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Unveiling the sociodemographic and socioeconomic determinants of antenatal care utilization in Bangladesh: insights from the 2017–18 BDHS

Md. Mojammel Haque Sakib[1*], Muhammad Khairul Alam[1], Nilufar Yasmin[1] and Rumana Rois[1]

Abstract

Background Antenatal care (ANC) is indispensable for supervising and enhancing the health of both the mother and the baby during pregnancy. It helps to reduce the risks of complications and ensures better pregnancy outcomes. This study investigates the aspects that influence antenatal care (ANC) visits in Bangladesh, focusing on sociodemographic and socioeconomic factors.

Methods The study used nationally representative data from the 2017–18 Bangladesh Demographic and Health Survey. Mann–Whitney and Kruskal–Wallis tests were conducted for bivariate analysis. The Boruta algorithm was utilized for variable selection. After employing various regression models, including Poisson Regression, Negative Binomial Regression, Zero-inflated Poisson Regression, and Zero-inflated Negative Binomial Regression (ZINB), we evaluated their performance and selected Zero-inflated Negative Binomial Regression (ZINB) for parameter estimation and interpretation.

Results Our results reveal that less than 50% of women meet the WHO-recommended minimum of four ANC visits. Rural women were 12% less likely than urban women to receive antenatal care (ANC) visits, indicating an urban–rural discrepancy. Women with secondary and higher education levels were significantly more likely to have frequent visits, with incidence rate ratios (IRRs) of 1.27 (95% CI: 1.14–1.42) and 1.34 (95% CI: 1.18–1.51), respectively. Similarly, women from households with rich wealth status (IRR: 1.14, 95% CI: 1.08–1.21) and those exposed to media coverage (IRR: 1.19, 95% CI: 1.14–1.25) were more likely to attend frequent ANC visits. Conversely, women with higher birth order (IRR: 0.95 & 0.84, 95% CI: 0.90–1.00 & 0.76–0.92), unintentional pregnancy (IRR: 0.91 & 0.83, 95% CI: 0.86–0.96 & 0.77–0.91) were less likely to have ANC visits.

Conclusion This study underscores a critical gap in ANC access, particularly among rural women, which poses challenges to achieving national and global maternal health targets. Addressing these disparities and making relevant policy implications such as expanding community-based ANC programs, integrating services into primary healthcare, and increasing awareness through mass media are required to enhance ANC accessibility and utilization in underserved populations.

Keywords Antenatal care visit, Maternal health, Bangladesh demographic and health survey, Negative binomial regression

*Correspondence:
Md. Mojammel Haque Sakib
mhaqsakib@gmail.com

Introduction

Maintaining the quality of antenatal care (ANC) is critical to elevating the support provided to women throughout their pregnancy, thereby safeguarding the well-being of both the mother and the baby [1]. High-quality ANC impacts pregnancy from both clinical and psychological perspectives, as it helps women prepare for childbirth and the responsibilities of motherhood [2]. Annually, an estimated 300,000 women succumb to complications stemming from pregnancy or childbirth worldwide, which is around 800 each day on average [3]. Annually, the South Asian region alone is responsible for over one-third of all maternal and child fatalities worldwide [4]. The most recent Sustainable Development Goals prioritize declining of global maternal mortality rates to 70 deaths per 100,000 live births and the neonatal mortality rate to 12 deaths per 1000 live births by the year 2030 [5, 6]. High-quality ANC protects against unexpected pregnancy outcomes. Although 62% of pregnant women globally participated in a minimum of four World Health Organization (WHO)-recommended antenatal care (ANC) activities in 2017, the comparable proportion for Bangladesh stood at only 47% [1].

Maternal health remains a critical public health issue in Bangladesh, with the maternal mortality ratio (MMR) reported as 173 deaths per 100,000 live births in 2017. [7] Despite significant improvements over the past decades, this rate is still far from the SDG target. Maternal mortality is primarily driven by preventable causes, including postpartum hemorrhage, eclampsia, and obstructed labor, which are often linked to inadequate utilization of maternal health services (MHS). While utilization of maternal health services in Bangladesh has shown gradual improvement, progress is uneven. The Bangladesh Demographic and Health Survey (BDHS) reveals that ANC visits from any healthcare facility increased by 31% between 2004 and 2017 [8–11]. Urban areas consistently outperform rural regions in terms of MHS utilization, with only 37% of rural women receiving four or more ANC visits compared to 63% of urban women. [12] Socioeconomic factors such as poverty, education, and geographic location play a significant role in these inequities, with women from the poorest quintile less likely to receive skilled care during pregnancy and childbirth compared to their wealthier counterparts [13, 14].

Widespread access to high-quality prenatal care (ANC) can play a significant role in helping to achieve national and international goals for mother and child health, such as lowering the rate of maternal and newborn mortality [15]. The Focused Antenatal Care (FANC) Model that was suggested by the World Health Organization (WHO) in the past, it is advised that when a pregnant woman is under typical conditions, she should have at least four ANC visits [16]. The 2016 WHO ANC Model incorporates eight ANC interactions to help accomplish the Sustainable Development Goals (SDGs) to reduce mother and child mortality [17]. However, Bangladesh still promotes four ANC visits according to the older WHO guidelines [16].

Inequities in using maternal health services are prevalent among developing countries [18, 19]. Maternal deaths due to inadequate healthcare utilization are more common among less-educated, poor, and rural populations [18, 20]. There is a stark disparity in South Asia, with a 33 percentage-point difference between urban and rural areas in the coverage of births attended by skilled health personnel [21]. The development agenda now prioritizes addressing these enduring disparities, highlighting the necessity of fair access to basic services for all demographic groups. Equitable access is becoming a more important factor in assessing the success of health systems, which is in line with gradually reaching universal health coverage (UHC) with an emphasis on equity [8].

The Bangladesh Demographic and Health Survey (BDHS) reveals increased ANC visits from any healthcare facility. Bangladesh continues to be one of the top ten nations in the world for maternal mortality, accounting for approximately 60% of all maternal deaths worldwide, even with this increase [7]. Many studies have looked into the factors that affect ANC visits and postpartum care in Bangladesh [1, 12, 16, 19, 22]. The majority of them emphasized the importance of women's education and their wealth status in receiving high-quality prenatal care, as well as the differences in prenatal care by area [1, 12, 13, 16, 23]. Several studies have revealed that decision-making authority over one's own health care and media access has a significant influence as well [12, 23]. Exposure to the media has also been found to have an impact on receiving prenatal treatment [19, 22, 24].

The Bangladeshi government is dedicated to accomplishing the Sustainable Development Goals (SDG) as it has presented two Voluntary National Review (VNR) so far [25]. Over recent decades, socioeconomic disparities and their ramifications on population health, particularly maternal and child health, have emerged as pivotal subjects of concern [26]. To provide policymakers with assistance in reducing the occurrence of maternal and infant mortality, it is of the utmost importance to identify the socioeconomic and socio-demographic factors that have an impact on maternal health.

With the assistance of a count regression model, the general goal of our study is to ascertain the degree to

which socioeconomic and demographic factors impact the total number of prenatal care visits. To the best of our knowledge, count regression models such as Poisson Regression (PR), Negative Binomial Regression (NBR), Zero-inflated Poisson Regression (ZIP), and Zero-inflated Negative Binomial Regression (ZINB) were not utilized in the process of modeling the number of prenatal visits using data from the BDHS (2017–18). So, this investigation will thereby increase the range of evidence in this field.

Methods and materials

Study setting

The data for this study was extracted from the Bangladesh Demographic and Health Survey 2017–18 dataset. The entire population of Bangladesh living in non-institutional housing was covered by the nationally representative Bangladesh Demographic and Health Survey (BDHS) for the 2017–18 fiscal year. The 2011 Bangladesh Bureau of Statistics (BBS) Population and Housing Census provided the sample frame for the study. An enumeration area (EA) is defined as a group of about 120 houses that make up the principal sampling unit (PSU).

Bangladesh is divided into eight administrative divisions: Barisal, Chittagong, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur, and Sylhet. Each division is further subdivided into zilas, which are then broken down into upazilas. Within upazilas, urban areas are organized into wards, which are further divided into mohallas, while rural areas are structured into union parishads (UPs) and subsequently into mouzas. This administrative framework facilitates the distinction between rural and urban areas across the country, representing each division. [10, 27].

A two-stage stratified sampling technique was used by the BDHS. According to ICF specifications and BBS implementation, 675 EAs (250 urban and 425 rural) were chosen in the first stage based on a probability proportionate to their size. In order to provide a sample frame for the second step, a thorough household listing was subsequently carried out within these EAs. In the second phase, a total of 20,250 households were carefully chosen in order to produce accurate estimates of population and health for the entire nation, as well as for each division and urban and rural areas separately. Approximately 20,127 married women between the ages of 15 and 49 were interviewed for the survey [27].

Three clusters were disqualified because of flooding, even though 672 clusters had a successful implementation. There were two rural clusters in Rajshahi and Rangpur and one urban cluster in Dhaka. In the end, the poll covered 20,160 households. Sampling weights were used in the analysis to make sure the data appropriately reflects the national and divisional levels of government. The integrity of the survey results is preserved by these weights, which are intended to reduce any notable variations in survey indicators.

Among 20,127 individuals, 5012 women provided responses regarding the number of antenatal care (ANC) visits they attended during their last pregnancy. However, 92 respondents were excluded from the analysis due to missing socio-demographic information. Consequently, the final analysis was conducted on 4920 observations, which increased to 4958 after applying sampling weights.

Outcome variable

The study's outcome variable was the number of antenatal care visits, representing how frequently expectant mothers received expert medical attention during their pregnancy. This variable provides insights into the quality and accessibility of prenatal care across the population, making it a critical indicator of a mother's health and access to healthcare services [2, 12]. Researchers can find trends and differences in healthcare access between various demographic groups by examining the number of visits, which can assist in guiding public health initiatives. We did not exclude the response variable's outliers (0.76%) since they provided valid information.

Explanatory variables

The explanatory variables in the study were categorized into socio-demographic, socio-economic, and contextual factors to provide a structured analysis of the determinants of antenatal care visits. Socio-demographic variables included the division (Dhaka, Chittagong, Khulna, Rajshahi, Mymensingh, Rangpur, Sylhet, Barisal), respondent's age group (15–19, 20–29, 31–49), place of residence (urban, rural), number of household members (1–5, 6–10, 11+), sex of the household head (male, female), and religion (Islam, Hinduism, Christianity, Buddhism). Socio-economic variables encompassed the highest level of education (no education, primary, secondary, higher), wealth index (poor, middle, rich), partner's education level (no education, primary, secondary, higher), husband's occupation (unemployed, agricultural or household work, service and sales, others), employment status (yes, no), and health insurance (yes, no). Contextual factors included birth order (1, 2–3, 4+), age at first birth (before 18, 18–25, 26+), birth in the last three years (1, more than one), whether the pregnancy was wanted at that time (yes, no) and media coverage (yes, no). These variables provided a strong framework for examining the factors influencing the use of prenatal care in Bangladesh.

Statistical analysis

First, the distribution of the number of antenatal care visits was analyzed by a bar plot. Then bivariate analysis was performed using either the Mann-Whiteney or Kruskall-Wallis test to ascertain the median number of visits for each category of covariates. The Kruskal–Wallis and Mann–Whitney tests are non-parametric methods for evaluating median differences between groups, with the former suitable for more than two groups and the latter for two groups [28]. The Boruta Algorithm, a machine learning feature selection method, was applied to choose covariates for modeling the data. This technique utilizes a random forest approach to determine feature importance by comparing actual features' accuracy loss to randomly shuffled shadow features, thus identifying critical attributes amidst random variations. [29]. However, it has certain limitations, including sensitivity to multicollinearity and computational intensity. Alternative methods such as LASSO, SHAP, and stepwise regression can also be considered for variable selection.

After that, using the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) and log-likelihood, we assessed four regression models such as Poisson regression (PR), Negative binomial regression (NBR), Zero-inflated Poisson regression (ZIP), Zero-inflated Negative binomial regression (ZINB).

The Poisson regression model (PR) is defined as

$$Y_i \sim \text{Poisson}(\lambda_i), \text{ where } \quad \lambda_i = \exp(X_i\boldsymbol{\beta}) \tag{1}$$

The Poisson model assumes that the mean and variance are equal which is often unrealistic in practice due to overdispersion. The Negative Binomial model introduces an overdispersion parameter θ to allow for variance greater than the mean.

$$Y_i \sim \text{NB}(\mu_i, \theta), \text{where} \quad \mu_i = \exp(X_i\boldsymbol{\beta}) \tag{2}$$

The variance is given by

$$\text{Var}(Y_i) = \mu_i + \frac{\mu_i^2}{\theta} \tag{3}$$

Since the data contains excess zeros, the Poisson and Negative Binomial models may not fit well. The Zero-Inflated Poisson (ZIP) model addresses this by combining a Poisson process with a binary logistic regression model to account for structural zeros. The model assumes that an observation can arise from

$$P(Y_i = 0) = p + (1-p)e^{-\lambda_i} \tag{4}$$

$$P(Y_i = y) = (1-p)\frac{\lambda_i^y e^{-\lambda_i}}{y!}, \quad y > 0 \tag{5}$$

where p is the probability of an excess zero, modelled using a logit function and Z_i is a set of covariates and $\boldsymbol{\gamma}$ is a vector of coefficients.

$$\log\left(\frac{p}{1-p}\right) = Z_i\gamma \tag{6}$$

The Zero-Inflated Negative Binomial (ZINB) model is an extension of ZIP that allows for overdispersion by replacing the Poisson component with a Negative Binomial component.

$$P(Y_i = 0) = p + (1-p)\left(1 + \frac{\lambda_i}{\theta}\right)^{-\theta} \tag{7}$$

$$P(Y_i = y) = (1-p)\frac{\Gamma(y+\theta)}{\Gamma(\theta)y!}\left(\frac{\lambda_i}{\lambda_i+\theta}\right)^y\left(\frac{\theta}{\lambda_i+\theta}\right)^\theta, \quad y > 0 \tag{8}$$

where $\Gamma(\cdot)$ is the gamma function, θ is the overdispersion parameter, λ_i follows a Negative Binomial distribution.

The Akaike information criterion is a mathematical framework used for model selection and parsimony assessment in model construction [30]. Since the ZINB model had a lower AIC value, we finally used it for parameter estimation and interpretation. A flowchart (Fig. 1) was used to illustrate the entire study. Stata 17 and R 4.3.1 were the statistical tools used during the analysis.

Results

Exploratory analysis

Table 1 summarizes the weighted (4958) and unweighted (4920) distributions across demographic, socioeconomic, and reproductive factors. Most respondents were aged 20–29 (58.2%), rural (73.2%), and from Dhaka (25.6%). Secondary education (49.0%) and Islam (91.9%) were predominant. Households were mostly male-headed (87.2%) with 1–5 members (51.0%). Wealth was evenly distributed, and 41.7% had their first birth before 18. Employment was low (37.1%), but media exposure was high (65.7%). Husbands mainly had secondary education (34.1%) and worked in service/sales (40.2%). Weighting adjustments affected regional and socioeconomic distributions.

Along with the background characteristics of the respondents Table 1 also presents the median number of ANC visits. The majority of respondents were aged 20–29 years, with a median of 3 ANC visits across all age groups ($p=0.002$). Median ANC visits varied significantly across divisions ($p<0.001$), with higher medians observed in Dhaka, Khulna, Rajshahi, and Rangpur (4 visits) compared to other divisions (3 visits). Urban residents had a higher median of 4 ANC visits compared to rural residents with 3 visits ($p<0.001$).

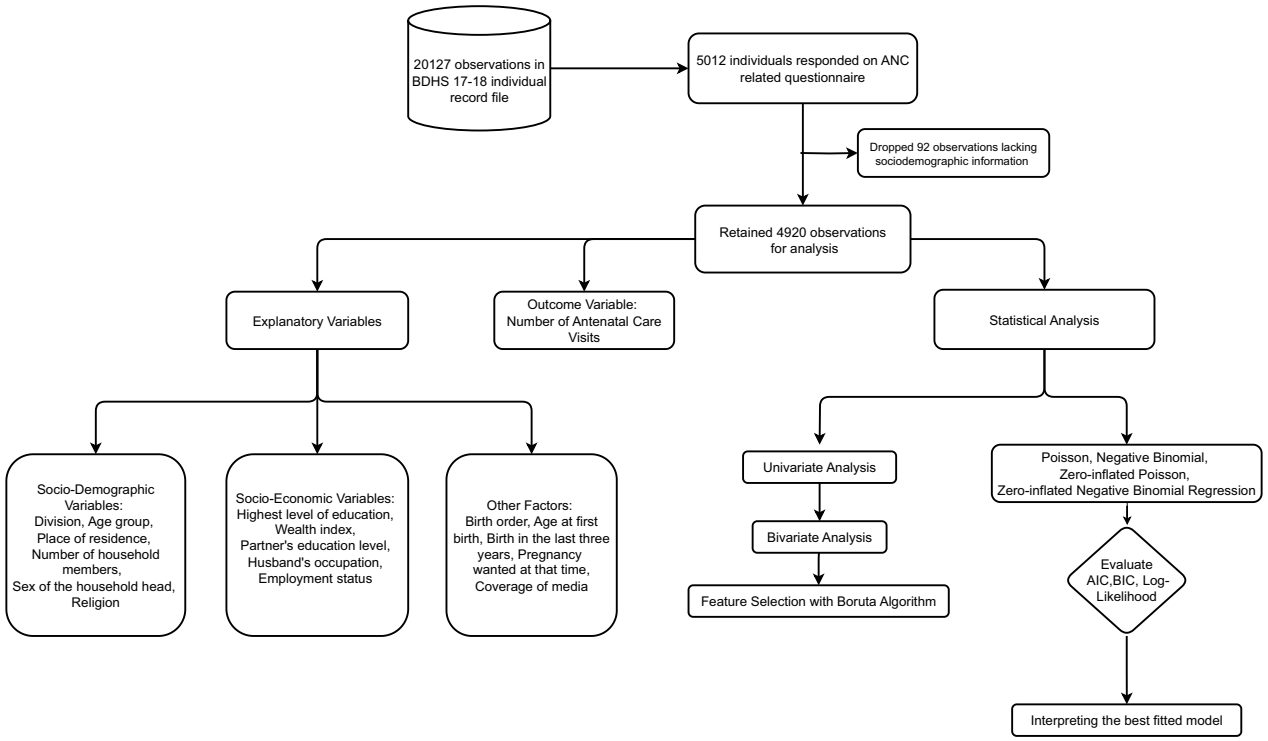

Fig. 1 A flowchart that outlines the comprehensive methodology employed in the study

Education level was strongly associated with ANC visits, as respondents with no or primary education reported a median of 2 visits, while those with secondary and higher education reported 4 and 5 visits, respectively ($p < 0.001$). Wealth also played a significant role, with the median ANC visits increasing from 2 in the poorest group to 4 in the richest group ($p < 0.001$).

Other sociodemographic factors also influenced ANC visits. Respondents with 1–5 household members and those with > 10 members reported higher medians (3–4 visits; $p = 0.012$). ANC visits were significantly higher among women with one birth order (4 visits) compared to those with 2–3 or ≥ 4 children ($p < 0.001$). Women who gave birth after 18 years reported more ANC visits, with a median of 4 visits for those aged 18–25 and 6 visits for those aged > 25 years ($p < 0.001$). Husband's education and occupation also showed significant associations, as women whose husbands had secondary or higher education and those engaged in service or sales reported higher ANC visits ($p < 0.001$). Similarly, media coverage exposure was linked to more visits, with respondents exposed to media having a median of 4 visits compared to 2 visits among those without ($p = 0.001$). These findings highlight the significant disparities in ANC utilization based on sociodemographic, reproductive, and contextual factors.

Subplot A in Fig. 2 shows the distribution of the count values as percentages, where the highest percentages are observed for counts of 2 and 3, each representing 15.7% of the total data, followed by 4 (12.1%). The percentages gradually decline for higher counts, with the lowest being for a count of 8 (5%). This trend reflects a concentration of the data around lower counts, with fewer instances observed as the count value increases. Subplot B presents a scatterplot of antenatal care (ANC) visits against the age of respondents, stratified by place of residence (Urban vs. Rural). Urban respondents, represented by red dots, appear to have more variability in ANC visits across different ages, particularly higher ANC visits in the younger age groups. Rural respondents, represented by blue dots, show a more clustered pattern with lower ANC visits overall.

Variable selection

The output of the Boruta Algorithm illustrated in Fig. 3 suggests that the number of births in the last three years, religion, sex of household head, and employment status are deemed unimportant in predicting the number of antenatal care visits. The remaining variables are considered important predictors of the number of antenatal visits. These findings led us to build a model

Table 1 Background characteristics of the respondents along with their median number of antenatal care visit (N = 4958)

Variables	Unweighted n (%)	Weighted n (%)	Median	*P* value
Age group				
15–19	1204 (24.5)	1249 (25.2)	3	
20–29	2883 (58.6)	2883 (58.2)	3	0.002[a]
31–49	833 (16.9)	826 (16.7)	3	
Division				
Barisal	524 (10.7)	282 (5.7)	3	
Chittagong	814 (16.5)	1047 (21.1)	3	
Dhaka	728 (14.8)	1271 (25.6)	4	
Khulna	510 (10.4)	452 (9.1)	4	< 0.001[a]
Mymensingh	594 (12.1)	424 (8.6)	3	
Rajshahi	519 (10.6)	579 (11.7)	4	
Rangpur	550 (11.2)	526 (10.6)	4	
Sylhet	681 (13.8)	378 (7.6)	3	
Place of residence				
Urban	1692 (34.4)	1328 (26.8)	4	
Rural	3228 (65.6)	3630 (73.2)	3	< 0.001[b]
Educational level				
No education	304 (6.2)	310 (6.2)	2	
Primary	1364 (27.7)	1367 (27.6)	2	
Secondary	2358 (47.9)	2431 (49.0)	4	< 0.001[a]
Higher	894 (18.2)	851 (17.2)	5	
Religion				
Islam	4503 (91.5)	4556 (91.9)	3	
Hinduism	392 (8.0)	375 (7.6)	4	0.059[a]
Buddhism	17 (0.3)	22 (0.4)	5	
Christianity	8 (0.2)	6 (0.1)	5.5	
Number of household members				
1–5	2482 (50.5)	2528 (51.0)	3	
6–10	2079 (42.3)	2083 (42.0)	3	0.012[a]
11 +	359 (7.3)	347 (7.0)	4	
Household head				
Male	4337 (88.2)	4324 (87.2)	3	
Female	583 (11.8)	635 (12.8)	3	0.235[b]
Wealth index				
Poor	2058 (41.8)	2039 (41.1)	2	
Middle	882 (17.9)	943 (19.0)	3	< 0.001[a]
Rich	1980 (40.2)	1976 (39.9)	4	
Birth order				
1	1864 (37.9)	1881 (37.9)	4	
2–3	2458 (50.0)	2467 (49.8)	3	< 0.001[a]
4 +	598 (12.2)	611 (12.3)	2	
Age at first birth				
Before 18	1990 (40.5)	2066 (41.7)	3	
18–25	2730 (55.5)	2721 (54.9)	4	< 0.001[a]
26 +	200 (4.1)	171 (3.5)	6	
Birth in three years				
One	4635 (94.2)	4677 (94.3)	3	
More than one	285 (5.8)	281 (5.7)	3	0.001[b]
Pregnancy wanted				

Table 1 (continued)

Variables	Unweighted n (%)	Weighted n (%)	Median	*P* value
Then	3876 (78.8)	3917 (79.0)	4	
Later	642 (13.1)	643 (13.0)	3	< 0.001[a]
No more	402 (8.2)	398 (8.0)	2	
Husband's educational level				
No education	678 (13.8)	678 (13.7)	2	
Primary	1654 (33.6)	1675 (33.8)	3	< 0.001[a]
Secondary	1633 (33.2)	1692 (34.1)	4	
Higher	955 (19.4)	912 (18.4)	5	
Employment status				
No	3081 (62.6)	3129 (62.9)	3	
Yes	1839 (37.4)	1839 (37.1)	3	0.041[b]
Media coverage				
No	1761 (35.8)	1701 (34.3)	2	
Yes	3159 (64.2)	3257 (65.7)	4	0.001[b]
Husband's occupation				
Unemployed	38 (0.7)	36 (0.7)	3	
Agricultural or Household work	924 (18.7)	955 (19.3)	3	0.001[a]
Service and Sales	2032 (41.3)	1992 (40.2)	4	
Others	1926 (39.1)	1975 (39.8)	3	
Total	**4920**	**4958**		

Bold values indicate the total number of observation

[a] Kruskal–Wallis test, [b]Mann–Whitney test

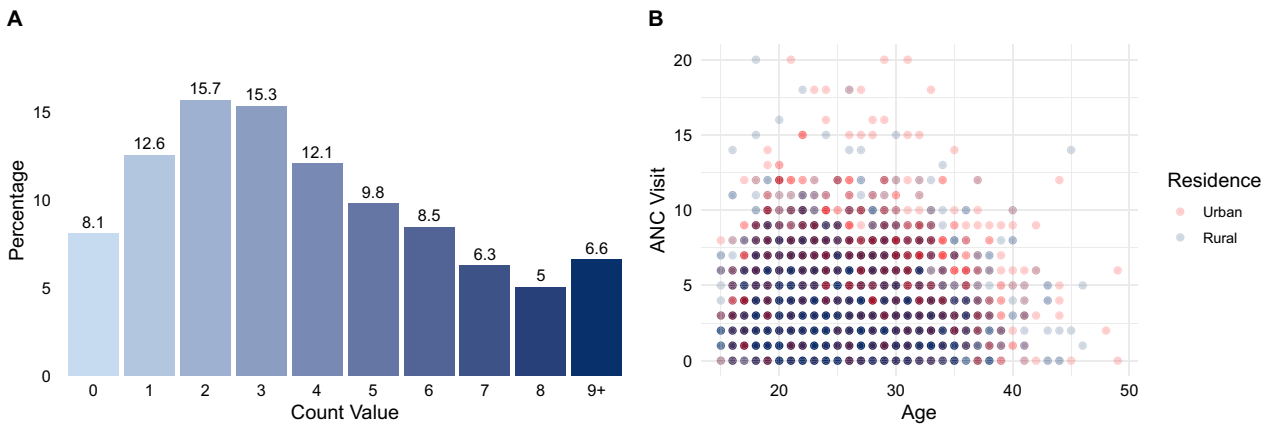

Fig. 2 Distribution of the number of ANC visits and scatterplot against age

by focusing on the confirmed important variables while considering the tentative ones cautiously.

Model selection

Table 2 compares four models—Poisson, Negative Binomial (NBR), Zero-Inflated Poisson (ZIP), and Zero-Inflated Negative Binomial (ZINB)—based on AIC, BIC, and log-likelihood values to assess their fit for antenatal care (ANC) visits. The Poisson model performed the worst, with the highest AIC (22,928.74) and BIC (23,110.77) and lowest log-likelihood (− 11,436.37), failing to address overdispersion and excess zeros. The NBR model improved the fit with lower AIC (22,180.17) and BIC (22,368.70), while

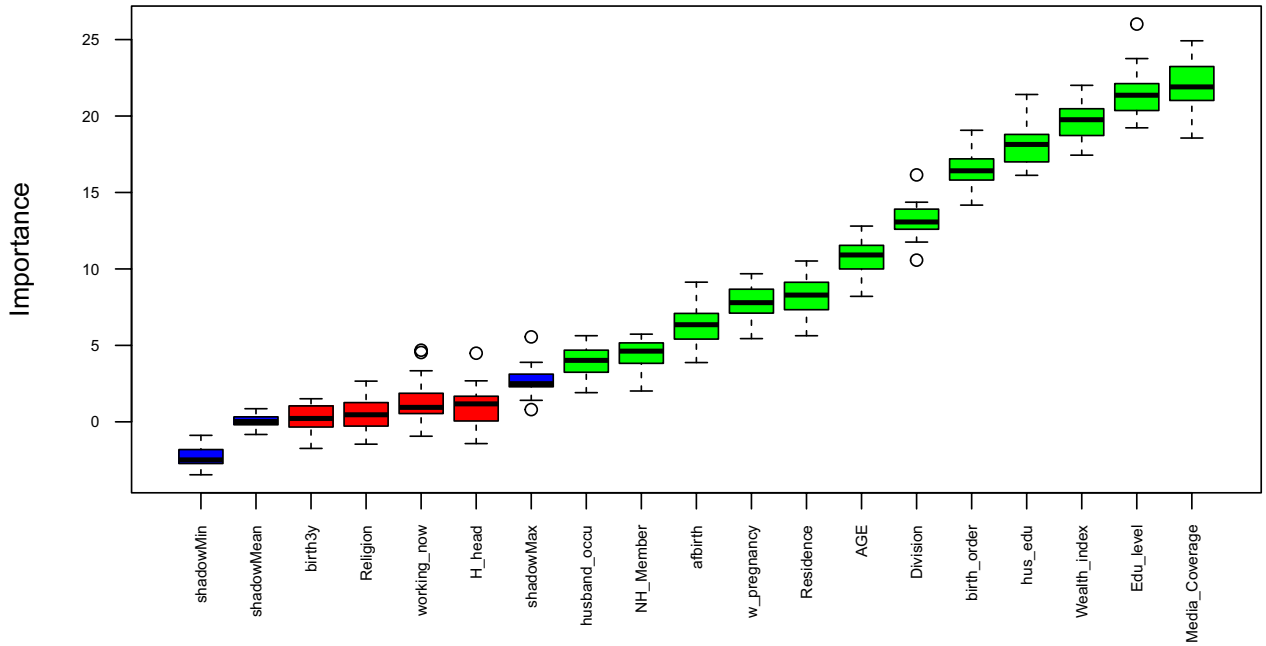

Fig. 3 Feature importance extracted from boruta algorithm

Table 2 Comparison of regression models based on AIC, BIC and log likelihood

Models	AIC	BIC	Log-Likelihood
Poisson	22,928.74	23,110.77	−11,436.37
Negative binomial	22,180.17	22,368.70	−11,061.08
Zero-inflated poisson	22,654.00	23,018.06	−11,271.00
Zero-inflated negative binomial	**22,125.32**	**22,495.88**	**−11,005.66**

Bold values refer to the metrics for best fitted model

the ZIP model accounted for excess zeros but not overdispersion, performing worse than NBR and ZINB. The ZINB model provided the best fit, with the lowest AIC (22,125.32) and BIC (22,495.88) and highest log-likelihood (−11,005.66), effectively addressing both overdispersion and zero inflation.

Model interpretation

Table 3 presents the incident rate ratios (IRRs) from the Zero-Inflated Negative Binomial (ZINB) regression analysis, highlighting the associations between various sociodemographic and reproductive factors and the number of antenatal care (ANC) visits.

Age group showed significant associations, with women aged 20–29 years (IRR: 1.09; 95% CI: 1.03–1.16; $p=0.003$) and those aged 30–49 years (IRR: 1.15; 95% CI: 1.05–1.25; $p=0.001$) attending more ANC visits compared to women aged 15–19 years. In terms of Division, women from Chittagong (IRR: 0.88; 95% CI: 0.81–0.95; $p<0.001$) and Sylhet (IRR: 0.92; 95% CI: 0.84–1.00; $p=0.051$) were less likely to attend ANC visits compared to those from Barisal. Conversely, women from Rangpur were significantly more likely to attend ANC visits (IRR: 1.21; 95% CI: 1.11–1.31; $p<0.001$). Other divisions, such as Dhaka, Khulna, Mymensingh, and Rajshahi, did not show consistent significant associations.

Place of residence was significantly associated with ANC visits, with rural women attending fewer visits (IRR: 0.88; 95% CI: 0.84–0.92; $p<0.001$) compared to urban women. Wealth index demonstrated a gradient, with women in the middle (IRR: 1.07; 95% CI: 1.01–1.13; $p=0.026$) and rich (IRR: 1.14; 95% CI: 1.08–1.21; $p<0.001$) wealth categories attending more ANC visits compared to women categorized as poor. Educational attainment also showed a significant positive trend. Women with primary education (IRR: 1.13; 95% CI: 1.02–1.27; $p=0.023$), secondary education (IRR: 1.27; 95% CI: 1.14–1.42; $p<0.001$), and higher education (IRR: 1.34; 95% CI: 1.18–1.51; $p<0.001$) attended more ANC visits compared to women with no education.

Birth order was inversely associated with ANC visits, with women having 2–3 children (IRR: 0.95; 95% CI: 0.90–1.00; $p=0.034$) and four or more children (IRR: 0.84; 95% CI: 0.76–0.92; $p<0.001$) attending fewer visits compared to first-time mothers. The effect of age at first birth was not statistically significant for women giving birth at 18–25 years (IRR: 0.96; 95% CI:

Table 3 Incident rate ratios (IRR) from zero-inflated negative binomial regression

Variables	IRR	95% CI	*P* value
Age group			
15–19 (ref)			
20–29	1.09	1.03–1.16	**0.003**
31–49	1.15	1.05–1.25	**0.001**
Division			
Barisal (ref)			
Chittagong	0.88	0.81–0.95	**< 0.001**
Dhaka	1.01	0.93–1.09	0.797
Khulna	1.11	1.02–1.21	**0.011**
Mymensingh	1.07	0.99–1.17	0.087
Rajshahi	1.04	0.95–1.13	0.402
Rangpur	1.21	1.11–1.31	**< 0.001**
Sylhet	0.92	0.84–1.00	0.051
Place of residence			
Urban (ref)			
Rural	0.88	0.84–0.92	**< 0.001**
Wealth index			
Poor (ref)			
Middle	1.07	1.01–1.13	**0.026**
Rich	1.14	1.08–1.21	**< 0.001**
Educational level			
No education (ref)			
Primary	1.13	1.02–1.27	**0.023**
Secondary	1.27	1.14–1.42	**< 0.001**
Higher	1.34	1.18–1.51	**< 0.001**
Birth order			
1 (ref)			
2–3	0.95	0.90–1.00	**0.034**
4 +	0.84	0.76–0.92	**< 0.001**
Age at first birth			
Before 18 (ref)			
18–25	0.96	0.92–1.01	0.105
26 +	1.01	0.91–1.12	0.814
Pregnancy wanted			
Then (ref)			
Later	0.91	0.86–0.96	**< 0.001**
No more	0.83	0.77–0.91	**< 0.001**
Number of household members			
1–5 (ref)			
6–10	0.99	0.95–1.03	0.585
11 +	0.99	0.92–1.07	0.808
Husband's educational level			
No education (ref)			
Primary	1.03	0.96–1.10	0.464
Secondary	1.13	1.05–1.21	**0.001**
Higher	1.25	1.15–1.36	**< 0.001**
Husband's occupation			
Unemployed (ref)			
Agricultural or household work	1.11	0.89–1.38	0.363
Service and sales	1.18	0.95–1.47	0.129
Others	1.16	0.93–1.44	0.183
Media coverage			
No (ref)			
Yes	1.19	1.14–1.25	**< 0.001**

Bold values refer to *p* values of significant variables

0.92–1.01; $p=0.105$) or after 25 years (IRR: 1.01; 95% CI: 0.91–1.12; $p=0.814$), compared to those giving birth before 18 years. Pregnancy wantedness demonstrated significant associations, with women reporting their pregnancies as wanted later (IRR: 0.91; 95% CI: 0.86–0.96; $p<0.001$) or no more (IRR: 0.83; 95% CI: 0.77–0.91; $p<0.001$) attending fewer ANC visits compared to those who wanted their pregnancies at the time.

Regarding number of household members, women in households with 6–10 members (IRR: 0.99; 95% CI: 0.95–1.03; $p=0.585$) or more than 10 members (IRR: 0.99; 95% CI: 0.92–1.07; $p=0.808$) did not show significant differences in ANC visits compared to those in households with 1–5 members. Husband's educational level showed significant positive associations with women whose husbands had secondary (IRR: 1.13; 95% CI: 1.05–1.21; $p=0.001$) and higher education (IRR: 1.25; 95% CI: 1.15–1.36; $p<0.001$) attending more ANC visits compared to those whose husbands had no education. However, primary education of the husband was not significantly associated (IRR: 1.03; 95% CI: 0.96–1.10; $p=0.464$). Finally, women with media coverage exposure were significantly more likely to attend ANC visits (IRR: 1.19; 95% CI: 1.14–1.25; $p<0.001$) compared to those without media exposure.

Discussion

This study has identified several sociodemographic and socioeconomic variables that are significantly associated with the frequency of antenatal care (ANC) visits in Bangladesh. The findings reveal that less than 50% of women meet the World Health Organization (WHO) recommended minimum of four ANC visits, which aligns with the results of Akter et al. [13]. This percentage is notably lower than in neighboring countries, such as India (59.25%) and Nepal (69%), but similar to Pakistan [31–33].

The study discovered that a woman's age affects how frequently she visits an ANC. Compared to younger mothers, older mothers were 15% more likely to have frequent ANC visits. This finding reflects the greater health awareness and decision-making autonomy often

associated with older women. However, the lower utilization among younger women, who are more likely to be first-time mothers, is concerning given their higher vulnerability to pregnancy-related complications.

Geographic disparities were another significant finding, with women in Rangpur having the highest ANC utilization, while women in Chittagong and Sylhet reported significantly lower rates. These regional differences may reflect variations in health infrastructure, accessibility, and cultural norms. The relatively lower utilization in Chittagong and Sylhet highlights the need for targeted interventions, such as improving service availability, addressing cultural barriers, and enhancing transportation infrastructure in these regions. Moreover, our study also found urban–rural inequality since rural women were found to have 12% less visits than their urban counterparts. This inequality can be attributed to various factors, including better availability and accessibility of medical facilities, higher socioeconomic status, and greater educational attainment in urban areas [19, 34]. Rural-focused initiatives, including mobile health clinics and community-based health worker programs, could bridge this gap by bringing services closer to underserved populations.

Education, particularly for women, emerged as a critical determinant of ANC quality. Women with secondary or higher education levels were 27% and 34% more likely to attend ANC visits than those without or only primary education. Another study by Haque et al. also found that the frequency of ANC visits was 10.6% lower for mothers who did not continue their education after marriage [35]. Educated women are generally more informed about health issues and the benefits of medical care over traditional treatments [36].

The wealth status of women is found to be another significant determinant since middle-class and rich women had 7% and 14% more visits compared to poor, which is also found in several studies [1, 24, 37]. Poor women often cannot afford the costs associated with high-quality ANC, including consultation fees, diagnostic tests, medications, and transportation to healthcare facilities [38]. Policies that expand financial protection, such as voucher schemes or conditional cash transfers, could mitigate this disparity and ensure that cost is not a deterrent for poor women.

Reproductive factors, including birth order and pregnancy wantedness, also played a significant role in shaping ANC utilization. Mothers who already have children were 5–16% less likely to have frequent ANC visits, which was also found in other studies [13, 22] A study in Ethiopia revealed that higher birth order was inversely related to the timing of the first ANC visit, which led to fewer ANC visits [39]. In addition, our study showed that women who desired a pregnancy later or who did not want more were 9% and 17% less likely to visit frequently than those who did. This is also found in two studies by Biswas et al. and Islam et al. [19, 23]. Unintended pregnancies are often linked to delayed initiation and insufficient use of antenatal care services [40]. Women with unintended pregnancies may be less prepared or less motivated to seek timely and regular prenatal care, leading to poorer maternal and child health outcomes.

The degree of education of a partner is equally important to ANC as the education of women. Women with highly educated partners tend to visit the ANC more frequently than those with less educated partners. Similar to a number of other studies, ours discovered media coverage to be a key influence, as women with media exposure found to have 19% more visits compared to those who did not [19, 23, 24]. Exposure to media increases awareness and knowledge about the importance of regular ANC visits, thereby encouraging more women to seek timely and comprehensive prenatal care [41]. Parallel to a study by Ali et al., we did not discover any significant association between the number of household members and the quality of ANC [24]. Expanding media campaigns, especially in rural and underserved areas, could further enhance awareness and utilization of ANC services.

Policy implication

The results of this study call for focused policy implications leading to improved antenatal care (ANC) utilization in Bangladesh. Geographic disparities must be addressed and ANC visits in regions with low rates, like Chittagong and Sylhet, should be prioritised, improving service availability through more robust healthcare systems, infrastructure, transportation, and overcoming cultural barriers. Existing mobile health clinics and community-based health worker programs serve rural and underserved populations. However, new initiatives should be rural-focused to bridge the urban–rural divide. Cost issues are a continuing barrier, particularly for poorer women. Favourable female educational policies and mass media awareness campaigns can raise awareness and influence maternal healthcare-seeking behaviours. Finally, addressing the needs of younger and first-time mothers, as well as those with unintended pregnancies, through counselling and programs could lead to more equitable and effective maternal healthcare utilization.

Strength and limitations

The main advantage of this study is that it used data that is representative of the entire country. In addition, we have evaluated four distinct statistical models and determined which is the most effective in estimating parameters and, consequently, interpreting the data.

The study accounts for several sociodemographic, socioeconomic, and reproductive factors but may not capture all potential confounders influencing ANC utilisation. For instance, cultural beliefs, healthcare provider attitudes, and the quality of ANC services were not assessed and could impact utilisation patterns.

Conclusion

This study highlights the significant impact of various sociodemographic and socioeconomic factors on antenatal care (ANC) visits in Bangladesh. Despite progress, the proportion of women meeting the WHO-recommended minimum ANC visits remains below 50%. Our findings indicate a notable urban–rural disparity, with rural women attending fewer ANC visits than their urban counterparts. Factors such as education level, wealth status, birth order, age, pregnancy intentions, and cesarean section history significantly influence ANC visit frequency. Women with higher education, and better wealth status are more likely to attend ANC visits. Conversely, higher birth order and unintended pregnancies reduce the likelihood of frequent ANC visits. These insights underscore the need for focused initiatives to address disparities and enhance ANC coverage, particularly among rural, less educated, and poorer women. By addressing these factors, policymakers can improve maternal health outcomes and work towards achieving national and international health goals.

Abbreviations

ANC	Antenatal care
BDHS	Bangladesh demographic and health survey
WHO	World Health Organization
PR	Poisson regression
NBR	Negative binomial regression
ZIP	Zero-inflated poisson regression
ZINB	Zero-inflated negative binomial regression
IRR	Incidence rate ratio
SDGs	Sustainable development goals
AIC	Akaike information criterion
CI	Confidence interval

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Author contributions

Md. Mojammel Haque Sakib was responsible for conceptualization, methodology, data analysis, and writing the original draft. Muhammad Khairul Alam contributed to conceptualization, methodology, data analysis, and writing the original draft. Mst. Nilufar Yasmin was involved in conceptualization and writing the review and editing. Rumana Rois took part in conceptualization, methodology, supervision, and writing the original draft.

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Availability of data and materials

The dataset used in this article is sourced from the DHS Program database, which is accessible at https://dhsprogram.com/Data/. The data sets utilized in the current analysis are available from the corresponding author upon reasonable request. For additional information, please contact the author in question.

Declarations

Ethics approval and consent to participate

This study used publicly available data from the Bangladesh Demographic and Health Survey (BDHS) 2017. The survey was ethically approved by the Institutional Review Board of ICF International and the Ethics Review Committee of NIPORT.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Department of Statistics and Data Science, Jahangirnagar University, Savar, Dhaka 1342, Bangladesh.

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