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Original Research Article

Evaluating the link between antenatal care and foetal outcomes in a rural tertiary care center in North India

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ABSTRACT

Background: Antenatal care (ANC) is essential for safeguarding the health of both mothers and newborns. Despite policy initiatives, rural India continues to face challenges in ensuring adequate and quality ANC. This study assessed the adequacy of ANC using a structured scoring system and examined its association with foetal outcomes in a rural tertiary care center in North India.
Methods: This cross-sectional study was carried out in a hospital setting, enrolling 175 mothers and their infants between August 2023 and January 2025. ANC quality was measured using a 10-domain scoring system (maximum score 40). Adequate ANC was defined as ≥24 points. Maternal and neonatal outcomes, including birth weight, Apgar scores, preterm delivery, and neonatal intensive care unit (NICU) admission, were compared between adequate and inadequate ANC groups.
Results: The mean ANC score was 24.95±8.27; 73.7% of women received adequate ANC. Adequate ANC was significantly associated with higher socioeconomic status, booked status, and caesarean deliveries ($p<0.001$). Neonates of inadequately supervised pregnancies had significantly higher odds of preterm birth (OR=24.8, $p<0.001$), low birth weight (OR=45.8, $p<0.001$), low Apgar score at 1 minute (OR=6.3, $p=0.012$), and NICU admission (OR=0.08, $p<0.001$).
Conclusions: Adequate ANC, as measured by a structured scoring system, was strongly associated with favourable foetal outcomes. Strengthening maternal health programs should emphasize early registration, comprehensive ANC contacts, improved record completeness, and quality counselling. Addressing socioeconomic barriers and promoting equitable access to ANC remain essential to reduce adverse outcomes in rural populations.

Keywords: Antenatal care, Rural India, Foetal outcomes, NICU admission, Apgar score, Low birth weight

INTRODUCTION

Globally, maternal and perinatal health continues to be a major public health challenge. Each year, nearly 260,000 pregnancy-related deaths, 2.3 million neonatal deaths, and more than 2 million stillbirths occur, with the majority concentrated in low- and middle-income countries (LMICs) (WHO, 2023).[1-3] Maternal mortality remains disproportionately higher in rural compared to urban populations, with a maternal mortality ratio (MMR) of 292 per 100,000 live births in rural regions versus 100 per 100,000 in urban settings.[4] In India, despite significant progress in maternal and child health, an estimated 1.3 million pregnancy-related deaths have occurred over the past two decades, and the perinatal mortality rate remains high at 26 per 1,000 live births, with rural areas contributing disproportionately to this burden.[5,6]

ANC is a proven intervention to improve maternal and foetal health.[7] Defined as the comprehensive package of medical and supportive services delivered during pregnancy, ANC facilitates the early detection and management of maternal complications such as

preeclampsia, gestational diabetes, anemia, and infections, while promoting foetal growth and development through nutritional and educational interventions.[7]

The world health organization's (WHO) 2016 ANC model recommends at least eight ANC contacts to optimize pregnancy outcomes, including nutritional supplementation, routine investigations, immunizations, and foetal assessments.[8] However, national data from the national family health survey-5 (NFHS-5) indicate that only 58.1% of Indian women receive adequate ANC, with the lowest utilization observed in rural populations.[9]

The problem is magnified by disparities in access and quality of ANC services between rural and urban populations. Rural women face barriers including inadequate infrastructure, shortage of trained personnel, financial limitations, sociocultural norms restricting healthcare utilization, and poor health literacy.[1] These challenges directly translate into worse foetal outcomes, including higher rates of preterm birth, low birth weight, perinatal asphyxia, and neonatal mortality.[1]

Studies show that inadequate ANC is linked to lower socioeconomic status, unbooked pregnancies, preterm and low-birth-weight infants, poor Apgar scores, and higher NICU admissions.[10-20] These findings emphasize the importance of not only the number but also the quality of ANC, including early initiation, sufficient visits, and comprehensive interventions. Despite strong evidence of ANC's benefits, limited research has examined foetal outcomes in rural tertiary centres of North India, where resource constraints and population differences may influence results. Addressing this gap is vital for developing context-specific interventions, strengthening maternal health programs, and achieving SDG targets 3.1 (maternal mortality <70/100,000 live births) and 3.2 (neonatal mortality ≤12/1,000 live births) by 2030.[21,22]

The present study is based on the hypothesis that adequate and high-quality ANC is significantly associated with improved foetal outcomes, including higher birth weight, better Apgar scores, fewer neonatal intensive care unit (NICU) admissions, and reduced perinatal mortality, compared to inadequate ANC in rural settings. The primary objective is to assess the association between ANC adequacy and foetal outcomes in a rural tertiary care center. The secondary objectives are to estimate the prevalence of adverse foetal outcomes-such as low birth weight, preterm birth, perinatal asphyxia, congenital anomalies, NICU admission, and stillbirth-and to correlate these outcomes with ANC components, including timing of initiation, number of visits, and quality of care. Additionally, the study aims to evaluate ANC quality using a structured scoring system and determine its predictive value for foetal outcomes.

The novelty of this study lies in its focus on a rural tertiary care setting in North India, addressing a critical evidence gap in the literature. Unlike most previous research, which has either examined urban populations or relied on pooled national data, this study employs a structured ANC quality scoring system adapted for the rural Indian context. By linking granular ANC components directly with specific foetal outcomes, the study provides actionable insights to inform targeted interventions and policy recommendations. Ultimately, this research contributes to bridging the rural-urban disparity in perinatal health by generating locally relevant evidence to strengthen maternal and child health programs.

METHODS

Study design and settings

This hospital-based cross-sectional study was conducted in the departments of pediatrics and obstetrics and gynaecology at Hind institute of medical sciences, Sitapur, over 18 months (August 2023–January 2025), enrolling 175 mothers and their neonates.

Inclusion and exclusion criteria

All pregnant women with singleton gestations who delivered at the rural tertiary care center during the study period, had documented ANC records, and provided informed consent were included. Exclusions were multiple pregnancies, major congenital anomalies diagnosed antenatally, incomplete or missing ANC records, refusal of consent, and deliveries outside the study hospital without adequate documentation.

Sample size calculation and Sampling method

The sample size was calculated using Cochrane's formula for single proportion: $n=Z^2\times p\times(1-p)/d^2$, where $Z=1.96$ (for 95% confidence level), p=anticipated prevalence of adequate ANC=9.2% based on previous research, and d=0.05 (absolute allowable error).[23,24] The minimum sample size was 128, which was inflated by 30% to account for possible non-response and incomplete data, giving a final target of 175 participants. A systematic random sampling technique was employed to select study participants from the antenatal clinic registers, ensuring representativeness and minimizing selection bias.

Data collection

Data were collected using a structured proforma, which included maternal sociodemographic and obstetric characteristics, details of ANC and neonatal outcomes. Maternal variables included age, socioeconomic status, gravida, parity, booking status, and mode of delivery. Neonatal parameters assessed were gestational age, birth weight, APGAR scores at one and five minutes, presence

of congenital anomalies, meconium-stained liquor, and NICU admission.

ANC scoring system

We developed a 10-domain ANC score (total 0-40) to quantify care content and quality. Domains and scoring were: Timing of registration (≤12 weeks=2, 13-20 weeks=1, >20/unbooked=0; max 2); number of ANC contacts (≥8=4, 4-7=3, 1-3=1, 0=0; max 4); basic clinical assessments (Blood Pressure, maternal weight, foetal heart-1 each; max 3); essential investigations (hemoglobin, urine protein, blood group/Rh, blood sugar, ≥1 ultrasound, human immunodeficiency virus (HIV)/syphilis-1 each; max 6); nutritional/preventive interventions [Iron folic acid (IFA)≥90 days=2; tetanus toxoid (TT) injection, nutrition counselling, calcium, deworming/malaria prophylaxis-1 each; max 6]; counselling and birth preparedness (danger signs, birth plan, breastfeeding/newborn care, postpartum family planning-1 each; max 4); risk screening and management [anemia, hypertensive disorders, gestational diabetes mellitus (GDM), high-risk referral, substance use, anti-D when indicated-1 each; max 6]; skilled provider and facility linkage (qualified provider visit, emergency referral contact, transport plan-1 each; max 3); record completeness and counselling quality (ANC card >80% complete, counselling on >2 topics, follow-up documented/adhered-1 each; max 3); and context-specific items relevant to India, including vitamin D supplementation/sunlight exposure counselling, screening for domestic violence, and documentation of linkage to institutional delivery schemes (max 3).

Scores were summed (higher=better); ANC was categorized as adequate ≥24 (≥60%) vs inadequate <24. The tool was pilot-tested on 20 records, showed good internal consistency (Cronbach's α=0.83), and predictive validity was assessed using multivariable logistic regression adjusted for maternal age, parity, and socioeconomic status.

Data analysis

Data were analyzed using SPSS version 26 for Windows (IBM, Armonk, NY, USA). Continuous variables were expressed as mean±SD/median with range, as appropriate. Categorical variables were presented as frequencies and percentages. Associations between maternal/neonatal factors and ANC adequacy were assessed using Chi-square test. Binary logistic regression analysis was performed to identify independent predictors of ANC adequacy, adjusting for potential confounders such as maternal age, parity, and socioeconomic status. P<0.05 was considered statistically significant.

RESULTS

The mean age of the mothers was 27.96±4.40 years (range: 21-35 years), with a median age of 28 years. The average number of antenatal visits was 4.78±1.85. Out of the 175 mothers, 129 (73.7%) had adequate ANC score ≥24, while 46 (26.3%) had inadequate care (ANC score <24) (Figure 1). The mean total ANC score was 24.95±8.27 (Table 1). Highest scores were in essential investigations and nutritional interventions, while record completeness and context-specific items scored lowest.

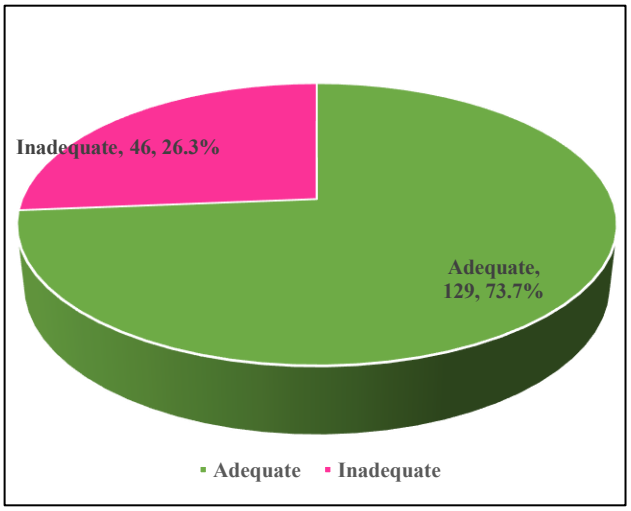

Figure 1: Adequacy of ANC among study participants, (n=175).

Most mothers were aged ≥28 years (52%), multigravida (76%), and multipara (68%) (Table 2). Adequate ANC was significantly more frequent among women from higher socioeconomic strata, booked cases, and those who delivered by caesarean section (p<0.0001 for each). Maternal age, gravida, parity, number of ANC visits, and birth status showed no significant association with ANC adequacy (p>0.05).

The mean birth weight of neonates was 2450.73±415.27 grams. The mean Apgar scores at 1 and 5 minutes were 7.4±1.21 and 9.6±0.56, respectively. Term deliveries (84%) were more likely to have adequate ANC compared to preterm births, where the majority had inadequate ANC (p<0.0001) (Table 3). A low APGAR score at 1 minute was significantly associated with inadequate ANC (p=0.005), while the APGAR score at 5 minutes showed no significant association. Low birth weight (<2500 g) infants were predominantly born to mothers with inadequate ANC (73.6%), showing a strong association (p<0.0001). No significant relationship was observed with congenital anomalies (p=0.444) or meconium-stained liquor (p=0.309). However, NICU admission was significantly higher among neonates born to mothers with inadequate ANC (74.1% vs. 17.6%; p<0.0001).

On binary logistic regression analysis, socioeconomic status (SES) showed a borderline association with ANC adequacy (p=0.055), with women from the upper class having higher odds of adequate ANC compared to the lower class (OR=6.19, 95% CI: 0.76-50.25), though not statistically significant (Table 4). Booking status did not

emerge as a significant predictor (p=0.999). Mode of delivery was significant, with vaginal deliveries being less likely to be associated with adequate ANC (OR=0.26, 95% CI: 0.12-0.54, p<0.001). Gestational age was a strong predictor, as preterm births were 24.8 times more likely in the inadequate ANC group (95% CI: 8.55-71.91, p<0.001). Similarly, neonates with APGAR score <7 at 1 min (OR=6.3, 95% CI: 1.51-26.35, p=0.012) and those with low birth weight (OR=45.8, 95% CI: 17.22-121.61, p<0.001) had significantly higher odds of being associated with inadequate ANC. NICU admission also showed a significant association, being more frequent among neonates of inadequately supervised pregnancies (OR=0.08, 95% CI: 0.03-0.20, p<0.001).

Table 1: ANC scoring system results, (n=175).

Domain (Maximum score)	Mean±SD
Timing of registration (Max 2)	1.84±0.44
Number of ANC care contacts (Max 4)	2.59±0.98
Basic clinical assessments (Max 3)	2.47±0.88
Essential investigations (Max 6)	4.81±1.52
Nutritional and preventive interventions (Max 6)	4.68±1.43
Counselling and birth preparedness (Max 4)	2.01±0.88
Risk screening and management (Max 6)	2.94±1.66
Skilled provider and facility linkage (Max 3)	1.35±0.61
Record completeness and counselling (Max 3)	1.33±0.70
Context-specific items (Max 3)	0.93±0.25
Total score (Max 40)	24.95±8.27

Table 2: Sociodemographic and obstetric characteristics of mothers and their association with ANC adequacy, (n=175).

Parameters		Total, N (%)	ANC adequate, N (%)	ANC inadequate, N (%)	Chi-square test	P value
Age (in years)	<28	84 (48.0)	63 (75.0)	21 (25.0)	0.138	0.710
	≥28	91 (52.0)	66 (72.5)	25 (27.5)		
Socioeconomic status	Upper	6 (3.4)	4 (66.7)	2 (33.3)	20.968	<0.0001
	Upper middle	11 (6.3)	10 (90.9)	1 (9.1)		
	Lower middle	23 (13.1)	23 (100.0)	0 (0.0)		
	Upper lower	33 (18.9)	29 (87.9)	4 (12.1)		
	Lower	102 (58.3)	63 (61.8)	39 (38.2)		
Gravida	Primigravida	42 (24.0)	30 (71.4)	12 (28.6)	0.149	0.699
	Multigravida	133 (76.0)	99 (74.4)	34 (25.6)		
Parity	Primipara	56 (32.0)	40 (71.4)	16 (28.6)	0.222	0.637
	Multipara	119 (68.0)	89 (74.8)	30 (25.2)		
Booked case	No	5 (2.9)	0 (0.0)	5 (100.0)	14.434	<0.0001
	Yes	170 (97.1)	129 (75.9)	41 (24.1)		
ANC visits	<8	169 (96.6)	123 (72.8)	46 (27.2)	2.215	0.137
	≥8	6 (3.4)	6 (100.0)	0 (0.0)		
Mode of delivery	Vaginal	44 (25.1)	23 (52.3)	21 (47.7)	13.946	<0.0001
	LSCS	131 (74.9)	106 (80.9)	25 (19.1)		
Birth status	Live	172 (98.3)	128 (74.4)	44 (25.6)	2.569	0.109
	Still	3 (1.7)	1 (33.3)	2 (66.7)		

*ANC=Antenatal care, LSCS=Lower segment Caesarean Section, Significant p<0.05

Table 3: Association of ANC score with neonatal outcomes, (n=175).

Parameters		Total, N (%)	ANC adequate, N (%)	ANC inadequate, N (%)	Chi-square test	P value
Gestational age	Term	147 (84.0)	124 (84.4)	23 (15.6)	53.674	<0.0001
	Preterm	28 (16.0)	5 (17.9)	23 (82.1)		
APGAR score at 1 minute	<7	9 (5.1)	3 (33.3)	6 (66.7)	7.985	0.005
	≥7	166 (94.9)	126 (75.9)	40 (24.1)		

Continued.

Parameters	Total, N (%)	ANC adequate, N (%)	ANC inadequate, N (%)	Chi-square test	P value	Parameters
APGAR score at 1 minute	<7	1 (0.6)	0 (0.0)	1 (100.0)	2.820	0.093
	≥7	174 (99.4)	129 (74.1)	45 (25.9)		
Birth weight (in gm)	<2500	53 (30.3)	14 (26.4)	39 (73.6)	87.779	<0.0001
	≥2500	122 (69.7)	115 (94.3)	7 (5.7)		
Congenital anomalies	Yes	2 (1.1)	1 (50.0)	1 (50.0)	0.587	0.444
	No	173 (98.9)	128 (74.0)	45 (26.0)		
MSL	Yes	7 (4.0)	4 (57.1)	3 (42.9)	1.033	0.309
	No	168 (96.0)	125 (74.4)	43 (25.6)		
NICU admission	Yes	27 (15.4)	7 (25.9)	20 (74.1)	37.628	<0.0001
	No	148 (84.6)	122 (82.4)	26 (17.6)		

*ANC=Antenatal care, MSL=meconium-stained liquor, NICU=neonatal intensive care unit, Significant p<0.05

Table 4: Binary logistic regression analysis of maternal and neonatal factors associated with ANC adequacy, (n=175).

Predictor variable	B	S.E.	Wald	Df	Sig.	Exp (B) (OR)	95% CI for exp (B)
Socioeconomic status	-	-	9.260	4	0.055	-	-
Upper	1.823	1.068	2.911	1	0.088	6.190	0.763-50.253
Upper middle	-18.900	8380.814	0.000	1	0.998	0.000	–
Lower middle	1.609	1.360	1.400	1	0.237	5.000	0.348-71.900
Upper lower	0.322	1.177	0.075	1	0.785	1.379	0.137-13.843
Booked case	22.349	17974.842	0.000	1	0.999	5.08E9	–
Mode of delivery	-1.354	0.375	13.038	1	0.000	0.258	0.124-0.539
Gestational age	3.211	0.543	34.945	1	0.000	24.800	8.553-71.910
APGAR at 1 min (<7)	1.841	0.730	6.357	1	0.012	6.300	1.506-26.347
Low birth weight	3.824	0.499	58.801	1	0.000	45.765	17.223-121.608
NICU admission	-2.596	0.489	28.131	1	0.000	0.075	0.029- 0.195

*ANC=Antenatal care, NICU=neonatal intensive care unit, B=regression coefficient, wald=wald chi-square statistic, SE=standard error, df=degrees of freedom, Exp (B) (OR)=Exponentiation of B (Odds ratio), SES=Socioeconomic status, CI=Confidence interval, Significant p<0.05.

DISCUSSION

This study examined the association between adequacy of ANC and foetal outcomes in a rural tertiary care center in North India. The findings support the hypothesis that adequate ANC is significantly associated with improved neonatal health indicators such as higher birth weight, better APGAR scores, lower preterm birth, and reduced NICU admissions. These results are consistent with prior evidence that ANC is a critical intervention for improving maternal and neonatal outcomes in LMICs.[7,16]

The structured ANC scoring system used in this study captured multiple domains including timing of registration, visit frequency, clinical assessments, laboratory investigations, preventive interventions, and counselling. Approximately 73.7% of mothers achieved adequate ANC, which is higher than national NFHS-5 data reporting 58.1% adequacy and analyses of NFHS-4 that reported adequacy of 51.4%.[9,10] This relatively higher adequacy in a rural tertiary setting may reflect improved institutional coverage, awareness, and government initiatives targeting maternal health. However, nearly one-fourth of women still received inadequate ANC, echoing persistent inequities in the rural areas highlighted by recent studies.[11,12] Socioeconomic status and booking status were strongly associated with ANC adequacy in univariate analysis, consistent with earlier findings that women from lower socioeconomic strata are disproportionately less likely to receive comprehensive ANC.[12] Although regression analysis in this study attenuated the association, other factors such as cultural practices and health literacy likely interact with economic determinants, as suggested by Thakkar et al.[11] Mode of delivery also showed a significant association, with adequate ANC linked to a higher rate of caesarean section. Similar associations were reported by Gaikwad et al who observed that women with adequate ANC had better outcomes and more timely obstetric interventions.[12]

Foetal outcomes in this study demonstrated robust associations with ANC adequacy. Preterm birth, low birth weight, and low Apgar scores were significantly more common among neonates of mothers with inadequate ANC. Low birth weight in particular showed a strong association, which aligns with Wenling et al who demonstrated that high-quality ANC significantly reduces the risk of preterm birth and low birth weight.[13] In the present study, a low Apgar score at one minute was

significantly associated with inadequate ANC, suggesting delayed neonatal adaptation and compromised intrapartum care among these pregnancies. Similar findings were reported by Abebe et al who identified inadequate ANC as a significant risk factor for low fifth-minute Apgar scores in Ethiopian neonates.[15] Likewise, NICU admission was markedly higher in the inadequate ANC group, reflecting findings from recent meta-analyses that ANC quality directly lowers neonatal morbidity and mortality.[15,16]

Our findings of low birth weight and NICU admissions associated with inadequate ANC are consistent with previous evidence, as Singh et al. also demonstrated that maternal anemia, a common antenatal complication, was significantly linked to lower birth weight and reduced cord blood hemoglobin in neonates, underscoring the importance of early screening and corrective interventions during pregnancy.[19] These observations underscore the role of ANC in preventing avoidable neonatal complications and reducing health system burden. Our findings also highlight that counselling quality during ANC remains a major gap. Evidence suggests that a large proportion of mothers do not receive structured breastfeeding education during antenatal visits, underscoring the need to strengthen counselling components of ANC to improve both neonatal outcomes and postnatal practices.[20]

Globally, the WHO recommends a minimum of eight ANC contacts to optimize outcomes.[8] In this study, only 3.4% of women achieved this benchmark, consistent with challenges reported in other LMICs.[17] Nevertheless, our findings suggest that the content and comprehensiveness of care, as reflected in ANC scores, were more predictive of outcomes than visit count alone. This supports the growing consensus that ANC programs should prioritize quality-adjusted measures over coverage alone, as highlighted by recent population-based assessments.[9,18]

The novelty of this study lies in its use of a locally adapted ANC quality scoring system, which demonstrated internal consistency and predictive validity. Unlike large-scale surveys that are often limited to coverage indicators, this hospital-based analysis enabled a detailed assessment of care processes and neonatal outcomes. Comparable findings were reported by Gaikwad et al in India and Amponsah-Tabi et al in Ghana, who emphasized the importance of context-specific evaluations of ANC quality.[13,17] By generating evidence from a rural tertiary center, this study contributes to bridging the rural–urban divide in perinatal health and aligns with global efforts to achieve SDG targets on maternal and neonatal mortality.[21,22]

Strengths and limitations

This study has several strengths. A major strength is the use of a structured and validated ANC scoring system, enabling a comprehensive evaluation of both maternal care quality and neonatal outcomes. The focus on a rural tertiary care center, often underrepresented in research, enhances contextual relevance. The relatively large sample size for a single-center rural study improves reliability of estimates.

However, certain limitations must be acknowledged. The cross-sectional design precludes causal inference between ANC adequacy and outcomes. Being hospital-based, the results may not reflect community-level utilization patterns, particularly among women delivering outside institutions. Dependence on ANC records may introduce documentation bias, while unmeasured factors such as maternal nutrition and interpregnancy interval could act as confounders. Future community-based longitudinal studies are needed to strengthen generalizability.

CONCLUSION

This study demonstrates that adequate and high-quality ANC is strongly associated with favourable neonatal outcomes, including reduced preterm birth, low birth weight, NICU admission, and low Apgar scores. Despite encouraging levels of ANC adequacy in this rural tertiary care setting, gaps persist that contribute to adverse foetal outcomes. Strengthening maternal health programs should focus on early registration, ensuring at least eight comprehensive ANC contacts, improving record completeness, and enhancing counselling and risk screening. Policy efforts must address socioeconomic and cultural barriers through community outreach, health education, and integration of institutional delivery schemes to improve equity.

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