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Original Research

Determinants of antenatal care utilization in India: a spatial evaluation of evidence for public health reforms

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ABSTRACT

Objective: The objective is to examine the spatial variations and to identify the determinants of antenatal care (ANC) utilization while controlling for the spatial dependence in the data.

Study design: This is an ecological study on ANC utilization data from District Level Household Survey-4 (2012–2013) in India.

Methods: A secondary data analysis was performed on the derived data. The unit of analysis in this ecological study was 275 districts from 20 states of India. The study comprises ever married women of reproductive age. Determinants of ANC utilization were obtained using ordinary least square (OLS), spatial lag, and spatial error models. Model adequacy check was performed using the Akaike information criterion, R-squared, log likelihood, and Schwarz criterion. The software used is GeoDa and Quantum Geographic Information System.

Results: The presence of spatial autocorrelation (Moron's I = 0.6210) enforces the usage of geographic properties while modeling. The geographic clustering of low-rate districts was observed in states in Northeast India. In the present study, the model adequacy check reveals that the spatial error model performs better than the spatial lag and OLS models. The spatial pattern of the percentage of pregnant women with full ANC was observed to be associated with literacy ($P = 0.04$), birth order ($P < 0.001$), Janani Suraksha Yojana beneficiaries ($P = 0.048$), and availability of health infrastructure, staff, and services ($P = 0.023$).

Conclusions: The present study findings provide valuable insights into factors affecting ANC utilization. In addition to available ANC services, customized safe motherhood interventions and region-specific awareness programs would enhance the utilization, ensuring better maternal and child health.

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Introduction

Complications in pregnancy and childbirth are the leading cause of deaths among women, with 0.5 million deaths per year across the globe.[1,2] Almost 88%–98% of all maternal deaths could be avoided by proper care and handling during the period of pregnancy.[3] According to the World Health Organization (WHO), not availing antenatal care (ANC) is the main reason for maternal mortality.[4,5] Availing ANC helps in identifying threats to the mother and unborn baby's health, as well as for counseling on nutrition.[6] ANC is among the four most fundamental pillars of safe motherhood along with family planning, safe delivery, and essential obstetric care.[7] According to WHO, full ANC consists of a minimum of four antenatal visits, tetanus toxoid vaccination, screening, treatment for infections, and identification of warning signs during pregnancy.[4,8] In India, maternal mortality ratio (MMR) has declined from 437 to 178 per 100,000 live births in the period 1990–2012. This falloff is due to the government's reproductive, maternal, newborn, and child health and adolescent interventions that include many programs such as the promotion of institutional deliveries through Janani Suraksha Yojana (JSY), complete obstetric care, antenatal, and postnatal care of pregnant women. Despite the efforts from the government and the falloff in the indicators of MMR over the decade, significant improvement is necessary for maternal mortality and morbidity.[9] Goal 5-A of the Millennium Development Goals (MDG) aimed at health improvement with the target of reducing MMR by 2015.[10,11] India has progressed in reducing the MMR; however, the MDG-5 goal has not been achieved. Knowledge, awareness, and motivation regarding the utilization of ANC services are fundamental as it influences the well-being of the mother and her child.[12]

Variation in ANC utilization across different areas of the country is suspected, which is not evident from the annual averages. The wide range (9.7%–70.3%) of ANC utilization across the districts in India necessitates the examination of spatial patterns. Adolescent maternal healthcare utilization was associated with several factors, including the low socioeconomic status, limited reproductive knowledge, and geographic region.[13] In the present study, we examine the spatial dissimilarity and identify the determinants of ANC utilization, while adjusting for spatial dependence in the data. This work should be considered a preliminary study of the spatial patterns and determinants of ANC utilization in India.

Methods

Data set

This ecological study uses the aggregate-level data from the fourth round of the District Level Household Survey (DLHS-4) conducted in the year 2012–2013. The survey was conducted by various regional agencies and coordinated by the International Institute of Population Sciences, Mumbai.[14] Districts were taken as the unit of analysis for the present study. The data on empowered action group states, Chandigarh, Assam, Daman and Diu, Dadra and Nagar Haveli, Jammu & Kashmir, Delhi, Lakshadweep, are not available in DLHS-4 and hence, are not analyzed in this study.

The DLHS-4 provides the maternal and child health (MCH) indicators and prevalence of a wide range conditions. A list of factors considered for the present study is depicted in Fig. 1; DLHS-4 defines full ANC as at least three visits for ANC checkup, at least one tetanus toxoid injection received, and 100 iron–folic acid tablets/syrup consumed.[14] The software used in this study was GeoDa[15] 1.6.6 (Arizona State University, Tempe, AZ, USA) and QGIS 2.0.[16] The outcome variable considered in this study was the district-level percentage of ANC utilization.

Spatial analysis

Spatial autocorrelation helps to understand the degree to which one object is similar to other nearby objects. A global index of spatial autocorrelation evaluates whether the pattern expressed is clustered, dispersed, or random. Spatial cluster detection is essential to identify the cluster of locations with lower utilization of ANC for the formulation of policies on MCH. Global spatial autocorrelation Moran's I was used to measure the overall clustering of the data and to project the strength and pattern of spatial autocorrelation. Moran's I and local indicators of spatial autocorrelation (LISA) statistic were used to detect cold spots of district-level ANC utilization after accounting for the spatial autocorrelation.[17] LISA statistic is obtained in the form of a map and is based on the pattern of spatial autocorrelation. LISA allows for the disintegration of global indicators, such as Moran's I, into the contribution of each observation. They may also be used to assess the influence of individual locations on the magnitude of the global statistic and to identify spatial outliers.[18] A significance map was used to show the areas with a statistically significant LISA statistic value.[19] Hot spots are the geographic units with high ANC utilization (%) and are surrounded by other geographic units with high ANC utilization (%). Similarly, a cold spot is a geographic unit with low ANC utilization (%) surrounded by other geographic units with low ANC utilization (%). High–high and low–low districts suggest the clustering of geographic units with similar values of ANC utilization (%), whereas the high–low and low–high districts indicate spatial outliers.[20] To provide the weights, we used a queen first-order contiguity matrix.[21] The combination of the cluster map and the significance map allows visualization of the location-wise pattern of ANC utilization (%). A $P < 0.05$ was considered significant throughout.

To explore the relationship between the percentage of ANC utilization and set of explanatory variables, the regression techniques were used. The application of appropriate regression technique depends on the violation of the necessary assumptions. The ordinary least squares (OLS) estimation was built on assumptions that random error terms, independent variables are uncorrelated, have a constant variance and follow normal distribution. The OLS inference being centered on the assumption of independence, the presence of spatial autocorrelation bias the resulting inference. The diagnosis of spatial dependence was performed to test the extent to which these assumptions were violated. A multicollinearity condition number was used to investigate if the independent

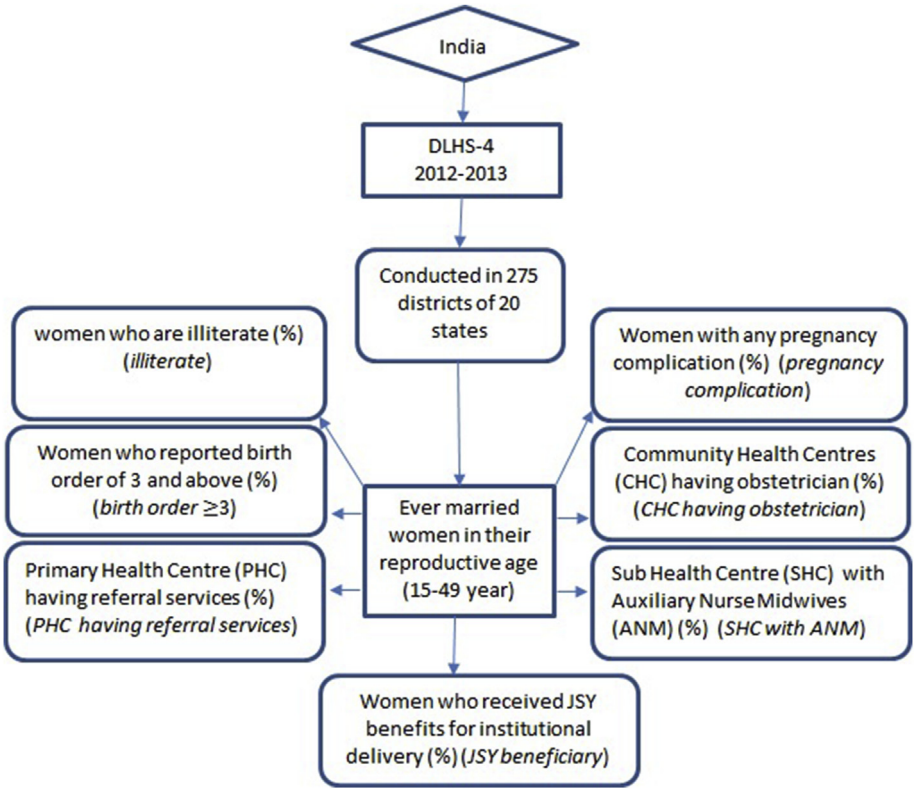

Fig. 1 – A flow diagram of the list of factors related to ANC utilization included for the analysis. DLHS, District Level Household Survey; ANC, antenatal care; JSY, Janani Suraksha Yojana.

variables are correlated. The Breusch–Pagan test was used to test for heteroskedasticity. To investigate if the error distribution was normal, Jarque–Bera test of normality of regression disturbances was used. A spatial regression technique was used to predict the value of an outcome variable based on values of a set of explanatory variables, taking into account the spatial dependence. Two forms of spatial dependence were spatial error and spatial lag.

Spatial error model

The dependency is said to be on the *spatial error* if the error terms across different spatial units are correlated. The spatial error model (SEM) with the parameters β, the matrix of observations on the explanatory variable (X), the spatial error coefficient (λ), the spatial lag of errors (W), the vector of spatially autocorrelated error term (u), and the vector of uncorrelated error terms (ε) is mentioned in equation (1).

$$y = X\beta + \lambda Wu + \varepsilon \quad (1)$$

If the spatial error coefficient $\lambda = 0$, then there exists no spatial correlation between the errors.

Spatial lag model

The spatial dependence is accounted to spatial lag if the dependent variable y in place i is affected by the independent variables in both places i and j.[22] The spatial lag model (SLM) for the matrix of observations on the explanatory variable (X), the parameters β and ρ, the vector of spatial lags for the dependent variables (W), and the vector of error terms (ε) is mentioned in equation (2).

$$y = X\beta + \rho Wy + \varepsilon \quad (2)$$

A spatial lag is a variable that averages the neighboring values of a location and controls spatial autocorrelation in the dependent variable. Dependence in the relationship between the dependent variable and spatial lag of itself supports the use of the SLM, and the dependence in the error terms endorses the use of SEM.[23–25] An OLS, spatial lag and spatial error regression were performed to model the ANC utilization. Comparison of the models was based on model diagnostic measures including, Akaike information criterion (AIC), R-squared, log likelihood, and Schwarz criterion. The aforementioned tests were performed using GeoDA software.

Results

The shapefile of India

The base map for the 275 districts of 20 states is given in Fig. 2(a). The blue-colored region represents the study area. This base map was obtained when the DLHS data were attached to the shapefile of India using the QGIS software.

Overall clustering of data

Global spatial autocorrelation Moran's I was used to measure the spatial autocorrelation among the values of ANC

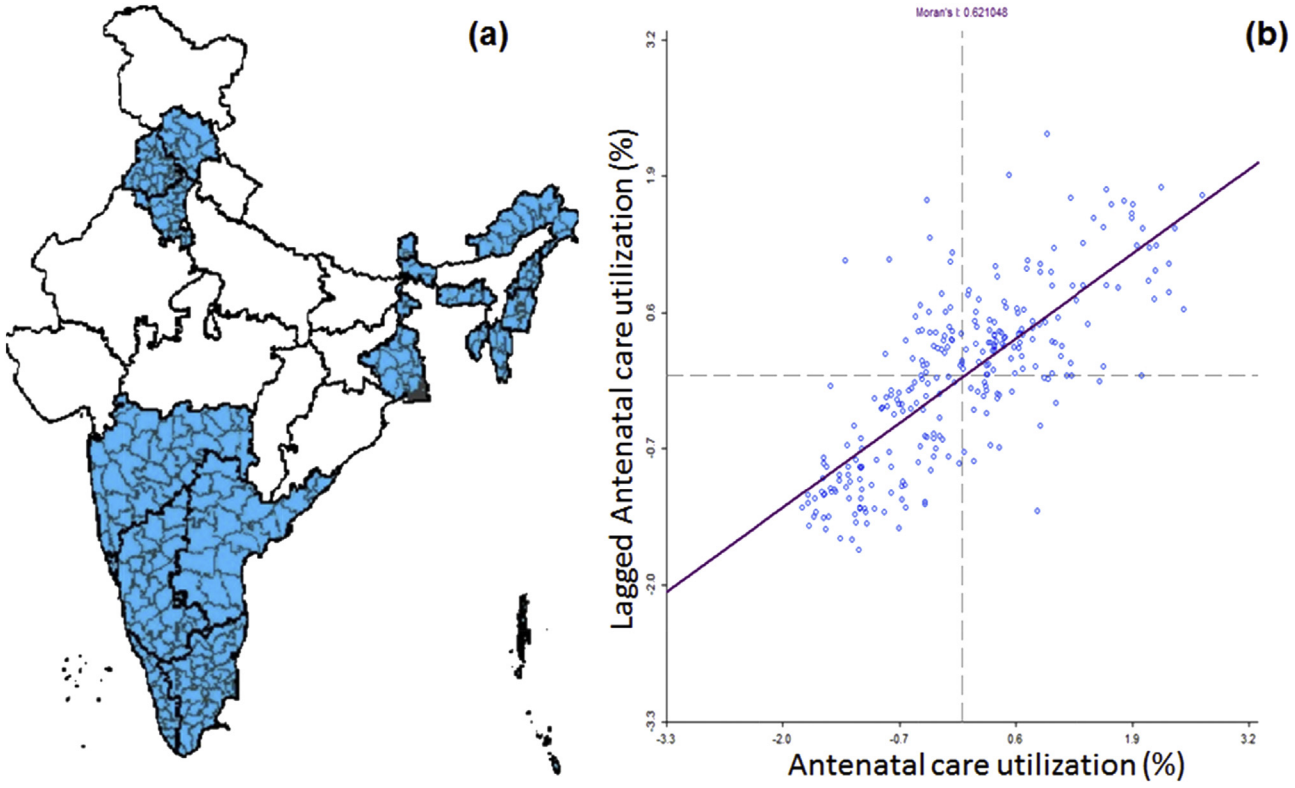

Fig. 2 – (a) DLHS data attached to the base map of India. (b) Moran's scatter plot, for full antenatal care utilization in India, provides a visual representation of spatial associations in the neighborhood of each district-level observation. It plots ANC utilization (%) on the X-axis and the spatial lag of ANC utilization (%) on the Y-axis. DLHS, District Level Household Survey; ANC, antenatal care.

utilization (%). Global Moran's I value for ANC utilization is observed to be 0.6210. Fig. 2(b) gives the Moran's scatter plot. The positive spatial autocorrelation signifies the importance of including a component of geography in the model for identifying the determinants of ANC utilization (%).

Cluster detection

This study reveals the presence of 32 hot spots and 63 cold spots of full ANC utilization in the study region. Locations with high values with similar neighbors are known as hot spots. Locations with low values with similar neighbors are known as cold spots. The hot spots are observed to exist in the districts of Kerala (07), Karnataka (14), Goa (02), Tamil Nadu (03), Maharashtra (01), Sikkim (04), and West Bengal (01). Cold spots exist in the districts of Haryana (19), Punjab (11), Arunachal Pradesh (15), Manipur (03), Meghalaya (04), and Nagaland (11). High–low and low–high clusters exist in Manipur (01), Andhra Pradesh (01), Karnataka (01), Kerala (03), and Tamil Nadu (02). The count in parentheses shows the number of significant cold spot(s) in respective states. The Fig. 3(a) and (b) allows visualization of the location-wise contribution to the ANC utilization. The statistically significant clusters which contribute to the global autocorrelation measure are listed in Table 1.

Spatial regression

Diagnostic tests for OLS assumptions suggest avoidable dependencies between the explanatory variable with the multicollinearity condition number 19.86. The Jarque–Bera test was used to examine the normality of the regression disturbances ($P < 0.006$). The test result indicates a violation of assumption on normally distributed errors. The Breusch–Pagan test indicates the possible existence of heteroskedasticity ($P < 0.001$), as the error variance is affected by the spatial dependence in the data. The violation of these assumptions necessitates the use of spatial regression. The estimates obtained using various models are shown in Table 2.

To determine the best model, we compare the model diagnostics for spatial lag and spatial error model. The model diagnostics used were AIC, Schwarz criterion, R-squared, and log likelihood. A model with lower AIC, higher log likelihood and lower Schwarz criterion and higher R-squared are said to have a better fit. It was observed that SEM compared with SLM had minimum AIC (2188.81 vs. 2207.47) and Schwarz criterion (2217.74 vs. 2240.03). SEM vs. SLM had highest log likelihood (−1086.4 vs. −1094.74) and R-squared (0.583 vs. 0.534). The spatial error model was observed to have the best fit and is hence used for further discussion. It was observed that for a unit increase in the JSY beneficiaries (%) and SHC with

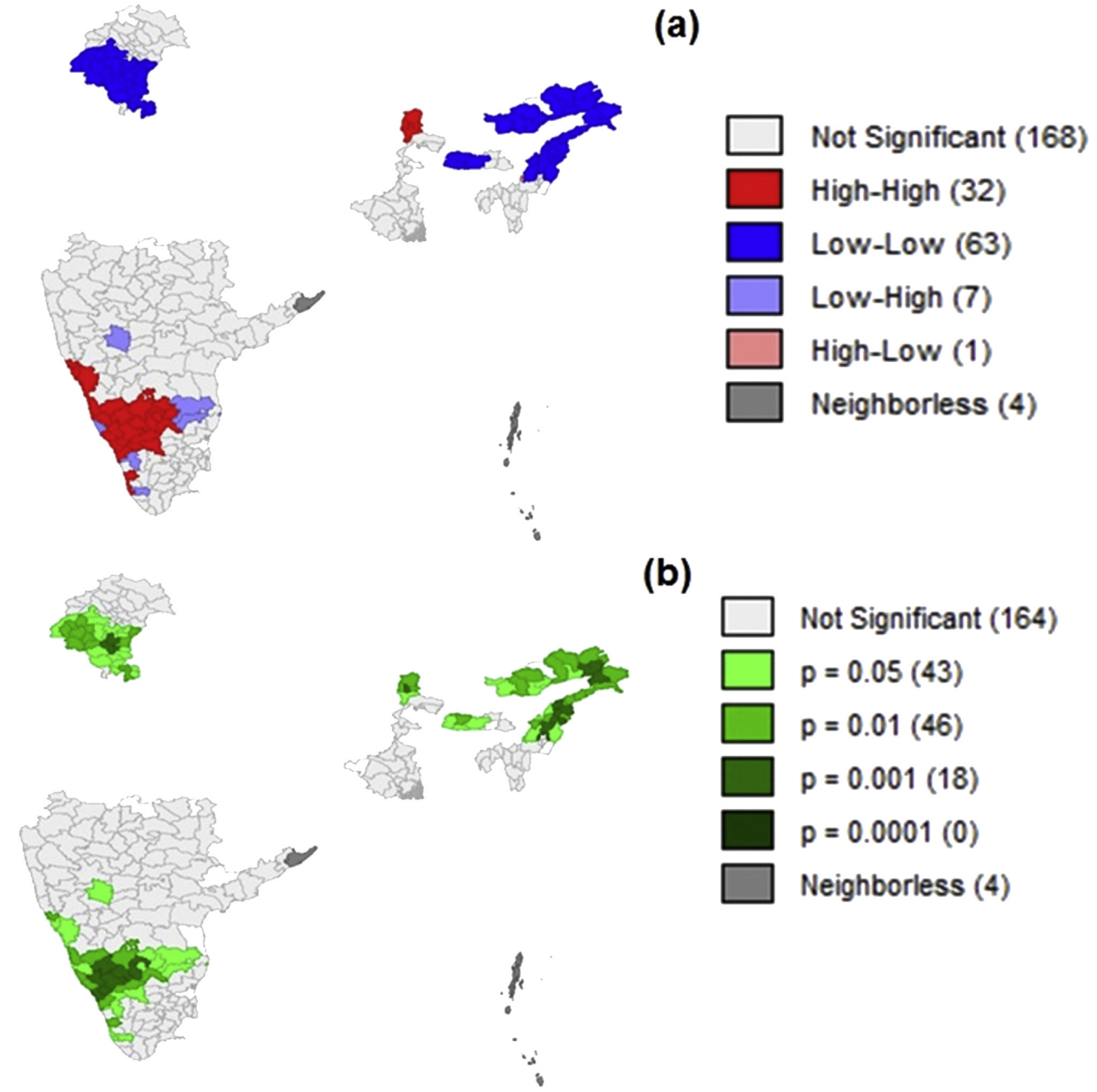

Fig. 3 – (a) Local indicators of the spatial association cluster map for ANC utilization in the study region. (b) Local indicators of the spatial association significance map for ANC utilization in the study region. The observed blank places on the map of India are due to the unavailability of data for empowered action group states. The analysis was performed only on the data available. ANC, antenatal care.

Auxiliary Nurse Midvives (ANM) (%), the ANC utilization (%) is expected to increase by 0.1% and 0.082%, respectively. With a unit (%) increase in illiterate and birth order≥3, we expect 0.17% and 0.47% decrease in the utilization of ANC.

Discussion

The presence of autocorrelation renders most statistical tests invalid, so it is important to test for. OLS yield biased estimates in the presence of spatial autocorrelation. While investigating the determinants in the presence of spatial autocorrelation, the use of spatial regression techniques is important. In the developing world, just half of the women attending ANC services receive the recommended number of visits.[26] The detection of cold spots over space gives valuable information about the vulnerable region that requires immediate attention toward ANC utilization. Although there are several studies performed on factors affecting ANC utilization, this study is the first effort of its kind to examine the factors

Table 1 – State-wise list of most significant clusters of ANC utilization in India at the district level.

Hot spot		Cold spot	
State	District	State	District
Kerala	Kozhikode	Manipur	Senapati
Kerala	Wayanad	Nagaland	Phek
Karnataka	Kodagu	Nagaland	Zunheboto
Karnataka	Hassan	Nagaland	Tuensang
Karnataka	Mysore	Nagaland	Mokokchung
Karnataka	Mandya	Arunachal Pradesh	Lohit
Karnataka	Ramanagara	Arunachal Pradesh	Lower Dibang Valley
Karnataka	Bangalore Rural	Haryana	Jind
Sikkim	South	Haryana	Kaithal

ANC, antenatal care.

associated with ANC utilization accounting for the spatial variations across India. This study reveals the presence of spatial autocorrelation of ANC utilization (%) which demands the usage of geographic properties while developing a model for population dispersed over the vast geographic area. The univariate LISA map helped to identify the locations with high ANC utilization surrounded by neighbors with high ANC utilization. These high–high locations were observed in Kerala, Karnataka, Goa, Tamil Nadu, Maharashtra, Sikkim, and West Bengal. The locations with low ANC utilization surrounded by neighbors with low ANC utilization were observed in Haryana, Punjab, Arunachal Pradesh, Manipur, Meghalaya, and Nagaland. Detection of these clusters helps policymakers identify the geographies demanding special attention. Knowledge of the geographic locations at the rear would benefit ineffective management of resources on time. Immediate action needs to be taken by allocating resources and creating awareness among the mass.

The present study identified that the illiterate, ones with birth order ≥3, not a beneficiary of JSY and those who do not have access to an SHC with ANM, are prone not to use full ANC. Studies[27] reveal a similar finding. ANMs are the primary source of information on services such as ANC and their importance in MCH care.[26] The JSY services include a timely recording of gestation, availing two tetanus toxoid injection and iron–folic acid tablets, receiving necessary instruction to handle difficulties, arranging transport to reach the health facility for delivery, staying in the health facility for 2–3 days to avoid delivery-related infections to mother and newborn.[28] These JSY services directly contribute to the WHO-recommended criteria on full ANC utilization.[4] The present study revealed the fact similar to the existing belief on the role of ANM and JSY services. We observed that with the increase in the percentage of SHC with ANM and with an increase in the percentage of beneficiaries of JSY, ANC utilization increases. Our finding is also in line with the WHO recommendation to ensure skilled care for all women, during pregnancy, childbirth, and the immediate postnatal period, to reduce maternal and newborn mortality.[29] Contrary to the WHO recommendation and present study findings, a study reveals that the availability of an ANM did not have a statistically significant effect on utilization of ANC services.[30] The percentage of increase in birth order ≥3 was observed to be associated with low ANC utilization. Studies[31–33] report on the similar lines and reveal that women with higher birth order have low utilization of healthcare services. The above may be for the reason that women in their prior pregnancy were informed about the needs and are thus less probable to pursue health services with the rise in the birth order. A study on determinants of ANC utilization in rural areas of India reported a significant reduction in the proportion of women obtaining ANC services with an increase in birth order and age.[30] The concentration of educated women points to the lower awareness of the need for care during childbirth. A study to investigate if mother's education affects ANC, characterized and estimated that maternal education had a strong influence on the utilization of ANC service. In addition to improving maternal and child care services, emphasis should be more on educating women.[34] Another study[35] reveals that low educational level, low income of the household, and not getting advice from health extension workers were associated with late ANC initiation.[36] The previously mentioned finding is in line with our result on factors associated with ANC utilization.

An intervention to improve early ANC initiation should focus on economic empowerment of women and a customized health education for migrant women. This study addressed the prevailing situation on ANC utilization using

Table 2 – Estimated regression coefficients obtained from OLS, spatial lag, and spatial error models.

Variables	OLS model		Spatial lag model		Spatial error model	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Constant	19.410	<0.001[a]	25.540	<0.001[a]	27.218	<0.001[a]
Illiterate	−0.108	0.061	−0.157	0.022	−0.166	0.040[a]
Birth order ≥3	−0.452	<0.001[a]	−0.795	<0.001[a]	−0.478	<0.001[a]
JSY beneficiary	0.118	0.056	0.266	<0.001[a]	0.102	0.048[a]
Pregnancy complication	0.077	0.249	0.233	<0.001[a]	0.093	0.161
SHC with ANM	0.076	0.018[a]	0.106	0.007[a]	0.082	0.023[a]
CHC having gynecologist	−0.136	0.217	−0.062	0.635	−0.116	0.237
PHC having referral	−0.003	0.892	−0.025	0.400	−0.013	0.668

ANC, antenatal care; OLS, ordinary least square; JSY, Janani Suraksha Yojana; SHC, Sub Health Center; CHC, Community Health Center; PHC, Primary Health Center; ANM, Auxiliary Nurse Midvives.

[a] $P < 0.05$ indicates that the factor has a significant impact on ANC utilization (%).

the aggregate level data available and advanced analytical techniques incorporating a component of geography. This study is beneficial for planning the healthcare facility at the district level. Despite the efforts mentioned previously, there are few limitations in the study. The unit of analysis is a district and not an individual. Analyzing district-level data may lead to the ecological fallacy. Thus, the findings cannot be generalized at the individual level. The DLHS-4 was conducted only in 20 states of India. Owing to unavailability of data in DLHS-4, the analysis was not performed on the remaining nine states. Better identification of risk factors is expected if the metadata with the names of finer blocks were available. Owing to the unavailability of data, factors such as the place of residence, wealth index, partner's education, final say on health care, and exposure to mass media were not considered for this study. These factors might play an important role, and hence, future work may use information on these aspects while explaining spatial dissimilarities in ANC utilization.

In summary, the utilization of ANC depends on knowledge and awareness among recipients and also on the availability and approachability of services with excellence. For the practical use of resources, the health education program should focus on high-risk groups of women in the detected cold spots of Haryana, Punjab, Arunachal Pradesh, Manipur, Meghalaya, and Nagaland. The identified cold spots need attention concerning priority allocation of auxiliary nurse midwives, organizing awareness programs concerning the importance of utilization of ANC and existing safe motherhood interventions. To ensure delivery of a healthy child and decrease in maternal deaths, literacy of mothers is pivotal. Knowledge of, and the use of ANC may improve by introducing need-based maternal and child healthcare programs. This study points to the fact that education is essential for enabling women to advocate the necessary actions and to be able to discriminate good or bad. To receive a significant reduction in the excessively high levels of maternal mortality and morbidity in developing countries such as India, the services need to be delivered based on a more comprehensive perspective of women's well-being with an emphasis on empowering women to look after their own health needs with a gratuity of healthier family.

Author statements

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Ethical approval

Not required. The study uses secondary data available from data.gov.in/catalog/district-level-household-and-facility-survey-dlhs-4 r the National Data Sharing and Accessibility Policy (NDSAP) of Government of India.

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Competing interests

None declared.

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