Original Article

Determinants of public institutional births in India: An analysis using the National Family Health Survey (NFHS-5) factsheet data

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Abstract

Background: Institutional births ensure deliveries happen under the supervision of skilled healthcare personnel in an enabling environment. For countries like India, with high neonatal and maternal mortalities, achieving 100% coverage of institutional births is a top policy priority. In this respect, public health institutions have a key role, given that they remain the preferred choice by most of the population, owing to the existing barriers to healthcare access. While research in this domain has focused on private health institutions, there are limited studies, especially in the Indian context, that look at the enablers of institutional births in public health facilities. In this study, we look to identify the significant predictors of institutional birth in public health facilities in India. **Method:** We rely on the National Family Health Survey (NFHS-5) factsheet data for analysis. Our dependent variable (DV) in this study is the % of institutional births in public health facilities. We first use Welch's *t*-test to determine if there is any significant difference between urban and rural areas in terms of the DV. We then use multiple linear regression and partial F-test to identify the best-fit model that predicts the variation in the DV. We generate two models in this study and use Akaike's Information Criterion (AIC) and adjusted R^2 values to identify the best-fit model. **Results:** We find no significant difference between urban and rural areas ($P = 0.02$, $\alpha = 0.05$) regarding the mean % of institutional births in public health facilities. The best-fit model is an interaction model with a moderate effect size (Adjusted R2 = 0.35) and an AIC of 179.93, lower than the competitive model (AIC = 183.56). We find household health insurance ($\beta = -0.29$) and homebirth conducted under the supervision of skilled healthcare personnel ($\beta = -0.56$) to be significant predictors of institutional births in public facilities in India. Additionally, we observe low body mass index (BMI) and obesity to have a synergistic impact on the DV. Our findings show that the interaction between low BMI and obesity has a strong negative influence ($\beta = -0.61$) on institutional births in public health facilities in India. **Conclusion:** Providing households with health insurance coverage may not improve the utilisation of public health facilities for deliveries in India, where other barriers to public healthcare access exist. Therefore, it is important to look at interventions that minimise the existing barriers to access. While the ultimate objective from a policy perspective should be achieving 100% coverage of institutional births in the long run, a short-term strategy makes sense in the Indian context, especially to manage the complications arising during births outside an institutional setting.

Keywords: Health insurance, homebirths, India, institutional births, multiple linear regression, NFHS-5, public healthcare utilisation

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Introduction

In the context of childbirth, births can take place either at home or at healthcare facilities, whether they are private or public. Institutional birth (IB) pertains to delivering babies in healthcare establishments, such as hospitals or birthing centres,

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under the watchful care and supervision of proficient healthcare practitioners and skilled health workers.[1] For this reason, IBs help mitigate maternal and neonatal complications to a large extent by providing a safe birthing environment for both the mother and the neonate.[2] Healthcare facilities enable access to vital prenatal and postnatal services provided by skilled birth attendants, emergency obstetric care, and constant monitoring, all of which are necessary for promoting favourable mother and baby health outcomes during childbirth. Homebirths, on the other side, pose a considerable challenge on the public healthcare front due to the risks and complications associated with pregnant women giving birth at home with or without any supervision. Barriers such as exorbitant expenses in private facilities, absence of health insurance coverage, scarcity of healthcare personnel and infrastructure in public facilities, socioeconomic disparities, cultural influences, geographical obstacles, and concerns about the quality of public healthcare services can hinder pregnant women in developing countries from accessing healthcare institutions during childbirth. Under the access-constrained environment, pregnant women are often left with no choice but to resort to homebirth. Hence, from a policy front, the proportion of IBs remains a key health indicator, especially in the context of developing nations such as India, with high maternal and neonatal mortality.[3,4]

Public IBs in India carry immense significance due to their potential to address healthcare disparities and improve the health outcomes of the socialised and marginalised population. Further, in resource-constrained settings, where access to quality healthcare remains a challenge, public healthcare institutions serve as lifeline for pregnant women, especially from semi-urban and rural areas, by providing them access to the optimal continuum of care required during a delivery episode.[2] Public facilities offer affordable or free services to ensure that a larger chunk of the population can access necessary maternal healthcare, reducing disparities and improving overall healthcare equity. Regarding public IBs, the recent National Family Health Survey-5 (NFHS-5, 2019-21) reveals that the percentage of public IBs has risen over time (i.e. from the NFHS-4), signalling a positive trend towards utilising public health institutions for births. Nevertheless, disparities have been noted among different states, districts, and socioeconomic groups regarding the usage of public healthcare facilities for childbirth owing to a range of factors.[5] An example of a significant barrier that could explain the variation is the proximity to the nearest public health centre, which is particularly challenging in rural and isolated regions. Pregnant women in these areas frequently face the burden of travelling considerable distances to access the nearest public healthcare facility for childbirth. The issue is exacerbated by the insufficient transportation infrastructure, which greatly hinders pregnant women's ability to conveniently reach these services. Moreover, these limitations to accessibility have a greater impact on socio-economically disadvantaged and marginalised populations and contribute to some extent to the existing health inequalities.[6,7] To effectively design future interventions and strategies to enhance access and usage of public health facilities for birthing in India, it is crucial to have a comprehensive understanding of the key factors that influence public IBs. Nevertheless, the existing literature examining the antecedents of public IBs in India is limited. Instead, extant studies have investigated IB from a private healthcare perspective.

Therefore, to address the aforementioned gaps and provide actionable insights to policymakers, and practitioners, our study empirically investigates two broad research questions related to public IBs in India: (a) Is there a significant difference between urban and rural geographies in terms of the percentage of public IBs? (b) what factors (variables) are significantly associated with public IBs in India? We rely on the National Family Health Survey (NFHS-5) factsheet data to answer the two research questions. The NFHS-5 compendium of factsheet is a representative dataset that contains data from urban and rural areas of 28 states and 8 Union territories (UTs) of India. The observation period for the survey was between 2014 and 2019, and the data were collected through a nationwide survey between 2019 and 2021. NFHS-5 factsheet provides information on various indicators related to population, reproductive and child health, family welfare, and nutrition.[8,9] We use Welch's *t*-test to answer the first research question. For the second research question, we use the multiple linear regression approach to identify an economical and robust model to determine the significant predictors and examine their relationship with public IBs in India. We observe no statistically significant difference between urban and rural areas in the mean percentage of public IBs during the NFHS-5 observation period. Further, we identify household health insurance coverage, homebirths under the supervision of skilled healthcare workers, and antenatal care (ANC) visits by pregnant women as significant predictors of public IBs in India. Finally, our results show that low body mass index (BMI) and obesity together are potential clinical risk factors that can have a negative impact on the utilisation of public healthcare institutions by pregnant women during childbirth.

Our study findings contribute to policy and practice and offer actionable insights regarding strategies needed to promote IBs and manage homebirths under scenarios where access to public healthcare institutions remains challenging. From a policy perspective, our research highlights the need to conduct a feasibility study to assess the effectiveness of public health insurance programmes such as Janani Suraksha Yojana (JSY) and Ayushman Bharat Yojana about public IBs in India. Although these schemes were designed to lower the healthcare affordability barrier, they may not improve healthcare institutional access to pregnant women during childbirth. Additionally, we argue that in a country such as India, where the public healthcare system is severely resource-constrained, policymakers should look at short-term and long-term measures to manage childbirths. From a long-term perspective, the ultimate goal should be to ensure that all births occur in public or private healthcare institutions. However, the short-term focus should be primarily directed at managing homebirths where the majority of clinical complications become very hard to manage, thereby putting the lives of both mother and newborn at risk. An effective short-term strategy

would be to follow a targeted outcome-driven approach and develop protocols and SOPs that consider the combined services of Accredited Social Health Activists (ASHAs) and physicians in the primary healthcare centres (PHCs) to provide the required continuum of home-based care to pregnant women who are at high risk due to low BMI, obesity, and other related clinical factors that restrict their access to healthcare institutions for childbirth.

From a practitioner's perspective, we discuss the centrality of physicians in the PHCs as key stakeholders in managing homebirths under a short-term strategy. The reason is that despite the promise that the ASHA programme has shown as a successful community-based intervention since its establishment, there are certain shortcomings in terms of providing quality care to pregnant women when it comes to homebirths, especially in high-risk cases that require expert supervision. Often, ASHAs lack the required training and technical expertise to effectively manage complications or make timely judgements related to hospital referrals. The involvement of primary physicians as healthcare experts in these scenarios becomes extremely important in mitigating some of the shortcomings related to the functioning of ASHAs during home-based care. Our findings show that pregnant women with low BMI and obesity must be prioritised as a target population that needs special attention from primary physicians in terms of providing home-based care during the delivery episode as they may not be able to access healthcare institutions easily. We discuss later that low BMI and obesity together act as a physical barrier that leads to restricted mobility, and hence, the likelihood of homebirth may be higher.

We recommend that primary care physicians look to establish an effective surveillance system within the community setting in collaboration with ASHAs to promptly detect pregnant women with low BMI and obesity at an early stage of pregnancy. The proposed system must include a regime of scheduled home visits, continuous monitoring, and immediate referral to district hospitals upon any early signs of complication in high-risk cases. Further, from a larger community perspective, we recommend that primary physicians must be in attendance in all the community-based programmes that focus on creating awareness among pregnant women about the importance of IBs because the community often sees primary physicians as a trusted voice owing to their healthcare-related expertise and hence, their participation along with ASHAs can add much value in terms of the desired outcome of community-based initiatives.

We organise the study in the following manner. The literature review comes next, followed by the method, results, and discussion sections. We conclude by providing future research areas and discussing the limitations of the present study.

Literature Review

Public healthcare service delivery in developing nations suffers from several deficiencies that hinder their accessibility and utilisation by pregnant women during childbirth. The primary obstacle arises from poor infrastructure and constrained resources in healthcare facilities, leading to subpar conditions for birthing. Public health centres suffer from a shortage of crucial equipment such as sterile birth kits and fully operational operating theatres, which undermines the safety and standard of IBs.[10,11] The second challenge involves socio-cultural factors, where traditional beliefs and preferences for homebirths discourage women from seeking institutional deliveries. In this regard, a study by Hodgins and D'Agostino[12] finds that deeply ingrained cultural practices and norms in certain communities undermine the perception and utilisation of institutional deliveries, leading to higher rates of homebirths and potential complications. Lastly, financial barriers pose significant challenges on the affordability front as out-of-pocket expenses related to transportation, medical fees, and supplies create financial burdens for women and their families, restricting their access to institutional delivery services.[13,14] These critical issues emphasise the need for comprehensive interventions addressing infrastructure deficiencies, cultural attitudes, and financial barriers to promote safe and accessible institutional deliveries in developing countries.

India has been working for decades to enhance its healthcare infrastructure but still needs to overcome tremendous hurdles in delivering primary healthcare to its population. The high maternal and neonatal mortality rates show India's healthcare system's shortcomings. Many supply- and demand-side variables in India create hurdles to seeking maternity care by the general population. Demand-side variables include the mother's education, family economic position, ethnicity, and religion; supply-side variables include the availability and proximity to a health centre, a female specialist, and drug availability. Furthermore, programme and neighbourhood characteristics substantially impact how people use delivery care.[15] Even though the cost of healthcare and the household's ability to pay for healthcare (economic variables) are significant barriers to facility-based delivery, few studies have examined the socioeconomic variations in the cost of care delivery in the Indian context.

Households contribute 71% of health spending in India, with the government accounting for 20%, businesses accounting for 6%, and foreign aid accounting for 2%.[16,17] Extremely high out-of-pocket (OOP) family health spending is usually devastating for households with low-income levels.[18] According to some national-level surveys and past studies, impoverished Indian families are more likely to borrow money or exchange possessions to pay for health care than wealthier households, a phenomenon referred to as distress financing.[19,20] Health spending on maternity and general health care is extremely high and proves distressing for low-income, rural families, especially those with lower levels of education, slum residents, and impoverished who regularly borrow to meet the high healthcare expenses.[21] India and other low and middle-income countries have highlighted grave policy concerns regarding ineffective targeting and misappropriation of public funds.[22] Early reviews of the National Rural Health Mission (NRHM) programmes show that lowering the affordability barriers has a favourable

influence on hospital delivery care service use, with utilisation rising from 39% in 2005-2006 to 79% in 2015-2016.[23] However, none of this research explicitly compared the public and private sector's contributions to increasing the number of persons receiving hospital delivery care or lowering socioeconomic inequalities.[16] Although significant increases in public health spending are essential for attaining health equity, the impact of such efforts on equity differs by nation and remains to be investigated.

Financial capability determines how services are delivered. In India, wealth significantly impacts both the mode of birth – institutional or at home, and the site of institutional delivery – public or private healthcare facilities.[24] Further, regional diversity has a more significant impact on delivery and building style than money, demonstrating the importance of social, cultural, and related elements in institutional dispatching.[25] Emerging countries confront these challenges by ensuring consistent coverage of medical delivery care services across public and private institutions.[26] The study by Govindasamy and Ramesh[27] from four North and South Indian states shows that increasing funding for women's education can help alleviate newborn, child, and maternal death rates. Additionally, location, religion, socioeconomic category of a family, women's autonomy and media exposure have all been shown to have a substantial effect on the usage of institutional facilities, especially in rural India. In this regard Raj *et al.*[28] found that women from the Scheduled Castes and Scheduled Tribes in Uttar Pradesh, India, were less likely to give birth at a hospital than women from the general population and other disadvantaged socioeconomic groups. In general, prenatal care (PNC) and skilled birth attendant (SBA) usage in India is associated with significant economic inequalities, regardless of the resident's state, mode of living (rural or metropolitan), or geographical location.[29,30]

The Indian government started the NRHM in 2005, which was later renamed the National Health Mission (NHM) in 2013 (Department of Health and Family Welfare, 2014). The programme aimed to improve public health centres' facilities and staff resources to increase access to maternity and paediatric healthcare services. A countrywide conditional cash distribution plan was one of the initiatives. It was established to enhance institutional delivery, focusing on supplemental medications, testing, and drop-off locations for pregnant women and mothers. An extensive network of community health workers was also established to improve links between communities and the public health system, as well as healthcare knowledge and understanding.[31]

Several notable research gaps exist in the current understanding of institutional delivery in India. Firstly, there is a need for comparative research that examines the effectiveness of healthcare financing reforms and the impact of health insurance coverage on facilitating access to maternal and child health services. While some studies have explored the relationship between health insurance and institutional delivery, more in-depth investigations across diverse contexts are necessary to ascertain the extent of their influence. Secondly, there is a dearth of comprehensive studies that delve into the underlying reasons behind women's continued preference for home births despite the availability of skilled birth attendants and well-equipped healthcare facilities. Lastly, the association between maternal obesity or low BMI and the likelihood of IB warrants further investigation, given malnutrition is a significant problem in India. A comprehensive examination of these relationships, including the underlying mechanisms and potential interventions to address the specific needs of obese or underweight women, would contribute significantly to the existing knowledge base. Closing these research gaps will advance evidence-based strategies aimed at improving institutional delivery rates and enhancing maternal and neonatal health outcomes in India.

Although the government of India has implemented economic incentive schemes such as JSY to encourage institutional delivery, many women still choose to give birth at home due to various accessibility-related obstacles. Additionally, women, in many cases, owing to cultural beliefs, believe that giving birth in a healthcare facility is not essential.[32] In a recent study conducted by Jain, Abbas, and Malhotra,[33] it was found that women who lacked formal education, were not employed, and had pregnancies that were not officially recognised tended to favour giving birth at home. Surprisingly, the study did not observe any statistically significant impact of socioeconomic position or women's age at marriage on homebirths. Another study by[34] revealed that most of the deliveries at home are concentrated among women in poor households or reported among women from rural communities.

However, the concerning pattern associated with homebirths has significant implications in terms of the increased likelihood of neonatal and infant mortality. Pregnant women who choose to give birth at home sometimes display reluctance towards immunisations, which worsens the health hazards. Home births lack comprehensive screening for a range of disorders, such as cardiac and metabolic conditions, that are regularly performed in healthcare institutions. This absence of screenings further exacerbates the risk of maternal and newborn fatalities. In addition, residences lack essential facilities to address critical medical emergencies, and births are most often overseen by traditional midwives or *Dais*, who often lack the required skills to ensure the health and safety of both the mother and child, hence increasing the risks involved.[35,36] Hence, it is imperative for a nation like India to develop dedicated strategies and planning for interventions for not only managing homebirths but also for raising awareness and providing education to expectant mothers regarding the advantages of institutional births and the downsides of homebirths.

Methods

Data, sample, and the dependant variable (DV)

We examine the NFHS-5 (2019-21) factsheet data for the required investigation and statistical analysis. The factsheet contains data on a wide range of indicators (health and

non-health related), collected through one the largest survey in India, i.e. National Family Health Survey 2019-21 (NFHS-5).[18] The NFHS-5 factsheet is publicly available and can be downloaded from the Ministry website (www.mohfw.gov.in). The sample size of this study is 71 (N = 71), which includes observations from 28 states and eight UTs (urban and rural areas) of India. Due to the unavailability of data, Chandigarh (rural) is not included in the final dataset containing information on 23 indicators listed in Table 1. The variable of interest or the dependent variable (DV) relevant to the purpose of our study is the % of institutional births in public facilities (*ib_phf*).

List of Variables

Welch's *t*-test

Welch's *t*-test is an unequal variances *t*-test that can determine whether the means of two independent groups are equal.[37] Accordingly, we use Welch's *t*-test in this study to determine if there is any significant difference in the mean % of institutional births between urban and rural areas.

Modelling

We generate two models (see results section for model summaries) using multiple linear regression techniques to identify the predictors that are significantly associated with the DV. We rely on Akaike's Information Criterion (AIC),[38] and the partial F-statistics[39,40] to select the model that best fits with the available dataset. AIC is an estimator of prediction error and an indicator of the relative quality of statistical models for a given data set.[41,42] Additionally, a partial F-test helps determine whether a statistically significant difference exists between a model and some nested version of the same model.[40,43] Therefore, AIC and the partial F-test statistic provide a reliable estimate to determine the model with the best fit from within a group of models. We use the coefficient of determination (R^2) as an additional check for fit and to estimate the % of the variation in the DV that the predictors in the best-fit model explain.[44] We count on the adjusted-R^2 estimates for our analysis as they account for the number of significant predictors in a model, thereby providing a more precise estimate of the variation in the DV. In addition, adjusted R^2 provides an estimate of the population compared to R^2, which provides the estimate as explained by the predictors in the sample.[45]

Model diagnostics

Model diagnostics involve checking whether the model meets the six basic assumptions of linear regression: linearity, normality, constant variance (homoscedasticity), absence of multicollinearity, independence of standardised residuals (absence of autocorrelation), and absence of any significant outliers.[46] Violating these assumptions can lead to biased and unreliable estimates of the regression coefficients.[47] Accordingly, we visualise the scatter plots to validate linearity (linear relationship between the independent variables and the DV), and the

Table 1: List of variables

Variable	Definition
ib_phf[a]	Institutional births in public facility (%)
households_health_ins	Households with any usual member covered under a health insurance/financing scheme (%)
women_literate	Women (age 15-49) who are literate (%)
women_school_10 y	Women (age 15-49) with 10 or more years of schooling (%)
women_internet	Women (age 15-49) who have ever used the internet (%)
women_marriage_less_18 y	Women (age 20-24) years married before age 18 years (%)
tfr	Total Fertility Rate (number of children per woman)
m_women_fp_unmet	Total Unmet need for Family Planning (currently married women (age 15-49)) (%)
m_women_space_unmet	Unmet need for spacing (currently married women age (15-49)) (%)
hw_comm_female_fp	Health worker ever talked to female non-users about family planning (%)
mothers_anc_1 trimester	Mothers who had an antenatal check-up in the first trimester (for last birth in the 5 years before the survey) (%)
mothers_4anc	Mothers who had at least 4 antenatal care visits (for last birth in the 5 years before the survey) (%)
mothers_mcp	Registered pregnancies for which the mother received a Mother and Child Protection (MCP) card (for last birth in the 5 years before the survey) (%)
avg_oop_phf	Average out-of-pocket expenditure per delivery in a public health facility (for last birth in the 5 years before the survey) (Rs.)
homebirth_skillled_hw	Home births that were conducted by skilled health personnel (in the 5 years before the survey) (%)
birth_skilled_hw	Births attended by skilled health personnel (in the 5 years before the survey) (%)
women_low_bmi	Women (age 15-49 years) whose body mass index (BMI) is below normal (BMI <18.5 kg/m^2) (%)
women_obesity	Women (age 15-49 years) who are overweight or obese (BMI ≥25.0 kg/m^2) (%)
women_high_waisthipratio	Women (age 15-49 years) who have a high-risk waist-to-hip ratio (≥0.85) (%)
women_anaemia	Women (age 15-49 years) who are anaemic (%)
women_bank_account	Women (age 15-49 years) having a bank or savings account that they themselves use (%)
women_mobile_selfuse	Women (age 15-49 years) having a mobile phone that they themselves use (%)
women_paidincash_12 months	Women (age 15-49 years) who worked in the last 12 months and were paid in cash (%)

[a]Dependent Variable (DV)

plot of "standardised residuals" against the "standardised predicted values" to verify constant variance.[46] Additionally, we use the Breusch-Pagan (BP) test to statistically establish the absence of any significant heteroscedasticity.[48] We review the quantile-quantile (Q-Q) plot and use the Shapiro-Wilk test to verify the normality assumption.[49] Further, consistent with Trunfio *et al.*,[46] we use the Variance Inflation Factor (VIF) (cut-off <5) and Tolerance (cut-off >0.2) values to detect multicollinearity in the best-fit model. Finally, we rely on Cook's Distance (cut-off <1)[50] to affirm the absence of significant outliers in the dataset and the results of the Durbin-Watson (DW) statistical test to demonstrate the independence of the residuals.[51]

Software

In this study, we use RStudio 2023.03.0 + 386 "Cherry Blossom" release to conduct the statistical analysis and the required investigation.[52]

Results

Descriptive statistics

Table 2 below shows the descriptive statistics of the 23 variables considered for this study. The results show that an average of 64.36% (SD ± 15.92%) of institutional births occurred in India in public health facilities before the NFHS-5 survey. The rural average was about 68% compared to 61% from the urban areas. Ladakh topped the list with 98% of institutional births in public facilities, while Kerela ranked lowest (about 34%).

Descriptive statistics of the key variables used in the study (N = 71).

Table 2: Descriptive statistics of the key variables used in the study (*n*=71)

Variable	Mean	SD	Min	Max
ib_phf[a]	64.36	15.92	30.23	98.38
households_health_ins	39.29	20.73	1.44	90.39
women_literate[#]	1.91	0.06	1.74	2.00
women_school_10 y	49.47	15.23	17.89	79.78
women_internet	46.57	18.47	13.98	89.99
women_marriage_less_18 y[#]	1.08	0.36	0.00	1.70
tfr	1.73	0.42	0.71	3.31
m_women_fp_unmet	10.04	4.18	4.44	28.15
m_women_space_unmet[#]	0.60	0.23	0.00	1.30
hw_comm_female_fp	21.20	7.17	5.21	36.60
mothers_anc_1 trimester	74.35	11.22	43.63	100.00
mothers_4anc	67.24	17.52	13.06	94.84
mothers_mcp	94.61	8.09	41.57	100.00
avg_oop_phf [##]	62.59	19.41	18.10	127.30
homebirth_skillled_hw	2.42	2.47	0.00	11.62
birth_skilled_hw	91.76	9.07	48.16	100.00
women_low_bmi	13.80	6.50	3.65	30.85
women_obesity	29.04	10.26	8.61	47.62
women_high_waisthipratio	61.34	12.01	38.56	89.18
women_anaemia	53.86	13.65	24.05	94.30
women_bank_account	40.08	20.61	-29.41	74.46
women_mobile_selfuse	78.20	15.19	0.00	96.70
women_paidincash_12 months	63.06	29.44	-80.98	96.93

Dataset used for analysis includes 71 observations from rural and urban areas of 28 states and 8 Union Territories (UTs). A total of 6,36,699 households were surveyed under NFHS-5, which included 1,60,138 urban and 4,76,561 rural households. Regarding gender, a total of 7,24,115 women (age 15-49 years) and 1,01,839 men (age 15-54 years) were included in the NFHS-5 survey. In the above table, SD represents the standard deviation. Min and Max represent the minimum and maximum values. [a]Dependant Variable (DV). [#]log transformation. [##]square root transformation

T-test statistics

From the results of the Welch's *t*-test, we found the difference in means for our sample data to be 13.98 [-0.46, 14.36], and the 95% confidence interval (CI) shows that the true difference in means lies between -0.46 and 14.36. Further, we found no significant difference in the mean % of institutional births between urban and rural areas ($P = 0.0654$, $\alpha = 0.05$).

Regression models

We developed two models to predict the variation in the DV: Model 1 and Model 2. We used the backward elimination technique to generate Model 1.[53] Model 1 had an AIC of 183.56 and an adjusted R^2 of 0.30. Further, we found all the predictors in Model 1 to be statistically significant at $\alpha = 0.05$. Next, we generated Model 2 to capture the interaction effect of the two predictors, *women_low_bmi* and *women_obesity* (refer to Table 1 for predictor details) on the DV. We used the partial F-test to validate the significance of the coefficient of the interaction term. As shown in Table 3 below, the partial F-test statistics is 5.28 ($P = 0.02$, $\alpha = 0.05$), indicating that the coefficient of the interaction is significant.[33,34]

Partial F-test estimates (Model 1 and Model 2).

Further, Model 2, the interaction model, had an AIC of 179.93 and an adjusted R^2 of 0.35. Because of its lower AIC, higher adjusted R^2 and the significance of the interaction term, Model 2 was deemed a better fit among the two models, given the data. Table 4 below shows regression summaries of the two models.

Ordinary Least Square (OLS) regression summaries of the models predicting the % of institutional births in public health facilities in India (N = 71).

The interaction model (Best fit)

The equation below represents the interaction model. In the equation, y represents the DV, and x_1 to x_5 are the five predictors, *households_health_ins, mothers_4anc, homebirth_skillled_hw, women_low_bmi and women_obesity* [refer to Table 1]. β_0 is the intercept value, and β_1 to β_5 are the estimated standardised regression coefficients of individual predictors. β_6 is the standardised coefficient estimate of the interaction term.

$$y = \beta_0 - \beta_1 x_1 + \beta_2 x_2 - \beta_3 x_3 + \beta_4 x_4 - \beta_5 x_5 - \beta_6 (x_4 * x_5)$$

Our results show [Table 4] a statistically significant association between *households_health_ins* ($P = 0.01$), *homebirth_skillled_hw* ($P = 0.00$, $\alpha = 0.05$) and the DV. In addition, we also find the association between the interaction term (*women_low_bmi* * *women_obesity*) and the DV to be statistically significant ($P = 0.02$,

$\alpha = 0.05$). However, we observed no significant association between *women_low_bmi*, *women_obesity* and the DV. In addition, we also did not find any significant association between *mothers_4anc* and the DV.

Finally, estimates of the standardised regression coefficients obtained for the model **(see Table 4 and equation above**), show a negative association between the two significant predictors, the interaction term and the DV.

Interaction model diagnostics

We find the DW test statistics for the interaction model to be 1.6, and it was within the acceptable range [1.5; 2.5] to demonstrate the absence of autocorrelation (or independence of residuals). Further, the Cook's distance for each observation was less than 1, so there were no influential outliers in the dataset that could influence the coefficient estimates.[46]

Figure 1 below shows the scatter plots between individual predictors in the model and the DV. Further, Figure 2 below shows the plot of "standardised residuals" against the "standardised predicted values" used to verify that the variance of the residuals is constant. As can be seen in Figure 2, the variance of residuals is not constant across predicted values, indicating a violation of the homoscedasticity assumption. The BP test statistic for the interaction model was 6.19 ($P = 0.4016$, $= 0.05$), indicating that the observed violation in homoscedasticity is not significant and hence acceptable.[54]

Figure 3 below shows the Q-Q plot used to verify the normality of standardised residuals. As can be seen, the points are quite close to the line, indicating a fair normal distribution of residuals.[46] Further, the Shapiro-Wilk test statistic was found to be 0.97 ($P = 0.11$, $\alpha = 0.05$), indicating no significant departure from the normality assumption.[55]

Lastly, Table 5 below shows the multicollinearity statistics for the interaction model. The VIF values are less than 5, and the Tolerance values are always greater than 0.2, indicating the absence of multicollinearity. The high VIF and low Tolerance values, as observed in the case of *women_low_bmi* and *women_obseity*, are because of the inclusion of the interaction term in the model, which is normal.[56]

Table 3: Partial F-test estimates (Model 1 and Model 2)

	Res.Df	RSS	Df	SS	*F*	*P*
Model 1	65	45.28				
Model 2	64	41.83	1	3.45	5.29	0.02*

Res.Df represents the Residual Degrees of Freedom. Df represents the number of constraints, i.e., the interaction term. RSS represents the residual sum of squares, and SS represents the difference in RSS between Model 1 and Model 2. F represents the F-statistics (in this case, the partial F-statistics), and *P* indicates the *P* value. α=0.05. * indicates *P*<0.05

Discussion

The purpose of this study was to determine the predictors that significantly impact public health institutional deliveries in India. We relied on the NFHS-5 factsheet data to carry out the required investigation. We developed a simple interaction model using multiple linear regression, and our model explains about 35% of the variance in the DV. We found household health insurance, homebirths under the supervision of skilled healthcare workers, low BMI, and obesity to be the significant factors impacting the DV. Finally, our model shows a synergetic influence of low BMI and obesity on the DV.

The centrality of public health institutions for deliveries in India

Institutional delivery is an essential component of the maternal and neonatal healthcare services continuum. As per the World Health Organization (WHO), maternal and neonatal deaths are preventable by providing good quality care and adequate access to basic healthcare services.[57] Maternal and neonatal complications are less likely when expectant mothers can access a nearby health facility rather than deliver at home.[58] Accordingly, institutional deliveries remain a key healthcare performance indicator for developing nations like India, with a high burden of neonatal and maternal deaths.[59] The associated data provides a rich source and

Table 4: Ordinary Least Square (OLS) regression summaries of the models predicting the % of institutional births in public health facilities in India (*n*=71)

	Model 1				Model 2			
Predictors	***β***	***t***	***P***	**95% CI [LL, UL]**	***β***	***t***	***P***	**95% CI [LL, UL]**
Intercept	0.00	0.00	1.00	[-0.19,0.19]	0.00	0.00	1.00	[-0.19,0.19]
households_health_ins	-0.31	-2.78	0.01*	[-0.52,-0.09]	-0.29	-2.68	0.01*	[-0.50,-0.07]
mothers_4anc	0.33	2.2	0.03*	[0.03,0.62]	0.29	1.95	0.06	[-0.00, 0.58]
homebirth_skillled_hw	-0.51	-3.24	0.00*	[-0.81,-0.20]	-0.56	-3.65	0.00*	[-0.87,-0.25]
women_low_bmi	-0.34	-2.76	0.01*	[-0.57,-0.09]	0.26	0.9	0.37	[-0.31,0.82]
women_obesity	-0.81	-4.97	0.00*	[-1.12,-0.48]	-0.25	-0.87	0.39	[-0.82,0.32]
women_low_bmi X women_obesity	–	–	–	–	-0.61	-2.3	0.02*	[-1.13,-0.08]
R^2			0.35*				0.40*	
95% CI			[0.12,0.46]				[0.16,0.50]	
Adjusted-R^2			0.30				0.35	
AIC			183.56				179.93	

Note *β* indicates standardised regression coefficients, *t* represents the t-statistics and *P* represents the *P* value. Square brackets are used to enclose the lower and upper limits of a 95% confidence interval. AIC indicates the Akaike's Information Criterion. *indicates *P*<0.05

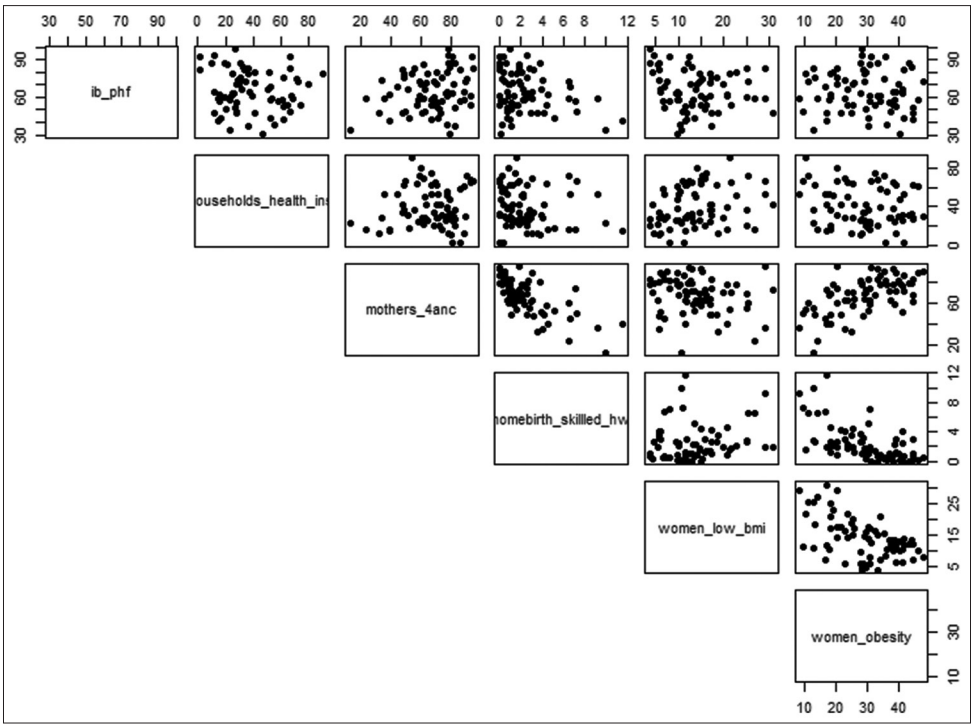

Figure 1: Scatter plots showing the association between the independent variables and the DV

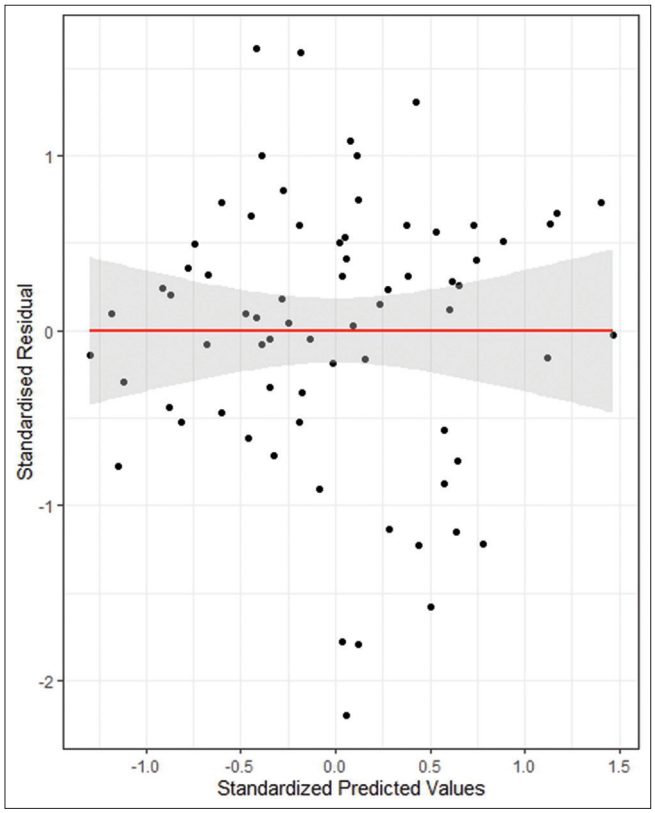

Figure 2: Plot of "standardised residuals" against the "standardised predicted values"

one of many ways for policymakers and researchers to assess the country's current state of public healthcare in terms of capacity, quality, and utilisation.

Table 5: Multicollinearity statistics

Predictor	Tolerance[a]	VIF[b]
households_health_ins	0.80	1.24
mothers_4anc	0.43	2.33
homebirth_skillled_hw	0.39	2.54
women_low_bmi	0.11	8.73
women_obesity	0.11	8.93
women_low_bmi X women_obesity	0.13	7.53

VIF represents the Variance Inflation Factor. [a]Tolerance cut-off >0.2. [b]VIF cut-off <5

Private health institutions provide better physical infrastructure and quality of care. However, they are expensive and sometimes inaccessible, limiting their utilisation for institutional births by households with low per-capita income and lower socioeconomic levels.[60] In this scenario, delivering at public health facilities or at home remains the most feasible option for expectant mothers, given the constraints. Our findings show that about 64% of institutional births occurred in public health facilities in India before the NFHS-5 survey. About 61% of births occurred in public health facilities from urban areas compared to 68% in rural areas. Our findings show no significant difference between urban and rural areas regarding the mean % of institutional births in public health facilities.

Our above findings align with the extant literature and show that public health facilities remain the major setting for delivery by expectant mothers from urban and rural areas in India. Therefore, from a policy perspective, it is logical to consider intervention strategies that can target and remove the existing barriers to public healthcare access. These strategies must ensure timely and quality care is available to expectant mothers at public health institutions before, during and after delivery.

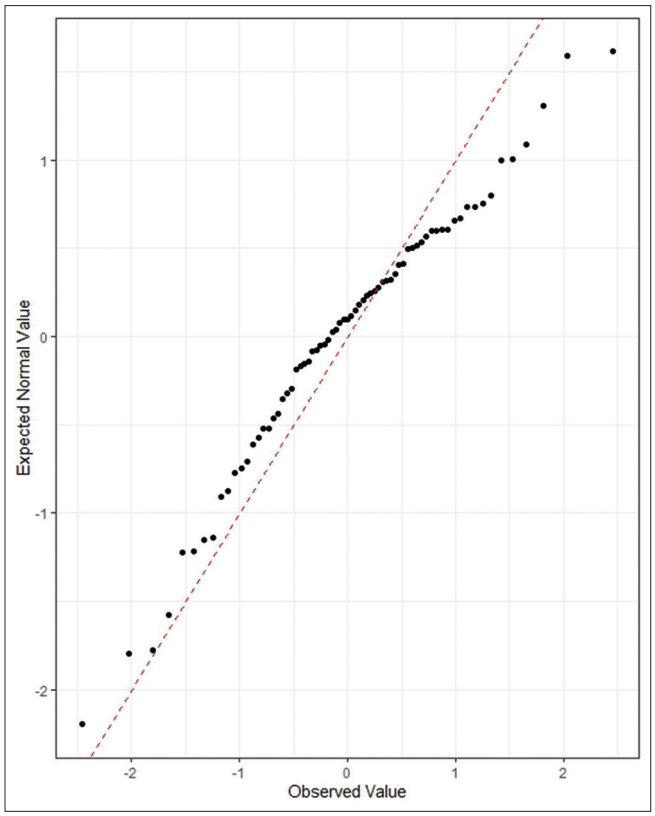

Figure 3: The Q-Q plot

Health insurance coverage and institutional births in public health facilities

The high cost of healthcare remains a primary concern for developing nations like India, which acts as a major barrier to access. While public healthcare services are cheaper than private providers, they are still significant. Study by Prinja *et al.*[2] shows that the unit cost per full ANC visit to a PHC or a community health centre (CHC) is about ₹650, and per postnatal care (PNC) visit, it is about ₹700. Further, at CHCs, the unit cost is about ₹3800 for institutional delivery. At District Hospital (DH) level, the cost can be as high as ₹4700 for an operation.[61] In the context of childbirths in India, schemes like JSY provide cash assistance to expectant mothers for delivery and post-delivery care.

Past studies have shown that sufficient healthcare financing, including adequate health insurance coverage, improves access to basic healthcare services in developing nations.[62] Further, studies have shown that health insurance can influence the use and quality of these services. By providing financial protection and reducing OOP expenses, health insurance enables pregnant women to access timely and adequate prenatal and PNC at private or public health institutions.[63] Very few studies, especially from India, have focused on the relationship between health insurance and IB in public health facilities. This information is extremely relevant in the context of India, where public healthcare is the preferred choice for many. However, the available evidence on this subject is inconclusive, given the differences in measurement, contradictory findings, and statistical limitations.

Our findings indicate that the proportion of IBs in public health facilities decreased in India with an increase in households with valid health insurance coverage before the NFHS-5 survey. Based on the findings, we make two crucial observations. First, although health insurance eases the financial burden related to high healthcare costs, this does not necessarily improve access to public health institutions for delivery. In this case, private health institutions or home delivery remain the only two alternatives. Second, in addition to the high cost of healthcare, it is worthwhile to investigate other barriers related to the accessibility of public healthcare in India that prevent expectant mothers, even with valid health coverage, from accessing them. Literature in this context from developing nations and India provides mixed observations. For instance, the study by Sekabaraga, Diop and Soucat[64] shows that women beneficiaries of a community-based health insurance scheme are more likely to deliver in modern health facilities than uninsured women. In contrast, the study by Aggarwal[65] found no discernible effect of the Yeshasvini health insurance scheme (in the state of Karnataka, India) on the choice of facility-based deliveries. Nonetheless, our findings present insights for policymakers and scholars looking to examine the impact of health insurance schemes on public healthcare access.

Low BMI and obesity, the potential barriers to access

The literature on the relationship between maternal obesity or low BMI and the likelihood of IB is complex and multifaceted. The dominant argument that emerges from the extant research relates to mobility. Muscle weakness, low BMI, and obesity are rated as critical determinants of mobility-related disorders in individuals[66] that significantly reduce the health-related quality of life.[67] Based on the literature, it can be understood that low BMI and obesity act as potential barriers to healthcare access. Therefore, expectant mothers with low BMI and obesity are less likely to access nearby health facilities owing to mobility-related issues easily. Further, the literature also points towards the maternal and neonatal complications arising from low BMI and obesity, increasing hospital length of stay (LOS).[68] The increased LOS results in a higher cost of healthcare due to extra monitoring and specialised care needed to reduce the overall risk of maternal and neonatal deaths.[69,70]

Our findings show that low BMI and obesity synergistically influence the proportion of institutional births in public health facilities. We observe a significant negative association (β = -0.61) between the interaction term and the % of institutional births in public health facilities. Altogether, our findings align with the literature and show that low BMI and obesity are critical barriers to institutional deliveries in public health facilities in India. Our findings are significant as they highlight the pressing need to deliver the required continuum of care to expectant mothers suffering from low BMI and obesity. From a policy perspective, measures must be directed at – (a) restructuring the current malnutrition programme to address the needs of expectant mothers, especially targeting expectant mothers with low BMI and obesity, and (b) providing

the required infrastructure that facilitates easy and timely access to nearby public health facilities.

Homebirths and the need for a short-term strategy

Our findings above highlight India's continuing challenges in providing citizens access to basic healthcare services. There is a high cost associated with private healthcare providers, and in most scenarios, private healthcare remains accessible to only a small chunk of the population. However, public healthcare is more affordable, but several barriers exist (both financial and non-financial) that prevent their utilisation by the people. In addition, the timing and quality of care provided at public health institutions are inadequate and require a serious upgrade. Given the combined scenario and the inability to access health institutions for birth, homebirths remain the only choice for many expectant mothers from disadvantaged socioeconomic areas and other marginalised populations with less education and low economic levels. Maternal delivery at home without skilled care at birth is a major public health issue in India that leads to numerous maternal and neonatal complications.[32] Therefore, it is necessary to ensure that no homebirths happen without the supervision of skilled healthcare workers.

In the long run, one of many ways to tackle the high neonatal and maternal mortality burden is to achieve 100% coverage of institutional deliveries. However, this is easier said than performed, given India's pre-existing challenges and barriers to healthcare access. Our findings, in this case, are significant and show that homebirths under the supervision of a skilled health worker negatively influence the proportion of births in public health facilities. The present situation calls for a short-term parallel strategy to ensure that no homebirths occur without the supervision of a healthcare worker. The strengthening of public healthcare facilities and more effective use of skilled birth attendants and their networking must be considered to provide the required supervision at home for mothers unable to deliver at a health institution. Nonetheless, the electronic and economic empowerment of women and their caregivers must be carried out to create awareness about the risks associated with homebirths and the benefits of delivering at a health institution. From a policy perspective, a combination of a short-term and a long-term strategy may help address the issue of high neonatal and maternal in India and ensure 100% coverage of institutional deliveries in the long run.

Homebirths and the role of primary physicians

Physicians at PHCs play a crucial role in providing public healthcare services to the community. They frequently serve as the initial point of contact for expert assistance during emergencies, making them healthcare professionals who operate as intermediaries between the community and public healthcare facilities, such as the district hospitals. Primary physicians are responsible for delivering both clinical and non-clinical services to the specific community where the PHC is situated. Clinical services involve the provision of appropriate diagnostics and tests, the dispensation of medications, and the management of any potential consequences. From a non-clinical perspective, primary care physicians collaborate with community health workers, such as ASHAs, to improve the quality and efficacy of public healthcare services through community-based programmes and interventions. Nevertheless, the scarcity of primary physicians has been a long-standing issue in India, which has resulted in a low doctor-to-patient ratio, consequently restricting the coverage of public healthcare services. Moreover, and as frequently observed, doctors at the PHCs are unable to deliver care at patients' homes due to their high workload. The ASHA programme, which is a community-based intervention, was specifically implemented to tackle the aforementioned problems regarding coverage. The programme has achieved significant success thus far. Nevertheless, ASHAs possess certain limitations in terms of their lack of both experience and expertise in administering healthcare services provided to the community.

As mentioned before, pregnant women who cannot attend public healthcare institutions for delivery due to impediments to accessibility are left with no alternative but to give birth at home. This is a worrying sign for India, as homebirths are linked to numerous complications that can endanger the health of both the mother and the newborn.[32,34] In such conditions, home-based care during the prenatal, birth, and postnatal stages becomes of utmost importance. Primary physicians here must collaborate and create a robust operational framework with ASHAs in delivering home-based care to pregnant women who are unable to reach healthcare facilities for childbirth. By fostering collaboration, primary physicians can address certain limitations associated with ASHAs by ensuring that ASHAs carry out their duties under the competent supervision of the physician. Nonetheless, to effectively manage homebirths in the short term, the government must focus on augmenting the doctor-to-patient ratio, particularly in rural regions, to achieve a more significant outcome. Primary care physicians, however, due to their heavy workload, need to establish systematic mechanisms and clinical protocols to: firstly, identify individuals at high risk (such as women with low BMI, obesity, and other medical conditions); secondly, implement a regimen of ongoing monitoring for these high-risk cases; thirdly, conduct regular home visits for high-risk women before and after delivery; and finally, ensure immediate referral for emergency situations involving these cases. We suggest that a one-size-fits-all approach by primary physicians in providing maternal healthcare services may not be ideal in the Indian scenario. The specific type and level of services needed should be determined and given priority on an individual basis, particularly in situations where there is a shortage of primary physicians. In the long run, primary physicians who are trusted voices within the community for their expertise should actively continue to participate in community health initiatives that aim to raise awareness among pregnant women about the risks associated with homebirths.

Conclusion

Research implications

Addressing the high neonatal and maternal mortality rates remains a top policy priority for a nation like India. Accordingly,

promoting and facilitating institutional births remains one of the government's primary objectives, as it helps manage the risk and complications associated with births outside an institutional setting. In this respect, the JSY launched in 2006 remains one of India's signature policy initiatives that was launched to promote institutional deliveries by upgrading the antenatal, delivery and postnatal services and providing incentives for food and transport to expectant mothers.[61] However, several barriers to healthcare exist in India that prevent expectant mothers from accessing healthcare institutions for birth. Our study shows that public health institutions remain the preferred setting for birth in the Indian context. Therefore, interventions must prioritise removing the existing barriers to public healthcare access. This would require an in-depth understanding of the determinants and co-determinants that affect institutional births in public health facilities.

Our study shows that household health insurance, low BMI and obesity are critical determinants of institutional birth in public health facilities in India. Hence, providing healthcare coverage like the JSY may not be a viable solution alone, and policymakers must look at a combined interventional strategy that removes other existing barriers to access. We debate that while achieving 100% coverage of institutional births should be the primary objective, the process is complicated, given the existing challenges and the effect can only be realised in the long term. Therefore, it makes sense to pursue a short-term strategy that ensures that all births that occur outside an institution are under the expert supervision of a skilled health worker. This would require upgrading the existing health infrastructure in terms of skills and capacity to provide the necessary and timely supervision at home for expectant mothers who cannot access a health institution for delivery.

Future research

Future research must establish a causal relationship between the predictors identified in the study and the institutional births in public health facilities. Further, studies may examine the factors determining the choice between a private, public, and home birth setup, especially in the rural context. From a policy perspective, achieving a seamless transition from homebirths to institutional births makes sense in the long run while ensuring that the required care and supervision are available at home while the transition is in place. It may be useful to rethink the role and responsibilities of government physicians ASHAs in providing the required continuum of care to expectant mothers who deliver at home. The focus must be on both time and quality of care, which means the current ASHA workforce would require an upgrade in skills required to provide quality and timely care to expectant mothers and provide immediate referral services when necessary.

Study limitations

The present study suffers from two major limitations. First, due to the small sample size (N = 71) of the NFHS-5 factsheet data. Further investigation using household or individual-level data can improve the predictive ability of the present model. Second, some states/UTs have smaller sample sizes for the survey than others, which could have resulted in mild approximation errors. Nevertheless, our study findings are robust, and the simple model developed in this study has a moderate effect size (Adjusted R^2 = 0.35). Our study provides actionable insights for policymakers and practitioners and a useful research framework for scholars willing to work in this domain.

Abbreviations

NHRM, National Rural Health Mission; SBA, Skilled birth attendants; WHO, World Health Organization; NFHS, National Family Health Survey; UT, Union territories; DV, Dependent Variable; AIC, Akaike's Information Criterion; BP, Breusch -Pagan; Q-Q, Quantile-Quantile; VIF, Variance Inflation Factor; CI, Confidence Interval; OLS, Ordinary Least Square; BMI, Body Mass Index; DW, Durbin Watson; ANC, Antenatal Care; PHC, Primary Health Centre; CHC, Community Health Centre; DH, District Hospital; JSY, Janani Suraksha Yojana; LOS, length of stay; ASHAs, Accredited Social Health Activists

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Conflicts of interest

There are no conflicts of interest.

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