

Levels and Determinants of Skilled Antenatal Care Utilization and Its Practice under WHO Recommendation in Northern Part of Bangladesh

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Abstract

Skilled antenatal care (ANC) is essential for maternal and newborn health. It enables timely detection and management of pregnancy complications. In 2016 WHO raised its recommendation to at least eight ANC visits and suggested some criterion per pregnancy to ensure comprehensive care. This study analyzes cross-sectional primary data from 1,195 mothers across four districts in northern Bangladesh. Bivariate associations of maternal and household factors with the practice of ANC use were tested using Kruskal–Wallis test, Mann-Whitney U test and Chi-square test of association. To model the count of Skilled ANC visits, a zero-inflated mixed Poisson regression with a random effect at the sub-district level was used. Overall, 80.8% of mothers received ANC from a skilled provider, and 47.9% received care meeting quality standards and only 18% achieved complete ANC, while awareness of WHO recommendations remained alarmingly low, just 10.1% of mothers knew of the minimum 4-visit guideline, and only 1.3% were aware of the 8-visit recommendation. In the unadjusted analysis, mothers from the poorest households were significantly less likely to receive skilled antenatal care compared to those from the richest households. Also better road access, greater maternal autonomy in decision-making, and ability to afford care were also positively associated with skilled and quality ANC uptake. Significant gaps remain in both the coverage and quality of antenatal care in northern Bangladesh. The findings of the study underscore the need for equity-focused, proper interventions to reduce disparities and improve access to high-quality ANC for underserved women.

Keywords: Antenatal care; Skilled providers; Zero-inflated Poisson; ICC; WHO recommendations

I. Introduction

Maternal health is a critical indicator of public health, as it directly influences maternal, neonatal, and child health outcomes. Ensuring good maternal health is essential for the well-being of both the mother and the child. Good maternal health not only reduces the risks of maternal and newborn deaths but also contributes to overall socio-economic development. Women in good health are more likely to have safe pregnancies, give birth to healthy children, and lead productive lives¹. On the other hand, poor maternal health often results in preventable complications, including low birth weight, preterm birth, stillbirth, and maternal death². The World Health Organization (WHO) has long emphasized the importance of maternal health as a cornerstone of sustainable development. The WHO outlines several key measures to improve maternal health, including access to Antenatal Care (ANC), which is essential for monitoring the health of both the mother and the fetus during pregnancy³. According to WHO recommendations, a minimum of 8 ANC visits should be made throughout pregnancy to ensure the health and safety of both the mother and child⁴. Regular ANC visits help in detecting pregnancy complications early, such as hypertension, gestational diabetes, infections, and prevent risks like stillbirth and premature birth⁵. ANC is a fundamental intervention that, when provided with the right services, can reduce maternal and neonatal mortality rates substantially.

Skilled ANC (SANC) refers to ANC provided by trained professionals such as doctors, nurses, or midwives. Regular visits to skilled professionals during pregnancy are essential for detecting pregnancy-related complications and ensuring timely interventions. These professionals are equipped to handle high-risk pregnancies and can refer cases that require specialized care⁴. Studies have shown that access to skilled ANC is one of the most effective ways to reduce maternal and neonatal deaths⁶. A study conducted in sub-Saharan Africa found that skilled care during pregnancy and delivery significantly decreased maternal and infant mortality⁷. In Bangladesh, however, significant gaps remain in terms of access to and utilization of skilled ANC, particularly in rural and northern regions⁸. Despite national progress in improving maternal health, disparities in access to quality healthcare persist. According to the Bangladesh Demographic and Health Survey (BDHS), while the national Maternal Mortality Ratio (MMR) has decreased from 574 per 100,000 live births in 1990 to 123 per 100,000 in 2020, the northern regions still face challenges in providing quality maternal healthcare⁹. The global situation regarding skilled ANC is mixed. According to the WHO, although progress has been made, millions of women in low-income and rural areas still lack access to skilled birth attendants and quality maternal care. In 2019, only 62% of women in sub-Saharan Africa received the recommended four ANC visits, compared to 98% of women in high-income countries¹⁰. In Bangladesh, the national coverage for skilled ANC is higher, but still far from universal. The BDHS 2022 reported that

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88% of women in Bangladesh received ANC, but only 21% received quality ANC, as recommended by the WHO¹¹. This gap indicates the disparities in maternal healthcare access, especially in rural and underserved regions.

The northern part of Bangladesh faces unique challenges regarding maternal healthcare. Factors such as limited healthcare infrastructure, poverty, lack of transportation, and inadequate healthcare professionals exacerbate the situation¹². Studies have shown that rural women in northern Bangladesh have lower access to skilled ANC compared to their urban counterparts¹³. In rural areas, many healthcare facilities are understaffed and lack necessary equipment, which limits the quality of care provided⁸. Additionally, long distances to healthcare facilities and poor road conditions further hinder access to ANC services¹⁴. In this context, addressing maternal health in northern Bangladesh is directly linked to the achievement of the United Nations Sustainable Development Goals (SDGs). Specifically, SDG 3, “Ensure healthy lives and promote well-being for all at all ages”, sets an ambitious target (Target 3.1) to reduce the global maternal mortality ratio to less than 70 per 100,000 live births by 2030¹⁵. Additionally, Target 3.7 emphasizes ensuring universal access to sexual and reproductive healthcare services, including quality ANC¹⁵. Strengthening skilled ANC utilization in Bangladesh aligns not only with national health priorities but also with the global commitment to achieving these SDG targets. Therefore, this study focuses on the northern regions of Bangladesh, where maternal health challenges are most acute. It aims to assess the utilization of skilled ANC and examine whether the frequency and quality of visits adhere to WHO guidelines. Furthermore, the study explores the socio-economic, demographic, and geographic factors influencing skilled ANC use among women in the region. By identifying the barriers and determinants of skilled ANC utilization, this research contributes to evidence-based policymaking and the design of targeted interventions that can help accelerate progress toward SDG 3 and ensure equitable maternal healthcare for all women in Bangladesh.

II. Methodology

Sampling Procedure

The study utilized primary data following a multistage stratified cluster sampling technique from the pregnant women and the women within a month of childbirth through a structured questionnaire. Assigning national level estimates and 2.5% margin of error the sample size was considered as 1195.

Mann–Whitney U Test

The Mann–Whitney U test (also called the Wilcoxon rank-sum test) is a non-parametric alternative to the independent-samples t-test which compares the distribution or median ranks of the two groups rather than the means when the dependent variable is ordinal or continuous but not normally distributed. The null hypothesis assumes that the

distributions of the two groups are equal while in the alternative hypothesis, it is assumed that the distributions of the two groups are not equal. The U statistic is calculated for group 1 as¹⁶

$$U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1,$$

where n_1 is the sample size of group 1, n_2 the sample size of group 2, R_1 is the sum of ranks in group 1.

Similarly, U_2 can be computed for group 2 as

$$U_2 = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2,$$

where R_2 is the sum of ranks in group 2. The smaller of U_1 and U_2 is used for significance testing.

Kruskal–Wallis Test

The Kruskal–Wallis does not assume normality of the data, making it particularly suitable for skewed or non-normally distributed datasets. As an extension of the Mann–Whitney U test, it evaluates whether there are statistically significant differences between the medians of the groups. In this study, the Kruskal–Wallis test was applied to assess overall group differences across categorical factors¹⁷.

$$H = \frac{12}{N(N+1)} \sum_{i=1}^k \frac{R_i^2}{n_i} - 3(N+1)$$

Where, k be the number of groups; n_i be the sample size of group i ; $N = \sum n_i$ be the total sample size, and R_i be the sum of ranks for group i . If H is large, it suggests at least one group median is different.

Chi-Square Test

The Chi-Square (χ^2) test of independence is a statistical method used to evaluate whether two categorical variables are related or independent. The mathematical expression can be expressed as¹⁸

$$\chi^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}},$$

where, O_{ij} = observed frequency; E_{ij} = expected frequency under independence observations

Zero-Inflated Mixed Poisson Model

In this study, the outcome variable was a count variable and showed a high proportion of zero counts, indicating that standard Poisson regression and Negative Binomial regression models would not adequately represent the data. Consequently, both the Zero-Inflated Poisson (ZIP) model and Zero Inflated Negative Binomial (ZINB) model were applied. Based on the Akaike Information Criterion (AIC), the ZIP model was selected as the primary analytic approach. Formally, let Y_i represent the count outcome for observation i . The probability mass function (pmf) of the ZIP model is defined as follows¹⁹

$$P(Y_i = y_i) = \begin{cases} \pi_i + (1 - \pi_i)e^{-\lambda_i}, & \text{if } y_i = 0 \\ (1 - \pi_i)\frac{\lambda_i e^{-\lambda_i}}{y_i!}, & \text{if } y_i > 0 \end{cases}$$

Here, π_i denotes the probability of a structural zero derived from the logistic component of the model, while λ_i represents the expected count from the Poisson distribution. In practice the data obtained for number of ANC visit may be correlated because of their clustering nature. By incorporating the cluster effect u_i , the model becomes $\log(\lambda_i) = X_i\beta + u_i$. The vector X_i includes the explanatory variables, and β refers to the vector of corresponding regression coefficients. Thus, the model assumes that with probability π_i , an observation will always be zero, and with probability $(1 - \pi_i)$, the count will follow a Poisson distribution with mean λ_i . The likelihood for this ZIP model is ²⁰

$$L(\pi, \lambda|y) = \prod_{y_i=0} \left[\left(\frac{\pi_i}{1 - \pi_i} + e^{-\lambda_i} \right) (1 - \pi_i) \right] \prod_{y_i>0} \left[\frac{(1 - \pi_i)e^{-\lambda_i}\lambda_i^{y_i}}{y_i!} \right].$$

The Incidence Rates Ratio (IRR) is a measure used to compare the rates of counts between two groups or for different levels of a predictor variable in regression models like Poisson or Zero-Inflated Poisson (ZIP) models. It is used primarily for count data or rate-based outcomes, where we are interested in the number of events occurring over a unit of time, space, or exposure. In ZIP regression model, the IRR

is derived from the exponentiation of the regression coefficient β_j associated with a predictor variable ²¹

$$IRR = \exp(\beta_j)$$

III. Data and Variables

Data

The dataset utilized in this study is a primary dataset collected from the northern regions of Bangladesh, specifically the districts of Kurigram, Lalmonirhat, Naogaon, and Rajshahi. The sample consists of 1,195 observations, all gathered from pregnant women or mothers who have given birth previous one year of the survey. The data include a comprehensive range of variables related to maternal health, such as demographic information, healthcare access, pregnancy-related conditions, and postnatal care.

Variables

The response variable of interest is skilled ANC that represents the number of ANC visits a woman has with a skilled professional(qualified doctors, nurses, government hospitals, or private medical centers) during her pregnancy. Based on some previous literatures some demographic, socioeconomic, women empowerment, health awareness, social barrier covariates have been considered^{22,23}. The full list of the variables along with the categories that were used in our study is given in Table 1.

Table 1.Variables and their categories

Variable type	Variable name	Categories
Dependent variable	Skilled ANC	No, Yes
	Quality ANC	No, Yes
	At least 4 ANC	No, Yes
	Complete ANC	No, Yes
Demographic covariates	Region	Rangpur, Rajshahi
	Place of residence	Urban, Rural
	Age at last birth	≤ 20 year, 20 to 35 years, ≥ 35 years
	Birth order	1 st order, 2 nd order, 3 rd or higher
Socioeconomic covariates	Religion	Muslim, Non-Muslim
	Institutional status	Not going, School, Madrasa
	Education level of mothers	No/Low education, Primary complete, secondary incomplete, secondary or higher
	Partner's occupation	Agriculture, Labor, Service, Business, Others
Women empowerment covariates	Wealth index	Poor, Middle, Rich
	Decision-making autonomy	No, Low, High
	Media exposure	No, Yes
	Exposure to violence	No, Yes
	Involved in financial activities	No, Yes
Health awareness covariates	Knowledge of WHO recommendation	Don't know, ANC ≥4, ANC ≥ 8
	Aware of the community clinic	No, Yes
	Pregnancy complication	No, Yes
Social barrier covariates	Family support	No, Yes
	ANC affordability	No, Yes
	Road Type	Paved, Dirt, Mixed
	Barrier to accessing health facilities	No, Yes
	Transportation availability	No, Yes
	Time to reach health facilities	< 20 minutes, > 20 minutes

IV. Results

Univariate and Bivariate Analysis

Figure 1 represents the percentage distribution of the ANC practice of the respondents of the study. The majority (80.8%) receive care from a skilled provider, almost half of the mothers (47.9%) are able to access quality services, whereas only 30.8% achieving the recommended minimum of four. However, only 18.0% of the mothers are able to fulfill all the three components.

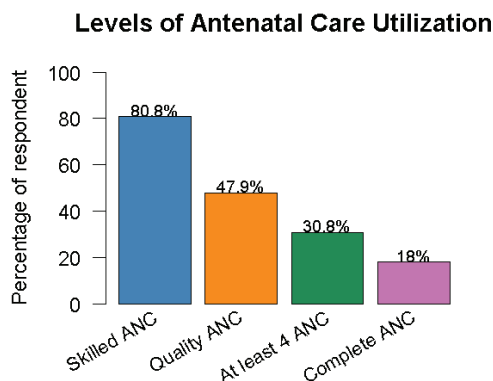


Fig. 1. Distribution of Levels of antenatal care

Table 2 presents the demographic, socioeconomic, empowerment, and health-related characteristics of the 1,195 mothers studied. Most respondents lived in rural areas (64.2%) and were from the Rangpur division (66.6%). The majority were Muslim (90.4%), and over half gave birth between ages 20–30 (53.1%). First-order births were most common (53.6%), followed by second (32.1%) and higher orders (14.3%). Regarding education, 33.3% had incomplete secondary education, 33.1% completed secondary, 20.5% attained primary, and 13.1% had little or no education. Partners were primarily engaged in labor (29.8%) and business (24.0%). Nearly half of the households were poor (43.8%). In terms of empowerment, 64.2% of mothers had high decision-making autonomy, and 78.1% participated in financial activities, though 26.7% experienced partner violence. Media exposure was common (73.4%). Awareness of WHO recommendation of ANC guidelines was low, only 10.1% knew of at least four visits, and 1.3% knew of eight. Most mothers had family support (77.7%), could afford ANC (73.0%), and lived near paved roads (77.2%). Although 82.9% reported no major barriers to accessing care, 41.8% required more than 20 minutes to reach the nearest health facility. Table 2 also presents the association between skilled ANC and others selected characteristics, along with Chi-square test results assessing their associations. Significant disparities in skilled ANC uptake were observed across several dimensions. Women from urban areas reported higher utilization (83.9%) compared to rural women (79.0%), with the difference reaching statistical significance (p -value = 0.041). While regional variation was evident, it was not statistically significant (p -value = 0.21), with uptake ranging from 78.9% in Rangpur to 84.5% in Rajshahi. Religious affiliation showed no significant effect (p -value =

0.228), though Muslim women (81.2%) had slightly higher utilization than non-Muslims (76.5%). Maternal age at last birth did not demonstrate a strong association (p -value = 0.124), although women over 30 years reported relatively lower uptake (74.8%). Birth order was not significantly related to SANC use (p -value = 0.561), though utilization declined slightly at higher orders. Institutional background demonstrated a significant association (p -value = 0.013); women with madrasa education had the highest uptake (90.3%), followed by those with school backgrounds (80.9%), while non-attendees reported the lowest (72.5%).

Mother's own education level, however, showed no significant association (p -value = 0.491). Partner's occupation was significantly related (p -value = 0.008), with the highest SANC uptake observed among women whose partners worked in service (87.6%), and the lowest among those in agriculture (76.3%) or "other" jobs (73.0%). Wealth status displayed a highly significant association (p -value < 0.001), with skilled ANC utilization steadily increasing from poor households (75.0%) to middle (81.5%) and rich (87.8%) households. Autonomy in household decision-making and media exposure were not significantly associated with SANC (p -value = 0.170 and p -value = 0.387, respectively). However, women exposed to domestic violence were significantly less likely to receive skilled ANC (76.8%) compared to those not exposed (82.2%, p -value = 0.037).

The results shown in Table 2 also provide a comprehensive overview of how the mean number of skilled antenatal care visits varies across different groups of respondent. The evaluation was conducted using the Kruskal-Wallis test and Mann-Whitney U tests for pairwise comparisons. Significant differences were observed across several background characteristics. Mothers residing in urban areas reported a higher mean number of SANC visits (2.83) compared to those in rural areas (2.40), with the difference being highly significant (p -value < 0.001). Regional disparities were also evident, as mothers from Rajshahi (2.74) had significantly more visits than those from Rangpur (2.46) (p -value < 0.001). In contrast, religion did not appear to have a significant influence on ANC attendance (p -value = 0.275). Maternal age at first birth and birth order did not show statistically significant associations with SANC visits (p -value = 0.756 and p -value = 0.712, respectively). Similarly, institutional status and involvement in financial activities were not significantly related to the average number of visits. However, a positive association was noted with maternal education: mothers with secondary or higher education reported more visits (2.78) than those with lower or no education (2.36), although this association only reached marginal significance (p -value = 0.079). Household wealth index also demonstrated a strong gradient, with mothers from richer households attending more visits (3.03) than those from poor households (2.21) with p -value less than 0.001. Decision-making autonomy showed a significant positive relationship with ANC utilization. Mothers with

high autonomy recorded more visits (2.67) than those with no autonomy (2.12) (p -value < 0.001). Exposure to violence was negatively associated with SANC attendance, with affected mothers reporting fewer visits (2.24 vs 2.67, p -value = 0.003). Conversely, media exposure did not show a significant effect (p -value = 0.827). Awareness of WHO recommendations strongly influenced SANC visits. Mothers who were informed of the recommended four or more ANC visits reported significantly higher utilization (2.89 and 2.93) compared to those unaware of the guidelines (2.51) (p -value = 0.016). However, awareness of community clinics showed no significant relationship with visit frequency (p -value = 0.232). Mothers reporting pregnancy complications attended more visits (2.82) compared to those without complications (2.26, p -value < 0.001). Financial capacity was critical, as mothers able to afford ANC reported substantially more visits (2.78) compared to those who could not (1.94, p -value < 0.001). Family support was similarly important, with supported mothers averaging 2.75 visits compared to only 1.86 among those lacking family support (p -value < 0.001). Accessibility-related factors also showed strong associations. Mothers with access to paved roads (2.72) reported more visits compared to those relying on dirt roads (1.32) or mixed roads (2.28) (p -value < 0.001). Distance barriers and lack of transportation significantly reduced ANC utilization, with mothers without transportation averaging only 1.67 visits compared to 2.69 among those with available transport (p -value < 0.001). Surprisingly, the time required to reach health facilities (< 20 minutes vs. ≥ 20 minutes) was not significantly related to SANC visits (p -value = 0.230).

Multiple Regression Analysis

The results from the random effects Zero-Inflated Poisson regression model for skilled antenatal care (ANC) utilization, accounting for clustering at the sub-district level, are presented in Table 3. Place of residence showed a marginal effect, with urban women being more likely to utilize skilled ANC than rural women (IRR = 1.11, p -value = 0.058). Partner's occupation indicated some variation, where laborers' and service workers' wives were slightly more likely to utilize ANC compared to those with agricultural partners, though results were only marginal.

Several factors, however, emerged as significant. Women exposed to violence had a substantially lower likelihood of using skilled ANC (IRR = 0.85, 95% CI: 0.76–0.96, p -value = 0.006), which indicates the role of sociocultural barriers. Conversely, women experiencing pregnancy complications were significantly more likely to seek skilled ANC (IRR = 1.14, 95% CI: 1.04–1.26, p -value = 0.005), suggesting that perceived health risks strongly motivate care-seeking. Structural factors also played an important role. Road type was a significant predictor, with women relying on dirt roads being less likely to use skilled ANC (IRR = 0.68, 95% CI: 0.53–0.88, p -value = 0.003). Similarly, women reporting distance as a barriers to access health facilities were less likely to seek care (IRR = 0.85, 95% CI: 0.74–0.98, p -value

= 0.026). The remaining covariates did not show significant associations.

The cluster variance of the model is 0.097, with a p -value of less than 0.001, indicating that the random effect (cluster) is statistically significant. This suggests that the variance due to the cluster (random grouping) is substantial and contributes meaningfully to the model. The Intra-class Correlation Coefficient (ICC) is 0.025, meaning that about 2.5% of the total variance in the outcome variable is explained by differences between clusters.

V. Discussion

This study investigated the levels and determinants of skilled antenatal care (SANC) utilization among women in the northern region of Bangladesh, employing both unadjusted and adjusted analyses to identify significant predictors. The findings demonstrate substantial inequalities in SANC uptake that are shaped by demographic, socioeconomic, women empowerment, health awareness, and social barrier factors. Although several background characteristics exhibited significant associations with the number of skilled ANC visits in the unadjusted analysis, the adjusted zero-inflated Poisson model revealed that wealth index, partner's occupation, exposure to violence, pregnancy complications, road type, and travel time to the nearest health facility remained the most significant predictors of SANC utilization.

The results underscore that women from wealthier households are more likely to utilize skilled ANC services than those from poorer households, consistent with persistent socioeconomic disparities reported in national surveys and previous research^{11,22}. Although the magnitude of this association decreased in the adjusted model, its direction remained stable, indicating the enduring influence of financial capacity on maternal healthcare use. While partner's occupation, particularly employment in the service sector, showed a positive association with SANC uptake in the unadjusted analysis, this relationship lost significance after adjustment. This pattern may reflect the mediating effects of household income, exposure to information, and decision-making dynamics within the household, as suggested in similar studies²⁴.

A notable finding is the strong negative association between exposure to violence and SANC utilization. Women who experienced physical or emotional violence were significantly less likely to seek skilled ANC, aligning with extensive literature showing how gender-based violence reduces autonomy, restricts mobility, and produces fear and psychological distress that inhibit health-seeking behavior^{25,26}. Women facing complications are more likely to recognize the importance of skilled care to safeguard their health and that of their child, which may explain the higher likelihood of SANC utilization among this group. The model also reveals important structural factors impacting SANC utilization. Women in areas with dirt roads and those facing distance as a barriers to visiting health facilities were

significantly less likely to seek skilled ANC²⁴. This finding is supported by research indicating that physical barriers, such as poor road infrastructure and long distances to healthcare facilities, are substantial hindrances to healthcare access in rural areas²⁷.

Interestingly, family support did not significantly influence ANC utilization in our study for the northern part of Bangladesh, which contrasts with the literature that emphasizes the role of family and community support in facilitating healthcare access, particularly for women in low-resource settings²⁸. This discrepancy may reflect cultural variations or differences in how family support is perceived or mobilized in different regions.

Overall, the findings reveal that skilled ANC utilization in northern Bangladesh is driven by economic capacity, women's autonomy, and social barriers such as domestic violence, perceived health needs, family support, and infrastructural constraints. These results mirror broader national and regional patterns and reinforce the need for integrated interventions that simultaneously address financial support, gender equity, community awareness, and rural infrastructure improvement.

VI. Conclusion

This study found that although most mothers received skilled antenatal care (SANC), significant disparities persist across

socioeconomic, empowerment, and structural factors. Urban residence, higher wealth, education, autonomy, media access, and better infrastructure were associated with greater SANC use, but only a few remained significant after adjusting for clustering effects. Exposure to violence markedly reduced the likelihood of SANC utilization, while pregnancy complications increased it. Poor road conditions and long distances to health facilities were strong negative predictors, indicating that structural and household-level barriers are the main obstacles to equitable care.

These findings emphasize the need for comprehensive strategies to improve maternal healthcare in northern Bangladesh. Efforts should focus on addressing violence against women, enhancing road and transport infrastructure, reducing financial barriers through fee exemptions and health insurance, and empowering women through greater decision-making autonomy and community engagement. Increasing awareness of WHO-recommended ANC visits through health education and media campaigns is also essential. Addressing both structural and sociocultural barriers will be key to ensuring equitable access and improved maternal health outcomes.

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Table 2. Percentage distribution of the respondents by the selected background characteristics and their association and average number of skilled ANC visits by selected covariates with *p*-value obtained from Kruskal-Wallis / Mann-Whitney U test.

Variable	Frequency (%)	Skilled ANC			Significant Pair (<i>p</i> -value)
		No	Yes	Mean (Median)	
Place of residence**					
Urban	428 (35.8)	69 (16.1%)	359 (83.9%)	2.83 (2.78)	
Rural	767 (64.2)	161 (21.0%)	606 (79.0%)	2.40 (2.28)	
Region					
Rangpur	796 (66.6)	168 (21.1%)	628 (78.9%)	2.46 (2.31)	
Rajshahi	399 (33.3)	62 (15.5%)	337 (84.5%)	2.74 (2.85)	
Religion					
Non-muslim	115 (9.6)	27 (23.5%)	88 (76.5%)	2.48 (2.15)	
Muslim	1080 (90.4)	203 (18.8%)	877 (81.2%)	2.56 (2.50)	
Age at last birth					
≤ 20 years	442 (37.0)	89 (20.1%)	353 (79.9%)	2.87 (2.91)	
20 to 30	634 (53.1)	111 (17.5%)	523 (82.5%)	2.81 (2.78)	
≥ 30 years	119 (10.0)	30 (25.2%)	89 (74.8%)	2.75 (3.00)	
Birth order					
1 st Order	641 (53.6)	121 (18.9%)	520 (81.1%)	2.53 (2.43)	
2 nd Order	383 (32.1)	71 (18.5%)	312 (81.5%)	2.62 (2.54)	
3 rd or higher	171 (14.3)	38 (22.2%)	133 (77.8%)	2.47 (2.44)	
Institutional status**					
Not going	102 (8.5)	28 (27.5)	74 (72.5%)	2.29 (2.40)	
School	1021 (85.4)	195 (19.1%)	826 (80.9%)	2.57 (2.47)	
Madrasa	72 (6.0)	7 (9.7%)	65 (90.3%)	2.69 (2.50)	
Education level of mother					
No / Low	156 (13.1)	36 (23.1%)	120 (76.9%)	2.36 (2.40)	
Primary complete	245 (20.5)	49 (20.0%)	196 (80.0%)	2.30 (2.29)	
Secondary	398 (33.3)	76 (19.1%)	322 (80.9%)	2.56 (2.45)	

incomplete					
Secondary	396 (33.1)	69 (17.4%)	327 (82.6%)	2.78 (2.65)	
complete or higher					
Partner's occupation ***					
Agriculture (A)	232 (19.4)	55 (23.7%)	177 (76.3%)	2.07 (2.01)	A-B (0.003)
Labor (L)	356 (29.8)	67 (18.8%)	289 (81.2%)	2.64 (2.57)	A-L (0.001)
Service (S)	209 (17.5)	26 (12.4%)	183 (87.6%)	3.02 (2.76)	A-S (<0.001)
Business (B)	287 (24.0)	52 (18.1 %)	235 (81.9%)	2.58 (2.52)	A-O (0.023)
Others (O)	111 (9.3)	30 (27.0%)	81 (73.0%)	2.33 (2.34)	B-S (0.070)
Wealth index ***					
Poor (P)	524 (43.8)	131 (25.0%)	393 (75.0%)	2.21 (2.09)	P-M (0.024)
Middle (M)	271 (22.7)	50 (18.5%)	221 (81.5%)	2.51 (2.40)	P-R (<0.001)
Rich (R)	400 (33.5)	49 (12.3%)	351 (87.8%)	3.03 (3.03)	M-R(<0.001)
Decision-making autonomy ***					
No (N)	173 (14.5)	42 (24.3%)	131 (75.7%)	2.12 (2.03)	N-H (<0.001)
Low (L)	254 (21.3)	44 (17.3%)	210 (82.7%)	2.48 (2.35)	N-L (0.036)
High (H)	768 (64.2)	144(18.8%)	624 (81.3%)	2.67 (2.63)	
Media exposure					
No	318 (26.6)	56 (17.6%)	262 (82.4%)	2.50 (2.42)	
Yes	877 (73.4)	174 (19.8%)	703 (80.2)	2.57 (2.48)	
Exposure to violence **					
No	876 (73.3)	156 (17.8%)	720 (82.2%)	2.67 (2.55)	
Yes	319 (26.7)	74 (23.2%)	245 (76.8%)	2.24 (2.20)	
Involved in financial activities					
No	234 (19.6)	44 (18.8%)	190 (81.2%)	2.51 (2.60)	
Yes	933 (78.1)	179 (19.2%)	754 (80.8%)	2.57 (2.44)	
Knowledge of WHO recommendation ***					
Don't know (D)	1058 (88.5)	208 (19.7%)	850 (80.3%)	2.51 (2.39)	D-F (0.006)
ANC $\geq$ 4 (F)	121 (10.1)	19 (15.7%)	102 (84.3%)	2.89 (3.13)	D-E (0.005)
ANC $\geq$ 8 (E)	16 (1.3)	3 (18.8%)	13 (81.3%)	2.93 (3.12)	
Aware of community clinic *					
No	271 (22.7)	42 (15.5%)	229 (84.5%)	2.76 (2.63)	
Yes	924 (77.3)	188 (20.3%)	736 (79.7%)	2.52 (2.42)	
Pregnancy complications ***					
No	572 (47.9)	137 (24.0%)	435 (76.0%)	2.26 (2.10)	
Yes	623 (52.1)	93 (14.9%)	530 (85.1%)	2.82 (2.82)	
Road type ***					
Dirt road (D)	95 (7.9)	45 (47.4%)	50 (52.6%)	2.72 (2.67)	P-D (<0.001)
Mixed Road (M)	178 (14.9)	46 (25.8%)	132 (74.2%)	1.32 (0.94)	P-M (0.001)
Paved road (P)	922 (77.2)	139 (15.1%)	783 (84.9%)	2.28 (2.12)	D-M (0.007)
Transport availability ***					
No	991 (82.9)	57 (37.7%)	94 (62.3%)	1.67 (1.37)	
Yes	204 (17.1)	169 (16.3%)	870 (83.7%)	2.69 (2.61)	
ANC affordability ***					
No	323 (27.0)	107 (33.8%)	210 (66.2%)	1.94 (1.73)	
Yes	872 (73.3)	119 (13.6%)	753 (86.4%)	2.78 (2.69)	
Family support ***					
No	266 (22.3)	101 (38.0%)	165 (62.0%)	1.86 (1.54)	
Yes	929 (77.7)	129 (13.9%)	800 (86.1%)	2.75 (2.69)	
Time to reach HF (minutes)					
$\leq$ 20	695 (58.2)	143 (20.6%)	552 (79.4%)	2.49 (2.42)	
$\geq$ 20	500 (41.8)	87 (17.4%)	413 (82.6%)	2.64 (2.52)	
Barrier to accessing HF					
No	156 (13.0)	184 (18.6%)	807 (81.4%)	2.62 (2.58)	
Yes	1039 (87.0)	46 (22.5%)	158 (77.5%)	2.24 (2.09)	

Note: *** (significant at 1%), ** (significant at 5%), * (significant at 10%)

Table 3. Results from the random effects Zero-Inflated Poisson regression model for skilled antenatal care (ANC) utilization along with *p*-value, Incidence Rate Ratio (IRR) and Confidence Interval (CI)

Category	Estimate	Std. error	<i>p</i> -value	IRR (95% CI)
Intercept	0.793	0.186	<0.001	2.211 (1.535, 3.185)
Place of residence				
Urban	-	-	-	-
Rural	0.100	0.053	0.058	1.105 (0.996, 1.227)
Region				
Rangpur	-	-	-	-
Rajshahi	-0.016	0.086	0.844	0.983 (0.830, 1.164)
Religion				
Non-Muslim	-	-	-	-
Muslim	-0.031	0.072	0.661	0.968 (0.839, 1.117)
Age at last birth				
≤ 20 years	-	-	-	-
20 to 30	-0.001	0.045	0.986	0.999 (0.913, 1.093)
≥30 years	0.129	0.079	0.104	1.137 (0.973, 1.330)
Birth order				
1 st Order	-	-	-	-
2 nd Order	0.073	0.048	0.126	1.076 (0.979, 1.183)
3 rd or higher	0.064	0.073	0.379	1.066 (0.923, 1.232)
Institutional status				
Not going	-	-	-	-
School	0.027	0.110	0.806	1.027 (0.826, 1.277)
Madrasa	0.027	0.137	0.839	1.028 (0.785, 1.345)
Education level of mother				
No / Low	-	-	-	-
Primary complete	-0.100	0.096	0.294	0.904 (0.749, 1.091)
Secondary incomplete	0.012	0.092	0.888	1.013 (0.844, 1.215)
Secondary complete or higher	0.021	0.095	0.822	1.021 (0.847, 1.230)
Partner's occupation				
Agriculture	-	-	-	-
Labor	0.106	0.063	0.093	1.112 (0.982, 1.129)
Service	0.117	0.073	0.107	1.124 (0.974, 1.298)
Business	0.033	0.068	0.629	1.033 (0.903, 1.183)
Others	-0.011	0.087	0.898	0.988 (0.833, 1.173)
Wealth index				
Poor	-	-	-	-
Middle	-0.054	0.055	0.326	0.946 (0.848, 1.056)
Rich	0.059	0.057	0.298	1.061 (0.948, 1.187)
Decision-making autonomy				
No	-	-	-	-
Low	0.016	0.074	0.826	1.016 (0.878, 1.176)
High	0.096	0.070	0.170	1.101 (0.959, 1.264)
Media exposure				
No	-	-	-	-
Yes	0.009	0.050	0.853	1.009 (0.914, 1.113)
Exposure to violence				
No	-	-	-	-
Yes	-0.158	0.058	0.006	0.853 (0.761, 0.957)
Involved in financial activities				
No	-	-	-	-
Yes	0.0825	0.056	0.145	1.086 (0.971, 1.213)
Knowledge of WHO recommendation				
Don't know	-	-	-	-
At least 4 ANC	0.108	0.066	0.104	1.114 (0.977, 1.269)
At least 8 ANC	0.096	0.161	0.549	1.101 (0.802, 1.510)
Aware of community clinic				
No	-	-	-	-
Yes	0.070	0.059	0.230	1.073 (0.955, 1.205)

Pregnancy complications				
No	-		-	-
Yes	0.134	0.048	0.005	1.143 (1.039, 1.257)
Road type				
Dirt road	-		-	-
Mixed road	-0.381	0.130	0.003	0.682 (0.528, 0.881)
Paved road	0.016	0.070	0.811	1.016 (0.886, 1.166)
Transport availability				
No	-		-	-
Yes	-0.012	0.102	0.905	0.987 (0.808, 1.207)
ANC affordability				
No	-		-	-
Yes	0.020	0.066	0.760	1.020 (0.896, 1.162)
Family support				
No	-		-	-
Yes	-0.083	0.076	0.278	0.920 (0.791, 1.069)
Time to reach HF (minute)				
≤ 20	-		-	-
≥ 20	-0.159	0.045	0.026	0.852 (0.740, 0.981)
Barrier to accessing HF				
No	-		-	-
Yes	0.056	0.071	0.215	1.057 (0.967, 1.156)
Cluster variance			<0.001	0.097
ICC			-	0.025

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