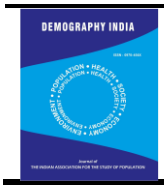

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Barriers to Institutional delivery in Himalayan region and others states of India: Evidence from the National Family Health Survey, 2019-21

Dharam Singh[1]* and N S Bist[2]

Abstract

This study investigates the barriers to institutional delivery in hilly and non-hilly regions of India, using data from the National Family Health Survey-5 (NFHS-5, 2019–21). Institutional delivery is a critical component of maternal healthcare, yet significant disparities persist across geographic regions. The study aims to identify the socio-economic, demographic, and geographic factors influencing institutional delivery rates and to assess the extent of regional disparities. The analysis is based on a sample of 232,920 women, descriptive statistics and logistic regression models were used to examine the association between institutional delivery and key predictors such as age, education, wealth, social groups, transportation, and access to healthcare facilities. The results reveal significant disparities, with hilly regions having consistently lower institutional delivery rates. The unadjusted odds ratio (OR = 0.58, 95% CI: 0.54–0.63, $p < 0.001$) indicates that women in hilly regions are 42% less likely to have institutional deliveries compared to non-hilly regions. After adjusting for socio-economic and demographic factors, the adjusted odds ratio further decreases to 0.52 (95% CI: 0.48–0.57, $p < 0.001$), underscoring the persistent disadvantage in hilly areas. Key predictors of institutional delivery include higher education (OR = 2.12 in hilly regions), wealth (richest women: OR = 4.01 in hilly regions). Geographic barriers, such as transportation difficulties and distance to healthcare facilities, disproportionately affect hilly regions, women facing significant difficulty with distance were about 43 % less likely to have institutional deliveries (OR = 0.57, 95 % CI 0.44–0.75, $p < 0.001$). The findings highlight the need for region-specific interventions or geographically differentiated policy designs, improved healthcare infrastructure, and enhanced transportation facilities to ensure equitable access to institutional delivery services across India.

Keywords

Access to healthcare, Institutional delivery, Regional disparity

*Corresponding Author

[1] *Research Scholar, International Institute for Population Sciences, Mumbai, India. Email-Id: ak5276041@gmail.com*

[2] *Adjunct Faculty, Department of Population Studies, Himachal Pradesh University, Shimla, India. Email-Id: nsbist55@gmail.com*

Introduction

The World Health Organization fact sheet from 2023 states that, globally, women die during pregnancy or childbirth every two minutes, illustrating the stark differences in maternal healthcare access[1]. As part of the Sustainable Development Goals (SDGs), countries have committed to reducing maternal deaths by 2030. One key goal under SDG 3 is to lower the global maternal mortality rate (MMR) to less than 70 deaths per 100,000 births[2]. Appropriate delivery care is crucial for both maternal and perinatal health and increasing skilled attendance at birth is a central goal of the safe motherhood and child survival movements[3].

Institutional delivery is a cornerstone for improving maternal and neonatal health outcomes globally. The World Health Organization (WHO, 2019)[4] emphasizes that access to skilled birth attendants during delivery is essential for preventing life-threatening complications and reducing maternal mortality. UNICEF (2020)[5] adds that facility-based care not only addresses complications during childbirth but also provides the necessary environment for effective postnatal care, such as neonatal resuscitation, breastfeeding support, and early detection of infections, which together help lower neonatal mortality rates. Furthermore, recent data from the World Bank (2021)[6] indicate that countries that have scaled up institutional delivery services have witnessed a decline in under-five mortality by 25-30% over the past decade. The body of research on the relationship between human capital accumulation and early life health is expanding. Bleakley (2010)[7] argues that how impoverished childhood health may hinder the development of human capital, which may have an impact on lifelong income through labour-market productivity channels or educational attainment. Consequently, institutional delivery can also be viewed as an investment in human capital and can significantly impact an economy's growth process.

Reducing maternal mortality hinges on ensuring timely skilled care during childbirth. Conceptual models help illustrate how geography affects maternal health. Thaddeus and Maine's (1994)[8] Three Delays framework identifies three sequential delays: (1) deciding to seek care, (2) reaching a facility, and (3) receiving adequate treatment. In mountainous areas, terrain chiefly worsens Delay 2: long travel times, poor road conditions, and transport shortages impede reaching care. (Phase I decisions and Phase III readiness are also indirectly affected by isolation and resource scarcity.) Accessibility models likewise note that rugged topography amplifies effective distance to services. Thus, Himalayan geography can systematically erode maternal health system performance by amplifying physical access barriers.

In India, while overall improvements in maternal health have been noted, significant disparities persist, especially in remote and hilly regions where infrastructure and transportation challenges are pronounced. These geographic and socio-economic barriers prevent equitable access to institutional delivery services, leading to uneven health outcomes across the country. Universal health coverage for maternal care remains a challenge in India, with significant disparities in access to institutional delivery services, particularly among rural and socio-economically disadvantaged populations (Prinja et al. (2015)[9]). Addressing these challenges requires targeted policy interventions aimed at strengthening

healthcare infrastructure, improving transportation networks, and expanding health insurance coverage. Such measures are critical to bridging the gap between urban centres and rural or hard-to-reach areas, ensuring that every woman has the opportunity to benefit from quality maternal healthcare services. Ultimately, enhancing institutional delivery is pivotal not only for reducing maternal and neonatal mortality but also for achieving broader sustainable development goals related to health and well-being. This study builds on such concepts to examine how hilly terrain, relative to the plains, constrains institutional delivery in India, using nationally representative data.

Literature review

Several studies have explored the determinants of maternal and child health service utilization in India, yet few have exclusively examined the barriers to institutional delivery in the Himalayan region. Mustafa & Sekhar (2021)[10] found that the utilization of MCH services was significantly lower among the women and children living in the Himalayan states compared with the rest of India the available literature indicates that geographic isolation and rugged terrain are among the most critical obstacles. Similarly, the World Health Organization (WHO, 2019) has emphasized that poor road connectivity and transportation challenges in mountainous areas contribute significantly to maternal mortality due to delays in receiving timely care. Kumar et al. (2014)[11] in his study found that distance to the nearest health facility exerts a negative effect on the probability of institutional delivery. Specifically, without controlling for potential endogeneity, they find that an increase of 1 km in distance is associated with a 0.8% decrease in the likelihood of institutional facility delivery. Saha & Paul (2021)[12] showed in their study that, Rural residence, disadvantaged social groups, and early marriage reduced institutional delivery utilization, while education, wealth, mass media exposure, and CHW interactions facilitated it. Distance to healthcare was a significant barrier, highlighting the need for improved maternal care quality and accessibility[12]. The interplay of these geographic, economic, and cultural barriers indicates that improving institutional delivery rates in the Himalayan region requires multifaceted interventions. These interventions should focus not only on enhancing healthcare infrastructure and transportation but also on community-based education programs to shift cultural norms and improve health awareness.

Many studies have examined the sociodemographic, geographic, and economic disparities in maternal health across India. However, few have focused exclusively on institutional delivery, particularly in the hilly Himalayan region. Institutional delivery is a crucial indicator of maternal healthcare quality, as it ensures that women receive skilled care during childbirth, thereby reducing the risks associated with home births. Despite its importance, there is a notable gap in the literature regarding how institutional delivery rates differ between the challenging terrains of the Himalayan region and the predominantly plain areas of the country. Understanding the disparities in institutional delivery is essential for gauging the status of universal health coverage and identifying critical intervention areas for policymakers. The specific objective of this research is "What are the key socio-demographic, economic, and geographic

barriers to institutional delivery in the Himalayan region of India, and how do these barriers compare with those in non-Himalayan states?

This investigation will provide valuable insights into the unique challenges faced by women in hilly areas, where factors such as difficult terrain, limited healthcare infrastructure, and transportation issues may hinder access to quality obstetric care. The evidence generated from this study is expected to inform targeted policy interventions aimed at enhancing maternal healthcare services, reducing maternal and neonatal mortality, and advancing progress toward the broader goals of universal health coverage.

Materials and Methods

Data source

We used data from the fifth round of India's Demographic and Health Survey (DHS), known as the National Family Health Survey (NFHS)-5. The NFHS-5 is a large-scale, nationally representative sample survey covering all 28 states and 8 union territories of India. It was carried out by the International Institute for Population Sciences (IIPS), Mumbai, under the stewardship of the Ministry of Health and Family Welfare (MoHFW), Government of India. The survey provides essential information on population, health, and family welfare, such as household characteristics, fertility and fertility preferences, utilization of maternal healthcare services, maternal mortality, nutrition and anaemia, family planning methods, child health status, noncommunicable diseases, women's autonomy, and domestic violence. For the present study, we utilized data on place of delivery, reasons for not delivering in a health facility, and background characteristics of the respondents.

Outcome variable

Institutional delivery was the outcome variable in this study. In NFHS-5, women were asked about their place of delivery. Place of delivery was categorized as home, public health sector, private health sector, NGO/trust hospital, and others. The public health sector includes the Govt./municipality hospital, Govt. dispensaries, UHC/UHP/UFWC, CHC/rural hospital, block PHC, sub-centre, and other public health facilities. The private health sector includes private hospitals, maternity homes, clinics, and other private sector health facilities. Women who gave birth to any public or private health sector or NGO/trust hospital/clinic were considered as delivered in a health institution. Women who delivered in a health facility were coded as '1' and those who gave birth at home and 'others' (other than a health facility) were coded as '0'.

Group variable

The group variable was hilly or non-hilly region. The states and UTs were divided into two categories: hilly states and non-hilly states. All the states lying in the Himalayan range were categorized as hilly. These states are: Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Meghalaya, Tripura, Mizoram and Ladakh. Because there is so little plain area in the Himalayan states, the majority of the people lives in a tangled, steep terrain. The present study, therefore, shows disparity in institutional delivery in Himalayan states and non- Himalayan states. On the whole, 36,382(15.4%) respondents were from the hilly Himalayan

region, whereas 196,538 (84.4%) were from the plains (non-hilly).

Explanatory variables

To assess determining factors associated with institutional delivery, present study incorporated several sociodemographic and socio-economic characteristics and geographic predictor variables in this study. Socio-demographic variables include women's age, age at first birth, no. of living children, educational level of women, caste, religion, household wealth status, and exposure to mass media, women's autonomy, health insurance, maternal, child protection card (MCP), place of residence, met with CHW (community health worker), distance as a problem, transportation as a problem. Women's age (15–24, 25– 34,35–49); age at first birth(below 18, above 18); no of living children(0-2,3-4,>=4); women's educational attainment (no education, primary, secondary, higher); Caste (Scheduled Castes (SCs), Scheduled Tribes (STs), Other Backward Class (OBC), Others); religion (Hindu, Muslim, Christian, Other); wealth quintile (poorest, poorer, middle, richer, richest); Women's exposure to mass media was assessed from the frequency of reading newspapers/magazines, listening to radio, and watching television, Based on access to these three media, women were categorized into three groups: no exposure (none of the media accessed), medium exposure (one or two media accessed), and high exposure (all three media accessed); women's autonomy (has autonomy "1" no autonomy"0") maternal and child protection card yes (coded as '1') no (coded as '0') similarly for health insurance yes (coded as '1') no (coded as '0'). Place of residence was categorized as urban and rural. Further there are three important intermediate predictor variables in the analysis., transportation as a problem, met with any community health worker (CHW), and perceived distance to the health facility. Transportation as problem (no problem, big problem, not a big problem), with regard to meeting with CHW, women were enquired whether they met with any CHW during the last three months of pregnancy, and it was dichotomized into yes (coded as '1') or no (coded as '0'). CHWs include Auxiliary nurse midwife, lady health visitor, ASHA, Anganwadi worker, or other community health workers. To understand the question of accessibility to medical care, women were asked to what extent they face difficulty regarding the distance to the health facility when they are sick and want to get medical advice or treatment. The responses of participants were recorded as follows: a big problem, not a big problem and no problem

Statistical analysis

In the present study, bivariate analysis was used to summarize the characteristics of the respondents using weighted percentage and frequencies. To explore the relationship between the independent and the dependent variables, bivariate analysis was performed using chi-square ($\chi 2$) tests. The association between the independent and the dependent variables was analysed by calculating the adjusted odds ratios (AOR) with 95% confidence interval (CI) using logistic regression models. All the statistical analyses were performed on STATA 17.0.

Results

Table 1 presents a comparative analysis of background characteristics between hilly (N=36,382) and non-hilly (N=196,538) regions, highlighting key demographic and socio-economic variables.

Table 1 Background characteristics of women who gave birth in last five years preceding the survey, NFHS-5 (2019–21).

Variables		Hilly (N=36,382)		Non-Hilly (196,538)	
Background characteristics		Percent	Sample(N)	Percent	Sample(N)
Age	15-24	21.5	7,685	33.3	64,261
	25-34	64.0	22,247	58.6	1,15,788
	35-49	14.6	6,450	8.1	16,489
Age at first birth	Below 18	8.7	3,804	11.7	21,596
	Above 18	91.3	32,578	88.3	1,74,942
No. of living children	0-2	71.0	23,370	69.0	1,33,635
	3-4	22.9	9,582	26.1	52,667
	>=4	6.1	3,430	5.0	10,236
Women's Education	No Education	14.7	5,659	21.6	45,551
	Primary	12.6	5,389	12.3	24,692
	Secondary	55.4	20,809	50.5	99,055
	Higher	17.3	4,525	15.6	27,240
Social/Caste Group	Others	40.6	9,789	22.7	39,072
	SC	15.3	3,306	23.5	44,542
	ST	27.7	20,237	9.5	26,881
	OBC	16.4	3,050	44.3	86,043
Religion	Hindu	50.7	11,248	80.3	1,59,807
	Muslim	24.3	5,789	16.0	27,733
	Christian	20.1	15,594	1.5	3,257
	Others	5.0	3,751	2.2	5,741
Wealth index	poorest	17.4	9,516	24.8	53,890
	poorer	22.1	10,081	21.7	44,382
	middle	21.0	7,689	19.5	37,394
	richer	20.5	5,695	18.3	33,399
	richest	19.0	3,401	15.6	27,473
Mass Media Exposure	No	19.6	8,886	28.5	58,881
	Medium	67.4	23,444	61.4	1,20,062
	High	13.0	4,052	10.1	17,595
Health insurance	No	75.6	26,383	76.8	1,43,826
	Yes	24.4	9,999	23.2	52,712
MCP card	No	27.2	11,546	29.6	55,944
	Yes	72.8	24,836	70.4	1,40,594
Place of Residence	Urban	23.8	6,084	26.7	41,115
	Rural	76.2	30,298	73.3	1,55,423
Women autonomy	No Autonomy	88.7	32,066	89.9	1,76,545
	Has Autonomy	11.3	4,316	10.1	19,993
Transportation	No problem	43.5	12,482	42.1	77,386
	Big problem	27.9	12,754	23.1	49,058
	Not a big problem	28.7	11,146	34.9	70,094
Met with CHW	No	54.0	22,301	42.8	79,950
	Yes	46.0	14,081	57.2	1,16,588
Distance to health facility	No problem	41.5	11,962	39.7	73,163
	Big problem	28.8	12,915	24.9	52,303
	Not a big problem	29.7	11,505	35.4	71,072

*Note: *Weighted percentage and unweighted frequency*

In terms of age distribution, a higher proportion of individuals aged 15-24 reside in non-hilly areas (33.3%) compared to hilly regions (21.5%). Conversely, hilly areas have a larger percentage of older individuals (35-49 years). Women in hilly regions tend to have their first birth after 18 years (91.3%) more frequently than those in non-hilly areas (88.3%). Education levels show that women in hilly regions have slightly higher secondary (55.4%) and higher education (17.3%) rates compared to non-hilly areas (50.5% and 15.6%, respectively). Socially, Scheduled Tribes (ST) constitute a larger proportion in hilly regions (27.7%) compared to non-hilly areas (9.5%). Religiously, hilly regions have a higher percentage of Christians (20.1%) because Christianity is practiced in several north-eastern states, and Muslims (24.3%), while non-hilly areas are predominantly Hindu (80.3%). Wealth distribution is relatively similar, though non-hilly areas have a higher proportion of the poorest (24.8%). Access to mass media and health insurance is marginally better in hilly regions, while women's autonomy remains low in both areas (11.3% in hilly vs. 10.1% in non-hilly). Women in hilly areas face greater transportation and distance barriers to healthcare, with 28.8% reporting distance as a big problem compared to 24.9% in non-hilly areas. Additionally, access to community health workers (CHW) is lower in hilly regions (46.0%) compared to 57.2% in non-hilly regions, which may impact maternal healthcare utilization. Overall, the table underscores significant regional disparities in demographic and socio-economic factors.

Table 2 presents a detailed comparison of institutional delivery rates between hilly (N=36,382) and non-hilly (N=196,538) regions, highlighting significant disparities across various demographic and socio-economic variables. Overall, institutional delivery rates are consistently lower in hilly regions compared to non-hilly areas, with notable gaps observed across age groups, education levels, wealth indices, and other key factors.

Younger women (15-24 years) in hilly regions have significantly lower institutional delivery rates (82%) compared to their counterparts in non-hilly areas (90.33%), indicating a gap of 8.33 percentage points (pp). Similarly, women who had their first birth below 18 years in hilly regions show a much lower rate (68.72%) compared to non-hilly areas (80.99%), with a gap of 12.27 pp. This suggests that early motherhood and younger age are associated with reduced access to institutional delivery services in hilly regions. Women with four or more children in hilly regions have the lowest institutional delivery rates (43.5%), compared to 67.99% in non-hilly areas, reflecting a substantial gap of 24.49 pp. This highlights the challenges faced by women with larger families in accessing healthcare services in hilly regions. Education plays a critical role in institutional delivery rates. Women with no education in hilly regions have a rate of 68.46%, compared to 74.92% in non-hilly areas, a gap of 6.46 pp. However, the gap widens significantly for women with primary education (19.45 pp), indicating that even basic education can substantially improve access to healthcare services. Women with higher education in both regions show near-universal institutional delivery rates, though the gap persists (2.19 pp). Scheduled Tribes (ST) in hilly regions have the lowest institutional delivery rates (66.88%) compared to non-hilly areas (83.66%), with a gap of 16.78 pp.

Table 2 Percentage distribution of institutional delivery by selected characteristics across hilly and non-hilly region, NFHS-5, 2019-2021

Variables	Hilly [N= 36,382]		Non-Hilly [N=196,538]		Gap(pp)
	Institutional delivery	%[95%CI]	Institutional delivery	%[95%CI]	
Age	(χ^2- 24.0376, p:<0.001)		(χ^2- 150.6743, p:<0.001)		
15-24	82	[80.19,83.68]	90.33	[89.92,90.73]	-8.33
25-34	83.54	[82.36,84.66]	88.67	[88.3,89.03]	-5.13
35-49	76.61	[74.16,78.89]	83.37	[82.45,84.25]	-6.76
Age at first birth	(χ^2- 151.5342, p:<0.001)		(χ^2- 643.3180, p:<0.001)		
Below 18	68.72	[65.6,71.68]	80.99	[80.05,81.88]	-12.27
Above 18	83.49	[82.35,84.57]	89.83	[89.52,90.13]	-6.34
No. of living children	(χ^2- 546.3047, p:<0.001)		(χ^2- 2107.7609, p:<0.001)		
0-2	89.01	[88.16,89.8]	93.14	[92.9,93.37]	-4.13
3-4	71.41	[69.22,73.51]	81.25	[80.61,81.88]	-9.84
>=4	43.5	[39.32,47.77]	67.99	[66.42,69.51]	-24.49
Women's Education	(χ^2- 251.3446, p:<0.001)		(χ^2- 1874.6934, p:<0.001		
No Education	68.46	[65.61,71.18]	74.92	[74.12,75.7]	-6.46
Primary	65.42	[62.23,68.47]	84.87	[84.13,85.59]	-19.45
Secondary	85.44	[84.35,86.46]	92.85	[92.57,93.12]	-7.41
Higher	95.74	[94.86,96.47]	97.93	[97.68,98.15]	-2.19
Social/Caste Group	(χ^2- 107.9325, p:<0.001)		(χ^2- 77.2692, p:<0.001		
Others	90.16	[88.9,91.29]	90.98	[90.31,91.6]	-0.82
SC	84.7	[82.19,86.92]	87.32	[86.71,87.9]	-2.62
ST	66.88	[64.69,69]	83.66	[82.72,84.55]	-16.78
OBC	86.04	[82.84,88.72]	89.56	[89.14,89.96]	-3.52
Religion	(χ^2- 140.1344, p:<0.001)		(χ^2- 86.7993, p:<0.001		
Hindu	88.12	[86.77,89.36]	89.55	[89.23,89.86]	-1.43
Muslim	87.16	[84.74,89.25]	84.15	[83.12,85.13]	3.01
Christian	61.7	[59.13,64.19]	92.34	[90.65,93.74]	-30.64
Others	80.34	[76.7,83.54]	92.6	[91.35,93.69]	-12.26
Wealth index	(χ^2- 242.6295, p:<0.001)		(χ^2- 1139.6922, p:<0.001		
Poorest	58.88	[56.31,61.39]	76.54	[75.8,77.27]	-17.66
Poorer	74.84	[72.68,76.89]	87.58	[87.05,88.1]	-12.74
Middle	85.56	[83.67,87.25]	92.51	[92.06,92.94]	-6.95
Richer	93.14	[91.76,94.31]	95.45	[95.08,95.79]	-2.31

Richest	96.51	[95.4,97.36]	97.48	[97.16,97.76]	-0.97
Mass Media Exposure	(χ^2- 206.0474, p:<0.001)		(χ^2- 1624.6923, p:<0.001		
No	65.62	[63.04,68.11]	78.43	[77.74,79.11]	-12.81
Medium	85.38	[84.3,86.41]	92.34	[92.06,92.61]	-6.96
High	90.65	[88.63,92.35]	96.54	[96.08,96.94]	-5.89
Health insurance	(χ^2- 22.7668, p:<0.001)		(χ^2- 261.6556, p:<0.001		
No	83.41	[82.21,84.54]	87.84	[87.46,88.21]	-4.43
Yes	78.47	[76.25,80.54]	91.97	[91.56,92.35]	-13.5
MCP Card	(χ^2- 659.1911, p :<0.001)		(χ^2- 1545.3919, p:<0.001		
No	69.48	[67.44,71.45]	82.64	[82,83.26]	-13.16
Yes	86.96	[85.99,87.86]	91.38	[91.11,91.64]	-4.42
Women autonomy	(χ^2- 0.6550, p=0.4184)		(χ^2- 1.0247, p=0.3114		
No Autonomy	82.09	[80.86,83.25]	88.83	[88.5,89.16]	-6.74
Has Autonomy	83.11	[80.59,85.36]	88.43	[87.63,89.2]	-5.32
Place of Residence	(χ^2- 83.2084, p:<0.001)		(χ^2- 239.9663, p:<0.001		
Urban	91.76	[89.89,93.3]	93.85	[93.24,94.41]	-2.09
Rural	79.21	[77.82,80.54]	86.95	[86.56,87.33]	-7.74
Met with CHW	(χ^2- 7.0967, p=0.0077)		(χ^2- 61.9081, p:<0.001		
No	81.2	[79.81,82.52]	87.71	[87.25,88.16]	-6.51
Yes	83.38	[81.88,84.77]	89.6	[89.24,89.96]	-6.22
Transportation	(χ^2-113.5687, p:<0.001		(χ^2- 347.3614, p:<0.001		
No problem	88.53	[87.24,89.71]	91.96	[91.59,92.31]	-3.43
Big problem	73.66	[71.57,75.65]	84.49	[83.86,85.11]	-10.83
Not a big problem	80.9	[79.19,82.5]	88.27	[87.81,88.72]	-7.37
Distance to health facility	(χ^2- 128.4017, p:<0.001)		(χ^2- 305.9102, p:<0.001		
No problem	89.06	[87.78,90.22]	91.96	[91.59,92.31]	-2.9
Big problem	73.23	[71.16,75.21]	84.49	[83.86,85.11]	-11.26
Not a big problem	81.3	[79.63,82.86]	88.27	[87.81,88.72]	-6.97

This underscores the compounded disadvantage faced by marginalized communities in hilly regions. Economic status significantly influences institutional delivery rates. The poorest women in hilly regions have a rate of 58.88%, compared to 76.54% in non-hilly areas, a gap of 17.66 pp. As wealth increases, the gap narrows, with the richest women in both regions showing nearly universal rates (96.51% vs. 97.48%,

gap of 0.97 pp). This indicates that economic disparities disproportionately affect healthcare access in hilly regions. Women with no mass media exposure in hilly regions have significantly lower institutional delivery rates (65.62%) compared to non-hilly areas (78.43%), a gap of 12.81 pp. Similarly, women without health insurance in hilly regions show lower rates (83.41%) compared to non-hilly areas (87.84%), with a gap of 4.43 pp. These findings suggest that awareness and financial barriers further exacerbate disparities in healthcare access. Rural women in hilly regions face a significant gap in institutional delivery rates (79.21%) compared to non-hilly areas (86.95%), a difference of 7.74 pp. Transportation issues also play a critical role, with women facing big problems in hilly regions showing a gap of 10.83 pp compared to non-hilly areas. Interaction with CHWs appears to positively influence institutional delivery rates in both hilly and non-hilly regions. In hilly areas, women who met with CHWs had a slightly higher institutional delivery rate (83.38%) compared to those who did not (81.2%), reflecting a modest but statistically significant difference. Similarly, in non-hilly regions, the rate was higher for women who met with CHWs (89.6%) compared to those who did not (87.71%). However, the gap between hilly and non-hilly regions persists even among women who interacted with CHWs (6.22 pp), suggesting that while CHWs play a role in improving access, their impact is not sufficient to bridge the geographical disparities entirely. Distance to health facilities is a significant barrier to institutional delivery, particularly in hilly regions. Women in hilly areas who reported "no problem" with distance had an institutional delivery rate of 89.06%, compared to 91.96% in non-hilly areas, a gap of 2.9 pp. However, for women who faced "big problems" with distance, the gap widened significantly, with hilly regions reporting a rate of 73.23% compared to 84.49% in non-hilly areas, a difference of 11.26 pp. This indicates that geographical barriers disproportionately affect women in hilly regions, limiting their access to healthcare facilities. Even when distance is "not a big problem," the gap remains notable (6.97 pp), underscoring the compounded challenges of terrain and infrastructure in hilly areas.

Table 3 presents the results of logistic regression analysis performed to examine the influence of socio-economic and demographic characteristics and geographic predictors on institutional delivery between hilly and non-hilly regions of India. The findings reveal significant regional disparities in institutional delivery rates across hilly and non-hilly regions of India. In hilly regions, older women aged 25-34 (OR=1.32, $p<0.001$) and 35-49 (OR=1.67, $p<0.001$) are more likely to opt for institutional deliveries compared to younger women, whereas in non-hilly regions, age does not significantly influence institutional delivery rates ($p>0.05$). Age at first birth shows a stark contrast, as it is not a significant factor in hilly regions (OR=0.96, $p=0.656$), but in non-hilly regions, women who delay childbirth beyond 18 years are more likely to have institutional deliveries (OR=1.27, $p<0.001$). Additionally, parity remains a crucial determinant, as women with three or more children are significantly less likely to choose institutional delivery in both regions, with a stronger negative impact in hilly areas. Education plays a pivotal role, with secondary (OR=1.49, $p<0.001$) and higher education (OR=2.12, $p<0.001$) increasing the likelihood of

institutional deliveries in hilly areas, whereas the effect is even more pronounced in non-hilly regions (OR=3.63, p<0.001). Social disparities also vary, as caste does not significantly impact institutional deliveries in hilly regions, but in non-hilly areas, Scheduled Castes (SC: OR=0.86, p=0.001) and Scheduled Tribes (ST: OR=0.78, p<0.001) experience lower institutional delivery rates. Religion also has contrasting effects; Muslim women in hilly regions are more likely to opt for institutional deliveries (OR=1.30, p=0.026), while in non-hilly areas, they are less likely (OR=0.68, p<0.001).Economic factors significantly influence institutional delivery rates, with the richest women in hilly (OR=4.01, p<0.001) and non-hilly regions (OR=3.68, p<0.001) being far more likely to access institutional care compared to the poorest. Exposure to mass media has a strong positive association with institutional delivery in both regions, highlighting the importance of awareness campaigns. Interestingly, health insurance improves institutional delivery rates in non-hilly areas (OR=1.43, p<0.001), but does not have a significant effect in hilly regions (OR=1.09, p=0.179), suggesting potential accessibility or service delivery issues in mountainous areas. Government schemes like the MCP card significantly enhance institutional delivery rates in both regions, emphasizing the effectiveness of targeted maternal health programs. However, rural residence poses a substantial barrier in hilly areas (OR=0.70, p=0.002), whereas it does not significantly affect institutional deliveries in non-hilly regions (OR=0.97, p=0.55). Transportation difficulties and distance to health facilities are major barriers in hilly areas. In hilly regions, women reporting big problems with distance had lower odds of institutional delivery (OR = 0.57, p < 0.001), corresponding to roughly a 43 % reduction in likelihood compared with those reporting no distance problem.

Table 3 Bivariate logistic regression modelling assessing socio-demographic and geographic predictors influencing institutional delivery in hilly and non-hilly region, NFHS-5, 2019-2021

	Hilly [N= 36,382]				Non-Hilly [N=1,96,538]			
	Odds ratio	[95% conf. interval]		P value	Odds ratio	[95% conf. interval]		P value
Age: 15-24®		lower limit	upper limit			lower limit	upper limit	
25-34	1.32	1.14	1.53	<0.001	0.99	0.94	1.04	0.669
35-49	1.67	1.36	2.06	<0.001	1.04	0.95	1.13	0.389
Age at first birth: Below 18®								
Above 18	0.96	0.82	1.13	0.656	1.27	1.19	1.35	<0.001
Number of living children: 0-2®								
3-4	0.45	0.39	0.51	<0.001	0.57	0.54	0.60	<0.001
>=4	0.23	0.19	0.29	<0.001	0.42	0.39	0.46	<0.001
Education: No education®								
Primary	0.96	0.81	1.14	0.676	1.37	1.29	1.46	<0.001
Secondary	1.49	1.30	1.71	<0.001	1.93	1.82	2.04	<0.001
Higher	2.12	1.62	2.78	<0.001	3.63	3.16	4.16	<0.001
social /caste group: others®								
SC	0.87	0.69	1.09	0.224	0.86	0.79	0.94	0.001
ST	0.92	0.75	1.12	0.398	0.78	0.70	0.86	<0.001

OBC	0.86	0.67	1.11	0.256	0.94	0.87	1.02	0.115
Religion: Hindu®								
Muslim	1.30	1.03	1.64	0.026	0.68	0.63	0.73	<0.001
Christian	0.50	0.41	0.60	<0.001	0.95	0.79	1.14	0.588
Others	0.87	0.70	1.09	0.239	1.04	0.88	1.23	0.652
Wealth: Poorest®								
Poorer	1.31	1.14	1.50	<0.001	1.50	1.42	1.59	<0.001
Middle	1.75	1.47	2.08	<0.001	1.98	1.83	2.14	<0.001
Richer	2.95	2.28	3.82	<0.001	2.67	2.41	2.96	<0.001
Richest	4.01	2.83	5.68	<0.001	3.68	3.16	4.28	<0.001
Mass media exposure: No®								
Medium	1.44	1.26	1.64	<0.001	1.32	1.26	1.40	<0.001
High	1.62	1.29	2.04	<0.001	1.57	1.37	1.81	<0.001
Health insurance: NO®								
Yes	1.09	0.96	1.25	0.179	1.43	1.35	1.51	<0.001
MCP Card: No®								
Yes	1.78	1.63	1.95	<0.001	1.62	1.56	1.69	<0.001
Autonomy: No autonomy®								
Has Autonomy	1.19	0.99	1.42	0.063	0.94	0.87	1.01	0.094
Place of residence: Urban®								
Rural	0.70	0.55	0.88	0.002	0.97	0.87	1.08	0.55
Met with CHW: No®								
Yes	1.07	0.95	1.20	0.299	1.27	1.21	1.33	<0.001
Transportation: No problem®								
Big problem	1.13	0.86	1.49	0.39	0.88	0.81	0.96	0.005
Not a big problem	1.11	0.91	1.37	0.305	0.99	0.92	1.06	0.673
Distance: No problem®								
Big problem	0.57	0.44	0.75	<0.001	0.88	0.80	0.96	0.003
Not a big problem	0.83	0.67	1.02	0.076	0.93	0.86	0.99	0.031

Table 4 presents the results of logistic regression analysis examining the likelihood of institutional delivery based on the region (hilly vs. non-hilly). It includes both unadjusted and adjusted odds ratios (OR) with 95% confidence intervals (CI) and p-values. The unadjusted odds ratio (OR = 0.58, 95% CI: 0.54–0.63, $p < 0.001$) indicates that women in hilly regions are 42% less likely to have institutional deliveries compared to those in non-hilly areas before accounting for other factors.

After adjusting for demographic and socio-economic variables, the adjusted OR drops further to 0.52 (95% CI: 0.48–0.57, $p < 0.001$), suggesting that even after controlling for confounding factors, women in hilly regions remain 48% less likely to opt for institutional deliveries.

The unadjusted constant (OR = 7.92, 95% CI: 7.67–8.19, p < 0.001) reflects the baseline odds of institutional delivery in non-hilly regions without considering other factors. The adjusted constant (OR = 2.38, 95% CI: 2.05–2.77, p < 0.001) shows a reduced but still significant likelihood of institutional delivery after including explanatory variables.

Table 4 Adjusted and unadjusted odd-ratio and 95%confidence interval for institutional delivery in hilly and non-hilly region of India.

Variable	Unadjusted odd ratio	95% CI	P value	Adjusted odd ratio	95% CI	P value
Region (Non-Hilly) ®						
Hilly	0.5829017	0.5353146-.634719	<0.001	0.5221416	0.477457-.5710081	<0.001
Constant	7.92384	7.667474-8.188778	<0.001	2.377988	2.045125-2.765027	<0.001

Discussion

The findings of this study highlight significant regional disparities in institutional delivery rates between hilly and non-hilly regions of India, with multiple socio-economic and demographic factors shaping maternal health-seeking behaviours. These disparities align with existing literature, which underscores the role of socio-economic inequality, cultural preferences, and infrastructural limitations in influencing institutional deliveries (Patel et al. 2021)[13] and (Montagu et al. 2019)[14]. The age at first birth is an important factor in non-hilly regions but not in hilly areas, reflecting potential differences in health awareness and accessibility of maternal care services. Educational attainment remains a strong predictor of institutional delivery across both regions, reinforcing previous findings that women with secondary or higher education are more likely to utilize maternal health services (Barman et al. 2020)[15]. However, the effect of education is more pronounced in non-hilly regions, suggesting that geographic barriers may reduce the full benefits of education on maternal healthcare utilization in hilly areas. This finding aligns with Montagu et al. (2019), who emphasize the importance of addressing systemic barriers such as poor infrastructure and geographic isolation to improve institutional delivery rates. Economic disparities further exacerbate differences in institutional delivery rates, with wealthier women significantly more likely to access institutional care. This pattern is consistent with global evidence indicating strong wealth-based inequalities in maternal healthcare utilization (Houweling et al. 2007)[16]. While economic status influences institutional delivery in both regions, the impact of the richest quintile is slightly higher in hilly areas, which may reflect the additional financial burden required to overcome geographic challenges such as transportation costs and facility accessibility. Social factors also play a distinctive role in institutional delivery choices. In non-hilly regions, caste-based disparities are evident, with Scheduled Castes and Scheduled Tribes experiencing lower institutional delivery rates. This finding underscores the persistent socio-cultural inequalities in healthcare access, as highlighted by Patel et al. (2021). However, caste does not significantly influence institutional delivery rates in hilly areas, potentially due to a more homogenous social

structure or different cultural perceptions of maternal healthcare. Religion also exhibits contrasting effects, with Muslim women in hilly regions being more likely to choose institutional delivery, while the opposite trend is observed in non-hilly regions. This could be indicative of region-specific variations in religious beliefs and healthcare awareness. Exposure to mass media and government schemes such as the MCP card positively influence institutional delivery in both regions. This finding aligns with Barman et al. (2020)[15], who emphasize the role of awareness campaigns in increasing institutional delivery rates. However, health insurance schemes show differential impacts, significantly improving institutional delivery rates in non-hilly regions while having no significant effect in hilly areas. This suggests potential issues related to service delivery and the effectiveness of health insurance implementation in mountainous regions. A major barrier identified in hilly regions is rural residence, which significantly reduces institutional delivery rates. Transportation difficulties and long distances substantially reduce institutional deliveries in hilly areas (OR = 0.57, $p < 0.001$), indicating about a 43 % lower likelihood of facility-based births. Despite several government initiatives to promote safe motherhood, geographic barriers continue to limit their effectiveness in mountainous regions. Schemes such as the *Janani Suraksha Yojana (JSY)* and *Janani Shishu Suraksha Karyakram (JSSK)* have increased institutional deliveries nationally by providing financial incentives and free transport, yet their impact remains uneven in the Himalayas. Studies indicate that the steep terrain, long travel times, and poor road conditions constrain the ability of ambulances and referral transport services to reach remote villages promptly (Salve et al. 2017)[17]. Similarly, fixed-day antenatal clinics under *Pradhan Mantri Surakshit Matritva Abhiyan (PMSMA)* often face low attendance in hilly districts due to difficult accessibility and weather disruptions. These findings suggest that while programmatic frameworks are sound, contextual challenges in high-altitude areas demand tailored solutions such as mountain-adapted ambulance services, community-based birthing centers, and strengthened outreach by Accredited Social Health Activists (ASHAs). These findings reinforce previous studies that highlight geographic isolation and poor infrastructure as critical barriers to maternal healthcare access (Montagu et al., 2019)[16]. In contrast, rural residence does not significantly impact institutional delivery rates in non-hilly regions, suggesting relatively better healthcare accessibility. It is also important to acknowledge certain methodological limitations. The analysis may be affected by omitted variable bias, as key structural determinants such as health facility density, road quality, and emergency transport availability were not directly captured in the NFHS-5 dataset. Prior studies have demonstrated that facility proximity and density substantially influence institutional delivery rates (Kumar et al. 2014)[10], and excluding these variables could bias estimates of geographic disadvantage. Moreover, the cross-sectional nature of NFHS data restricts causal inference; while associations can be identified, temporal dynamics or reverse causality cannot be ruled out. Future longitudinal or quasi-experimental studies would provide stronger evidence regarding causal relationships between terrain, health system accessibility, and maternal health outcomes.

Overall, the findings of this study emphasize the need for region-specific interventions to address maternal healthcare disparities. While economic and educational empowerment remain crucial strategies, targeted efforts to improve healthcare infrastructure, enhance transportation facilities, and optimize the implementation of health insurance in hilly regions are essential. Moreover, culturally sensitive awareness programs and community engagement initiatives could help mitigate socio-cultural barriers and improve institutional delivery rates. Strengthening respectful maternity care and evidence-based practices, as advocated by Miller et al. (2016)[18], will further contribute to equitable maternal health outcomes across diverse geographic regions of India.

Conclusion

Geographic Disparities: The regression analysis confirms that hilly regions face significant challenges in providing access to institutional delivery services, particularly for rural women and those facing transportation and distance barriers.

Socio-Economic Barriers: Wealth, education, and social identity are strong predictors of institutional delivery. Women from poorer households, marginalized communities, and those with lower education levels are disproportionately affected, particularly in hilly regions.

Policy Implications: The findings suggest the need for targeted interventions, such as improving healthcare infrastructure in rural and hilly areas, increasing awareness through mass media campaigns, and expanding health insurance coverage. Additionally, programs aimed at reducing early marriages and improving education levels, particularly among marginalized communities, could significantly improve maternal health outcome. In light of these findings, future maternal health strategies should adopt geographically differentiated policy designs that strengthen emergency obstetric referral systems, expand maternal and child health (MCH) coverage, and ensure timely transport in hilly and remote areas to bridge the last-mile access gap.

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