ORIGINAL ARTICLE

Impact of Antenatal Education on Essential Newborn Care Knowledge among Pregnant Women: A Randomized Controlled Trial from Rural Bihar

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Abstract

Background: Essential Newborn Care (ENC) encompasses key practices such as early and exclusive breastfeeding, thermal protection, hygienic cord care and recognition of danger signs. Despite improvements in institutional delivery coverage, gaps in maternal knowledge regarding ENC remain a major contributor to neonatal morbidity and mortality in rural Bihar. This study assessed the effectiveness of structured antenatal education in improving ENC knowledge among pregnant women. **Material & Methods:** A single-blind, parallel-group randomized controlled trial was conducted among 132 pregnant women in their third trimester from a rural part of Bihar, India. Participants were randomly allocated to an intervention group or a control group. Baseline ENC knowledge was assessed using a pretested structured questionnaire. The intervention group received structured antenatal education using a flipchart-based module, while the control group received routine antenatal counselling only. Knowledge assessment was repeated two months postpartum. Data were analyzed using appropriate descriptive and inferential statistics, including logistic regression to identify predictors of knowledge improvement. **Results:** Baseline knowledge scores were comparable between the two groups. At follow-up, the intervention group demonstrated a significant improvement in overall ENC knowledge compared to the control group ($p < 0.001$).Women receiving antenatal education were nearly fourteen times more likely to demonstrate knowledge improvement (AOR=13.98; 95% CI: 5.56-25.15). Multivariate analysis revealed that receipt of antenatal education was the strongest predictor of knowledge improvement. **Conclusions:** Structured antenatal education delivered through a flipchart-based approach significantly improves maternal ENC knowledge. Incorporating such focused educational interventions into routine antenatal services can strengthen maternal preparedness for newborn care and may improve newborn care practices in resource-limited settings.

Keywords: Essential newborn care; Antenatal education; Maternal knowledge; Rural health; Randomized controlled trial

Introduction:

The neonatal period, defined as the first 28 days of life, represents the most vulnerable phase of human survival and accounts for a substantial proportion of childhood mortality worldwide. Despite remarkable global progress in reducing under-five mortality over the past three decades, the decline in neonatal mortality has been comparatively slower, particularly in low- and middle-income countries (LMICs). Currently, neonatal deaths constitute nearly 47% of all under-five deaths globally, underscoring the disproportionate burden borne during this early stage of life.[1-3]According to the World Health Organization (WHO), approximately 2.3-2.4 million neonatal deaths occur annually, with the highest burden concentrated in South Asia and sub-Saharan Africa.[4] Although the global neonatal mortality rate (NMR) declined from 37 per 1,000 live births in 1990 to 17 per 1,000 live births in 2022, progress has been uneven across regions.[5] India alone contributes nearly one-fifth of the global neonatal deaths, with a national NMR of 20 per 1,000 live births as reported by the Sample Registration System (2020).[6] Rural areas continue to experience a disproportionately higher burden, reflecting persistent disparities in healthcare access, quality of care, and maternal awareness.[7] Essential Newborn Care (ENC) comprises a set of simple, evidence-

based practices aimed at improving neonatal survival and wellbeing. These include early initiation and exclusive breastfeeding, thermal protection, hygienic cord care, early identification of danger signs, and timely referral for complications.[8] Majority of the neonatal deaths can be prevented through effective implementation of these low-cost interventions. Early initiation of breastfeeding alone has been shown to reduce neonatal mortality by up to 22%, while appropriatehygienic practices further reduce infection-related deaths.[9,10] Despite this strong evidence base, the adoption of optimal newborn care practices remains suboptimal in many rural settings. Maternal knowledge plays a pivotal role in determining newborn care practices. Several studies from rural India and neighboring countries have documented substantial gaps in knowledge related to breastfeeding, cord care, thermal protection, and recognition of neonatal danger signs.[11-13] These gaps are influenced by multiple factors, including low educational attainment, sociocultural beliefs, limited access to health information, and reliance on traditional practices. Inadequate awareness and delayed health-seeking behavior continue to contribute significantly to preventable neonatal morbidity and mortality. Antenatal care offers a critical window of opportunity to equip expectant mothers with essential knowledge required for appropriate newborn care. Antenatal education has been shown to improve maternal understanding, confidence, and preparedness for newborn care practices. A randomized controlled trial from Karnataka demonstrated significant improvement in maternal knowledge following structured antenatal education using flipchart-based teaching methods.[14] However, despite national programs emphasizing antenatal counselling, structured education on essential newborn care is often inconsistently delivered in routine practice, particularly in rural health settings. Recognizing the importance of maternal education, several national and global initiatives - including the Sustainable Development Goals (SDG 3.2), Every Newborn Action Plan (ENAP), Janani Suraksha Yojana (JSY), Janani Shishu Suraksha Karyakram (JSSK), and Home-Based Newborn Care (HBNC)have emphasized strengthening antenatal and community-based interventions to reduce neonatal mortality.[5,15] Despite these efforts, progress toward achieving the SDG target of reducing neonatal mortality to 12 per 1,000 live births by 2030 remains slow, particularly in rural India.

In this context, strengthening antenatal education emerges as a feasible, low-cost, and scalable strategy to improve maternal preparedness and newborn care practices. However, there is limited evidence from eastern India assessing the effectiveness of structured antenatal education on maternal knowledge related to essential newborn care. Therefore, the present study was undertaken to determine the effectiveness of structured antenatal education in improving essential newborn care knowledge among third-trimester pregnant women in a rural part of Bihar, India.

Material and Methods

Study Design and Setting

An open-label, parallel-group randomized controlled trial was conducted in the rural field practice area of the Indira Gandhi Institute of Medical Sciences (IGIMS), Maner, Patna, Bihar, India. The study was carried out over a period of 18 months, from June 2023 to December 2024. The rural field practice area caters to a predominantly agrarian population with regular antenatal care services delivered through the Rural Health Training Centre (RHTC).

Study Population and Eligibility Criteria

The study population comprised pregnant women in their third trimester (≥28 weeks of gestation) attending antenatal clinics at the RHTC. Women who were willing to participate and provided written informed consent were included. Those who declined participation or were unwilling to provide consent were excluded. Women who could not be followed up after delivery despite repeated contact attempts were excluded from the final analysis.

Sample Size

The sample size was calculated using the formula for comparison of two proportions, based on findings from a randomized controlled trial by Eluri et al. The expected proportion of correct newborn care practices was 80.6% in the intervention group and 57.7% in the control group, with a confidence level of 95% and power of 80%. The minimum required sample size was 60 participants per group. To account for a possible attrition rate of 10%, the final sample size was increased to 66 participants per group, resulting in a total sample of 132 pregnant women.

Sampling and Randomization

On each PMSMA clinic day (9th and 21st of every month), a line list of eligible pregnant women attending the antenatal clinic was prepared. Participants were then selected using simple random sampling from this list until the required sample size was achieved.

Randomization was performed using a computer-generated random sequence created in Microsoft Excel (Office 365). Allocation was done in a 1:1 ratio into intervention and control groups based on a pre-generated randomization list. Each participant was assigned a unique Participant Identification Number (PIN), and allocation followed the computer-generated randomization sequence.The study employed an

open-label design. Due to the nature of the educational intervention, neither participants nor the investigator could be blinded to group allocation. To minimize bias, outcome assessment was performed using standardized pre-tested questionnaires and identical assessment procedures for both groups.

Study Tools

Knowledge regarding essential newborn care was assessed using a pre-tested, semi-structured questionnaire covering four domains: feeding, thermal care, hygiene, and danger signs. The questionnaire consisted of 24 items distributed across feeding practices (6 items), thermal care (5 items), hygiene practices (6 items), and recognition of neonatal danger signs (7 items).Responses were scored as correct or incorrect based on standard WHO and national newborn care guidelines. The intervention consisted of a structured flipchart-based educational module developed using guidelines from the World Health Organization, Indian Academy of Pediatrics, and the Ministry of Health and Family Welfare. The flipchart included simple language and pictorial illustrations in Hindi to enhance comprehension. The questionnaire and Flipchart module were reviewed by faculty members from the Department of Community Medicine and Pediatrics to assess content relevance, clarity, and face validity.

Study Procedure

A pilot study was conducted among 25 pregnant women to assess feasibility and clarity of the study instruments. Minor modifications were made to simplify language, improve clarity of selected questionnaire items, and enhance comprehensibility of flipchart illustrations. Baseline data were collected at enrollment using the structured questionnaire. Participants in the intervention group received individual antenatal education through home visits using the flipchart, delivered by the investigator with assistance from ASHA or Anganwadi workers. Each session lasted approximately 10 minutes and involved interactive discussion. The control group received routine antenatal care without structured education on essential newborn care. Follow-up assessment was conducted two months after delivery. This time point was selected to allow adequate retention of the educational content while also accounting for local postpartum practices in rural Bihar, where recently delivered women often have restricted mobility and reduced participation in community activities during the early postnatal period. Conducting the assessment after two months facilitated participant contact and minimized loss to follow-up while ensuring sufficient time for knowledge retention. Participants in both groups were provided essential newborn care education after completion of data collection for ethical reasons. Thus a total of 2 home-visits was conducted in both control and intervention group. Five participants were lost to follow-up (two in the intervention group and three in the control group), primarily due to relocation after delivery. These participants were excluded from the final analysis. A per-protocol analysis was therefore performed, including only those participants who completed both baseline and follow-up assessments.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using Jamovi statistical software (Version 2.6.44; The Jamovi Project, Sydney, Australia). Data were cleaned and checked for completeness prior to analysis. Descriptive statistics were used to summarize baseline characteristics. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean ± standard deviation (SD). Normality of continuous variables was assessed using visual inspection and the Shapiro-Wilk test. Comparisons between intervention and control groups were performed using the independent samples t-test for continuous variables and the Chi-square test or Fisher's exact test for categorical variables, as appropriate. Within-group comparisons of knowledge scores between baseline and follow-up were assessed using the paired t-test.Knowledge levels were categorized using Bloom's cut-off criteria as poor (<60%), moderate (61-79%), and good (?80%). Differences in knowledge categories between groups were analyzed using the Chi-square test. Knowledge improvement was defined as movement from a lower knowledge category to a higher knowledge category between baseline and follow-up assessments. When expected cell counts were less than five, Monte Carlo simulation was applied to obtain Monte Carlo estimated p-values.Binary logistic regression analysis was performed to identify factors associated with improvement in essential newborn care knowledge. Variables with biological plausibility or statistical significance in univariate analysis were included in the multivariable model. Results were expressed as adjusted odds ratios (aORs) with 95% confidence intervals (CI). All statistical tests were two-tailed, and a p-value <0.05 was considered statistically significant.

Ethical Considerations

Ethical approval was obtained from the Institutional Ethics Committee of IGIMS, Patna (Approval No. 960/IEC/IGIMS/2023 dated 10 April 2023). Written informed consent was obtained from all participants prior to enrollment. Confidentiality of participant information was strictly maintained, and participants were informed of their right to withdraw from the study at any time without any consequences. The study was registered with the Clinical

Trials Registry of India (CTRI/2023/05/052234).

Results

Participant Flow and Baseline Characteristics

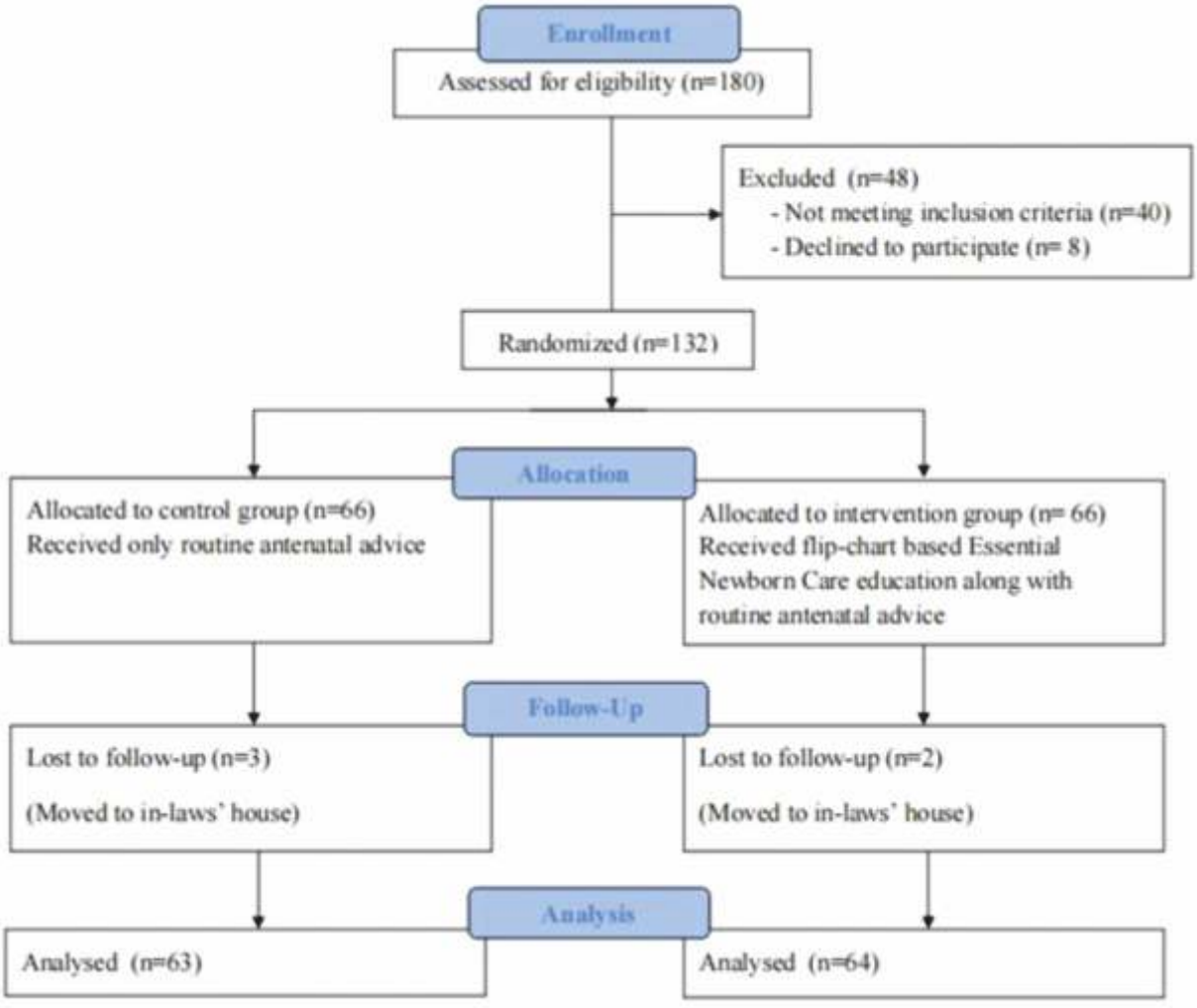

Figure 1: CONSORT flow diagram showing participant enrolment, allocation, follow-up, and analysis

As illustrated in Figure 1, a total of 132 pregnant women were enrolled in the study, with 66 participants allocated to each of the intervention and control groups. During follow-up, five participants were lost to follow-up (two from the intervention group and three from the control group). Thus, data from 127 participants (64 in the intervention group and 63 in the control group) were included in the final analysis.

Table 1: Socio-demographic Characteristics of the Participants

Sociodemographic Variable of Participants		Control Group N(%)	Intervention Group N(%)	Total N(%)	$\chi 2$ value	p value
Age	≤20 years	8 (6.3)	8 (6.3)	16 (12.6)	3.027	0.388
	21-25 years	30 (23.6)	37 (29.1)	67 (52.8)		
	26-30 years	17 (13.4)	16 (12.6)	33 (26.0)		
	>30 years	8 (6.2)	3 (2.4)	11 (8.6)		

Educational Qualification	Illiterate	6 (4.7)	5 (3.9)	11 (8.7)	8.504	0.131
	Primary School	19 (15.0)	18 (14.2)	37 (29.1)		
	Middle School	5 (3.9)	11 (8.7)	16 (12.6)		
	High School	9 (7.1)	17 (13.4)	26 (20.5)		
	Intermediate	12 (9.4)	8 (6.3)	20 (15.7)		
	Graduation	12 (9.4)	5 (3.9)	17 (13.4)		
Occupation	Housewife	56 (44.1)	49 (38.6)	105 (82.7)	7.348	0.062
	Farming	5 (3.9)	4 (3.1)	9 (7.1)		
	Tailor	0 (0)	4 (3.1)	4 (3.1)		
	Teacher	2 (1.6)	7 (5.5)	9 (7.1)		
Type of Family	Nuclear Family	22 (17.3)	26 (20.5)	48 (37.8)	0.445	0.801
	Three Generation Family	10 (7.9)	9 (7.1)	19 (15.0)		
	Joint Family	31 (24.4)	29 (22.8)	60 (47.2)		
Religion	Hinduism	63 (49.6%)	64 (50.4%)	127 (100%)	-	-
Socio Economic Status (Modified BG Prasad Scale, 2024)	Upper Class	2 (1.6)	2 (1.6)	4 (3.1)	1.137	0.888
	Upper Middle Class	8 (6.3)	11 (8.7)	19 (15.0)		
	Middle Class	21 (16.5)	19 (15.0)	40 (31.5)		
	Lower Middle Class	29 (22.8)	27 (21.3)	56 (44.1)		
	Lower Class	3 (2.4)	5 (3.9)	8 (6.3)		
Order of Pregnancy	Primi Gravida	42 (33.1)	45 (35.4)	87 (68.5)	0.196	0.658
	Multi Gravida	21 (16.5)	19 (15.0)	40 (31.5)		
Number of ANC visits completed at recruitment	1 visit	6 (4.7)	4 (3.2)	10 (7.9)	0.523	0.770
	2 visits	33 (26.0)	36 (28.3)	69 (54.3)		
	3 visits	24 (18.9)	24 (18.9)	48 (37.8)		
Number of ANC visits completed at the term	At least 4 visits	40 (31.5)	44 (34.6)	84 (66.1)	0.392	0.531
	<4 visits	23 (18.1)	20 (15.7)	43 (33.9)		
Site of Delivery	Private Hospital	21 (16.5)	21 (16.5)	42 (33.1)	0.004	0.950
	Government Hospital	42 (33.1)	43 (33.9)	85 (66.9)		
Participant enrolment Timing	28-33 weeks ofpregnancy	41 (32.3)	28 (22.0)	69 (54.3)	5.821	0.016*
	34-40 weeks of pregnancy	22 (17.3)	36 (28.3)	58 (45.7)		
*statistically significant at p<0.05						

Baseline sociodemographic characteristics were comparable between the two groups (Table 1). The majority of participants belonged to the 21-25-year age group, with a mean age of 24.50 ± 3.40 years. Most participants were homemakers and had attained primary or secondary education. Nearly half of the women belonged to joint families, and the majority were from lower-middle and middle socioeconomic classes as per the Modified B.G. Prasad classification (2024). No statistically significant differences were observed between the intervention and control groups with respect to age, education, occupation, family type, or socioeconomic status ($p > 0.05$).Pregnancy-related characteristics were also comparable between groups. Most participants were primigravida, had attended at least two antenatal visits at recruitment, and completed four or more ANC visits by term. The majority delivered in government health facilities. A statistically significant difference was observed only in the timing of enrollment, with a greater proportion of women in the control group enrolled earlier in the third trimester ($p = 0.016$).

Baseline Essential Newborn Care Knowledge

At baseline, overall ENC knowledge scores were comparable between the intervention and control groups (13.77 ± 3.04 vs. 13.65 ± 2.78; $p = 0.825$), indicating similar pre-intervention knowledge levels (Table 2).

Table 2: Baseline Mean Knowledge Scores in Control Group and Intervention Group

Domains	Intervention Group	Control Group	Mean difference	Independent t-test value	p-value
Overall ENC knowledge	13.77 ± 3.038	13.65 ± 2.783	0.115	0.222	0.825
Knowledge about feeding practices	2.83 ± 0.656	2.54 ± 1.148	0.288	1.742	0.084
Knowledge about hygiene practices	3.72 ± 0.519	3.43 ± 1.214	0.290	1.756	0.082
Knowledge about thermal care	2.86 ± 0.710	3.29 ± 0.831	-0.426	-3.110	0.002
Knowledge about danger signs	4.33 ± 1.728	4.40 ± 0.925	-0.069	-0.279	0.781
*statistically significant at p<0.05					

No statistically significant differences were observed in the domains of feeding practices, hygiene, or danger signs.However, the control group demonstrated significantly higher baseline knowledge in the thermal care domain compared to the intervention group (3.29 ± 0.83 vs. 2.86 ± 0.71; p = 0.002). Apart from this, baseline knowledge distribution across all domains was comparable between groups, confirming baseline equivalence prior to the intervention.

Effect of Antenatal Education on ENC Knowledge

Follow-up Knowledge Scores

At follow-up, the intervention group demonstrated significantly higher knowledge scores across all ENC domains compared to the control group (Table 3).

Table 3: Follow-up Mean Knowledge Scores in Control Group and Intervention Group

Domain	Intervention Group	Control Group	Mean difference	Independent t-test value	p-value
Overall ENC knowledge	18.63 ± 3.160	13.83 ± 2.860	4.800	8.970	<0.001*
Knowledge about feeding practices	4.50 ± 1.690	2.98 ± 1.540	1.516	5.281	<0.001*
Knowledge about hygiene practices	4.56 ± 1.500	2.98 ± 1.431	1.578	6.065	<0.001*
Knowledge about thermal care	3.81 ± 1.283	2.68 ± 1.175	1.130	5.172	<0.001*
Knowledge about	5.98 ± 0.968	4.98 ± 1.009	1.000	5.706	<0.001*
danger signs					
*statistically significant at p<0.001					

The mean overall knowledge score in the intervention group increased to 18.63 ± 3.16 compared to 13.83 ± 2.86 in the control group (p < 0.001). These findings indicate a strong positive effect of antenatal education on maternal knowledge.In the control group, only marginal changes in knowledge were observed between baseline and follow-up (Table 3). Although small improvements were noted in feeding practices and danger sign recognition, overall knowledge gain was not statistically significant (p = 0.236). A decline was observed in hygiene and thermal care scores, suggesting the absence of sustained knowledge reinforcement.

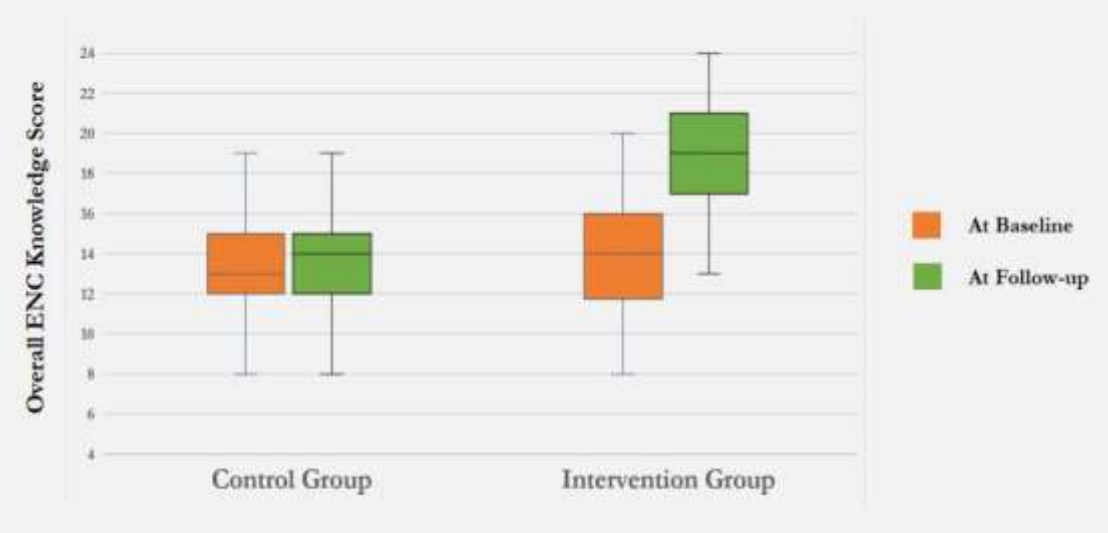

Figure 2: Box Plot Comparing Baseline and Follow-up Knowledge Scores in Control and Intervention Groups

Figure 2 illustrates the change in overall Essential Newborn Care (ENC) knowledge scores from baseline to follow-up in both study groups. At baseline, knowledge levels were comparable between the control and intervention groups, with median (IQR) scores of 14.0 (12.0-15.0) and 14.0 (11.8-16.0), respectively, and nearly identical mean scores (13.65 vs. 13.77), confirming baseline equivalence. At follow-up, a marked improvement was observed in the intervention group, with the median score increasing to 19.0 (17.0-21.0) and the mean rising to 18.63, indicating a substantial overall gain in knowledge. In contrast, the control group showed minimal change, with median and mean scores remaining largely unchanged at 14.0 (12.0-15.0) and 13.83, respectively. The box plot further demonstrates increased dispersion of scores in the intervention group at follow-up, reflecting individual-level gains following education, while the control group showed minimal variability over time. These findings clearly demonstrate the effectiveness of antenatal education in improving ENC knowledge among women in the intervention group.

Knowledge Category Distribution

At baseline, knowledge category distribution was comparable between groups, with most participants falling in the poor or moderate categories (p = 0.629).At follow-up, a marked shift was observed in the intervention group (Table 4). More than half of the participants in the intervention group (56.3%) achieved good knowledge status, compared to only 7.9% in the control group (p < 0.001). Conversely, poor knowledge persisted in 41.3% of the control group but only 12.5% of the intervention group.

Table 4: Baseline Knowledge Category in Control and Intervention Group

Time of assessment	Group	Knowledge CategoryN(%)			Total N(%)	$\chi 2$	p-value
		Good	Moderate	Poor			
Baseline	IG	4 (6.3)	29 (45.3)	31 (48.4)	64 (100%)	0.926	0.629
	CG	6 (9.5)	24 (38.1)	33 (52.4)	63 (100%)		
Follow-up	IG	36 (56.3)	20 (31.2)	8 (12.5)	64 (100%)	35.73	<0.001*
	CG	5 (7.9)	32 (50.8)	26 (41.3)	63 (100%)		
CG : Control group, IG : Intervention group							

Table 5: Improvement in Knowledge in Control and Intervention Group

Allocation Group	Improvement in Knowledge			OR (95% C.I)	$\chi 2$ p-value
	Yes N(%)	No N(%)	Total N (%)		
Intervention	48 (75.0)	16 (25.0)	64 (100)	12.750 (5.472-19.709)	39.878 <0.001*
Control	12 (19.1)	51 (80.9)	63 (100)		

*statistically significant at p<0.001

Knowledge improvement, defined as a positive shift in knowledge category from baseline to follow-up, was significantly higher in the intervention group compared to the control group. Among participants who received antenatal education, 48 of 64 women (75.0%) demonstrated improvement in Essential Newborn Care (ENC) knowledge, whereas only 12 of 63 women (19.1%) in the control group showed any improvement, with the majority remaining unchanged (Table 5). This difference was highly statistically significant ($?^2$ = 39.878, p < 0.001). Women in the intervention group had markedly higher odds of knowledge improvement (OR = 12.75; 95% CI: 5.47-19.71), and the relative risk of improvement was nearly four times greater compared to the control group (RR = 3.94; 95% CI: 2.32-6.68). On multivariate analysis, antenatal education emerged as the strongest independent predictor of knowledge gain (AOR = 13.98; 95% CI: 5.56-25.15; p < 0.001). Factors such as maternal age, education, family type, occupation, parity, socioeconomic status, number of antenatal visits, and place of delivery, were not significantly associated with knowledge improvement. (Table 6).

Table 6: Factors Associated with Knowledge Improvement

Factors		Improvement in Knowledge N (%)		AOR (95% CI)	p-value
		Yes (n=60)	No (n=67)		
Allocation	Intervention Group	48 (75.0)	16 (25.0)	13.981 (5.561-25.150)	<0.001*
	Control Group	12 (19.1)	51 (80.9)	1	
Age	>25 years	18 (14.2)	26 (32.3)	0.768 (0.305-1.937)	0.577
	≤25 years	42 (33.1)	41 (32.3)	1	
Education	Intermediate and Graduate	24 (18.9)	18 (14.2)	1.386 (0.481-3.991)	0.546
	Middle and High school	16 (12.6)	21 (16.5)	1.986 (0.578-6.830)	0.276
	Up to Primary school	20 (15.7)	28 (22.0)	1	
Occupation	Employed	4 (3.1)	5 (3.9)	1.721 (0.256-11.559)	0.635
	Unemployed	56 (44.1)	62 (48.8)	1	
Socioeconomic status	Higher SES	13 (10.2)	10 (7.9)	1.560 (0.492-4.947)	0.450
	Lower SES	47 (37.0)	57 (44.9)	1	
Order of Pregnancy	Primigravida	40 (31.5)	47 (37.0)	1.454 (0.562-3.765)	0.440
	Multigravida	20 (15.7)	20 (15.7)	1	
Site of Delivery	Government Hospital	42 (33.1)	43 (33.9)	0.680 (0.270-1.710)	0.412
	Private Hospital	18 (14.2)	24 (18.9)	1	
No. of ANC visits	Atleast 4 ANC visits	41 (32.3)	43 (33.9)	1.103 (0.428-2.839)	0.839
	<4 ANC visits	19 (15.0)	24 (18.9)	1	

Further, a subgroup analysis based on the timing of intervention revealed that participants who received antenatal educational intervention during the late third trimester (34-40 weeks) demonstrated significantly higher knowledge improvement compared to those enrolled earlier (28-33 weeks). Knowledge improvement was observed in 89.0% of women in the late-intervention group compared to 57.0% in the early-intervention group. The odds of improvement were significantly higher among those receiving the intervention later in pregnancy (OR = 6.00; 95% CI: 3.63-10.17; $?^2 = 8.47$; $p < 0.01$).

Discussion

The present randomized controlled trial demonstrates that structured antenatal education delivered during the third trimester leads to a significant improvement in maternal knowledge of essential newborn care (ENC). At baseline, knowledge levels were low to moderate in both groups, reflecting persistent gaps in maternal awareness despite routine antenatal service utilization. Similar baseline deficiencies have been consistently reported across rural and peri-urban India, where institutional delivery rates have improved but understanding of newborn care practices remains suboptimal. Studies from various parts of India have documented comparable patterns, particularly with respect to thermal care, hygienic practices, and recognition of neonatal danger signs, highlighting the continued need for focused educational interventions during pregnancy. [13,16-18]

Following the intervention, a marked improvement in overall ENC knowledge was observed among women in the intervention group, with significant gains across all domains. In contrast, the control group showed minimal change, underscoring the limited impact of routine antenatal care in the absence of structured education. These findings are in strong agreement with previous randomized trials conducted in India, including those by Eluri et al. and Verma et al., which demonstrated substantial improvements in maternal knowledge following flipchart-based or structured counselling interventions.[14,19] Similar effects have been reported from other low- and middle-income countries where antenatal educational interventions led to significant gains in knowledge related to breastfeeding, thermal protection, and newborn danger signs.[20-22]

The observed improvement across all knowledge domains suggests that comprehensive, visually supported education is more effective than isolated counselling messages. This aligns with evidence from systematic reviews showing that bundled educational interventions produce greater and more sustained knowledge gains than single-topic counselling.[23,24] In the present study, the intervention group demonstrated not only higher mean knowledge scores but also a marked shift in knowledge categories, with more than half achieving a "good" knowledge level at follow-up. In contrast, a substantial proportion of women in the control group continued to remain in the poor or moderate knowledge categories. These findings mirror observations from studies in Karnataka, Uttar Pradesh, and Bangladesh, where structured antenatal education significantly increased the proportion of women attaining adequate newborn care knowledge.[19,25,26]

An important finding of this study was that antenatal education emerged as the strongest independent predictor of knowledge improvement, even after adjusting for maternal age, education, parity, socioeconomic status, and antenatal care utilization. Women who received the intervention were nearly fourteen times more likely to demonstrate knowledge improvement compared to controls. This reinforces evidence from earlier studies indicating that contact with health services alone does not ensure learning unless education is delivered in a structured and comprehensible manner.[12,27] The lack of association between knowledge gain and maternal education or number of ANC visits further highlights that the quality of counselling, rather than mere service utilization, determines learning outcomes.

A noteworthy finding of the present study was the influence of timing of the educational intervention on knowledge gain. Women who received antenatal education during the later part of the third trimester demonstrated significantly greater improvement in knowledge compared to those enrolled earlier in pregnancy. This suggests that educational interventions delivered closer to term may be more effective, possibly due to increased perceived relevance, better retention, and heightened readiness for newborn care as delivery approaches. The finding aligns with behavioural learning principles, wherein information provided nearer to the time of application is more likely to be retained and translated into practice. These results indicate that the final antenatal visits may represent an optimal window for delivering focused essential newborn care education, thereby maximizing its impact within routine antenatal care services.

The findings of this study have important programmatic implications. The demonstrated effectiveness of a simple, low-cost flipchart-based intervention supports its integration into routine antenatal services, particularly under national platforms such as PMSMA and HBNC. Frontline health workers such as ASHAs and ANMs are well positioned to deliver such interventions, and their involvement could substantially strengthen maternal preparedness for newborn care. [28,29]

The findings of the present study are further supported by evidence from recent systematic reviews and meta-analyses evaluating antenatal and community-based maternal educational interventions. A systematic review and meta-analysis by Albarqi et al. reported that comprehensive prenatal care interventions, including educational, nutritional,

and psychosocial components, were associated with substantial improvements in neonatal outcomes, with high-quality prenatal care reducing neonatal mortality by approximately 41%. [30] Similarly, a Cochrane systematic review by Lassi et al., which included 33 community-based trials conducted across low- and middle-income countries, demonstrated that maternal and newborn educational care packages significantly reduced overall neonatal mortality (RR: 0.87; 95% CI: 0.78-0.96) and early neonatal mortality (RR: 0.74; 95% CI: 0.66-0.84), while also improving antenatal care utilization and early initiation of breastfeeding. Although the present study assessed knowledge outcomes rather than neonatal endpoints, the observed improvement in maternal essential newborn care knowledge is consistent with the broader body of evidence suggesting that structured educational interventions delivered during the antenatal period can enhance maternal preparedness and support practices associated with improved newborn health and survival. [31]

This study has several notable strengths. This study adds to the limited body of randomized evidence from rural India evaluating the effectiveness of structured antenatal education on essential newborn care knowledge. The randomized design enhances internal validity and minimizes selection bias, while the use of standardized, pretested instruments ensured uniform assessment across participants. Unlike many previous studies that focused only on postnatal mothers or relied solely on cross-sectional assessments, this study prospectively evaluated knowledge change from the antenatal to the postnatal period, allowing for a clearer attribution of effect to the educational intervention. The inclusion of multiple ENC domains and the use of objective scoring further strengthen the robustness of the findings. In addition, conducting the intervention within the routine public health system setting enhances the programmatic relevance and real-world applicability of the results.

Certain limitations should also be acknowledged. Knowledge assessment was based on interviewer-administered questionnaires, which may have introduced social desirability and/or recall bias, despite efforts to standardize data collection. The follow-up period was limited to two months postpartum, which restricted assessment of long-term knowledge retention and sustained behavioral change. The study was conducted in a single rural field practice area, which may limit generalizability to urban settings or other sociocultural contexts. Furthermore, blinding was not feasible due to the nature of the educational intervention; however, standardized tools and uniform assessment procedures were used to minimize potential bias. Finally, the analysis followed a per-protocol approach because outcome data were unavailable for participants lost to follow-up after delivery. Although attrition was low (3.8%), exclusion of these participants may have slightly overestimated the intervention effect compared with an intention-to-treat analysis. However, given the small number of losses and the balanced attrition across study groups, the impact on the overall findings is likely to be minimal.

Despite these limitations, the study provides strong evidence that structured antenatal education delivered during routine antenatal care can significantly improve maternal knowledge of essential newborn care. The findings support the integration of focused educational interventions into existing maternal health programs, particularly in resource-limited rural settings.

The findings of this study provide clear evidence that structured antenatal education is an effective strategy for improving maternal knowledge related to essential newborn care. By addressing key domains of newborn health during the antenatal period, such interventions enhance maternal readiness at the time of delivery and early postnatal care. The observed gains in knowledge underscore the value of incorporating focused, standardized educational components into routine antenatal services. Given the simplicity, feasibility, and low resource requirement of the intervention, its integration within existing public health delivery platforms holds considerable promise for strengthening newborn care practices at the community level. Wider implementation of such educational strategies could play an important role in strengthening maternal preparedness and newborn care practices, particularly in rural and resource-constrained settings.

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