 0.464, indicating that 46.4% of the variation in pregnancy wastages was due to individual and contextual factors.

Discussion

The study presented the prevalence of PL, spatial pattern and clustering across different districts and identified risk factors for PL in India using multilevel analysis. The overall prevalence of PL in India is 11% which is higher than in many less developed countries such as the Democratic Republic of the Congo (2.9%), Ghana (4.9 %) and Zambia (0.8%).[27] An Ethiopian study found higher PL of 13.9% .[1] In India among the states, the highest rates of PL are found in Manipur, followed by Delhi, Pondicherry, and Goa, while the lowest rates are observed in Lakshadweep, Meghalaya, and Arunachal Pradesh. These results are in accordance with a recent study conducted by Swain et al using the data from NFHS-5 to analyse the pattern and trend of PL from 1992-2021.[7]

The study also highlights the spatial pattern of PL by districts; presenting 84 districts as hot spots of PL with a high prevalence. These major hot spots were found in Northern and Eastern Indian states such as states of Manipur, Delhi, Uttar Pradesh, Haryana, Rajasthan, Odisha and some districts in Tamil Nadu, Pondicherry and Maharashtra. The cold spots consisted of districts of the states of Madhya Pradesh, Rajasthan, Chhattisgarh, Maharashtra, Andhra Pradesh, Jammu and Kashmir and Mizoram. These hotspots signify socio-cultural differences, economic inequality, health system and accessibility barriers and variations in ailments among women. The socio-cultural barriers such as teenage and delayed pregnancies, age at and mode of conception, and psychological well-being of women can affect pregnancy outcomes.[33,36] Additionally, high pregnancy losses are influenced by medical conditions and factors, including anaemia, infection, hypertension, hyperglycemia, spousal violence, and environmental pollution.[34,35] Further, economic inequality across states and rural and urban areas, varied levels of financing for health and accessibility to health care services lead to such difference in prevalence of PLs.[26]

The study also assessed the risk factors for PL in India. Significant positive associations were found for women's age, parity, working status, place of residence, mass media exposure, wealth status, tobacco use, region, and ethnic fractionalization index with PL. For maternal age, our study found that women aged 35-49 years were more likely to experience PL compared to younger women under 20 years of age. These results for maternal age are similar to previous studies in the literature.[8,10,13] Parity was negatively associated with PL, indicating that women with more than one child had a lower risk of experiencing these outcomes.

Urban residents and women belonging to a high wealth index were at a higher risk of experiencing PL than their rural residents and women belonging to a poor wealth index, similar results were reflected in the study assessing PL risk factors using NFHS-4 data.[7,8] This can be due to a sedentary lifestyle seen most commonly among the urban and rich population. Though they have accessibility and affordability to health services; their lifestyle induces various health problems such as diabetes, and hypertension which increases their chances of experiencing PL. In our study, exposure to mass media is also associated with PL. Women with ‘partial’ and ‘full’ mass media exposure are more likely to experience PL than those with ‘no’ media exposure. Although, the literature shows increase in mass media consumption by mothers has increased the uptake of health services and thus better health outcomes [27,28,29]; our study results vary from the existing literature in this context. Also, some studies have shown that women with media exposure may have greater self-efficacy in making informed decisions about abortion.[36] Some literature highlights the complex relationship between media exposure and public health outcomes. While media can raise awareness about health issues, it does not always lead to positive outcomes.[37] Furthermore, other studies have highlighted that excessive use of social media is associated with reduced physical activity and poor sleep, which may contribute to adverse pregnancy outcomes.[38] Women who used tobacco had a higher risk of PL, the results were similar to existing literature.[8,11,30,31]

The spatial distribution of PL shows that regionally, women from the North, East, and Central regions had a higher risk of PL compared to their counterparts. The literature presents mixed results for this variable based on the same dataset employed for the study. The study by Swain et al shows that PL risk is higher in the east of India as compared to other regions.[10] while another study assessing the pattern and trends in PL from 1990 to 2021 shows that South India also shows an increased risk of PL.[7]

While there was no statistically significant correlation between community education and PL, women with higher levels of education did show increased chances. Unfavorable pregnancy outcomes were strongly associated with the ethnic fractionalization index, and the likelihood of these outcomes increased significantly in communities with lower ethnic and religious concentration.[39] The existing literature supports these findings, emphasizing that ethnic diversity within a community may lead to unequal access to healthcare, which may result in poor health outcomes.[40] Furthermore, other research has shown that ethnic and racial disparities continue to worsen or persist in fetal, neonatal, and maternal outcomes.

Conclusion

This study emphasized the high prevalence of PL in India whilst presenting the risk factors using nationally represented data. PL serves as an excellent tool to assess the effectiveness of maternal and child health programs and is an indicator of maternal and child health services in the nation. Despite India's ongoing efforts to improve maternal and child health, the prevalence of PL has increased from 2015-16 to 2019-21. This trend of PL calls for equitable and actionable measures to improve the MCH services as well as uptake in India. The identification of regional variation and contributing risk factors can be employed to formulate targeted intervention, and deliver 'what is needed' to the 'where it is needed'. Studies like these will help channel the resources of the nation aimed at strengthening MCH and yield better outcomes in the long run. Region-wise approach the improve the health indicators is recommended to achieve favorable health outcomes.

Acknowledgments
The authors express their sincere gratitude to the Director, ICMR-National Institute for Research in Reproductive and Child Health, Mumbai and the Additional Director General Dr. Sanghamitra Pati for their comments and support for the study.

Competing Interests
The authors have no conflict of interest.

Ethical Approval

This study received ethical approval from ICMR-NIRRCH (IEC No: D/ICEC/Sci-35/39/2022 dated 27/04/2022). The study utilized publicly available secondary data published by the National Family Health Survey, the Government of India, and the Demographic and Health Surveys Program. Consent was obtained from the study participants by the respective organizations. Therefore, obtaining consent for participation in our research study is not applicable.

Funding
No funding was received for this research.

References

1. Tadese M, Dagne K, Wubetu AD, Abeway S, Bekele A, Misganaw Kebede W, et al. Assessment of the adverse pregnancy outcomes and its associated factors among deliveries at Debre Berhan Comprehensive Specialized Hospital, Northeast Ethiopia. PLoS One. 2022 Jul 8;17(7):e0271287. doi: 10.1371/journal.pone.0271287.
2. Shaohua L, Shorey S. Psychosocial interventions on psychological outcomes of parents with perinatal loss: A systematic review and meta-analysis. Int J Nurs Stud. 2021 May;117:103871. doi: 10.1016/j.ijnurstu.2021.103871. Epub 2021 Jan 12.
3. Standard Treatment Guidelines. Management of Recurrent Spontaneous Abortion-2017. http://www.clinicalestablishments.gov.in/WriteReadData/3361.pdf. Accessed on 8 November 2022.
4. A neglected tragedy. The global burden of stillbirths 2020. https://www.unicef.org/media/84851/file/UN-IGME-the-global-burden-of-stillbirths-2020.pdf. Accessed on 8 November 2022.
5. Dugas C, Slane VH. Miscarriage. 2021 Jan 29 StatPearls. 2021 Treasure Island (FL) StatPearls.
6. World Health Organization. Trends in maternal mortality 2000 to 2017: estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division [Internet].

Geneva: World Health Organization; 2019 [cited 2024 Jul 28]. 104 p. Available from: https://www.iris.who.int/handle/10665/327595.

7. Swain PK, Jena A. Trend, Pattern, and Prevalence of Adverse Pregnancy Outcomes among Women of Reproductive Age in India, 1992-2021. Indian J Community Med. 2024 Jul-Aug;49(4):622-628. doi: 10.4103/ijcm.ijcm_337_23. Epub 2024 Jul 9.
8. Patel KK, Saroj RK, Kumar M. Prevalence and Determinants of Adverse Pregnancy Outcomes among Women in India: A Secondary Data Analysis. Indian J Community Med. 2021 Jul-Sep;46(3):434-437. doi: 10.4103/ijcm.IJCM_569_20. Epub 2021 Oct 13.
9. Dhaded SM, Somannavar MS, Jacob JP, McClure EM, Vernekar SS, Yogesh Kumar S, Kavi A, Ramadurg UY, Moore JL, Wallace DP, Derman RJ, Goldenberg RL, Goudar SS. Early pregnancy loss in Belagavi, Karnataka, India 2014-2017: a prospective population-based observational study in a low-resource setting. Reprod Health. 2018 Jun 22;15(Suppl 1):95. doi: 10.1186/s12978-018-0525-4.
10. Swain P, Jena A, Behera R. Demography India Associated Risk Factors of Adverse Pregnancy Outcomes among Women of Reproductive Age in India: A Study Based on NFHS-5. Demography India. 2024 Jun 16; Demography India Vol. 53,:134–45.
11. Doke PP, Palkar SH, Gothankar JS, Patil AV, Chutke AP, Pore PD, Deshpande AV, Bhuyan KK, Karnataki MV, Shrotri AN. Association between adverse pregnancy outcomes and preceding risk factors: a cross-sectional study from Nashik District, India. BMC Pregnancy Childbirth. 2021 Oct 18;21(1):700. doi: 10.1186/s12884-021-04174-w.
12. Bramhankar M, Reshmi RS. Spousal violence against women and its consequences on pregnancy outcomes and reproductive health of women in India. BMC Womens Health. 2021 Nov 1;21(1):382. doi: 10.1186/s12905-021-01515-x.
13. Lawn JE, Blencowe H, Waiswa P, Amouzou A, Mathers C, Hogan D, Flenady V, Frøen JF, Qureshi ZU, Calderwood C, Shiekh S, Jassir FB, You D, McClure EM, Mathai M, Cousens S; Lancet Ending Preventable Stillbirths Series study group; Lancet Stillbirth Epidemiology investigator group. Stillbirths: rates, risk factors, and acceleration towards 2030. Lancet. 2016 Feb 6;387(10018):587-603. doi: 10.1016/S0140-6736(15)00837-5.
14. Kassahun EA, Mitku HD, Getu MA. Adverse birth outcomes and its associated factors among women who delivered in North Wollo zone, northeast Ethiopia: a facility based cross-sectional study. BMC Res Notes. 2019 Jun 24;12(1):357. doi: 10.1186/s13104-019-4387-9.
15. Rawat D, Chowdhury SR, Yadav AK, Gupta Y, Singh N, Sharma KA, et al. Meta-analysis comparing diabetes in pregnancy study group India (DIPSI) vs the international association of the diabetes and pregnancy study groups (IADPSG) criteria for diagnosis of gestational diabetes among Indian population. Taiwan J Obstet Gynecol. 2023 Jul;62(4):498-505. doi: 10.1016/j.tjog.2023.03.013.
16. Blencowe H, Cousens S, Oestergaard MZ, Chou D, Moller AB, Narwal R, Adler A, Vera Garcia C, Rohde S, Say L, Lawn JE. National, regional, and worldwide estimates of preterm birth rates in the year 2010 with time trends since 1990 for selected countries: a systematic analysis and implications. Lancet. 2012 Jun 9;379(9832):2162-72. doi: 10.1016/S0140-6736(12)60820-4.
17. Padhi BK, Baker KK, Dutta A, Cumming O, Freeman MC, Satpathy R, et al. Risk of Adverse Pregnancy Outcomes among Women Practicing Poor Sanitation in Rural India: A Population-Based Prospective Cohort Study. PLoS Med. 2015 Jul 7;12(7):e1001851. doi: 10.1371/journal.pmed.1001851.

18. Shivashankarappa DH, Joy NA, D SM. Adverse pregnancy outcome and its association with the various determinants of current pregnancy in a district hospital, urban Bengaluru, India. International Journal of Community Medicine and Public Health. 2024 Feb 29;11(3):1223–8.

19. Kuppusamy P, Prusty RK, Kale DP. High-risk pregnancy in India: Prevalence and contributing risk factors - a national survey-based analysis. J Glob Health. 2023 Sep 15;13:04116. doi: 10.7189/jogh.13.04116.

20. National Family Health Survey (NFHS-5). - India Report. NFHS-5_Phase-II_0.pdf [Internet]. [cited 2024 Jul 28]. Available from: https://www.main.mohfw.gov.in/sites/default/files/NFHS-5_Phase-II_0.pdf.

21. Kuppusamy P, Prusty RK, Chaaithanya IK, Gajbhiye RK, Sachdeva G. Pregnancy outcomes among Indian women: increased prevalence of miscarriage and stillbirth during 2015-2021. BMC Pregnancy Childbirth. 2023 Mar 8;23(1):150. doi: 10.1186/s12884-023-05470-3.

22. Dutta M, Bhise M, Prashad L, Chaurasia H, Debnath P. Prevalence and risk factors of anemia among children 6–59 months in India: A multilevel analysis. Clinical Epidemiology and Global Health. 2020 Sep 1; 8(3):868–78.

23. Usman M, Reddy US, Siddiqui LA, Banerjee A. Exploration of spatial clustering in maternal health continuum of care across districts of India: A geospatial analysis of demographic and health survey data. PLoS One. 2022 Dec 15;17(12):e0279117. doi: 10.1371/journal.pone.0279117.

24. Purbey A, Nambiar A, Roy Choudhury D, Vennam T, Balani K, Agnihotri SB. Stillbirth rates and its spatial patterns in India: an exploration of HMIS data. Lancet Reg Health Southeast Asia. 2022 Dec 6;9:100116. doi: 10.1016/j.lansea.2022.100116.

25. Adeleye K, Ogungbe O, Yeboah-Kordieh Y, Gresh A, Iradukunda F. Exploring Multilevel Determinants of Stillbirth: A Comprehensive Analysis Across Sub-Saharan African Countries. medRxiv. 2024:2024-05. Available from: https://www.medrxiv.org/content/10.1101/2024.05.16.24307507v1.

26. Tandon A, Roder-DeWan S, Chopra M, Chhabra S, Croke K, Cros M, et al. Adverse birth outcomes among women with ‘low-risk’pregnancies in India: findings from the Fifth National Family Health Survey, 2019–21. The Lancet Regional Health-Southeast Asia. 2023 Aug 1;15.

27. Meher R, Patro RP. Interstate level comparison of people’s health status and the state of public health care services in India. Journal of Health Management. 2014 Dec; 16(4):489-507.

28. Dhawan D, Pinnamaneni R, Bekalu M, Viswanath K. Association between different types of mass media and antenatal care visits in India: a cross-sectional study from the National Family Health Survey (2015-2016). BMJ Open. 2020 Dec 15;10(12):e042839. doi: 10.1136/bmjopen-2020-042839.

29. Fatema K, Lariscy JT. Mass media exposure and maternal healthcare utilization in South Asia. SSM Popul Health. 2020 Jun 7;11:100614. doi: 10.1016/j.ssmph.2020.100614.

30. Shenoy RD, Sindgikar SP, Shenoy V, Uppoor R, Rao R, Singh S. Pregnancy Outcome in Occupational Tobacco Exposure: A Cohort Study from South India. Indian J Community Med. 2020 Jan-Mar;45(1):54-59. doi: 10.4103/ijcm.IJCM_195_19.

31. Ratnasiri AWG, Gordon L, Dieckmann RA, Lee HC, Parry SS, Arief VN, et al. Smoking during Pregnancy and Adverse Birth and Maternal Outcomes in California, 2007 to 2016. Am J Perinatol. 2020 Nov;37(13):1364-1376. doi: 10.1055/s-0039-1693689. Epub 2019 Jul 31.

32. Alliance for Maternal and Newborn Health Improvement (AMANHI) mortality study group. Population-based rates, timing, and causes of maternal deaths, stillbirths, and neonatal deaths in south Asia and sub-Saharan Africa: a multi-country prospective cohort study. Lancet Glob Health. 2018 Dec;6(12):e1297-e1308. doi: 10.1016/S2214-109X(18)30385-1. Epub 2018 Oct 22.
33. McMahon CA, Boivin J, Gibson FL, Hammarberg K, Wynter K, Saunders D, et al. Age at first birth, mode of conception and psychological wellbeing in pregnancy: findings from the parental age and transition to parenthood Australia (PATPA) study. Hum Reprod. 2011 Jun;26(6):1389-98. doi: 10.1093/humrep/der076. Epub 2011 Mar 25.
34. Xue T, Guan T, Geng G, Zhang Q, Zhao Y, Zhu T. Estimation of pregnancy losses attributable to exposure to ambient fine particles in south Asia: an epidemiological case-control study. Lancet Planet Health. 2021 Jan;5(1):e15-e24. doi: 10.1016/S2542-5196(20)30268-0.
35. Padhi BK, Baker KK, Dutta A, Cumming O, Freeman MC, Satpathy R, Das BS, Panigrahi P. Risk of Adverse Pregnancy Outcomes among Women Practicing Poor Sanitation in Rural India: A Population-Based Prospective Cohort Study. PLoS Med. 2015 Jul 7;12(7):e1001851. doi: 10.1371/journal.pmed.1001851.
36. Ahinkorah BO, Seidu AA, Mensah GY, Budu E. Mass media exposure and self-efficacy in abortion decision-making among adolescent girls and young women in Ghana: Analysis of the 2017 Maternal Health Survey. PLoS One. 2020 Oct 9;15(10):e0239894. doi:10.1371/journal.pone.0239894.
37. Kanchan S, Gaidhane A. Social Media Role and Its Impact on Public Health: A Narrative Review. Cureus. 2023 Jan 13;15(1):e33737. doi: 10.7759/cureus.33737.
38. Zhang X, Liu J, Han N, Yin J. Social Media Use, Unhealthy Lifestyles, and the Risk of Miscarriage Among Pregnant Women During the COVID-19 Pandemic: Prospective Observational Study. JMIR Public Health Surveill. 2021 Jan 5;7(1):e25241. doi: 10.2196/25241.
39. Sheikh J, Allotey J, Kew T, Fernández-Félix BM, Zamora J, Khalil A, et al. Effects of race and ethnicity on perinatal outcomes in high-income and upper-middle-income countries: an individual participant data meta-analysis of 2 198 655 pregnancies. Lancet. 2022 Dec 10;400(10368):2049-2062. doi: 10.1016/S0140-6736(22)01191-6.
40. van Daalen KR, Kaiser J, Kebede S, Cipriano G, Maimouni H, Olumese E, et al. Racial discrimination and adverse pregnancy outcomes: a systematic review and meta-analysis. BMJ Glob Health. 2022 Aug;7(8):e009227. doi: 10.1136/bmjgh-2022-009227.

Table 1: Percentage Distribution of Study Sample by Socio-Demographic Profile, India 2019-21

Background Variables	**Percent**	**Number**
Age at end of Pregnancy (yr)		
<20	12.6	29,184
20-34	83.6	214,354
35-49	3.8	11,847
Parity		
One	27.6	67,921
Two	39.1	95,802
Three+	33.3	87,078
Place of Residence		
Rural	72.6	201,906
Urban	27.4	53,479
Working Status		
No	78.4	29,453
Yes	21.6	9,605
Wealth Status		
Poor	45.2	125,923
Middle	19.7	50,159
Rich	35.1	79,303
Mass Media		
No exposure	27.8	72,913
Partial exposure	65.7	165,875
Full exposure	6.5	16,597
Tobacco User		
No	96.7	239,609
Yes	3.3	15,776
Alcohol User		
No	99.5	251,512
Yes	0.5	3,873
Region		
North	13.3	47,660
North-East	3.6	36,059
Central	28.0	66,773
East	26.2	50,232
West	12.4	22,328
South	16.5	32,333
Community Education		
Low	26.0	68,441
High	74.0	186,944
Ethnic Fractionalization Index		
Totally Homogeneous	18.3	63,296
Not Homogeneous	81.7	192,089
Religion Fractionalization Index		
Totally Homogeneous	65.5	173,928
Not Homogeneous	34.5	81,457
Total Sample	100	255,385

Table 2: Prevalence of Pregnancy Loss (PL) across Socio-Demographic Variables with Chi-Square Analysis, India 2019-21

Background	Prevalence of PL (%)	P-value	Number
Age at end of Pregnancy (yr)		0.000	
<20	11.0		29,184
20-34	10.7		214,354
35-49	19.2		11,847
Parity		0.000	
One	13.7		67,921
Two	8.5		95,802
Three+	6.7		87,078
Place of Residence		0.000	
Rural	10.3		201,906
Urban	13.1		53,479
Working Status		0.162	
No	10.6		29,453
Yes	11.9		9,605
Wealth Status		0.000	
Poor	9.3		125,923
Middle	11.9		50,159
Rich	13.0		79,303
Mass Media		0.000	
No exposure	8.7		16,597
Partial exposure	12.0		165,875
Full exposure	11.7		72,913
Tobacco User		0.000	
No	11.0		239,609
Yes	12.9		15,776
Alcohol User		0.930	
No	11.1		251,512
Yes	12.4		3,873
Region		0.000	
North	11.8		47,660
North-East	11.4		36,059
Central	11.4		66,773
East	10.9		50,232
West	10.7		22,328
South	10.4		32,333
Community Education Index		0.000	
Low	9.3		68,441
High	11.7		186,944
Ethnic Fractionalization Index		0.000	
Totally Homogeneous	10.1		63,296
Not Homogeneous	11.3		192,089
Religion Fractionalization Index		0.562	
Totally Homogeneous	11.1		173,928
Not Homogeneous	11.0		81,457
Total prevalence for India	11.1		255,385

Table 3: Results for the Individual and Community-Level Factors Linked to Pregnancy Loss (PL) in India, 2019-21

	Model 2
Background Variables	**aOR (95% CI)**
Fixed Effect Part	
Age at end of Pregnancy	
<20	1.00
20-34	1.43(1.26-1.63)
35-49	3.80(3.15-4.58)
Parity	
1	1.00
2	0.60(0.55-0.65)
≥3	0.39(0.35-0.43)
Place of Residence	
Rural	1.00
Urban	1.15(1.04-1.26)
Working Status	
No	1.00
Yes	1.17(1.07-1.27)
Wealth Status	
Poor	1.00
Middle	1.20(1.08-1.33)
Rich	1.20(1.08-1.34)
Mass Media	
No exposure	1.00
Partial exposure	1.19(1.02-1.38)
Full exposure	0.98(0.83-1.17)
Tobacco User	
No	1.00
Yes	1.28(1.09-1.49)
Alcohol User	
No	1.00
Yes	1.23(0.93-1.63)
Region	
South	1.00
North	1.20(1.03-1.40)
North-East	1.11(0.93-1.33)
Central	1.26(1.08-1.47)
East	1.56(1.32-1.83)
West	0.97(0.80-1.18)
Community Education	
Low	1.00
High	1.03(0.93-1.13)
Ethnic Fractionalization Index	
Totally Homogeneous	1.00
Not Homogeneous	1.19(1.08-1.32)

Religion Fractionalization Index	
Totally Homogeneous	1.00
Not Homogeneous	1.02(0.94-1.11)
Random Effect Part	
District	0.095(0.06-0.13)
Variance Partition Coefficient (%)	
Level2 (District)	2.80
Proportion Change in variance	0.464

Model 1 (empty model, not shown in this table) contains no exposure variables, decomposing total variance at the district level.

Model 2 contains exposure variables at both the individual and contextual levels.

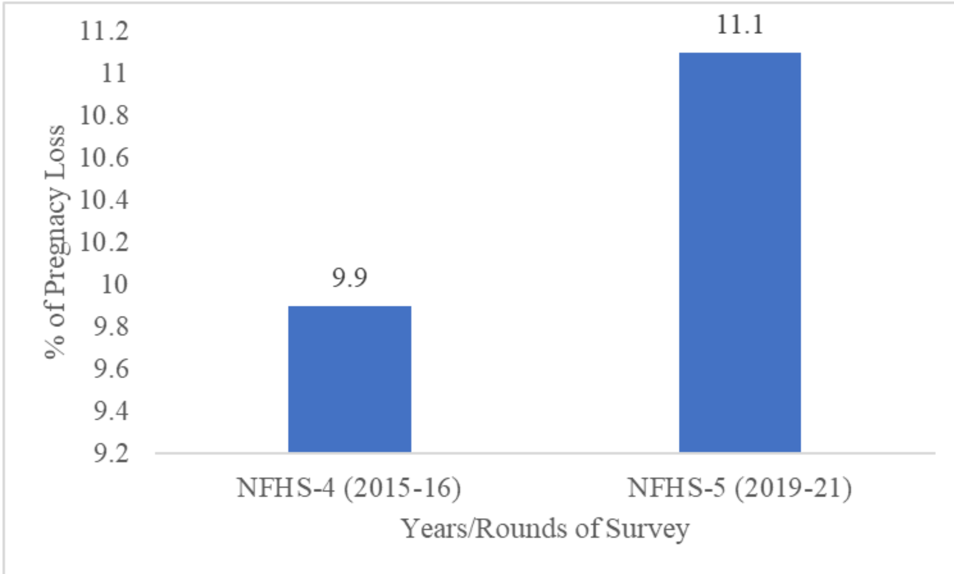

Figure 1: Changes in prevalence of Pregnancy Loss (PLs) in India during 2015-16 to 2019-21

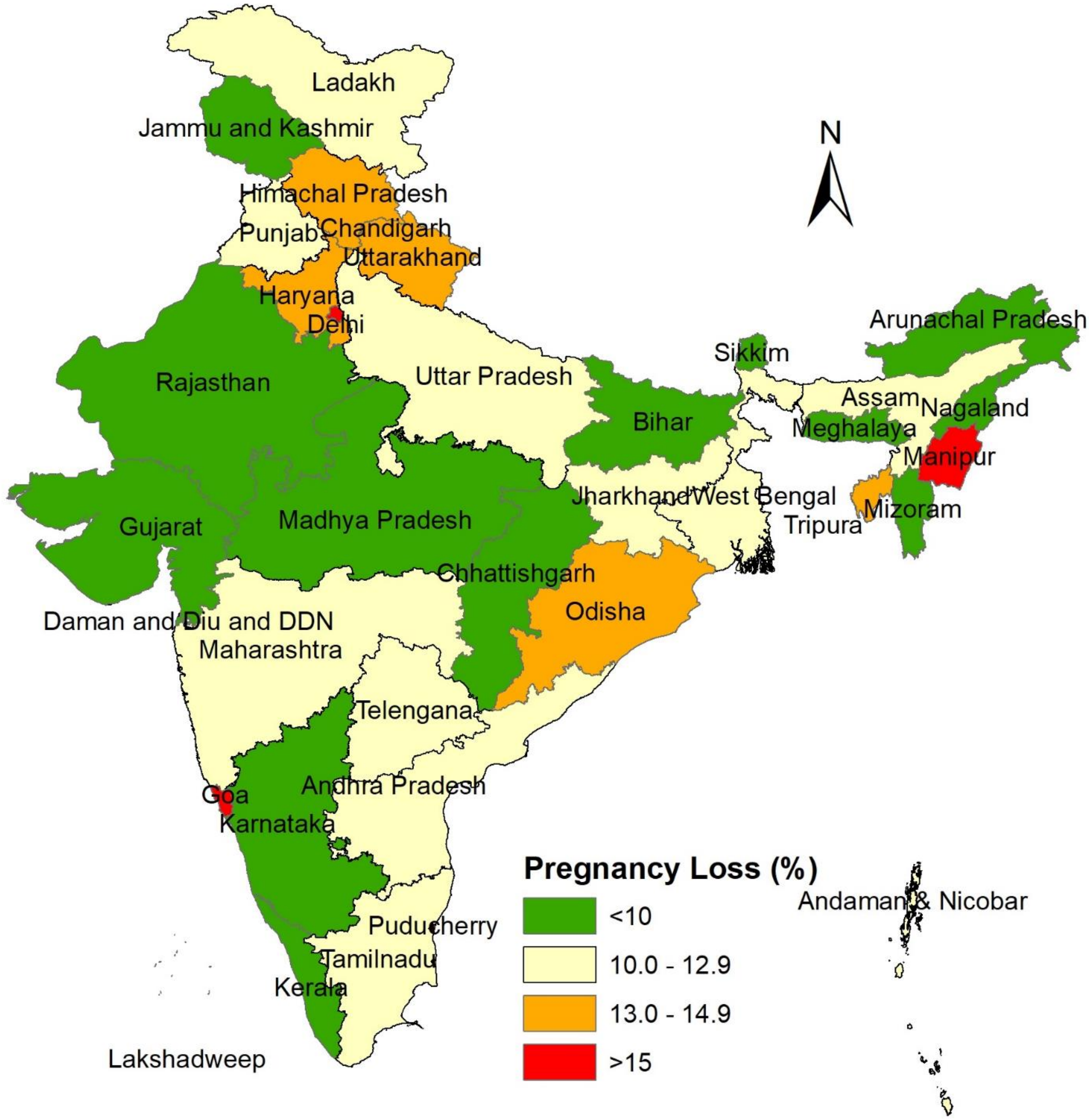

Figure 2: Prevalence of PLs among Women by States in India, 2019-21

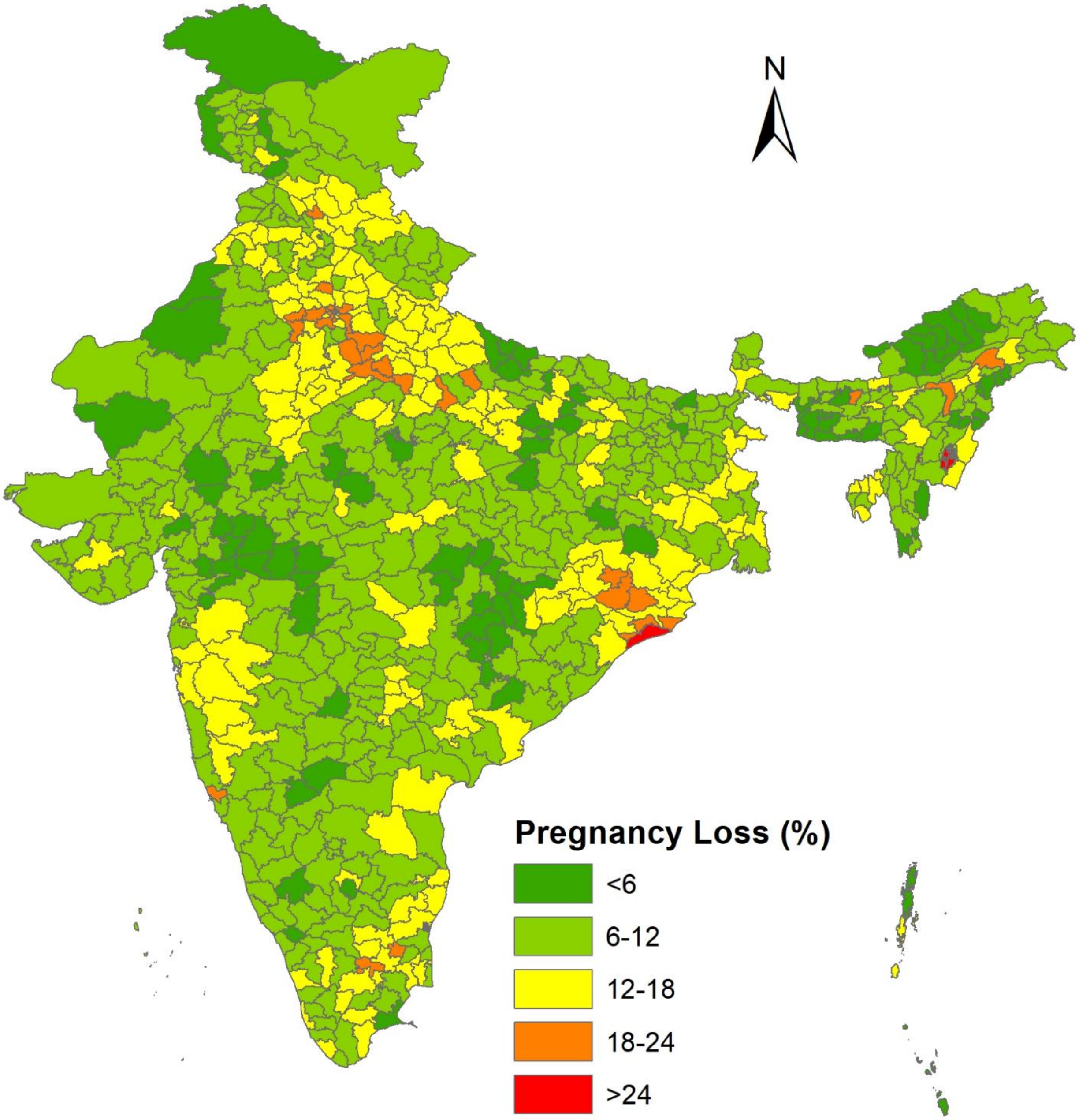

Figure 3: Prevalence of PLs among Women by Districts in India, 2019-21

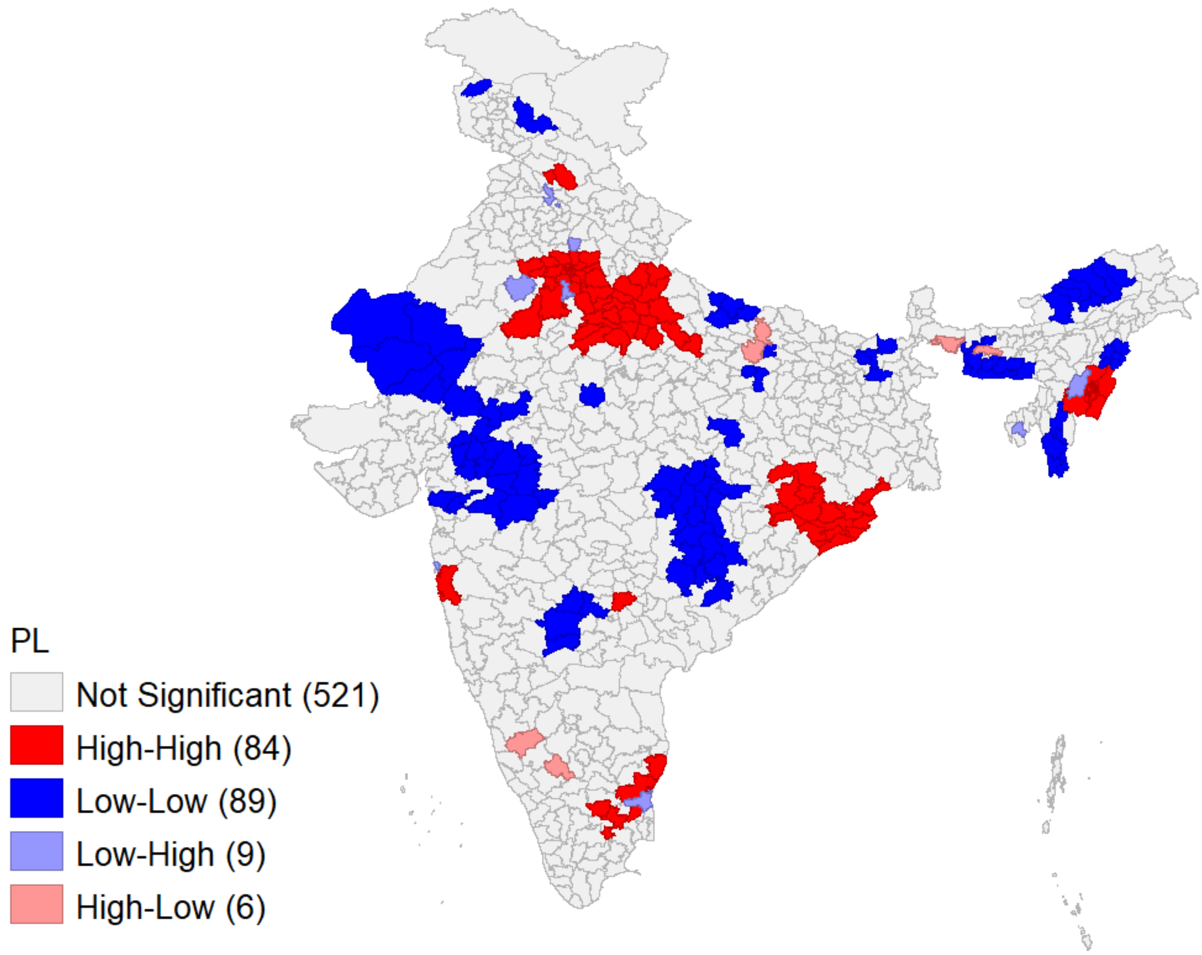

Figure 4: Univariate LISA Cluster showing Spatial Clustering and Outliers of Pregnancy Loss (Moran's I=0.559)

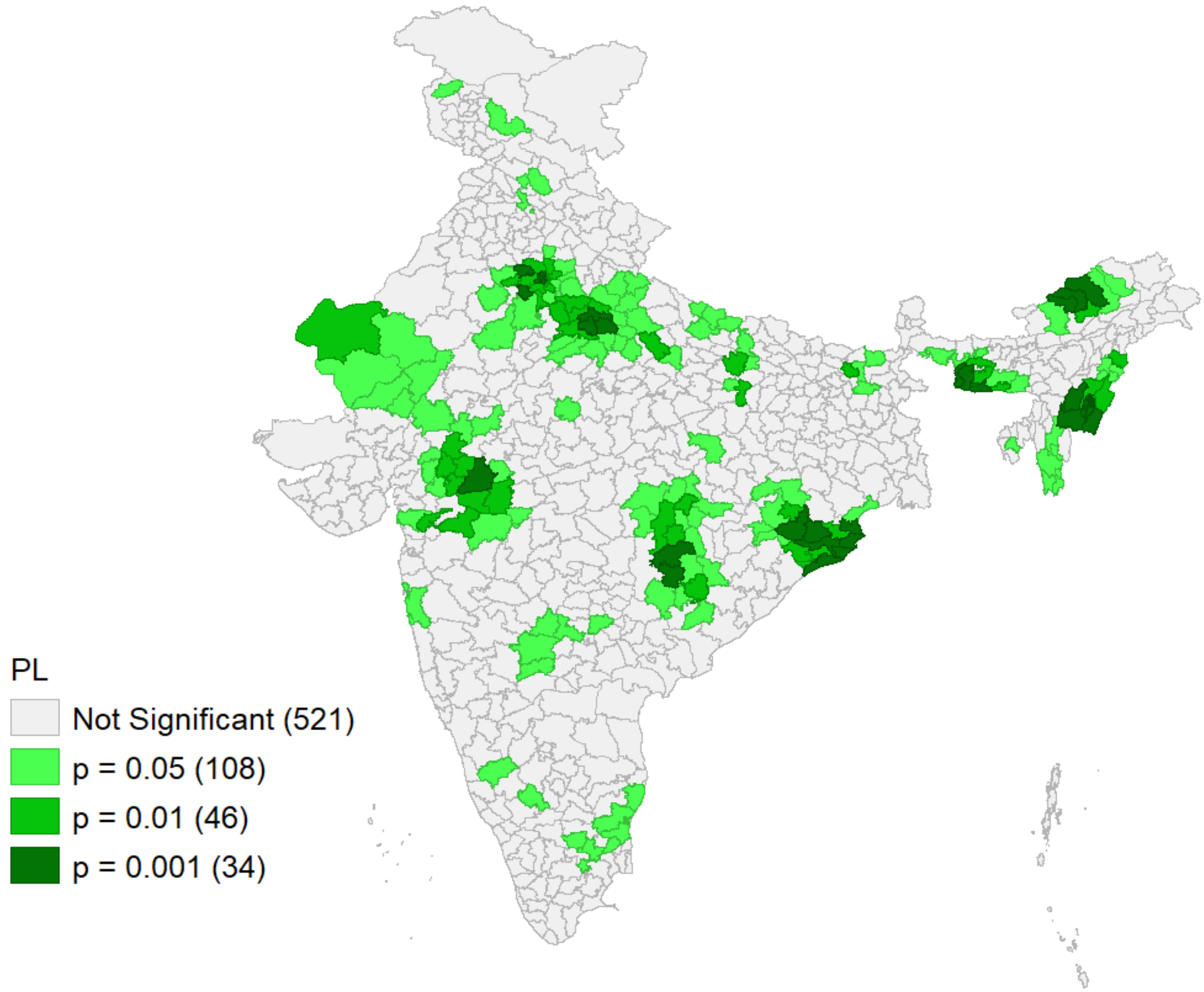

Figure 5: Significance Map for Pregnancy Loss showing significant locations among Indian districts