Annals of Health Research

(The Journal of the Medical and Dental Consultants' Association of Nigeria, OOUTH, Sagamu, Nigeria)

CC BY-NC **Volume 12, Issue 2: 210-224**

June 2026

doi:10.30442/ahr.1202-07-327

ORIGINAL RESEARCH

Antenatal care utilization and its Associated factors in Nigeria: Poisson-Compound models approach

Kolawole S Oritogun[1] , Adekunle D Alabi[1] , Ebunoluwa O Jaiyesimi [2], Gbenayon J Mautin [1], Omotayo E Adeleke[3]

[1]Department of Community Medicine and Primary Care, Faculty of Clinical Sciences, Olabisi Onabanjo University, Sagamu, Ogun State, Nigeria

[2]Department of Community Medicine and Primary Care, Olabisi Onabanjo University Teaching Hospital, Sagamu, Ogun State, Nigeria

[3]Department of Anthropology, Faculty of Science, University of Ibadan, Ibadan, Nigeria

Correspondence: Kolawole Sunday Oritogun, Department of Community Medicine and Primary Care, Faculty of Clinical Sciences, Olabisi Onabanjo University, Sagamu, Ogun State, Nigeria . Email:ksoritogun@gmail.com,oritogun.kola@oouagoiwoye.edu.ng; ORCID -http://orcid.org/0000-0003-0335-0770

Citation: Oritogun KS , Alabi AD , Jaiyesimi EO, Mautin GJ, Adeleke OE. Antenatal Care Utilization And Its Associated Factors In Nigeria: Poisson-Compound Models Approach. Ann Health Res 2026;12(2): 210-224 https://doi.org/ 10.30442/ahr. 1202-07-327

Abstract

Background: Antenatal care (ANC) provides preventive, promotive, and curative services during pregnancy and contributes to improved maternal and neonatal outcomes. Despite its benefits, ANC utilization remains suboptimal in Nigeria. Due to this public health importance, there is a need to identify factors associated with ANC utilization using appropriate statistical model.

Objective: This study compared Poisson compound models to determine the most suitable model for antenatal care visits and its associated factors in Nigeria.

Methods: This study used secondary data from the 2024 Nigeria Demographic and Health Survey (NDHS). The outcome variable was the number of antenatal care visits. Four count regression models were fitted: Poisson Regression, Zero-Inflated Poisson (ZIP), Negative Binomial (NB), and Zero-Inflated Negative Binomial (ZINB) models. Model comparison was based on Deviance (Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC). Incidence Rate Ratios (IRR). P-value <0.05 was considered statistically significant.

Results: The Zero-Inflated Negative Binomial model produced the lowest Deviance (61964.5), AIC (62030.5), and BIC (62278.7) values compared with the other models, indicating the best fit for antenatal care utilization. ANC utilization was associated with maternal age, geopolitical zone, residence, education, religion, marital status, employment, birth order, partner's education/occupation, wealth, and healthcare distance (IRR=0.843–1.788; p<0.05).

Conclusion: The ZINB model was the most appropriate model for antenatal care visits in Nigeria. The findings also emphasize the need for robust analytical approaches in evaluating maternal healthcare utilization patterns in developing countries with limited health resources.

Keywords: Antenatal care, Count regression, Maternal health, Nigeria, Zero-inflated model

Introduction

Antenatal care (ANC) is an essential program for delivering preventive, promotive, and curative health services during pregnancy. [1,2] Ninety five percent of global maternal deaths occur in low- and middle-income countries. [3,4] Timely and adequate utilization of maternal healthcare services, particularly antenatal care, can substantially reduce pregnancy-related morbidity and mortality. [5,6] In this bid, the World Health Organization (WHO) recommends a minimum of eight ANC contacts. [1] The ANC package includes clinical assessments, nutritional support, immunization, and health education. [2,6] Furthermore, adequate ANC utilization has been associated with increased likelihood of skilled birth attendance and improved continuity of care. [7,8]

Despite the benefits of ANC, it's utilization in many sub-Saharan African countries, including Nigeria remains suboptimal. [4,9] Nigeria ranks among the countries with the highest maternal mortality ratios worldwide. [3,10] Completion of the recommended number of ANC visits in Nigeria remains low; reflecting gaps in access, quality, and continuity of care. [9,11] Factors influencing antenatal care utilization in Nigeria and similar settings include socio-demographic, economic, reproductive and health system, and access to mass media. [12–18]

Barriers to adequate antenatal care utilization include financial constraints, transportation challenges, and disparities in healthcare infrastructure particularly in rural and underserved communities. [17,19] Late initiation of ANC and irregular attendance further undermine the effectiveness of maternal health interventions. [11,16,20,21]

Several studies have assessed the suitability of count regression models for analysing healthcare utilization data characterized by excess zeros and over-dispersion. Yusuf et al.[22] examined antenatal care (ANC) utilization in Nigeria using data from the 2013 Nigeria Demographic and Health Survey (NDHS). The study compared Zero-Inflated Poisson (ZIP), Zero-Inflated Negative Binomial (ZINB), Hurdle Poisson (HP), and Hurdle Negative Binomial (HNB) models and found that the ZINB model provided the best fit for ANC utilization data based on Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values. [29-30]

Similarly, Bekalo and Kebede [23] evaluated alternative count regression models and reported that zero-inflated models outperformed conventional Poisson and Negative Binomial models when the data contained a substantial proportion of zero observations. Their findings emphasized the importance of accounting for excess zeros in healthcare utilization studies.

In Nigeria, Bassey et al. [24] applied Zero-Inflated Poisson and Zero-Inflated Negative Binomial models to maternal healthcare utilization data. The study concluded that zero-inflated models provided a more realistic representation of healthcare utilization behaviour than traditional count regression models. Abu Bakar et al. [25] investigated outpatient healthcare utilization using national survey data and observed that healthcare utilization data frequently violate the equidispersion assumption of the

Poisson model. The study therefore recommended the use of advanced count regression models capable of addressing over-dispersion and excess zeros.

Furthermore, Lee et al. [26] assessed the performance of Negative Binomial and Zero-Inflated Negative Binomial models in analysing medical count data. The findings showed that the ZINB model performed better when the outcome variable exhibited both excess zeros and over-dispersion.Overall, empirical evidence suggests that advanced count regression models, particularly the Zero-Inflated Negative Binomial model, often outperform the conventional Poisson regression model when analysing healthcare utilization data characterized by excess zeros and over-dispersion. However, empirical studies comparing Poisson, Negative Binomial, Zero-Inflated Poisson, and Zero-Inflated Negative Binomial models using recent ANC utilization data in Nigeria remain limited. This gap justifies the need for further comparative assessment of these models to determine the most appropriate model for ANC utilization data. The objective of this study was to compare these count regression models and identify the most appropriate model for antenatal care visits in Nigeria.

Methods

The dataset for this study was the secondary data of the Nigeria Demographic and Health Survey (NDHS), 2024. The sampling frame for the 2024 Nigeria Demographic and Health Survey (NDHS) was derived from the updated cartographic frame developed for Nigeria's forthcoming first fully digital Population and Housing Census. The country is divided into 36 states and the Federal Capital Territory (FCT), constituting a total of 37 subnational units. Each state is further segmented into local government areas (LGAs), which are subsequently divided into localities.

The 2024 NDHS adopted a stratified two-stage sampling design. Stratification was carried out by separating each of the 36 states and the FCT into urban and rural place of residence resulting in 74 distinct sampling strata. Within each stratum, samples were drawn independently using a two-stage selection procedure. Poisson regression is the traditional and most commonly used model for identifying factors associated with count data such as the number of antenatal care (ANC) visits. However, the application of Poisson regression may be inadequate when over-dispersion exists, that is, when the variance of the outcome variable exceeds its mean. Under such circumstances, alternative count regression models that can accommodate over-dispersion and excess zeros, including the Negative Binomial (NB), Zero-Inflated Poisson (ZIP), and Zero-Inflated Negative Binomial (ZINB) models, become more appropriate.

The detailed study design and sampling procedures used in this study are fully documented in the National Population Commission and ICF (2024) Nigeria Demographic and Health Survey (NDHS) final report. [27]

The number of antenatal visits for this study is a count data, so this study made use of count regression models: Poisson, Zero-

inflated Poisson, Negative Binomial and Zero-inflated Negative Binomial models.[24,30] The criteria for model comparison were Deviance, Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC). The model that gives the smallest value of these criteria denotes the best model of them all. The parameters for the models, incidence rate ratios (IRR) and confidence intervals at 95% level were stated. SPSS statistical software package, and R- programming language were used for the analysis.

Poisson Regression Model

$$Y_i \sim \text{Poisson}(\mu_i); \quad \log(\mu_i) = \alpha_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki}$$

Where: Y_i represents the count response variable (Number of antenatal care visits).• μ_i is the expected count for observation I; α_0 is the intercept; $\beta_1 \ldots \beta_k$ are regression coefficients.
$X_1 \ldots X_k$ are independent variables.
The Poisson regression model assumes that the mean and variance of the count variable are equal.

Zero-Inflated Poisson (ZIP) Regression Model

$$P(Y_i = 0) = \rho_i + (1 - \rho_i)\, e^{-\mu_i}; \; P(Y_i = y) = (1 - \rho_i)\left[e^{-\mu_i}\frac{\mu_i{}^y}{y!}\right], \; y > 0$$

$$\log(\mu_i) = \beta_0 + \beta_1 X_{1i} + \ldots + \beta_k X_{ki}; \; \text{logit}(\rho_i) = \omega_0 + \omega_1 Z_{1i} + \ldots + \omega_m Z_{mi}$$

Where: ρ_i represents the probability of excess zeros; μ_i is the mean count; β parameters are coefficients for the count model; ω parameters are coefficients for the zero-inflation model; X and Z are explanatory variables. The ZIP model is appropriate when the data contain more zeros than expected under a standard Poisson distribution.

Negative Binomial Regression Model

$$Y_i \sim \text{NB}(\mu_i, \phi); \log(\mu_i) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki}$$

Where: Y_i is the count outcome variable; μ_i is the expected mean count; ϕ is the dispersion parameter; β coefficients represent the effects of predictors; The Negative Binomial model is used when overdispersion exists, meaning the variance exceeds the mean.

Zero-Inflated Negative Binomial (ZINB) Regression Model

$$P(Y_i = 0) = \rho_i + (1 - \rho_i)\,\text{NB}(Y_i = 0); \; P(Y_i = y) = (1 - \rho_i)\,\text{NB}(Y_i = y), \; y > 0$$
$$\log(\mu_i) = \beta_0 + \beta_1 X_{1i} + \ldots + \beta_k X_{ki}; \; \text{logit}(\rho_i) = \omega_0 + \omega_1 Z_{1i} + \ldots + \omega_m Z_{mi}$$

Where: ρ_i denotes the probability of structural zeros; μ_i is the expected count; ϕ is the dispersion parameter; β and ω are vectors of regression coefficients; The ZINB model is suitable for count data characterized by both overdispersion and excess zeros.

Poisson regression is the traditional and most commonly used model for identifying factors associated with count data such as the number of antenatal care (ANC) visits. However, the application of Poisson regression may be inadequate when over-dispersion exists, that is, when the variance of the outcome variable exceeds its mean. Under such circumstances, alternative count regression models that can accommodate over-dispersion and excess zeros, including

the Negative Binomial (NB), Zero-Inflated Poisson (ZIP), and Zero-Inflated Negative Binomial (ZINB) models, become more appropriate.[22] Poisson and Negative Binomial models are widely used for count data analysis. When excess zeros are present, Zero-Inflated Poisson and Zero-Inflated Negative Binomial models provide more flexible alternatives for modeling count outcomes.

Results

Table I shows the result of the criteria used to identify the best model for ANC utilization. All the parameters for Model 4 (Zero-inflated Negative Binomial Model) consistently showed lowest values.

Table II shows the Poisson model of ANC factors. Women aged 25–49 years demonstrated significantly higher ANC utilization than women aged 15–19 years, with IRRs ranging from 1.111 to 1.190. Women in the South West had the highest ANC utilization (IRR=1.872; 95% CI: 1.817–1.927). Urban residence significantly increased ANC utilization by 6.9% (IRR=1.069; 95% CI: 1.048–1.091). Women with no education had significantly lower ANC utilization (IRR=0.685; 95% CI: 0.658–0.713). Rich women had 20.7% higher ANC utilization compared with women in the middle wealth category (IRR=1.207; 95% CI: 1.178–1.237). Increasing birth order reduced ANC utilization (IRR=0.979; 95% CI: 0.972–0.987).

Table I: Comparison of Models of ANC Factors

Model Parameters	Model 1	Model 2	Model 3	Model 4
Deviance	72076.4	62944.2	64957.6	61964.5
AIC	72076.4	63008.2	65021.6	62030.5
BIC	72371.6	63248.9	65262.3	62278.7

Model 1: Poisson; Model 2: Zero Inflated Poisson; Model 3: Negative Binomial; Model 4: Zero inflated Negative Binomial; AIC: Akaike Information Criterium; BIC: Bayesian Information Criterium.

Table II: Poisson Model of ANC Factors

Variables	Estimates	p-value	IRR	95% Confidence Interval	
				Lower	Upper
Age group: 15-19 (Ref.)					
20-24	0.071	0.004	1.074	1.023	1.126
25-29	0.105	0.000	1.111	1.056	1.169
30-34	0.146	0.000	1.157	1.092	1.225
35-39	0.171	0.000	1.186	1.111	1.266
40-44	0.174	0.000	1.190	1.103	1.283
4549	0.166	0.001	1.181	1.067	1.306
Geopolitical Zone: North Central (Ref.)			1.000		
North East	0.232	0.000	1.261	1.223	1.300
North West	-0.035	0.000	0.966	0.937	0.995
South East	0.399	0.000	1.490	1.443	1.540
South South	0.355	0.000	1.426	1.380	1.473
South West	0.627	0.000	1.872	1.817	1.927
Residence: Rural (Ref.)			1.000		
Urban	0.067	0.000	1.069	1.048	1.091
Education: Tertiary/ Higher (Ref.)			1.000		
No Education	-0.379	0.000	0.685	0.658	0.713
Primary	-0.163	0.000	0.850	0.818	0.882
Secondary	-0.062	0.000	0.940	0.916	0.964
Religion: Catholic (Ref.)			1.000		
Islam	0.038	0.033	1.039	1.003	1.076
Other Christians	0.028	0.063	1.028	0.998	1.059
Traditionalist/others	0.070	0.266	1.073	0.948	1.214
Age of Respondent at first birth	0.003	0.029	1.003	1.000	1.006
Marital Status: Married (Ref.)			1.000		
Never in Union/ Widow	-0.194	0.000	0.824	0.793	0.856
Respondent currently working: No (Ref.)			1.000		
Yes	0.107	0.000	1.113	1.092	1.134
Birth Order Number	-0.021	0.000	0.979	0.972	0.987
Partner's Education: Secondary (Ref.)			1.000		
Tertiary of Higher Education	0.038	0.001	1.039	1.015	1.063
No Education	-0.334	0.000	0.716	0.694	0.739
Primary Education	-0.079	0.000	0.924	0.895	0.954
Partner's Occupation: Not working (Ref.)			1.000		
Working	-0.028	0.222	0.972	0.931	1.017
Wealth-index: Middle (Ref.)			1.000		
Poor	-0.186	0.000	0.830	0.807	0.853
Rich	0.188	0.000	1.207	1.178	1.237
Radio frequent use: No (Ref.)			1.000		
Yes	0.038	0.000	1.039	1.020	1.058
Distance to Health Facility: barrier (Ref.)			1.000		
Not a big problem	0.119	0.000	1.126	1.104	1.149

Table III: Zero-Inflated Poisson Model of ANC Factors

Variables	Estimates	p-value	IRR	95% Confidence Interval	
				Lower	Upper
Age group: 15-19 (Ref.)					
20-24	0.077	0.003	1.080	1.027	1.137
25-29	0.104	0.000	1.109	1.051	1.171
30-34	0.110	0.000	1.117	1.052	1.186
35-39	0.134	0.000	1.144	1.069	1.224
40-44	0.157	0.000	1.170	1.082	1.265
4549	0.144	0.007	1.155	1.041	1.282
Geopolitical Zone: North Central (Ref.)			1.000		
North East	-0.094	0.000	0.910	0.881	0.941
North West	-0.151	0.000	0.860	0.833	0.888
South East	0.280	0.000	1.324	1.281	1.368
South South	0.340	0.000	1.405	1.360	1.453
South West	0.568	0.000	1.764	1.712	1.817
Residence: Rural (Ref.)			1.000		
Urban	0.034	0.001	1.035	1.014	1.056
Education: Tertiary/ Higher (Ref.)					
No Education	-0.133	0.000	0.875	0.841	0.911
Primary	-0.096	0.000	0.909	0.875	0.944
Secondary	-0.052	0.000	0.949	0.925	0.974
Religion: Catholic (Ref.)					
Islam	0.046	0.011	1.047	1.010	1.084
Other Christians	0.046	0.002	1.047	1.017	1.078
Traditionalist/others	0.122	0.064	1.130	0.993	1.285
Age of Respondent at first birth	0.002	0.183	1.002	0.999	1.005
Marital Status: Married (Ref.)					
Never in Union/ Widow	-0.069	0.001	0.934	0.898	0.971
Respondent currently working: No (Ref.)					
Yes	0.038	0.000	1.039	1.019	1.059
Birth Order Number	-0.017	0.000	0.983	0.976	0.991
Partner's Education: Secondary (Ref.)					
Tertiary of Higher Education	0.018	0.124	1.018	0.995	1.042
No Education	-0.107	0.000	0.898	0.870	0.927
Primary Education	-0.044	0.007	0.957	0.926	0.988
Partner's Occupation: Not working (Ref.)					
Working	-0.094	0.000	0.911	0.869	0.954
Wealth-index: Middle (Ref.)					
Poor	-0.090	0.000	0.914	0.888	0.940
Rich	0.109	0.000	1.115	1.089	1.143
Radio frequent use: No (Ref.)					
Yes	0.109	0.306	1.010	0.991	1.028
Distance to Health Facility: barrier (Ref.)					
Not a big problem	0.050	0.000	0.011	1.030	1.073

Table IV: Negative Binomial Model of ANC Factors in Nigeria

Variables	Estimates	p-value	IRR	95% Confidence Interval	
				Lower	Upper
Age group: 15-19 (Ref.)					
20-24	0.030	0.444	1.031	0.954	1.114
25-29	0.051	0.233	1.053	0.968	1.145
30-34	0.097	0.050	1.102	1.000	1.215
35-39	0.113	0.050	1.119	1.000	1.253
40-44	0.102	0.133	1.108	0.969	1.266
4549	0.092	0.307	1.096	0.919	1.307
Geopolitical Zone: North Central (Ref.)			1.000		
North East	0.331	0.000	1.392	1.322	1.466
North West	0.006	0.813	1.006	0.957	1.057
South East	0.407	0.000	1.502	1.412	1.598
South South	0.340	0.000	1.405	1.319	1.496
South West	0.634	0.000	1.885	1.776	1.999
Residence: Rural (Ref.)			1.000		
Urban	0.070	0.000	1.073	1.034	1.113
Education: Tertiary/ Higher (Ref.)					
No Education	-0.411	0.000	0.663	0.616	0.713
Primary	-0.162	0.000	0.851	0.791	0.914
Secondary	-0.069	0.012	0.933	0.884	0.985
Religion: Catholic (Ref.)					
Islam	0.019	0.568	1.020	0.954	1.090
Other Christians	0.029	0.330	1.029	0.972	1.090
Traditionalist/others	-0.013	0.905	0.987	0.797	1.223
Age of Respondent at first birth	0.004	0.208	1.004	0.998	1.009
Marital Status: Married (Ref.)					
Never in Union/ Widow	-0.198	0.000	0.821	0.765	0.880
Respondent currently working: No (Ref.)					
Yes	0.121	0.000	1.129	1.092	1.166
Birth Order Number	-0.011	0.095	0.989	0.976	1.002
Partner's Education: Secondary (Ref.)					
Tertiary of Higher Education	0.039	0.102	1.039	0.992	1.088
No Education	-0.360	0.000	0.698	0.664	0.733
Primary Education	-0.059	0.045	0.943	0.891	0.999
Partner's Occupation: Not working (Ref.)					
Working	-0.033	0.375	0.968	0.900	1.041
Wealth-index: Middle (Ref.)					
Poor	-0.212	0.000	0.809	0.773	0.846
Rich	0.185	0.000	1.203	1.150	1.258
Radio frequent use: No (Ref.)					
Yes	0.051	0.005	1.052	1.015	1.090
Distance to Health Facility: barrier (Ref.)					
Not a big problem	0.141	0.000	1.151	1.113	1.191

Table III shows the Zero-inflated Poisson model of ANC factors. Women living in the South West had significantly higher ANC utilization (IRR=1.764; 95% CI: 1.712–1.817). Urban residence increased ANC utilization by 3.5% (IRR=1.035; 95% CI: 1.014–1.056). Women with no education had substantially lower ANC utilization compared with women with tertiary education (IRR=0.875; 95% CI: 0.841–0.911). Women currently working had 3.9% higher ANC utilization (IRR=1.039; 95% CI: 1.019–1.059). Women who reported that distance to health facility was not a major problem had significantly lower ANC utilization (IRR=0.011; 95% CI: 1.030–1.073).

Table IV shows the Negative Binomial Model of ANC Factors. Women living in the South West had significantly higher ANC utilization (IRR=1.885; 95% CI: 1.776–1.999). Urban residence increased ANC utilization by 7.3% (IRR=1.073; 95% CI: 1.034–1.113). Women with no education had substantially lower ANC utilization compared with women with tertiary education (IRR=0.663; 95% CI: 0.616–0.713). Women currently working had 12.9% higher ANC utilization (IRR=1.129; 95% CI: 1.092–1.166). Women who reported that distance to health facility was not a major problem had significantly higher ANC utilization (IRR=1.151; 95% CI: 1.113–1.191).

Table V shows the Zero-Inflated Negative Binomial regression model of antenatal care (ANC) utilization among women in Nigeria. Compared with women aged 15–19 years, women aged 25–29 years had an 8.8% higher rate of ANC utilization (IRR=1.088; 95% CI: 1.018–1.164). Similarly, women aged 30–34 years, 35–39 years, and 40–44 years demonstrated 10.3% (IRR=1.103; 95% CI: 1.023–1.190), 12.8% (IRR=1.128; 95% CI: 1.035–1.229), and 14.5% (IRR=1.145; 95% CI: 1.036–1.266) higher rates of ANC utilization, respectively. However, women aged 20–24 years and 45–49 years did not differ significantly from women aged 15–19 years in ANC utilization. Geopolitical zone was significantly associated with ANC utilization. Relative to women residing in the North Central zone, women in the South East had a 34.7% higher rate of ANC utilization (IRR=1.347; 95% CI: 1.291–1.407), while women in the South South and South West exhibited 40.6% (IRR=1.406; 95% CI: 1.346–1.468) and 78.8% (IRR=1.788; 95% CI: 1.718–1.861) higher rates of ANC utilization, respectively. Conversely, women in the North West had a significantly lower rate of ANC utilization by 10.8% compared with those in the North Central zone (IRR=0.892; 95% CI: 0.857–0.928).

Women residing in urban areas demonstrated a 3.6% higher rate of ANC utilization compared with women in rural areas (IRR=1.036; 95% CI: 1.009–1.064).

Educational attainment showed a significant inverse association with reduced ANC utilization among women with lower educational levels compared with women who attained tertiary education. Women with no formal education had a 15.7% lower rate of ANC utilization (IRR=0.843; 95% CI: 0.801–0.887), while women with

primary and secondary education had 10.2% (IRR=0.898; 95% CI: 0.854–0.943) and 5.6% (IRR=0.944; 95% CI: 0.912–0.977) lower rates of ANC utilization, respectively.

Religion was also associated with ANC utilization. Compared with Catholic women, women who identified as Other Christians had a significantly higher rate of ANC utilization by 4.6% (IRR=1.046; 95% CI: 1.006–1.087). However, no statistically significant differences were observed among Muslim women or Traditionalist/other religious groups relative to Catholics.

Age at first birth was not significantly associated with ANC utilization (IRR=1.002; 95% CI: 0.998–1.006).

Marital status significantly influenced ANC utilization. Women who were never in union or widowed had a 7.9% lower rate of ANC utilization compared with married women (IRR=0.921; 95% CI: 0.875–0.969).

Employment status of respondents was significantly associated with ANC utilization. Women who were currently working demonstrated a 4.6% higher rate of ANC utilization compared with women who were not working (IRR=1.046; 95% CI: 1.020–1.072).

Birth order was inversely associated with ANC utilization. For every unit increase in birth order, the rate of ANC utilization decreased by 1.5% (IRR=0.985; 95% CI: 0.975–0.995).

Partner's educational attainment significantly influenced ANC utilization. Compared with women whose partners had secondary education, women whose partners had no formal education demonstrated a 12.5% lower rate of ANC utilization (IRR=0.875; 95% CI: 0.841–0.910), while those whose partners had primary education had a 4.7% lower rate of ANC utilization (IRR=0.953; 95% CI: 0.914–0.993). No statistically significant difference was observed among women whose partners had tertiary education.

Partner's occupation was significantly associated with ANC utilization. Women whose partners were working had a 7.6% lower rate of ANC utilization compared with women whose partners were not working (IRR=0.924; 95% CI: 0.870–0.981).

Household wealth status significantly predicted ANC utilization. Compared with women from middle-income households, women from poor households had a 9.4% lower rate of ANC utilization (IRR=0.906; 95% CI: 0.875–0.939), whereas women from rich households demonstrated a 12.8% higher rate of ANC utilization (IRR=1.128; 95% CI: 1.093–1.164).

Frequency of radio use was not significantly associated with ANC utilization (IRR=1.015; 95% CI: 0.991–1.040).

Perceived distance to a health facility significantly influenced ANC utilization. Women who reported that distance to a health facility was not a major problem demonstrated a 6.2% higher rate of ANC utilization compared with women who perceived distance as a barrier (IRR=1.062; 95% CI: 1.034–1.091)

Table V: Zero-Inflated Negative Binomial Model of ANC Factors in Nigeria

Variables	Estimates	p-value	IRR	95% Confidence Interval	
				Lower	Upper
Age group: 15-19 (Ref.)					
20-24	0.059	0.069	1.061	0.995	1.130
25-29	0.085	0.014	1.088	1.018	1.164
30-34	0.098	0.011	1.103	1.023	1.190
35-39	0.120	0.006	1.128	1.035	1.229
40-44	0.136	0.008	1.145	1.036	1.266
4549	0.124	0.070	1.132	0.990	1.294
Geopolitical Zone: North Central (Ref.)					
North East	0.059	0.114	0.967	0.928	1.008
North West	0.085	0.000	0.892	0.857	0.928
South East	0.098	0.000	1.347	1.291	1.407
South South	0.120	0.000	1.406	1.346	1.468
South West	0.136	0.000	1.788	1.718	1.861
Residence: Rural (Ref.)					
Urban	0.035	0.009	1.036	1.009	1.064
Education: Tertiary/ Higher (Ref.)					
No Education	-0.171	0.000	0.843	0.801	0.887
Primary	-0.108	0.000	0.898	0.854	0.943
Secondary	-0.057	0.001	0.944	0.912	0.977
Religion: Catholic (Ref.)					
Islam	0.041	0.081	1.042	0.995	1.091
Other Christians	0.045	0.024	1.046	1.006	1.087
Traditionalist/others	0.086	0.333	1.090	0.916	1.297
Age of Respondent at first birth	0.002	0.245	1.002	0.998	1.006
Marital Status: Married (Ref.)					
Never in Union/ Widow	-0.083	0.001	0.921	0.875	0.969
Respondent currently working: No (Ref.)					
Yes	0.045	0.000	1.046	1.020	1.072
Birth Order Number	-0.015	0.003	0.985	0.975	0.995
Partner's Education: Secondary (Ref.)					
Tertiary of Higher Education	0.021	0.165	1.022	0.991	1.053
No Education	-0.134	0.000	0.875	0.841	0.910
Primary Education	-0.048	0.023	0.953	0.914	0.993
Partner's Occupation: Not working (Ref.)					
Working	-0.079	0.009	0.924	0.870	0.981
Wealth-index: Middle (Ref.)					
Poor	-0.098	0.000	0.906	0.875	0.939
Rich	0.120	0.000	1.128	1.093	1.164
Radio frequent use: No (Ref.)					
Yes	0.015	0.225	1.015	0.991	1.040
Distance to Health Facility: barrier (Ref.)					
Not a big problem	0.060	0.000	1.062	1.034	1.091

Discussion

Zero-Inflated Negative Binomial provided the best fit for antenatal care (ANC) utilization based on AIC, BIC, and deviance, indicating excess zeros and overdispersion in the data, consistent with previous studies. [22,28] Maternal age, geopolitical zone, residence, education, religion, marital status, employment, birth order, partner's education and occupation, wealth index and distance to health facilities predicted ANC utilization.

Women aged 25–44 years had higher ANC utilization than adolescents aged 15–19 years, consistent with findings from Nigeria and sub-Saharan Africa. [5,12,15] Younger women often experience poor autonomy, limited finances, stigma, and inadequate knowledge of pregnancy complications. Recent Nigerian evidence also reported lower ANC use among adolescent mothers because of socioeconomic vulnerability and poor healthcare access. [29]

Women residing in the South West, South South, and South East demonstrated higher ANC utilization than those in the North West. These disparities reflect differences in education, healthcare infrastructure, culture, and economic development. [13,14] Recent evidence similarly documented lower adequate ANC attendance in northern Nigeria. [32] Urban residence also significantly increased ANC utilization, likely because urban women have better access to healthcare facilities, transportation, skilled providers, and health information. Earlier Nigerian studies and recent nationwide evidence reported poorer ANC access among rural women. [11,13,17,32]

Maternal education strongly predicted ANC utilization, with women lacking tertiary education showing lower utilization. Previous studies similarly identified education as a major determinant of maternal healthcare-seeking behaviour. [12–14] Education improves health knowledge, decision-making, and economic empowerment. Partner's education also positively influenced ANC attendance, consistent with findings from Jigawa State, Nigeria. [31]

Economic status significantly influenced ANC utilization. Women from poorer households consistently recorded lower utilization, while richer women utilized ANC more frequently. Financial barriers such as transportation, consultation fees, and medication costs remain important obstacles to maternal healthcare access in Nigeria. Similar findings have been reported previously. [5,13,21] Employment also increased ANC utilization, likely through improved financial autonomy and exposure to health information, supporting earlier evidence on women's empowerment and maternal healthcare utilization. [18]

Higher birth order reduced ANC utilization, possibly because multiparous women perceive less need for repeated visits. [15,16] Distance to healthcare facilities also influenced utilization, as transportation difficulties and poor healthcare distribution continue to limit access. [17] Radio exposure improved ANC attendance in some models, highlighting the importance of health communication. [18] The consistency of findings across all models strengthens the reliability of these determinants, while the Zero-Inflated Negative Binomial model

provided more robust estimates for excess zero ANC counts. [32]

Conclusion

Zero-Inflated Negative Binomial model fitted ANC utilization in Nigeria than other models considered in the study. Improving ANC utilization in Nigeria requires multidimensional interventions targeting socioeconomic inequalities, educational disadvantage, regional disparities, and healthcare accessibility barriers. Policies aimed at improving female education, poverty reduction, transportation systems, rural healthcare infrastructure, and women's economic empowerment may substantially improve maternal healthcare utilization. Strengthening health promotion campaigns through community engagement and mass media may also improve awareness regarding the benefits of timely and adequate ANC attendance. Given Nigeria's persistently high maternal mortality burden, improving ANC utilization remains essential for achieving Sustainable Development Goal 3 and reducing preventable maternal and neonatal deaths.

Ethical Approval: This study used secondary data from the Nigeria Demographic and Health Survey (NDHS) 2024, which obtained ethical approval from relevant national and institutional review boards. We obtained permission to use the dataset from the NDHS board. All authors agree to be accountable for all aspects of the work and ensure that questions related to the accuracy or integrity of any part of the study are appropriately investigated and resolved.

Author Contributions: KSO: participated in conception, data acquisition, data analysis and interpretation, drafting, supervised the research process, and reviewed the final manuscript. ADA, EOJ and GJM: participated in conception, data acquisition, and revising the manuscript for important intellectual content; and final approval of the version to be published. OEA: Participated in literature review, interpretation of results and discussion sections.

Funding Supports: The authors received no specific funding for this study.

Conflict of Interest: The authors declare no conflict of interest

Acknowledgements: The authors appreciate the Nigerian Population Commission and other organizations involved in NDHS studies, for making the data available for our study. We also appreciate Omotola D. Adeleke for his effort in this study.

Publication history: Submitted 15 May 2026, Accepted on 21 June 2026

References

1. World Health Organization. WHO recommendations on antenatal care for a positive pregnancy experience. Geneva: World Health Organization; 2016.

2. World Health Organization. Antenatal care [Internet]. Geneva: World Health Organization; 2024 [cited 2026 Apr 20]. Available from: https://www.who.int/health-topics/antenatal-care

3. World Health Organization. Trends in maternal mortality 2000–2020. Geneva: World Health Organization; 2023.

4. UNICEF. Maternal mortality: global trends [Internet]. New York: UNICEF; 2022 [cited 2026 Apr 20]. Available from: https://data.unicef.org/topic/maternal-health/maternal-mortality/

5. Tessema ZT, Teshale AB, Tesema GA, Yeshaw Y, Worku MG. Determinants of completing recommended antenatal care utilization in sub-Saharan Africa from 2006 to 2018: evidence from 36 countries using Demographic and Health Surveys. BMC Pregnancy Childbirth**.** 2021;21:192. doi:10.1186/s12884-021-03669-w.

6. Kuhnt J, Vollmer S. Antenatal care services and its implications for vital and health outcomes of children: evidence from 193 surveys in 69 low-income and middle-income countries. BMJ Open. 2017;7:e017122. doi:10.1136/bmjopen-2017-017122.

7.Singh K, Story WT, Moran AC. Assessing the continuum of care pathway for maternal health in South Asia and sub-Saharan Africa. BMJ Glob Health. 2020;5(6):e002332. doi:10.1136/bmjgh-2019-002332.

8. Ekholuenetale M, Benebo FO. Individual household and community level factors associated with skilled birth attendants during delivery in Nigeria. PLoS One. 2020;15(3):e0230315. doi:10.1371/journal.pone.0230315.

9. National Population Commission (NPC) [Nigeria], ICF. Nigeria demographic and health survey 2018. Abuja, Nigeria, and Rockville (MD): NPC and ICF; 2019.

10. World Bank. Maternal mortality ratio (modeled estimate, per 100,000 live births) – Nigeria [Internet]. Washington (DC): World Bank; [cited 2026 Apr 20]. Available from: https://data.worldbank.org/indicator/SH.STA.MMRT?locations=NG

11. Bolarinwa OA, Ahinkorah BO, Seidu AA, Ameyaw EK, Okyere J, Hagan JE Jr, *et al.* Factors associated with antenatal care utilization in Nigeria: a multilevel analysis. BMC Health Serv Res. 2021;21(1):1104. doi:10.1186/s12913-021-07164-7.

12. Yaya S, Uthman OA, Amouzou A, Ekholuenetale M, Bishwajit G. Wealth, education and antenatal care utilization in sub-Saharan Africa. Arch Public Health**.** 2020;78:123. doi:10.1186/s13690-020-00475-5.

13. Fagbamigbe AF, Idemudia ES. Barriers to antenatal care use in Nigeria: evidence from non-users and implications for maternal health programming. Int J Equity Health. 2019;18:244. doi:10.1186/s12939-019-1112-y.

14. Adewuyi EO, Auta A, Khanal V, Bamidele OD, Bryce E, Martins TAG, et al. Rural–urban inequalities in maternal healthcare utilization in Nigeria. BMC Pregnancy Childbirth. 2018;18:1–9. doi:10.1186/s12884-018-1714-1.

15. Ekholuenetale M, Nzoputam CI, Barrow A, Onikan A. Women's enlightenment and early antenatal care initiation are determinants of antenatal care attendance in Nigeria. PLoS One. 2020;15(4):e0231231. doi:10.1371/journal.pone.0231231.

16. Tekelab T, Chojenta C, Smith R, Loxton D. Timing of antenatal care initiation and associated factors in sub-Saharan Africa: a systematic review and meta-analysis. PLoS One. 2019;14(5):e0219722. doi:10.1371/journal.pone.0219722.

17. Okedo-Alex IN, Akamike IC, Ezeanosike OB, Uneke CJ. Barriers to antenatal care services utilization in Nigeria: a systematic review. Int J Gynaecol Obstet**.** 2019;145(2):188–196. doi:10.1002/ijgo.12750.

18. Yaya S, Ghose B. Media exposure and maternal healthcare service utilization in sub-Saharan Africa. PLoS One. 2020;15(4):e0230522. doi:10.1371/journal.pone.0230522.

19. Aregbeshola BS, Khan SM. Out-of-pocket payments, catastrophic health expenditure and poverty among households in Nigeria 2010. Int J Health Policy Manag. 2018;7(9):798–806. doi:10.15171/ijhpm.2018.19.

20. Moller AB, Petzold M, Chou D, Say L. Early antenatal care visit: a systematic analysis of regional and global levels and trends of coverage from 1990 to 2013. Lancet Glob Health. 2019;7(7):e977–e983. doi:10.1016/S2214-109X(19)30275-6.

21. Arsenault C, Jordan K, Lee D, Dinsa G, Manzi F, Marchant T*, et al.* Equity in antenatal care quality: an analysis of 91 national household surveys. Lancet Glob Health. 2018;6(4):e363–e375. doi:10.1016/S2214-109X(18)30040-2.

22. Yusuf OB, Ugalahi LO. On the performance of the Poisson, negative binomial and generalized Poisson regression models in the prediction of antenatal care visits in Nigeria. Am J Math Stat. 2015;5(3):128–136. doi:10.5923/j.ajms.20150503.04.

23. Bekalo DB, Kebede DT. Zero-inflated models for count data: an application to number of antenatal care service visits. Ann Data Sci. 2021;8(4):683–708. doi:10.1007/s40745-021-00328-x.

24. Bassey UE, Akinyemi MI, Njoku KF. On zero inflated models with applications to maternal healthcare utilization. Int J Math Sci Optim Theory Appl. 2022;7(2):65–75. doi:10.52968/28309288.

25. Abu Bakar NS, Ab Hamid J, Mohd Nor Sham MSJ, Mohd Nor Sham M, Jailani AS. Count data models for outpatient health services utilisation. BMC Med Res Methodol. 2022;22(1):261. doi:10.1186/s12874-022-01733-3.

26. Lee KH, Pedroza C, Avritscher EBC, Mosquera RA, Tyson JE. Evaluation of negative binomial and zero-inflated negative binomial models for the analysis of zero-inflated count data: application to the telemedicine for children with medical complexity trial. Trials. 2023;24(1):613. doi:10.1186/s13063-023-07648-8.

27. National Population Commission, ICF International. Nigeria demographic and health survey 2023–24. Abuja, Nigeria, and Rockville, Maryland, USA: National Population Commission and ICF; 2024.

28. Xu Y, Li Y, Wang X. A comparison of zero-inflated and hurdle models for modeling zero-inflated count data. J Stat Distrib Appl. 2021;8(1):8. doi:10.1186/s40488-021-00121-4.

29. Oladele R, Ojo E, Okoduwa GE, Olajide OA, Olufadewa II, Adesina M, *et al.* Utilization of antenatal care by young mothers and adolescents in Nigeria. Discov Public Health. 2024;21:206. doi:10.1186/s12982-024-00335-2.

30. Adewuyi EO, Auta A, Adewuyi MI, Bamidele OD, Martins TAG, Kunnuji MO, *et al.* Antenatal care utilisation and receipt of its components in Nigeria: assessing disparities between rural and urban areas. PLoS One. 2024;19(7):e0307316. doi:10.1371/journal.pone.0307316.

31. Sabo A, Alzoubi MM, Saidu AY, Usman US, Saulawa IM, Al-Mugheed K, *et al.* Determinants of utilization of antenatal care services among women of childbearing age in Jigawa State, Nigeria. Int J Public Health. 2024;69:1607385. doi:10.3389/ijph.2024.1607385.

32. Egbon OA, Gayawan E. Modeling the spatial patterns of antenatal care utilization in Nigeria with inference based on Pólya-Gamma mixtures. J Appl Stat. 2024;51(5):866–890. doi:10.1080/02664763.2023.2245678.

This open-access document is licensed for distribution under the terms and conditions of the Creative Commons Attribution License (http://creativecommons.org/licenses/by-nc/4.0). This permits unrestricted, non-commercial use, reproduction and distribution in any medium provided the original source is adequately cited and credited.