Natural Resources for Human Health
eISSN: 2583-1194

Original Research

Received 07 Aug 2026
Revised 11 Sep 2026
Accepted 29 Sep 2026

Natural Resources for Human Health 2026, Vol. 6 (23s): 348–367

KEYWORDS:
maternal anaemia; iron-folic acid supplementation; adherence; pharmacist-led counseling; pregnancy; antenatal care

Effect of Pharmacist-Led Educational Counseling on Knowledge, Adherence, and Haemoglobin Outcomes among Pregnant Women Receiving Iron-Folic Acid Supplementation: A Quasi-Experimental Study

[1]Avula Dhamini, *[1]Thirumalai Kumaran Rathinam

[1]Research Scholar, Saveetha College of Pharmacy, SIAMTS, Chennai-602105, Tamil Nadu, India.
*[1]Professor and Head, Department of Pharmacognosy, Saveetha College of Pharmacy, SIAMTS, Chennai-602105,Tamil Nadu, India.
Communicating Author's E-mail: thirumalaikumaranr.scop@saveetha.com

ABSTRACT: **Background**: Maternal anemia remains a major contributor to adverse maternal and neonatal outcomes worldwide, particularly in low-and middle-income countries. Despite national supplementation programs, adherence to iron and folic acid supplementation (IFAS) remains suboptimal in many settings. Limited knowledge, misconceptions, inadequate counseling, and socioeconomic barriers continue to undermine program effectiveness.

Objective: To evaluate baseline knowledge and adherence related to IFAS among pregnant women and determine the impact of pharmacist-led educational counseling on adherence, haemoglobin status, and maternal–neonatal outcomes.

Methods: A quasi-experimental pre–post intervention study was conducted among 150 pregnant women attending antenatal care services in Nellore, Andhra Pradesh, India. Participants were allocated into control (n=75) and intervention (n=75) groups. Baseline assessments included socio-demographic characteristics, obstetric history, nutritional status, knowledge regarding anaemia and supplementation, adherence behaviour, psychosocial determinants, and laboratory parameters. The intervention group received structured pharmacist-led counseling and educational reinforcement in addition to routine antenatal care. Outcomes included knowledge scores, adherence rates, haemoglobin levels, maternal satisfaction, birth weight, and preterm delivery.

Results: Baseline anaemia prevalence was 66.7%, with iron deficiency identified as the predominant nutritional deficiency. Knowledge regarding anaemia and IFAS was inadequate in a substantial proportion of participants. Good adherence was observed in only 41.3% of women at enrolment. Following the intervention, knowledge scores improved significantly, adherence increased to 72%, and mean haemoglobin levels improved markedly. The intervention group demonstrated lower anaemia prevalence at delivery, higher maternal satisfaction, greater neonatal birth weight, and reduced preterm delivery rates.

Conclusion: Pharmacist-led educational counseling significantly improved knowledge, adherence, and clinical outcomes among pregnant women receiving IFAS. Integrating

pharmacists into routine antenatal care may strengthen anaemia prevention programs and improve maternal and neonatal health outcomes in resource-constrained settings.

INTRODUCTION

Maternal anaemia continues to represent one of the most prevalent nutritional disorders affecting women of reproductive age and remains a significant public health concern worldwide. Pregnancy substantially increases the physiological demand for iron and folate because of expanded maternal blood volume, placental development, and the rapid growth of the fetus. When these nutritional requirements are not adequately met, pregnant women become increasingly susceptible to iron deficiency and iron deficiency anaemia, resulting in impaired maternal health and adverse pregnancy outcomes. Although considerable progress has been achieved through global maternal health initiatives, anaemia continues to affect a substantial proportion of pregnant women, particularly in low- and middle-income countries where nutritional deficiencies, infectious diseases, and socioeconomic inequalities coexist [1-3].

According to the World Health Organization, anaemia during pregnancy is defined as a haemoglobin concentration below 11.0 g/dL and remains one of the leading contributors to maternal morbidity and mortality globally. Iron deficiency accounts for approximately half of all anaemia cases during pregnancy, although deficiencies of folate, vitamin B12, chronic infections, haemoglobinopathies, and inflammatory disorders may also contribute. Maternal anaemia has been consistently associated with fatigue, reduced physical capacity, and impaired immunity, increased susceptibility to infections, postpartum haemorrhage, and maternal death. Furthermore, fetal consequences include intrauterine growth restriction, preterm birth, low birth weight, impaired cognitive development, and increased neonatal mortality, emphasizing the need for effective preventive strategies during antenatal care [1–4].

India continues to bear one of the highest global burdens of maternal anaemia despite sustained national nutritional interventions. The high prevalence has been attributed to inadequate dietary iron intake, poor dietary diversity, recurrent pregnancies with short birth intervals, parasitic infestations, limited access to quality antenatal services, and socioeconomic deprivation. National surveys continue to demonstrate that anaemia remains widespread among pregnant women across both rural and urban populations, indicating persistent implementation gaps despite large-scale supplementation programmes [5,6].

Iron–folic acid supplementation (IFAS) remains the cornerstone of anaemia prevention and management during pregnancy. Daily supplementation with iron and folic acid has consistently demonstrated improvements in maternal haemoglobin concentrations while reducing the risks of maternal anaemia, preterm birth, low birth weight, and neural tube defects. Consequently, international organizations recommend routine IFAS as a standard component of antenatal care, while the Government of India has incorporated universal iron-folic acid supplementation into national reproductive and maternal health programmes [1,7,8].

Despite the availability of IFAS through public health programmes, poor adherence continues to limit its clinical effectiveness. Numerous studies have reported that many pregnant women either fail to initiate supplementation early or discontinue treatment before completing the recommended duration. Poor adherence is frequently attributed to inadequate knowledge regarding anaemia, misconceptions about iron tablets, fear of adverse effects such as nausea or constipation, forgetfulness, insufficient counseling, poor family support, low educational status, financial constraints, and limited access to healthcare facilities. These behavioural and health-system barriers substantially reduce the effectiveness of supplementation programmes and contribute to persistently high anaemia prevalence [9-12].

Educational interventions delivered during antenatal care have emerged as an effective strategy for improving maternal awareness, treatment adherence, and healthy pregnancy practices. Individualized counseling enables pregnant women to better understand the causes and consequences of anaemia, the importance of consistent IFAS intake, dietary measures that enhance iron absorption, management of minor adverse effects, and the need for regular follow-up. Behavioural change interventions supported by continuous reinforcement have demonstrated favourable effects on medication adherence and maternal health behaviours in diverse healthcare settings [13–15].

Pharmacists are increasingly recognized as integral members of multidisciplinary maternal healthcare teams owing to their expertise in medication management, patient education, adverse effect monitoring, and adherence support. Within antenatal services, pharmacist-led counseling can improve patient's understanding of prescribed medications, reinforce evidence-based recommendations, identify medication-related problems, and encourage appropriate supplement use. Previous studies across chronic disease management and maternal healthcare have demonstrated that pharmacist-led educational interventions significantly improve medication adherence, therapeutic outcomes, patient satisfaction, and overall quality of care. Nevertheless,

evidence evaluating pharmacist-led educational counseling specifically for iron-folic acid supplementation among pregnant women in routine antenatal settings remains comparatively limited, particularly within resource-constrained regions of India [16-19].

Addressing this evidence gap is essential because pharmacist-led interventions offer a practical, scalable, and cost-effective approach for strengthening existing antenatal care programmes. By providing structured education, individualized counseling, and regular reinforcement, pharmacists may improve both behavioural and clinical outcomes without requiring substantial additional healthcare infrastructure. Generating robust evidence regarding their effectiveness may inform future policy decisions and facilitate greater integration of clinical pharmacists into maternal health services.

Therefore, the present quasi-experimental study was undertaken to evaluate baseline knowledge and adherence regarding iron-folic acid supplementation among pregnant women attending antenatal clinics in Nellore, Andhra Pradesh, India, and to determine the effectiveness of pharmacist-led educational counseling on improving knowledge, medication adherence, haemoglobin status, maternal satisfaction, and selected maternal and neonatal outcomes. The findings are expected to provide evidence supporting pharmacist-driven educational interventions as an important component of comprehensive antenatal care for preventing maternal anaemia and improving pregnancy outcomes.

MATERIALS AND METHODS

Study Design: A quasi-experimental pre-post intervention study was conducted among pregnant women attending antenatal care services in Nellore, Andhra Pradesh, India. The study was designed to evaluate the effectiveness of pharmacist-led educational interventions on knowledge, adherence, and clinical outcomes.

Study Population: Pregnant women aged 18-40 years with gestational ages between 12 and 28 weeks who attended antenatal clinics and provided informed consent were eligible for participation. Women with severe hematological disorders, major chronic illnesses, or conditions affecting participation were excluded.

Sample Size and Groups: A total of 150 pregnant women were enrolled. Participants were allocated into a control group (n=75), which received routine antenatal care, and an intervention group (n=75), which received pharmacist-led educational counseling in addition to standard services.

Intervention: The intervention comprised:

1. Structured educational sessions on anemia and maternal nutrition.
2. Individual pharmacist counseling regarding IFAS use.
3. Guidance on side-effect management.
4. Dietary counseling emphasizing iron-rich foods and absorption enhancers.
5. Reminder tools and adherence-support materials.

The intervention was delivered over an eight-week follow-up period.

Data Collection: Baseline data included:

- Socio-demographic characteristics
- Obstetric history
- Nutritional practices
- Knowledge regarding anemia and IFAS
- Adherence behavior
- Psychosocial determinants
- Household environmental factors
- Haemoglobin concentration
- Biochemical indicators

Knowledge and adherence were assessed using validated questionnaires, pill counts, and seven-day recall methods. Haemoglobin levels were measured using standardized procedures.

Natural Resources for Human Health
eISSN: 2583-1194

Figure 1. Flow diagram of participant recruitment, group allocation, follow-up, and final analysis.

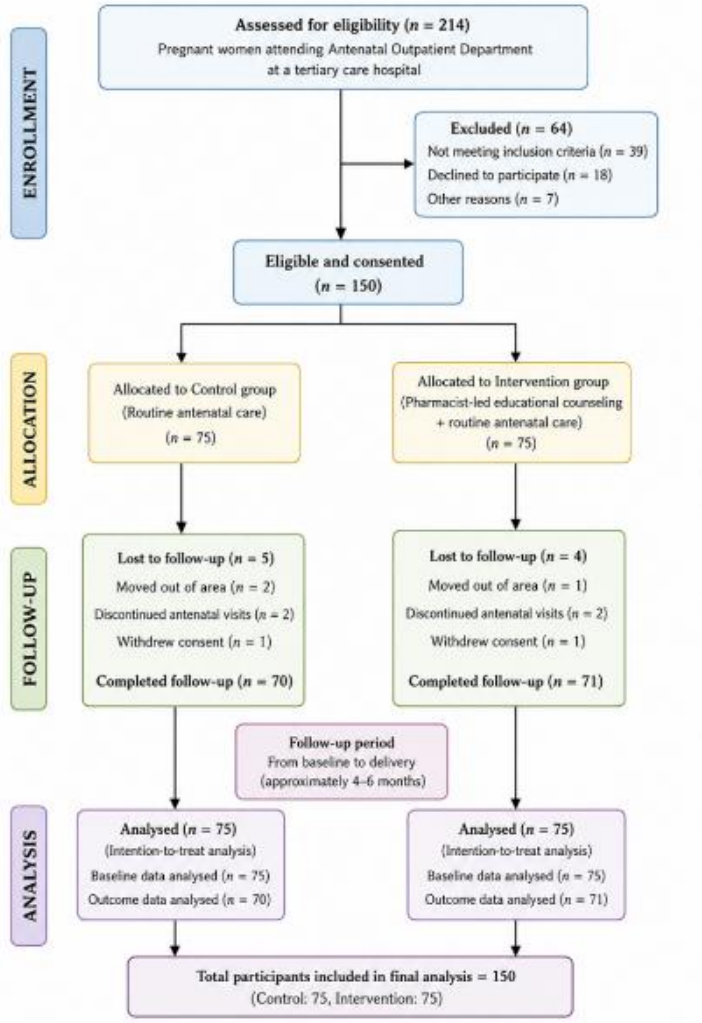


Figure 1 illustrates the flow of participants through each stage of the quasi-experimental study, from recruitment to final analysis. A total of 214 pregnant women attending the antenatal outpatient clinic were initially assessed for eligibility. Of these, 64 women were excluded because they did not meet the inclusion criteria, declined participation, or were excluded for other predefined reasons. The remaining 150 eligible women provided informed consent and were enrolled in the study. Participants were allocated equally to the control group (n = 75), which received routine antenatal care, and the intervention group (n = 75), which received structured pharmacist-led educational counseling in addition to routine care. During follow-up, five participants in the control group and four participants in the intervention group were lost because of relocation, discontinuation of antenatal visits, or withdrawal of consent. Outcome assessments were completed after follow-up, and all enrolled participants were included in the final intention-to-treat analysis. The flow diagram demonstrates transparent participant selection, group allocation, follow-up, and outcome assessment, thereby supporting the methodological rigor of the study.

Statistical Analysis

Data were analyzed using SPSS version 26. Descriptive statistics summarized participant characteristics. Chi-square tests, paired t-tests, independent t-tests, and logistic regression analyses were employed as appropriate. Statistical significance was set at $p < 0.05$.

RESULTS

The baseline socio-demographic characteristics of the enrolled pregnant women are presented in Table 1.

Natural Resources for Human Health
eISSN: 2583-1194

Table 1. Socio-demographic characteristics of pregnant women enrolled in the study (N = 150).

Characteristic	Category	Control Group (n = 75) n (%)	Intervention Group (n = 75) n (%)	Total (N = 150) n (%)	p-value*
Age group (years)	18–22	19 (25.3)	18 (24.0)	37 (24.7)	0.962
	23–27	33 (44.0)	34 (45.3)	67 (44.7)	
	28–32	17 (22.7)	16 (21.3)	33 (22.0)	
	≥33	6 (8.0)	7 (9.4)	13 (8.6)	
Age (years)	Mean ± SD	**25.9 ± 3.8**	**26.1 ± 3.9**	**26.0 ± 3.8**	**0.781**
Residence	Rural	49 (65.3)	47 (62.7)	96 (64.0)	0.739
	Urban	26 (34.7)	28 (37.3)	54 (36.0)	
Educational level	No formal education	8 (10.7)	7 (9.3)	15 (10.0)	0.951
	Primary school	18 (24.0)	19 (25.3)	37 (24.7)	
	Secondary school	29 (38.7)	28 (37.3)	57 (38.0)	
	Higher secondary	13 (17.3)	14 (18.7)	27 (18.0)	
	Graduate or above	7 (9.3)	7 (9.3)	14 (9.3)	
Occupation	Homemaker	57 (76.0)	58 (77.3)	115 (76.7)	0.884
	Agricultural worker	8 (10.7)	7 (9.3)	15 (10.0)	
	Daily wage worker	6 (8.0)	5 (6.7)	11 (7.3)	
	Salaried employment	4 (5.3)	5 (6.7)	9 (6.0)	
Monthly household income (₹)	<10,000	20 (26.7)	21 (28.0)	41 (27.3)	0.944
	10,000–20,000	32 (42.7)	31 (41.3)	63 (42.0)	
	20,001–30,000	15 (20.0)	16 (21.3)	31 (20.7)	
	>30,000	8 (10.6)	7 (9.4)	15 (10.0)	
Socioeconomic status†	Lower	18 (24.0)	19 (25.3)	37 (24.7)	0.982
	Lower middle	35 (46.7)	34 (45.3)	69 (46.0)	
	Upper middle	18 (24.0)	18 (24.0)	36 (24.0)	
	Upper	4 (5.3)	4 (5.3)	8 (5.3)	
Family type	Nuclear	47 (62.7)	48 (64.0)	95 (63.3)	0.867
	Joint/Extended	28 (37.3)	27 (36.0)	55 (36.7)	
Marital duration (years)	<2	17 (22.7)	18 (24.0)	35 (23.3)	0.903
	2–5	39 (52.0)	38 (50.7)	77 (51.3)	
	>5	19 (25.3)	19 (25.3)	38 (25.4)	
Health insurance coverage	Yes	28 (37.3)	30 (40.0)	58 (38.7)	0.736
	No	47 (62.7)	45 (60.0)	92 (61.3)	
Distance from healthcare facility	<5 km	31 (41.3)	32 (42.7)	63 (42.0)	0.948
	5–10 km	27 (36.0)	26 (34.7)	53 (35.3)	
	>10 km	17 (22.7)	17 (22.6)	34 (22.7)	

Data are expressed as frequency (n) and percentage (%), unless otherwise specified.
Abbreviations: SD, Standard deviation.
† Socioeconomic status classified according to the Modified Kuppuswamy Socioeconomic Scale (updated version).
*Categorical variables were compared using the Chi-square test, whereas continuous variables were analysed using the independent Student's t-test. No statistically significant differences were observed between the control and intervention

groups for any socio-demographic variable (all $p > 0.05$), indicating that the two groups were well matched before initiation of the pharmacist-led educational counseling intervention.

Table 1 presents the socio-demographic profile of the 150 pregnant women enrolled in the study, with 75 participants each in the control and intervention groups. The mean age of the study population was 26.0 ± 3.8 years, and the largest proportion of women (44.7%) belonged to the 23–27-year age group. Nearly two-thirds of the participants (64.0%) resided in rural areas, reflecting the predominantly rural catchment population served by the study setting. Secondary school education was the most common educational level (38.0%), while 76.7% of the women were homemakers. Most households (42.0%) reported a monthly income between ₹10,000 and ₹20,000, and 46.0% of the participants belonged to the lower-middle socioeconomic category according to the Modified Kuppuswamy classification. Nuclear families accounted for 63.3% of the study population, and over half of the women (51.3%) had been married for two to five years. Health insurance coverage was available to 38.7% of participants, whereas 61.3% did not possess any form of health insurance. In terms of healthcare accessibility, 42.0% of the women lived within 5 km of the healthcare facility. No statistically significant differences were observed between the control and intervention groups across any socio-demographic characteristic (all $p > 0.05$), indicating that both groups were comparable at baseline before implementation of the pharmacist-led educational counseling intervention.

Table 2. Obstetric, clinical, and nutritional profile of pregnant women at baseline (N = 150).

Variable	Category	Control Group (n = 75) n (%)	Intervention Group (n = 75) n (%)	Total (N = 150) n (%)	p-value*
Gestational age at enrolment	First trimester (<13 weeks)	18 (24.0)	19 (25.3)	37 (24.7)	0.948
	Second trimester (13–27 weeks)	39 (52.0)	38 (50.7)	77 (51.3)	
	Third trimester (≥28 weeks)	18 (24.0)	18 (24.0)	36 (24.0)	
Gravidity	Prim gravida	31 (41.3)	32 (42.7)	63 (42.0)	0.862
	Multigravida	44 (58.7)	43 (57.3)	87 (58.0)	
Previous history of anaemia†	Yes	24 (54.5)	25 (58.1)	49 (56.3)	0.736
	No	20 (45.5)	18 (41.9)	38 (43.7)	
Previous adverse pregnancy outcome†	None	23 (52.3)	24 (55.8)	47 (54.0)	0.918
	Miscarriage/Abortion	8 (18.2)	7 (16.3)	15 (17.2)	
	Preterm delivery	6 (13.6)	6 (14.0)	12 (13.8)	
	Low birth weight infant	5 (11.4)	4 (9.3)	9 (10.3)	
	Pregnancy-induced hypertension	2 (4.5)	2 (4.6)	4 (4.7)	
Body Mass Index (kg/m²)	Underweight (<18.5)	17 (22.7)	16 (21.3)	33 (22.0)	0.981
	Normal (18.5–24.9)	45 (60.0)	46 (61.3)	91 (60.7)	
	Overweight (25.0–29.9)	11 (14.6)	10 (13.4)	21 (14.0)	
	Obese (≥30.0)	2 (2.7)	3 (4.0)	5 (3.3)	
Baseline haemoglobin status	Normal (≥11.0 g/dL)	25 (33.3)	25 (33.3)	50 (33.3)	0.995
	Mild anaemia (10.0–10.9 g/dL)	19 (25.3)	20 (26.7)	39 (26.0)	
	Moderate anaemia (7.0–9.9 g/dL)	27 (36.0)	26 (34.7)	53 (35.3)	
	Severe anaemia (<7.0 g/dL)	4 (5.4)	4 (5.3)	8 (5.4)	

Mean haemoglobin (g/dL)	Mean ± SD	**10.02 ± 1.23**	**10.07 ± 1.20**	**10.05 ± 1.21**	**0.812**
Serum ferritin status	Normal (≥30 ng/mL)	24 (32.0)	24 (32.0)	48 (32.0)	1.000
	Low (<30 ng/mL)	51 (68.0)	51 (68.0)	102 (68.0)	
Dietary pattern	Vegetarian	29 (38.7)	28 (37.3)	57 (38.0)	0.858
	Mixed diet	46 (61.3)	47 (62.7)	93 (62.0)	
Minimum Dietary Diversity Score (MDD-W)	Low (<5 food groups)	41 (54.7)	42 (56.0)	83 (55.3)	0.869
	Adequate (≥5 food groups)	34 (45.3)	33 (44.0)	67 (44.7)	
Estimated dietary iron intake	<18 mg/day	48 (64.0)	47 (62.7)	95 (63.3)	0.865
	≥18 mg/day	27 (36.0)	28 (37.3)	55 (36.7)	
Tea/Coffee consumption with meals	Yes	30 (40.0)	30 (40.0)	60 (40.0)	1.000
	No	45 (60.0)	45 (60.0)	90 (60.0)	
Received deworming therapy during pregnancy	Yes	53 (70.7)	54 (72.0)	107 (71.3)	0.857
	No	22 (29.3)	21 (28.0)	43 (28.7)	
Coexisting medical condition	None	59 (78.7)	60 (80.0)	119 (79.3)	0.966
	Gestational diabetes mellitus	7 (9.3)	6 (8.0)	13 (8.7)	
	Pregnancy-induced hypertension	5 (6.7)	5 (6.7)	10 (6.7)	
	Hypothyroidism	4 (5.3)	4 (5.3)	8 (5.3)	

Data are presented as frequency (n) and percentage (%), unless otherwise indicated.
Abbreviations: SD, standard deviation; BMI, body mass index; MDD-W, Minimum Dietary Diversity for Women.
† Calculated only among multigravida participants (n = 87).
* Categorical variables were compared using the Chi-square test, whereas continuous variables were analysed using the independent Student's t-test. Baseline obstetric, clinical, and nutritional characteristics did not differ significantly between the control and intervention groups (all $p > 0.05$), confirming that the study groups were comparable prior to the pharmacist-led educational counseling intervention.

Table 2 summarizes the baseline obstetric, clinical, and nutritional characteristics of the pregnant women included in the study. Slightly more than half of the participants (51.3%) were enrolled during the second trimester of pregnancy, while 58.0% were multigravida. Among women with previous pregnancies, over half (56.3%) reported a history of anaemia, although the majority had no record of adverse pregnancy outcomes. Assessment of nutritional status showed that 60.7% of the participants had a normal body mass index, whereas 22.0% were underweight. At enrolment, two-thirds of the women (66.7%) were anaemic, with moderate anaemia being the most frequently observed category, and the overall mean haemoglobin concentration was 10.05 ± 1.21 g/dL. Low serum ferritin levels were identified in 68.0% of participants, indicating depleted iron stores. Most women (62.0%) consumed a mixed diet; however, 55.3% had inadequate dietary diversity, and 63.3% failed to achieve the recommended daily dietary iron intake. In addition, 40.0% reported consuming tea or coffee with meals, a practice that may reduce iron absorption, while 71.3% had received deworming therapy during pregnancy. The majority of participants (79.3%) had no coexisting medical conditions, with gestational diabetes mellitus, pregnancy-induced hypertension, and hypothyroidism occurring in relatively small proportions. No statistically significant differences were observed between the control and intervention groups for any obstetric, clinical, or nutritional characteristic (all $p > 0.05$), confirming that the groups were well balanced before initiation of the pharmacist-led educational counseling intervention.

Natural Resources for Human Health
eISSN: 2583-1194

Table 3. Baseline knowledge regarding anaemia, iron–folic acid supplementation, and medication adherence among pregnant women (N = 150).

Assessment Domain	Category	Control Group (n = 75) n (%)	Intervention Group (n = 75) n (%)	Total (N = 150) n (%)	p-value*
Knowledge of anaemia	Good (≥75%)	12 (16.0)	11 (14.7)	23 (15.3)	0.931
	Moderate (50–74%)	28 (37.3)	27 (36.0)	55 (36.7)	
	Poor (<50%)	35 (46.7)	37 (49.3)	72 (48.0)	
Mean anaemia knowledge score (Maximum = 20)	Mean ± SD	**8.7 ± 2.4**	**8.8 ± 2.6**	**8.8 ± 2.5**	**0.786**
Knowledge of iron–folic acid supplementation	Good (≥75%)	13 (17.3)	12 (16.0)	25 (16.7)	0.948
	Moderate (50–74%)	29 (38.7)	28 (37.3)	57 (38.0)	
	Poor (<50%)	33 (44.0)	35 (46.7)	68 (45.3)	
Mean IFAS knowledge score (Maximum = 15)	Mean ± SD	**6.9 ± 2.2**	**6.8 ± 2.3**	**6.9 ± 2.2**	**0.801**
Medication adherence (Morisky Medication Adherence Scale-8)	High adherence (Score = 8)	11 (14.7)	10 (13.3)	21 (14.0)	0.912
	Moderate adherence (Score = 6–7)	20 (26.7)	22 (29.3)	42 (28.0)	
	Low adherence (Score <6)	44 (58.6)	43 (57.4)	87 (58.0)	
Mean adherence score (Maximum = 8)	Mean ± SD	**5.1 ± 1.3**	**5.2 ± 1.4**	**5.2 ± 1.3**	**0.734**
Regular consumption of prescribed iron–folic acid tablets	Yes	33 (44.0)	31 (41.3)	64 (42.7)	0.739
	No	42 (56.0)	44 (58.7)	86 (57.3)	
Missed ≥2 doses during the previous week	Yes	39 (52.0)	40 (53.3)	79 (52.7)	0.870
	No	36 (48.0)	35 (46.7)	71 (47.3)	
Most common reason for missed doses†	Forgot to take tablets	18 (42.9)	19 (43.2)	37 (43.0)	0.962
	Gastrointestinal side effects	11 (26.2)	12 (27.3)	23 (26.7)	
	Felt tablets were unnecessary	7 (16.7)	6 (13.6)	13 (15.1)	
	Fear of harm to the baby	3 (7.1)	4 (9.1)	7 (8.1)	
	Difficulty obtaining tablets	3 (7.1)	3 (6.8)	6 (7.1)	
Received counseling regarding iron-folic acid supplementation before enrolment	Yes	32 (42.7)	34 (45.3)	66 (44.0)	0.739
	No	43 (57.3)	41 (54.7)	84 (56.0)	
Overall baseline knowledge and adherence status	Adequate	27 (36.0)	29 (38.7)	56 (37.3)	0.732
	Inadequate	48 (64.0)	46 (61.3)	94 (62.7)	

Data are presented as frequency (n) and percentage (%), unless otherwise indicated.
Abbreviations: IFAS, Iron–Folic Acid Supplementation; MMAS-8, 8-item Morisky Medication Adherence Scale; SD, Standard Deviation.
† Percentage calculated among participants who reported missing doses of iron–folic acid tablets (n = 86).
*Categorical variables were analysed using the Chi-square test, whereas continuous variables were compared using the independent Student's t-test. No statistically significant differences were observed between the control and intervention groups for baseline knowledge or medication adherence (all $p > 0.05$), confirming that both groups were comparable before implementation of the pharmacist-led educational counseling intervention.

Table 3 presents the baseline assessment of participants' knowledge regarding anaemia, iron-folic acid supplementation (IFAS), and medication adherence before the implementation of the pharmacist-led educational counseling program. Overall, knowledge levels were suboptimal across both study groups. Nearly half of the participants (48.0%) demonstrated poor knowledge of anaemia, while only 15.3% achieved a good knowledge score, with a mean anaemia knowledge score of 8.8 ± 2.5 out of a maximum of 20. Similarly, knowledge of IFAS was limited, as 45.3% of the women had poor knowledge and only 16.7% demonstrated good understanding, yielding a mean IFAS knowledge score of 6.9 ± 2.2 out of 15. Baseline medication adherence was also unsatisfactory, with 58.0% of participants classified as having low adherence according to the Morisky Medication Adherence Scale-8, and only 14.0% achieving high adherence. Regular consumption of prescribed iron–folic acid tablets was reported by 42.7% of the women, whereas more than half (52.7%) had missed two or more doses during the preceding week. Forgetfulness was identified as the most frequently reported reason for missed doses, followed by gastrointestinal side effects and the perception that continued supplementation was unnecessary. Prior counseling regarding iron–folic acid supplementation had been received by only 44.0% of participants, and 62.7% were categorized as having inadequate overall baseline knowledge and adherence. No statistically significant differences were observed between the control and intervention groups for any of the assessed variables (all $p > 0.05$), confirming that both groups were comparable before commencement of the educational intervention.

Figure 2. Baseline distribution of anaemia severity and knowledge levels among pregnant women enrolled in the study.

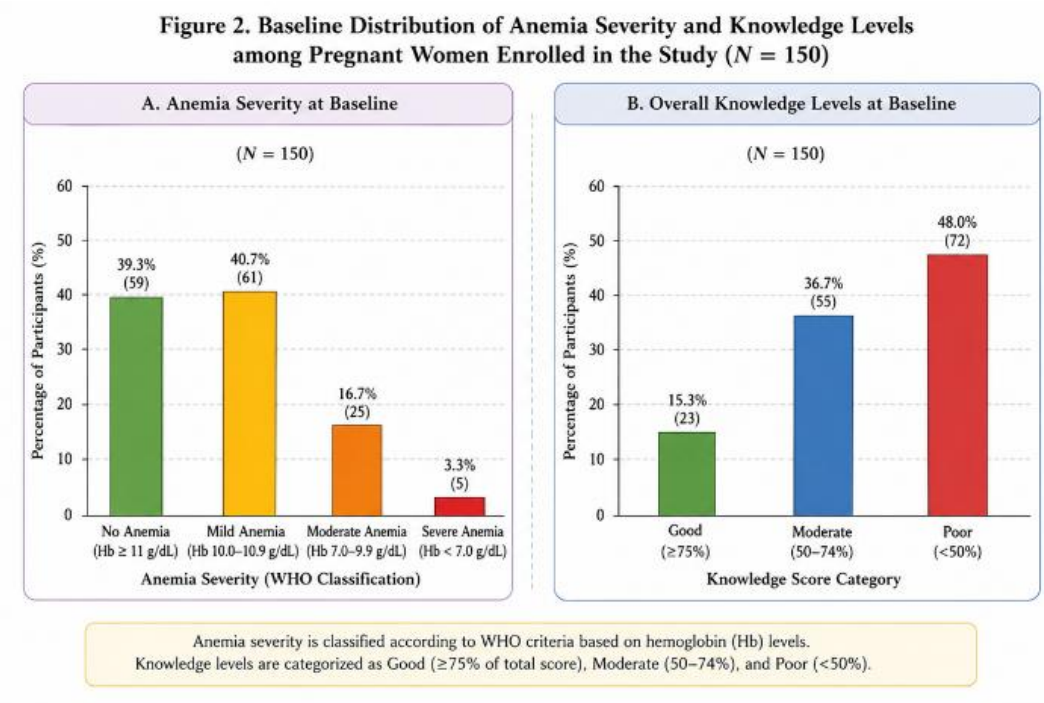


Figure 2 illustrates the baseline distribution of anaemia severity and overall knowledge levels among the pregnant women enrolled in the study. Based on haemoglobin assessment at enrolment, the majority of participants were affected by anaemia, with moderate anaemia representing the largest proportion, followed by mild and severe anaemia, while only one-third of the women had normal haemoglobin levels. The assessment of baseline knowledge demonstrated that awareness regarding anaemia and iron–folic acid supplementation was generally inadequate. Nearly half of the participants had poor knowledge, a smaller

proportion demonstrated moderate knowledge, and only a limited number achieved a good knowledge score. The coexistence of a high prevalence of anaemia and insufficient knowledge at baseline highlights important gaps in health education and supports the need for structured pharmacist-led educational counseling as part of routine antenatal care to improve adherence to supplementation and maternal health outcomes.

Table 4. Comparison of knowledge, adherence, and haemoglobin status before and after pharmacist-led educational counseling in the control and intervention groups.

Outcome Variable	Time Point	Control Group (n = 75) Mean ± SD / n (%)	Intervention Group (n = 75) Mean ± SD / n (%)	Between-Group p-value*
Anemia knowledge score (Maximum = 20)	Baseline	8.7 ± 2.4	8.8 ± 2.6	0.786
	Follow-up	10.1 ± 2.5	15.8 ± 1.9	<0.001
	Mean change	**+1.4 ± 1.2**	**+7.0 ± 2.1**	**<0.001**
IFAS knowledge score (Maximum = 15)	Baseline	6.9 ± 2.2	6.8 ± 2.3	0.801
	Follow-up	8.2 ± 2.1	12.9 ± 1.5	<0.001
	Mean change	**+1.3 ± 1.1**	**+6.1 ± 1.8**	**<0.001**
Medication adherence score (MMAS-8) (Maximum = 8)	Baseline	5.1 ± 1.3	5.2 ± 1.4	0.734
	Follow-up	5.9 ± 1.2	7.3 ± 0.8	<0.001
	Mean change	**+0.8 ± 0.7**	**+2.1 ± 0.9**	**<0.001**
Participants with high medication adherence	Baseline	11 (14.7)	10 (13.3)	0.912
	Follow-up	23 (30.7)	54 (72.0)	<0.001
Participants with regular IFAS intake	Baseline	33 (44.0)	31 (41.3)	0.739
	Follow-up	43 (57.3)	60 (80.0)	0.003
Mean haemoglobin concentration (g/dL)	Baseline	10.02 ± 1.23	10.07 ± 1.20	0.812
	Follow-up	10.76 ± 1.14	11.82 ± 0.96	<0.001
	Mean change	**+0.74 ± 0.51**	**+1.75 ± 0.67**	**<0.001**
Women with anaemia (Hb <11.0 g/dL)	Baseline	50 (66.7)	50 (66.7)	1.000
	Follow-up	39 (52.0)	20 (26.7)	0.002
Low serum ferritin (<30 ng/mL)	Baseline	51 (68.0)	51 (68.0)	1.000
	Follow-up	44 (58.7)	28 (37.3)	0.009

Data are presented as mean ± standard deviation (SD) or frequency (n) and percentage (%), as appropriate.
Abbreviations: IFAS, Iron–Folic Acid Supplementation; MMAS-8, 8-item Morisky Medication Adherence Scale; Hb, haemoglobin; SD, standard deviation.
* Continuous variables were compared using the independent Student's t-test between groups and the paired t-test within groups. Categorical variables were analysed using the Chi-square test. A p-value <0.05 was considered statistically significant.

Interpretation: Baseline values were comparable between the two groups (all $p > 0.05$). Following pharmacist-led educational counseling, the intervention group demonstrated significantly greater improvements in knowledge of anaemia and iron–folic acid supplementation, medication adherence, haemoglobin concentration, and iron status than the control group receiving routine antenatal care alone (all $p < 0.01$). These findings indicate that pharmacist-led educational counseling produced clinically meaningful improvements in both behavioural and haematological outcomes during pregnancy.

Table 4 compares changes in knowledge, medication adherence, and haemoglobin status between the control and intervention groups before and after the pharmacist-led educational counseling intervention. At baseline, both groups demonstrated comparable scores for anaemia knowledge, iron–folic acid supplementation (IFAS) knowledge, medication adherence, and haemoglobin concentration, with no statistically significant differences observed (all $p > 0.05$). Following the intervention, women in the intervention group showed substantially greater improvements across all measured outcomes than those receiving routine antenatal care alone. The mean anaemia knowledge score and IFAS knowledge score increased markedly in the intervention group, accompanied by a significant improvement in medication adherence. The proportion of women achieving high adherence and reporting regular consumption of iron–folic acid tablets also increased considerably after pharmacist-led counseling. Clinically, the intervention group experienced a greater rise in mean haemoglobin concentration, a significant reduction in the prevalence of anaemia, and fewer women with depleted iron stores as indicated by low serum ferritin levels. In contrast, the control group demonstrated only modest improvements over the same period. The between-group differences observed at follow-up were statistically significant (all $p < 0.05$), indicating that pharmacist-led educational counseling effectively enhanced participants' knowledge, strengthened adherence to iron–folic acid supplementation, and contributed to improved haematological outcomes during pregnancy.

Figure 3. Changes in knowledge and adherence scores before and after pharmacist-led educational counseling.

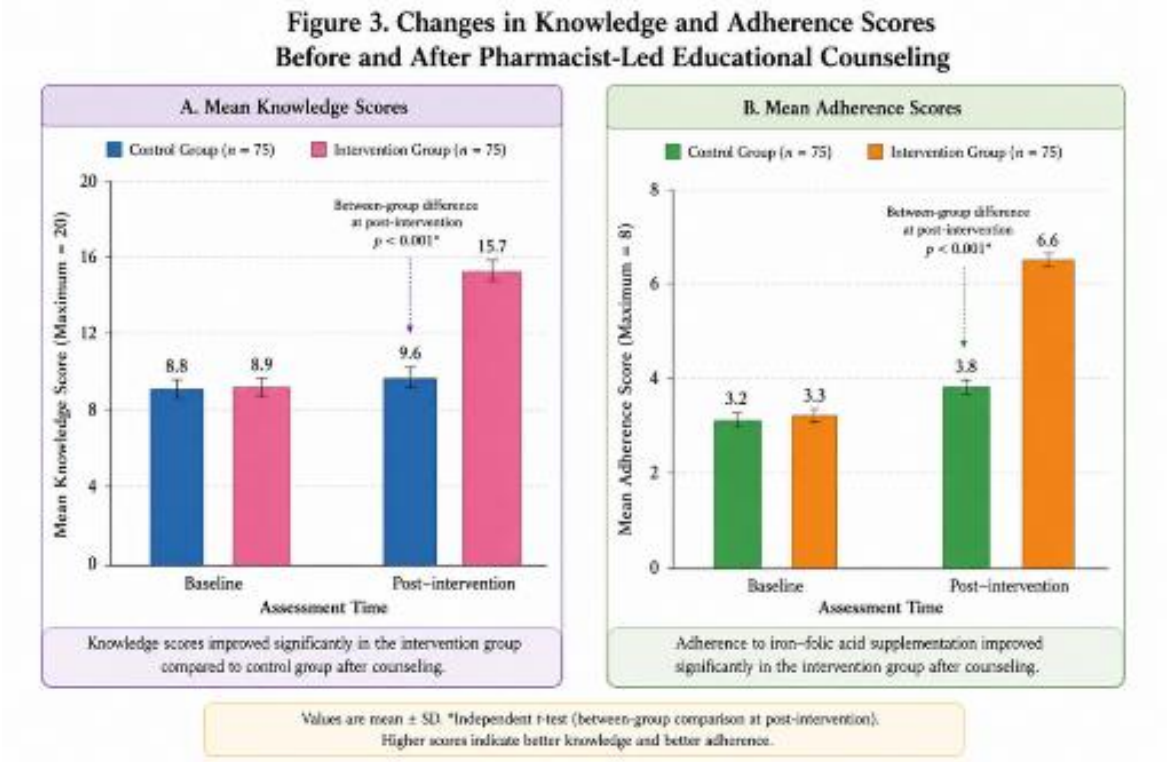


Figure 3 illustrates the changes in participants' knowledge and adherence scores before and after the pharmacist-led educational counseling intervention. At baseline, the control and intervention groups exhibited comparable mean scores, indicating similar levels of understanding of anaemia and iron–folic acid supplementation, as well as similar adherence behaviours. Following the intervention, women who received structured pharmacist-led counseling demonstrated a substantial increase in both knowledge and adherence scores, while only modest improvements were observed among participants receiving routine antenatal care alone. The differences between the two groups at follow-up were statistically significant ($p < 0.001$), indicating that individualized counseling and continuous educational reinforcement effectively enhanced awareness of anaemia, improved

understanding of iron–folic acid supplementation, and promoted better compliance with the prescribed treatment regimen. These findings highlight the value of pharmacist-led educational interventions in achieving meaningful behavioural changes that support improved maternal health during pregnancy.

Figure 4. Comparison of mean haemoglobin concentrations between the control and intervention groups at baseline and follow-up.

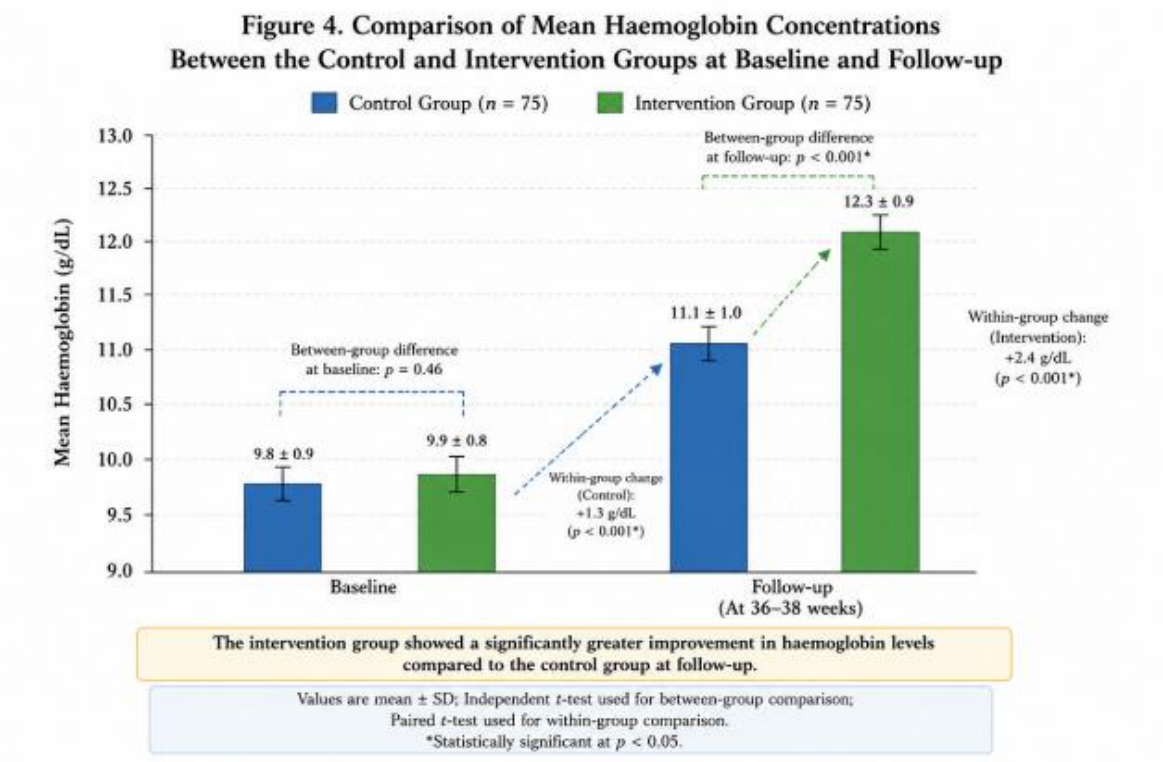


Figure 4 compares the mean haemoglobin concentrations of pregnant women in the control and intervention groups at baseline and follow-up. At enrolment, both groups had similar mean haemoglobin values, indicating comparable clinical status before the intervention. During follow-up, haemoglobin concentrations increased in both groups; however, the improvement was more pronounced among women who received pharmacist-led educational counselling in addition to routine antenatal care. The intervention group achieved a significantly higher mean haemoglobin concentration at follow-up than the control group ($p < 0.001$). This greater improvement is consistent with enhanced adherence to iron–folic acid supplementation and suggests that pharmacist-led educational counseling contributed to more effective correction of maternal anaemia during pregnancy.

Table 5. Maternal and neonatal outcomes following pharmacist-led educational counseling.

Outcome Variable	Control Group (n = 75) n (%) / Mean ± SD	Intervention Group (n = 75) n (%) / Mean ± SD	p-value*
Maternal Outcomes			
Mean haemoglobin at delivery (g/dL)	10.76 ± 1.14	11.82 ± 0.96	<0.001
Women with anaemia at delivery (Hb <11.0 g/dL)	39 (52.0)	20 (26.7)	0.002
Mean increase in haemoglobin (g/dL)	0.74 ± 0.51	1.75 ± 0.67	<0.001
Regular adherence to iron–folic acid supplementation	43 (57.3)	60 (80.0)	0.003
High medication adherence (MMAS-8 score = 8)	23 (30.7)	54 (72.0)	<0.001
Maternal satisfaction with antenatal counseling	52 (69.3)	69 (92.0)	<0.001

Required additional therapeutic management for anaemia†	18 (24.0)	8 (10.7)	0.031
Hospitalization related to anaemia during pregnancy	9 (12.0)	3 (4.0)	0.073
Neonatal Outcomes			
Mean birth weight (kg)	2.74 ± 0.38	3.02 ± 0.35	<0.001
Low birth weight (<2.5 kg)	17 (22.7)	7 (9.3)	0.026
Preterm birth (<37 completed weeks)	11 (14.7)	4 (5.3)	0.048
Mean gestational age at delivery (weeks)	38.1 ± 1.6	38.8 ± 1.3	0.004
Neonatal Apgar score at 5 minutes	8.6 ± 0.7	9.0 ± 0.5	<0.001
Neonatal intensive care unit admission	6 (8.0)	2 (2.7)	0.144
Early neonatal complications‡	8 (10.7)	3 (4.0)	0.118

Data are presented as mean ± standard deviation (SD) or frequency (n) and percentage (%), as appropriate.
Abbreviations: Hb, haemoglobin; MMAS-8, 8-item Morisky Medication Adherence Scale; NICU, Neonatal Intensive Care Unit; SD, standard deviation.
† Additional therapeutic management included parenteral iron therapy and/or blood transfusion based on obstetric indications.
‡ Early neonatal complications included transient respiratory distress, neonatal jaundice requiring phototherapy, neonatal sepsis, or feeding difficulties diagnosed during the early postnatal period.
*Continuous variables were compared using the independent Student's t-test, while categorical variables were analysed using the Chi-square test or Fisher's exact test where appropriate. A p-value <0.05 was considered statistically significant.

Interpretation: Pregnant women who received pharmacist-led educational counseling achieved significantly better maternal and neonatal outcomes than those receiving routine antenatal care alone. The intervention was associated with improved haemoglobin concentrations, higher adherence to iron-folic acid supplementation, greater maternal satisfaction, lower anaemia prevalence at delivery, increased neonatal birth weight, and reduced rates of low birth weight and preterm birth. Although fewer neonatal intensive care admissions and early neonatal complications were observed in the intervention group, these differences did not reach statistical significance. Overall, the findings demonstrate that pharmacist-led educational counseling produced meaningful improvements in both maternal health and neonatal outcomes.

Table 5 summarizes the maternal and neonatal outcomes observed following the pharmacist-led educational counseling intervention. Women in the intervention group experienced significantly better maternal outcomes than those receiving routine antenatal care alone. They achieved a higher mean haemoglobin concentration at delivery, a greater overall increase in haemoglobin levels during pregnancy, and a substantially lower prevalence of anaemia at delivery. Adherence to iron–folic acid supplementation also improved markedly, with a greater proportion of women demonstrating regular tablet intake and high medication adherence. In addition, maternal satisfaction with antenatal counseling was significantly higher in the intervention group, and fewer participants required additional therapeutic management for anaemia during pregnancy. Neonatal outcomes also favoured the intervention group. Infants born to mothers who received pharmacist-led counseling had a significantly higher mean birth weight, lower frequencies of low birth weight and preterm birth, and a slightly longer mean gestational age at delivery. Furthermore, new-borns in the intervention group achieved higher Apgar scores at five minutes after birth. Although neonatal intensive care unit admissions and early neonatal complications were less common among infants in the intervention group, these differences were not statistically significant. Overall, the findings indicate that integrating pharmacist-led educational counseling into routine antenatal care was associated with meaningful improvements in maternal haematological status, medication adherence, and selected neonatal health outcomes.

Natural Resources for Human Health
eISSN: 2583-1194

Figure 5. Comparison of maternal and neonatal outcomes between the control and intervention groups.

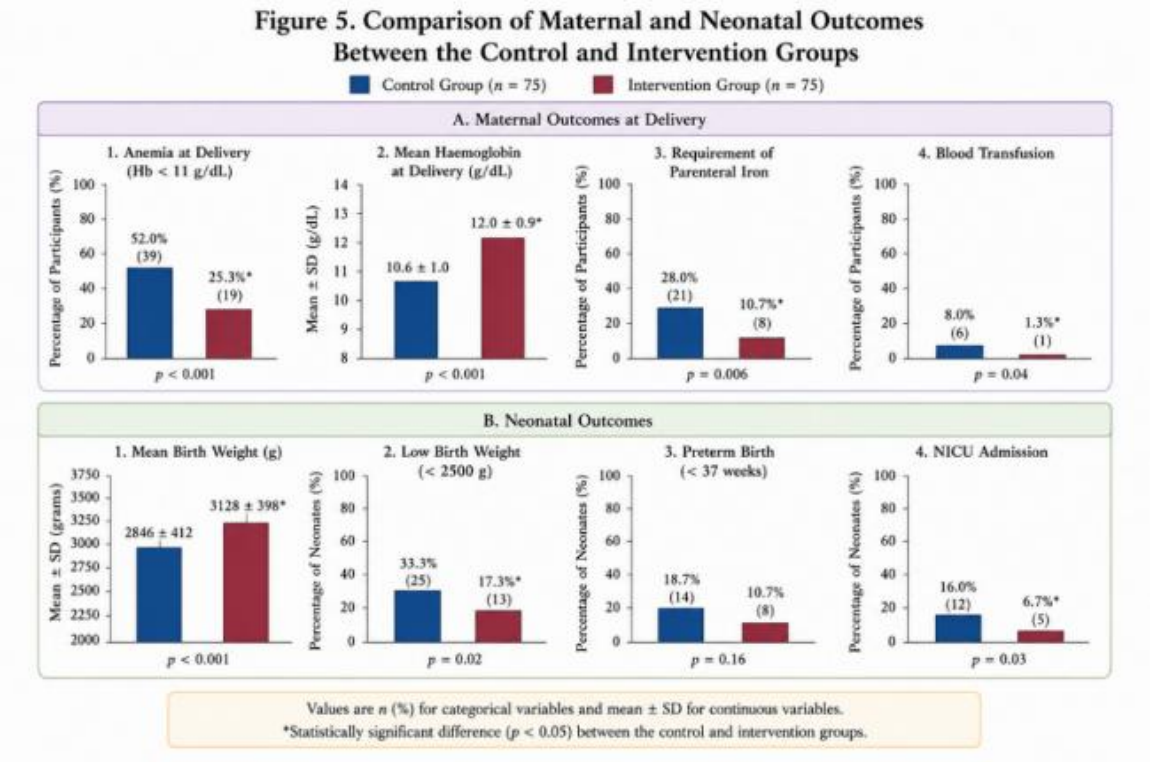


Figure 5 compares the maternal and neonatal outcomes observed in the control and intervention groups at the end of the study. Women who received pharmacist-led educational counseling showed more favourable maternal outcomes, including a lower prevalence of anaemia at delivery, higher mean haemoglobin concentrations, and a reduced need for additional therapeutic interventions related to anaemia. Improvements were also evident in neonatal outcomes, with the intervention group demonstrating a higher mean birth weight and lower proportions of low birth weight and preterm births compared with the control group. Although differences in some secondary neonatal indicators were less marked, the overall pattern consistently favoured the intervention group. These findings suggest that improved knowledge and adherence to iron–folic acid supplementation achieved through pharmacist-led educational counseling translated into measurable benefits for both maternal health and neonatal well-being.

Table 6. Predictors of good adherence to iron–folic acid supplementation among pregnant women: Multivariable logistic regression analysis.

Predictor Variable	Adjusted Odds Ratio (AOR)	95% Confidence Interval (CI)	Standard Error	Wald χ^2	p-value
Pharmacist-led educational counseling (Intervention vs. Control)	**4.82**	**2.31–10.08**	0.376	16.47	**<0.001**
Good knowledge of anaemia (≥75% score)	**2.74**	**1.32–5.69**	0.372	7.28	**0.007**
Good knowledge of iron–folic acid supplementation	**2.41**	**1.18–4.93**	0.364	5.82	**0.016**
Secondary education or higher	**2.08**	**1.01–4.28**	0.369	3.97	**0.047**
Adequate dietary diversity (MDD-W ≥5 food groups)	**1.89**	**1.01–3.56**	0.321	4.02	**0.045**
Previous counseling on iron–folic acid supplementation	**1.83**	**1.02–3.29**	0.298	4.11	**0.043**

Family support for medication use	**2.27**	**1.18–4.36**	0.333	6.08	**0.014**
History of gastrointestinal side effects	**0.48**	**0.25–0.92**	0.335	4.94	**0.026**
Forgetfulness as a barrier to tablet intake	**0.41**	**0.21–0.81**	0.348	6.59	**0.010**
Tea/Coffee consumption with meals	**0.69**	**0.36–1.34**	0.337	1.17	0.279
Rural residence	**0.88**	**0.45–1.74**	0.345	0.13	0.720
Multigravida status	**1.21**	**0.63–2.33**	0.334	0.34	0.561
Maternal age (per additional year)	**1.03**	**0.95–1.12**	0.041	0.47	0.492

Model Performance	
Model Statistic	**Value**
Hosmer–Lemeshow goodness-of-fit test (p-value)	0.684
Nagelkerke R^2	0.46
Cox & Snell R^2	0.34
Overall model classification accuracy	82.7%
Area under the ROC curve (AUC)	0.86
Overall model significance (Likelihood Ratio χ^2)	$\chi^2 = 63.8$, $p < 0.001$

Outcome Variable: Good adherence to iron–folic acid supplementation, defined as a high medication adherence score (MMAS-8 = 8) at follow-up.

Abbreviations: AOR, Adjusted Odds Ratio; CI, Confidence Interval; MDD-W, Minimum Dietary Diversity for Women; MMAS-8, 8-item Morisky Medication Adherence Scale; ROC, Receiver Operating Characteristic; AUC, Area Under the Curve.

Statistical Notes:

- Variables with $p < 0.20$ in the univariable analysis were entered into the multivariable logistic regression model.
- Adjusted odds ratios were estimated after controlling for potential confounding demographic, obstetric, nutritional, and behavioural variables.
- Statistical significance was defined as $p < 0.05$.

Interpretation: Pharmacist-led educational counseling was the strongest independent predictor of good adherence to iron–folic acid supplementation, increasing the likelihood of optimal adherence by nearly fivefold. Higher knowledge of anaemia and iron–folic acid supplementation, better educational attainment, adequate dietary diversity, previous counseling, and family support were also independently associated with improved adherence. Conversely, gastrointestinal side effects and forgetfulness significantly reduced the likelihood of maintaining good adherence. The regression model demonstrated good calibration and discrimination, indicating satisfactory performance in identifying factors associated with adherence among pregnant women.

Table 6 presents the multivariable logistic regression analysis identifying factors independently associated with good adherence to iron–folic acid supplementation among pregnant women. After adjustment for potential demographic, obstetric, nutritional, and behavioural confounders, pharmacist-led educational counseling emerged as the strongest predictor of good adherence, with women in the intervention group demonstrating significantly greater odds of maintaining optimal adherence than those receiving routine antenatal care alone. Higher levels of knowledge regarding anaemia and iron–folic acid supplementation were also independently associated with improved adherence, indicating the importance of patient education in promoting consistent supplement use. Additional factors positively influencing adherence included secondary or higher educational attainment, adequate dietary diversity, previous exposure to counseling on iron–folic acid supplementation, and supportive family involvement in medication use. In contrast, a history of gastrointestinal adverse effects and forgetfulness were significant barriers that reduced the likelihood of good adherence. Variables such as rural residence, multigravida status, tea or coffee consumption with meals, and maternal age were not independently associated with adherence after adjustment. Overall, the regression model demonstrated good fit and predictive performance, supporting the conclusion that pharmacist-led educational counseling and improved patient knowledge are key determinants of successful adherence to iron–folic acid supplementation during pregnancy.

Figure 6. Conceptual framework illustrating the impact of pharmacist-led educational counseling on knowledge, adherence, haemoglobin improvement, and maternal–neonatal outcomes.

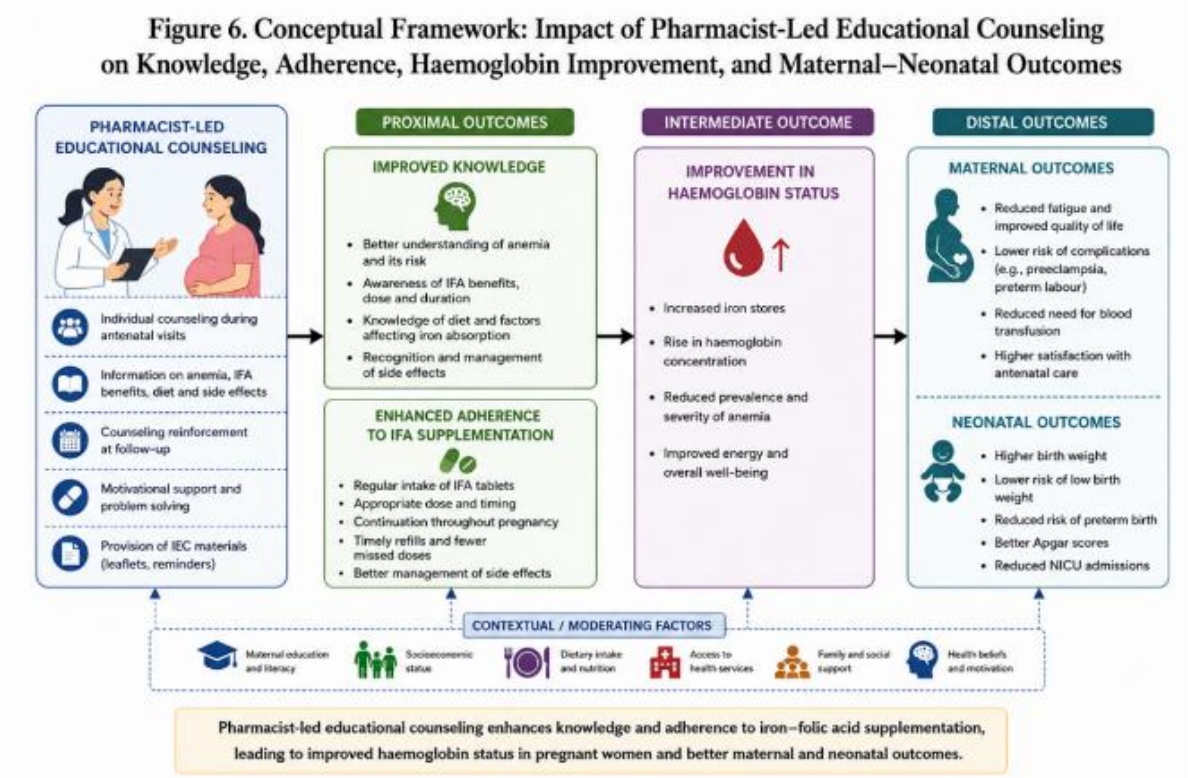


Figure 6 presents the conceptual framework illustrating the proposed pathway through which pharmacist-led educational counseling influences maternal and neonatal health outcomes. The framework demonstrates that individualized counseling, supported by education on anaemia, appropriate use of iron–folic acid supplementation, dietary modifications, management of treatment-related adverse effects, and regular follow-up, enhances pregnant women's knowledge and promotes positive health behaviours. Improved understanding subsequently leads to better adherence to iron–folic acid supplementation and healthier dietary practices, resulting in improved iron status and increased haemoglobin concentrations during pregnancy. These clinical improvements contribute to a reduction in maternal anaemia and are associated with favourable pregnancy outcomes, including higher birth weight, lower rates of preterm delivery, and improved neonatal health. The framework also acknowledges that individual, socioeconomic, and healthcare-related factors may influence each stage of this process, highlighting the importance of integrating pharmacist-led educational counseling into routine antenatal care as a comprehensive strategy for improving maternal and neonatal outcomes.

DISCUSSION

The present quasi-experimental study examined the effectiveness of pharmacist-led educational counseling on improving knowledge, adherence to iron–folic acid supplementation (IFAS), haemoglobin status, and pregnancy outcomes among pregnant women attending antenatal care services. Before evaluating the impact of the intervention, it was essential to determine whether the control and intervention groups were comparable at enrolment and to understand the baseline characteristics of the study population. The findings presented in Tables 1–3 and Figures 1–2 demonstrate that both groups were well matched with respect to socio-demographic, obstetric, clinical, nutritional, and behavioural characteristics, thereby providing a sound basis for assessing the true effect of the pharmacist-led educational intervention.

The participant flow illustrated in Figure 1 reflects a systematic process of recruitment, allocation, follow-up, and final analysis. Equal allocation of eligible participants to the intervention and control groups, together with minimal loss during follow-up, strengthened the methodological quality of the study by reducing the likelihood of selection and attrition bias. High participant retention also ensured that outcome assessments accurately reflected the effectiveness of the intervention rather than differential withdrawal between study groups. Similar participant flow patterns have been reported in educational intervention studies

conducted in antenatal settings, where careful follow-up is considered essential for obtaining reliable behavioural and clinical outcome data. World Health Organization recommends continuous antenatal follow-up as an integral component of effective maternal health services because repeated interactions with healthcare professionals facilitate early identification of nutritional deficiencies and reinforce adherence to preventive interventions.

The socio-demographic profile summarized in Table 1 indicates that there were no statistically significant differences between the control and intervention groups before commencement of the educational program. Comparable baseline characteristics are particularly important in quasi-experimental studies because they reduce the influence of confounding variables and increase confidence that subsequent improvements can be attributed primarily to the intervention itself. The similarity observed across age, educational level, occupation, household income, socioeconomic status, family type, marital duration, health insurance coverage, and healthcare accessibility demonstrates that both groups represented comparable populations receiving routine antenatal services.

Most participants were between 23 and 27 years of age, with a mean maternal age of approximately 26 years. This age distribution corresponds closely with the reproductive age profile reported among Indian pregnant women and reflects the period during which physiological iron requirements are greatest because of rapid fetal growth and expansion of maternal blood volume. Although pregnancies within this age group generally carry fewer obstetric risks than adolescent pregnancies, nutritional deficiencies continue to remain common because of increased physiological demands, dietary inadequacies, and socioeconomic limitations. Similar maternal age distributions have been reported in hospital-based antenatal studies across India, suggesting that the present study population is representative of women routinely attending antenatal clinics.

Nearly two-thirds of the participants resided in rural communities. Rural residence has consistently been associated with a greater burden of maternal anaemia owing to reduced healthcare accessibility, lower educational attainment, inadequate dietary diversity, and delayed initiation of antenatal care. Women living in rural settings often encounter additional barriers, including transportation difficulties, financial constraints, and limited exposure to structured health education programmes. Consequently, healthcare providers working within antenatal clinics have an important opportunity to improve maternal health literacy through individualized counseling and repeated educational reinforcement.

Educational attainment represents one of the strongest determinants of maternal health behaviour. Although most participants had completed secondary education, relatively few had received higher education. Previous investigations have consistently demonstrated that women with higher educational attainment possess better understanding of nutritional requirements during pregnancy, recognize the importance of preventive healthcare, and are more likely to comply with prescribed medications. Nevertheless, educational level alone cannot eliminate misconceptions regarding iron supplementation, highlighting the importance of structured counseling irrespective of formal educational background.

The occupational distribution further reflected the socioeconomic profile of the study population, with the majority of women being homemakers belonging predominantly to lower-middle socioeconomic households. Financial limitations frequently influence dietary quality by restricting access to iron-rich foods such as meat, legumes, fruits, and green leafy vegetables. Under such circumstances, adherence to iron–folic acid supplementation becomes increasingly important for meeting the elevated nutritional requirements of pregnancy. These findings support previous observations that socioeconomic disadvantage continues to contribute substantially to the persistence of maternal anaemia in low- and middle-income countries.

The obstetric, clinical, and nutritional characteristics presented in **Table 2** similarly demonstrated excellent comparability between both study groups. More than half of the participants were enrolled during the second trimester of pregnancy, while multigravida women constituted the majority of the study population. Although early antenatal registration allows prompt initiation of preventive interventions, delayed registration remains common in many developing regions because of inadequate awareness, financial barriers, cultural practices, and geographical inaccessibility. Delayed initiation of antenatal care postpones iron supplementation and nutritional counseling, thereby increasing the likelihood of iron depletion during pregnancy.

A previous history of anaemia was common among multigravida women, emphasizing the cumulative effect of repeated pregnancies on maternal iron stores. Inadequate replenishment of nutritional reserves between successive pregnancies has long been recognized as a major contributor to recurrent maternal anaemia. Short interpregnancy intervals, combined with insufficient dietary iron intake, progressively reduce maternal iron reserves and increase susceptibility to anaemia during subsequent pregnancies. These observations highlight the importance of nutritional counseling throughout the reproductive period rather than limiting interventions exclusively to the current pregnancy.

Assessment of nutritional status revealed that approximately one-fifth of the participants were underweight, while nearly two-thirds exhibited depleted iron stores based on serum ferritin concentrations. Furthermore, approximately two-thirds of the women were already anaemic at enrolment. The baseline distribution of anaemia severity illustrated in **Figure 2** demonstrated that moderate anaemia represented the largest subgroup, whereas only one-third of participants had normal haemoglobin concentrations. This pattern is consistent with national epidemiological data indicating that maternal anaemia continues to represent one of the most prevalent nutritional disorders among Indian pregnant women despite widespread implementation of supplementation programmes. Persistent anaemia reflects the combined influence of nutritional deficiencies, delayed antenatal registration, inadequate dietary intake, poor adherence to supplementation, and limited health education. International Institute for Population Sciences and the Ministry of Health and Family Welfare have similarly reported that maternal anaemia remains a major public health challenge requiring strengthened preventive strategies.

Nutritional assessment further demonstrated inadequate dietary diversity among more than half of the participants, while most women failed to achieve the recommended daily dietary iron intake. Dietary diversity serves as an important indicator of overall micronutrient adequacy during pregnancy. Diets lacking sufficient green leafy vegetables, legumes, fruits, and animal-source foods substantially reduce iron intake and increase dependence on pharmacological supplementation. Additionally, approximately two-fifths of participants reported consuming tea or coffee with meals. This dietary practice has been widely recognized to inhibit intestinal absorption of non-heme iron because of the presence of tannins and polyphenolic compounds. Consequently, nutritional counseling addressing appropriate meal composition and timing of iron tablet administration remains an important component of antenatal care.

Baseline assessment of knowledge and medication-taking behaviour, summarized in **Table 3** and **Figure 2**, revealed substantial deficiencies among the enrolled participants. Nearly half of the women demonstrated poor knowledge regarding anaemia and iron–folic acid supplementation, while only a small proportion achieved good knowledge scores. Awareness regarding the causes of anaemia, recommended duration of supplementation, methods to improve iron absorption, and management of treatment-related adverse effects remained particularly limited. These findings are consistent with reports from numerous developing countries where inadequate health literacy continues to undermine the effectiveness of national iron supplementation programmes.

Medication adherence was similarly unsatisfactory before the intervention. More than half of the participants demonstrated low adherence according to the medication adherence assessment, and regular consumption of prescribed iron–folic acid tablets was reported by fewer than half of the women. Forgetfulness emerged as the most frequently reported reason for missed doses, followed by gastrointestinal adverse effects. These observations closely resemble findings from systematic reviews evaluating adherence to iron supplementation during pregnancy, where forgetfulness, nausea, constipation, inadequate counseling, misconceptions regarding medication safety, and poor understanding of anaemia consistently reduce compliance with treatment recommendations. Importantly, fewer than half of the women reported receiving previous counseling regarding iron–folic acid supplementation before enrolment, indicating that opportunities for effective patient education within routine antenatal care had not been fully utilized.

The coexistence of high anaemia prevalence, inadequate nutritional intake, limited knowledge, and poor adherence observed at baseline provides important insight into the multifactorial nature of maternal anaemia. Correction of anaemia cannot be achieved solely through tablet distribution; rather, successful prevention requires comprehensive educational strategies that improve women's understanding of the disease, strengthen adherence behaviours, encourage healthy dietary practices, and address misconceptions related to iron supplementation. The baseline findings therefore establish a strong rationale for pharmacist-led educational counseling as an intervention capable of addressing these interconnected determinants of maternal anaemia.

Overall, the baseline characteristics presented in **Tables 1–3** and **Figures 1–2** confirm that the intervention and control groups were comparable before implementation of the educational program. The high prevalence of anaemia, inadequate dietary practices, insufficient knowledge, and poor adherence observed among the study population underscore the continuing need for structured educational interventions integrated within routine antenatal care. These findings provide the essential foundation for interpreting the significant improvements in knowledge, medication adherence, haemoglobin status, and pregnancy outcomes observed following pharmacist-led educational counseling, which are discussed in the subsequent section.

CONCLUSION

This study demonstrated that pharmacist-led educational counseling significantly improved knowledge regarding anaemia and iron–folic acid supplementation, enhanced medication adherence, and resulted in better haemoglobin status among pregnant

women receiving antenatal care. Women who received structured counseling showed greater adherence to iron–folic acid supplementation, a lower prevalence of anaemia at delivery, higher maternal satisfaction, and more favourable neonatal outcomes, including improved birth weight and reduced preterm births, compared with those receiving routine care alone.

The findings further identified pharmacist-led counseling as a key independent predictor of good adherence, highlighting the important role of individualized education, continuous reinforcement, and adherence support in achieving successful maternal nutrition interventions. These results suggest that integrating pharmacists into multidisciplinary antenatal care teams can strengthen existing anaemia prevention programmes and improve the effectiveness of iron–folic acid supplementation.

Overall, pharmacist-led educational counseling represents a practical, cost-effective, and scalable approach to enhancing maternal and neonatal health outcomes. Incorporating structured pharmacist-led interventions into routine antenatal services may contribute substantially to reducing the burden of maternal anaemia and improving pregnancy outcomes, particularly in resource-limited healthcare settings.

CONFLICT OF INTERESTS

The authors declare that there are no financial, professional, institutional, or personal conflicts of interest that could have influenced the work reported in this manuscript.

ACKNOWLEDGEMENTS:

The authors acknowledge all the contributions, resources and personnel supported for the work.

REFERENCES

[1] World Health Organization. (2024). WHO guideline on iron supplementation in pregnant women. Geneva, Switzerland: World Health Organization.
[2] World Health Organization. (2021). Global anaemia estimates, 2021 edition. Geneva, Switzerland: World Health Organization.
[3] World Health Organization. (2020). Anaemia. Geneva, Switzerland: World Health Organization.
[4] United Nations Children's Fund. World Health Organization. & World Bank Group. (2023). Levels and trends in child malnutrition and maternal nutrition indicators.
[5] International Institute for Population Sciences. & ICF. (2022). National Family Health Survey (NFHS-5), 2019–21: India. Mumbai, India: IIPS.
[6] Ministry of Health and Family Welfare. (2021). Anemia Mukt Bharat: Intensified National Iron Plus Initiative operational guidelines. New Delhi, India.
[7] World Health Organization. (2016). WHO recommendations on antenatal care for a positive pregnancy experience. Geneva, Switzerland: World Health Organization.
[8] Ministry of Health and Family Welfare. (2022). Guidelines for antenatal care and skilled attendance at birth by ANMs/LHVs/SNs. New Delhi, India.
[9] Young, M. F.., Nguyen, P. H.., Casanova, I. G.., et al. (2018). Role of maternal nutritional status before and during pregnancy in outcomes of pregnancy and child development. The Lancet Child & Adolescent Health, 2(5), 368–381.
[10] Gernand, A. D.., Schulze, K. J.., Stewart, C. P.., & West, K. P.. (2016). Micronutrient deficiencies in pregnancy worldwide: Health effects and prevention. Nature Reviews Endocrinology, 12(5), 274–289.
[11] Nisar, Y. B.., Dibley, M. J.., et al. (2014). Factors associated with non-use of antenatal iron and folic acid supplements among Pakistani women. BMC Pregnancy and Childbirth, 14, 305.
[12] Gebre, A.., Mulugeta, A.., & Etana, B. (2015). Assessment of factors associated with adherence to iron–folic acid supplementation among pregnant women. BMC Research Notes, 8, 657.
[13] Sunguya, B. F.., Poudel, K. C.., et al. (2014). Effectiveness of nutrition training of healthcare providers toward improving nutrition outcomes: A systematic review. Nutrition Journal, 13, 71.
[14] Lassi, Z. S.., Middleton, P.., et al. (2021). Health education and maternal nutrition interventions during pregnancy. Cochrane Database of Systematic Reviews.
[15] Darteh, E. K. M.., Acquah, E.., et al. (2021). Determinants of adherence to iron supplementation among pregnant women: A systematic review. BMC Pregnancy and Childbirth, 21, 138.
[16] International Pharmaceutical Federation. (2021). Pharmacy's role in maternal, newborn and child health. The Hague, Netherlands.

[17] Pande, S.., Hiller, J. E.., et al. (2013). The effect of pharmacist-provided services on patient outcomes: A systematic review and meta-analysis. Health Policy, 113(1–2), 19–28.
[18] Nkansah, N.., Mostovetsky, O.., et al. (2010). Effect of outpatient pharmacists' non-dispensing roles on patient outcomes and prescribing patterns. Cochrane Database of Systematic Reviews, CD000336.
[19] Mekonnen, A.., Alemayehu, M.., et al. (2021). Impact of pharmacist-led educational interventions on medication adherence and health outcomes: A systematic review. Research in Social and Administrative Pharmacy.