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Does Mobile Phone Tele-Reminder Increased Iron Status and Diet Quality of Pregnant Women Availing Antenatal Care Services at Phebe and Charles B. Dunbar Hospitals Bong County, Liberia A Cluster Randomized Control Trial

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ABSTRACT

Anemia in pregnancy is a serious public health problem in Liberia. This study aimed to assess the effect of mobile phone tele-reminder on the iron status and diet quality of pregnant women in Liberia. A two-arm, double-blinded cluster randomized control trial was conducted in this study, with ANC screening rooms as a unit of randomization. At the Phebe and Charles B. Dunbar hospitals in Bong County, Liberia, 150 pregnant women who had never previously attended an ANC were recruited for the study (75 intervention women and 75 control women). Iron status measured as hemoglobin (g/dl) and diet quality were primary outcomes of this study. Secondary outcome measures were adherence to daily iron and folic acid supplementation and prevalence of anemia among pregnant women with malaria infection. The analysis was an intent-to-treat. The effect of the intervention on the primary study outcome (iron status) was examined using an independent sample t-test (for group-level analysis). Effects of treatment on diet quality was measured using the Fisher's Exact Test. A binary logistic regression with a 95% Confidence Interval (CI) was used to analyze the effect of treatment on secondary outcomes. Pregnant women assigned to the intervention group had a significantly greater mean hemoglobin level after the two interventions, t (2.4) = 447, $p<0.05$; d = 0.23). In the intervention group, there were significant odds in the consumption of 2-3 fish/meat/poultry products compared to the control group (93% versus 83%, adjusted odds ratio, 2.93; 95% CI, 0.99-8.70). A trend towards adherence to the IFA supplementation and an increase in consumption of iron-rich foods was observed. In Liberia, mobile phone tele-reminders appeared to be effective in improving iron status, diet quality, and IFA supplementation adherence when integrated into an existing antenatal care protocol.

INTRODUCTION

One of the most life-threatening dietary and health-related concerns is anemia in pregnancy. The World Health Organization (2001) defined anemia in pregnancy as hemoglobin less than 11 g/dl, while iron deficiency anemia (IDA) was characterized as serum ferritin <12 ug/L, with a hemoglobin level of less than 11 g/L and a hematocrit level of less than 33% (Center for Disease Control and Prevention, 1998 and World Health Organization, 2001). In many developing countries, anemia in pregnancy is a major health problem associated with maternal and perinatal mortality, premature deliveries, low birth weight, and other adverse outcomes (Mahomed & Hytten, 1989). It is estimated that only 15% of pregnant women in developed countries suffer from anemia (WHO, 1993). Approximately 35%-75% of pregnant women in developing countries are anemic (van den Broek *et al*., 2000, Ogunbode 2003). In pregnancy, iron deficiency is the most common cause of anemia (Van den Broke *et al*., 2000). Predisposing factors of anemia in pregnancy, include grand multiparity, low socioeconomic status, malaria infestation, late booking, HIV infection, and inadequate child spacing (Adinma *et al*., 2002, Van den Broek *et al*., 2000). Poor nutrition, iron deficiency, micronutrient deficiencies (folic acid, vitamin A, and vitamin B12 deficiency), diseases (malaria, hookworm infestation, schistosomiasis, HIV infection), and genetically inherited hemoglobinopathies (thalassemia) are all linked to iron deficiency anemia in pregnancy (Di Renzo *et al*, 2015). With antenatal care, maternal deaths can be reduced, and protecting the lives of pregnant women and their unborn children can be achieved (Carroli, Rooney, & Villar, 2001).

LITERATURE REVIEW

Anemia Situation in Liberia

Anemia is a major concern among pregnant women, leading to increased maternal mortality and poor birth outcomes as well as reductions in work productivity. Anemia in pregnancy has become a serious health and nutritional problem. Pregnant women (52%) are more likely than their breastfeeding counterparts (48%) and non-breastfeeding/non-pregnant (43%) to suffer from anemia. About 45 percent of women in Liberia suffer from anemia, according to a study from the Demography and Health Survey (2019-2020). Only 43% of expectant mothers took iron supplements for at least 90 days. About 64% of pregnant women took deworming drugs. Six percent (6%) of pregnant women did not take an iron supplement (LDHS 2019). Due to an increase in blood volume during pregnancy, women are more likely to develop anemia. Due to an increased risk of blood loss during labor, early delivery, low birth weight, and perinatal mortality, severe anemia can be dangerous for

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both the mother and the child. Pregnant women are advised to consume iron-rich foods, take iron-folate supplements, and practice good sanitation and hygiene to avoid intestinal worms, in order to prevent anemia.

Causes of Anemia in Pregnancy

The main causes of anemia during pregnancy are nutritional deficiencies, bacterial, parasitic, and inborn red blood cell disorders like thalassemia. Micronutrient deficiencies such as those in folic acid, vitamin A, and vitamin B12, and HIV infection can cause anemia in pregnancy (Breymann, 2015; Di Renzo *et al*., 2015). Additional factors associated with anemia during pregnancy include gestational age at the first prenatal, educational status, and antenatal intake of iron pills (Chotnopparatpattara *et al*., 2003, Suega *et al*., 2002). Non-compliance to antenatal care services is key challenging factor in combating anemia in pregnancy (Mithra *et al*., 2014).

Diet and Anemia in Pregnancy

In low-income countries, pregnant women need continual dietary counseling because their diets are both poor in vitamins, minerals, and other essential nutrients that can improve the level of iron. Plant sources of iron have low bioavailability, according to Allen and Gillespie (2001) (only 2-5 percent of iron absorbed). Failure to take dark green leafy vegetables and inadequate consumption of chicken is determinants of anemia in pregnancy (Tadesse *et al*, 2017). In low-income countries, diets are high in protein, vitamins, and minerals which are too expensive for many families. Nutritional anemia occurs when the daily intake of key micronutrients is insufficient, resulting in the body being unable to fulfill the physiological needs of growth, maintenance, or loss (Gleason *et al*, 2007). Poor diet, suboptimum ANC, and being underweight were associated with moderate and severe anemia (Agbozo *et al*., 2020). Ages of the mothers, counseling on the iron-folate supplement, knowledge of anemia, knowledge of iron-folate supplement, and frequency of ANC visits were found to be significantly associated factors of compliance with iron-folate supplementation during pregnancy (Arega, Abebe, & Aman 2015). Anemia has been linked to postpartum hemorrhage, premature labor, low birth weight, small for gestational age newborns, and perinatal death (Sifakis & Pharmakides, 2000; Smith *et al*, 2019). Work productivity has been discovered to be affected by iron deficiency anemia, which could result in a loss of 1.3 percent of GDP (Plessow *et al*, 2015).

Effects of Mobile Phone Technology on Anemia Prevention in Pregnancy

There is no research on how mobile phones can improve iron status and diet quality of pregnant women in Sub-Saharan Africa, of which Liberia is a part. However, mobile phone use in health care settings has been shown to reduce maternal death from anemia in recent studies. However, In Africa, more than 600 million people own a cell phone. To strengthen healthcare systems, mobile phones are becoming increasingly important (Howitt *et al*, 2012). In clinical settings, mobile phone use increases ANC visits and improves early recognition of pregnancy-related situations (Lund *et al*, 2014). Pregnant women who utilized mobile phones utilized antenatal care services and professional delivery services more than those who did not (Tang *et al*, 2019). Pregnant women feel more confident about seeking medical care during pregnancy and childbirth and recognizing signs of illness in their newborns with teleconsultation (Entsieh *et al*., 2015). Women who received the SMS every week were more likely to attend eight ANC visits compared to those who did not (Osanyin *et al*, 2022). Women who utilized mobile phones were more likely to use iron tablets and attend ANC in a randomized controlled trial conducted by Bangal *et al*, (2017). Using mobile phones to send short message services on focused antenatal care (FANC) has positive effects on the uptake of focused antenatal care among pregnant women in middle and low-income countries (Wagnew *et al*., 2018).

METHODOLOGY

Design

This study was three months, two-arm double-blinded cluster randomized controlled trial conducted in two major referral hospitals. The study took place from May 2022 to August 2022 at the Phebe and Charles B. Dunbar hospitals, Bong County, Republic of Liberia. The antenatal care screening rooms with assigned midwives, caring for pregnant women who avail antenatal care services were the units of randomization. A cluster randomized control trial randomizes groups of participants rather than individuals to each treatment arm. Each of the selected hospitals has three active and functional screening rooms for pregnant women. Trained midwives provide all antenatal care in the screening rooms. This study considered each screen room as a cluster. There were two intervention groups (control and experimental) in these two arms trials. We adopted a cluster randomized controlled trial because there was a possibility that pregnant women receiving antenatal care at the Phebe Hospital would be close relatives of pregnant women receiving antenatal care at the Charles B. Dunbar Hospital. There was a risk of contamination within and between clusters due to this relatedness. The cluster randomized control trial minimizes the risk of contamination.

Ethical Consideration

This study was approved by the Research Ethics Board of the University of the Philippines Los Banos. The administration of the Phebe Hospital also provided ethical clearance for the conduct of this study. The trial is registered In Pan African Clinical Trial Registry (PACTR202204658979734).

Clustering and Randomization

The randomization units were antenatal care screening

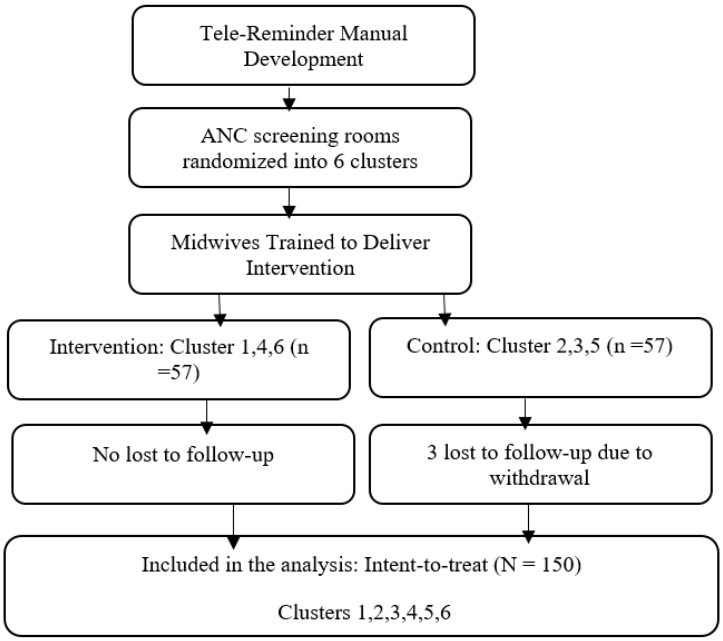

Figure 1: Operationalization of the Study

rooms with licensed midwives. In cluster randomized controlled trials, the groups are randomized, rather than the individual participants. In each of these hospitals, there were three screening rooms dedicated solely to providing ANC to pregnant women. Each screening room was considered a cluster by the researcher in this study. There were three clusters at Phebe Hospital referred to as 1, 2, and 3, while there were three clusters at Charles B. Dunbar Hospital referred to as 4, 5, and 6. A team of midwives administered ANC to six clusters of pregnant women receiving ANC for the first time. In clinical research, randomization refers to the assignment of study participants to either a treatment group or a control group solely by chance. The six screening rooms (six clusters) were randomized into an intervention (clusters 1,4, & 6) and a control group (clusters 2,3, & 5).

Setting

The study was conducted in Phebe and the Charles B. Dunbar hospitals. In Liberia, the two hospitals are located in Bong County, which is a centrally located county. In 1964, Bong County was established. In terms of area and population, Bong County ranks third in Liberia. One of 15 counties that comprise the first level of administrative division in the nation, Bong County has twelve districts. Lofa and Gbarpolu counties border it on the north, Margibi and Montserrado counties on the west, Grand Bassa County on the south, and Nimba County on the east. In addition to rice production, the county once became known as the food basket of Liberia. Cocoa, coffee, rubber, and palms are also grown in the county.

In rural Liberia, Phebe Hospital provides health care to about 450,000 people. In 1921, the Lutheran Church co-founded the hospital. Through the national budget, the government has funded the hospital for years. Charles B. Dunbar Hospital is the only hospital in central Liberia that specializes in maternity care.

Participants

Hospitals and individual levels of analysis were considered in this cluster randomized control trial. For this study, hospitals with the highest attendance at antenatal care-equipped medical and laboratory facilities, and more ANC screening facilities were selected. Phebe and Charles B. Dunbar hospitals are centrally located referral hospitals in Liberia with high ANC attendance rates. As far as ANC services are concerned, both of these hospitals meet the minimum recommendations for providing ANC services in Liberia. The sample population was pregnant women receiving ANC for the first time at the selected hospitals.

Sample Size Calculation

The sample population consisted of all consenting pregnant women receiving their first ANC visit. According to the Demography and Health Survey Report (2019), anemia is more prevalent among pregnant women (52%) than breastfeeding women (48%). The new intervention is proposed to reduce anemia prevalence among pregnant women by 25%. Similarity among subjects within preexisting groups or clusters reduces the variability of responses in a cluster sample, making it difficult to detect true differences between groups. Intracluster correlation coefficients (ICC) measure the degree of dependence within a cluster. After adjusting for individual and cluster-level characteristics, the effective sample size was determined by using the median ICC in primary healthcare research of 0.005 (Adams *et al.*, 2004). To determine the effective sample size, the first step was to calculate the sample size required for individual randomized controlled trials. In the second step, the derived sample size from the individual randomized controlled trial was then adjusted for the design effect (DE). The effective sample size was 150 pregnant women in their first trimester of pregnancy. Seventy-five pregnant women were assigned to each treatment arm.

Each treatment arm was further randomized into three clusters. For every cluster, 25 participants were assigned.

Selection Criteria

This study included pregnant women who sought antenatal care for the first time, consented, and was free of chronic illnesses receiving antenatal care at Phebe and Charles B. Dunbar hospitals. Self-ownership of a mobile phone or close relatives in the same household was added as a selection criterion.

Admission of Participants

Each hospital had three screening rooms dedicated exclusively to ANC services. A pregnant woman seeking ANC for the first time was directed to the registration room to obtain a valid hospital card and identification number. In subsequent hospital visits, the patient used the hospital card and identification number to access health care services. HIV/AIDS counseling followed the registration process, which aims to prevent mother-to-child transmission of HIV/AIDS. The patient card was taken to any of the screening rooms for further processing by the midwives assigned to those rooms after counseling. A patient received healthcare from the screening room where her card was transferred. Six clusters (screening rooms) were randomized so that three (3) clusters administered standard/routine interventions during the study period, while the remaining three clusters administered intervention treatment. As mentioned in the selection criteria, the admission criteria were the same for both arms. The control and intervention groups were blinded. Certain information that might influence participants was kept from them. During the intervention, midwives were blinded. Neither the primary nor secondary outcomes were disclosed to the midwives during the study. During training, the three midwives selected randomly for the intervention treatment learned how to use the Tele-reminder manual effectively. The remaining three midwives who administered the control treatment were not trained to use the tele-reminder manual.

Outcomes

The primary outcome was iron status measured as hemoglobin (g/dl). Low iron status was defined as hemoglobin less than 11 g/dl. The secondary outcome variables were adherence to IFA supplementation, antenatal care satisfaction, and consumption of 2-3 iron-rich foods per day.

Treatment in the Control Group

The control group received routine and standard ANC services. The participants in this group were followed up every month. A similar pattern of routine ANC services was followed in every subsequent follow-up. Every follow-up included measurements of primary and secondary outcomes. The assigned midwives administered routine ANC during each ANC visit. Iron status measured in hemoglobin (g/dl) was the primary outcome variable. In addition, monthly adherence to IFA supplementation, ANC satisfaction level, and consumption of 2-3 iron-rich foods per day were also measured as secondary outcome variables (Table 1).

Treatment in the Intervention Group

Each participant in the intervention group received slightly different interventions than those administered to respondents in the control group. A mobile phone tele-reminder was delivered through phone calls and SMS biweekly to participants in the intervention group.

During the mobile phone calls, Participants were

Table 1: Core Health Messages Sent Via SMS

Types of Treatment	Core Health Messages Via SMS
Iron and Folate acid supplementation	"Increase your blood volume by taking one iron tablet a day"
Malaria Prevention	"Before you go to sleep, please hang the mosquito net over you"
Adherence to the ANC visit schedule	"Come to the hospital at the end of the month for treatment"
Hygiene Practices	"To prevent sickness, wash your hands frequently after using the toilet, before eating, and before cooking"

Table 2: Treatment in the Control and Treatment Clusters

Treatment Types	Control group (Routine Care)	Intervention Group (Routine + New treatment)	Reference
Diet Intervention	-Pregnant women were counseled about healthy eating and physical activity during pregnancy. -Using Visual aid containing the various food groups, pregnant women were counseled on the need to eat food from the different food groups daily to be kept healthy during pregnancy.	-Diet counseling focused on iron-rich foods (vegetables, fruits, and meat/fish products). -Participants were reminded biweekly to consume daily iron- and vitamin-rich foods from local markets and backyard gardens.	Sunuwar *et al*, (2019). Otoo & Adam (2016) WHO recommendations on ANC for a positive pregnancy experience (2016)

Iron and Folic acid supplements	Both hospitals routinely provided daily oral iron and folic acid supplementation to each participant	-Biweekly tele-reminders reminded participants to take iron and folate supplements. -IFA supplementation was emphasized in all	Gomes *et al.* (2021). WHO recommendations on ANC for a positive pregnancy experience (2016)
Malaria Prevention	A mosquito net was given to each participant to prevent malaria. In the second trimester of pregnancy, participants received intermittent preventive treatment with sulfadoxine-pyrimethamine (IPTp - SP). Based on hospital practice, dosing was determined	A biweekly tele-reminder emphasized the use of mosquito nets and the importance of adhering to IPTp-SP guidelines. A message (SMS) reminded them to use mosquito nets regularly and take the IPTp-SP.	Ngabo *et al.* (2012). WHO recommendations on ANC for a positive pregnancy experience (2016)
Hygiene Education	Participants were instructed to wash their hands with soap and water after using the latrine and touching contaminated surfaces. Participants were encouraged to keep their environment clean at all time	During follow-up visits, participants received handwashing soaps in addition to tele-reminders. Participants were reminded of the importance of washing their hands with soap and water after using the toilet, before cooking, and before eating Participants were also reminded biweekly to keep their environment clean	Sheth *et al.* (2010). WHO recommendations on ANC for a positive pregnancy experience (2016)
Prevention of intestinal parasites/ worm	Participants were treated with preventive anthelmintics according to hospital practice before undergoing their first ANC in the second trimester		WHO recommendations on ANC for a positive pregnancy experience (2016)

counseled only on food groups with rich sources of iron. They were also counseled on the consumption of vitamin-rich foods that enhance iron absorption. In this group, participants were presented with a list of affordable, available, and accessible local foods that are good sources of iron and vitamins. We developed a tele-reminder manual that midwives used as a guide in administering the treatment to the participants.

Development of Antenatal Care Tele-Reminder Messages

Health messages delivered to the participants in this study are referred to as "Core Antenatal Care Tele-Reminder Messages". There were three phases to the development of these core healthcare reminder messages. In phase one, the researcher reviewed World Health Organization guidelines on antenatal care published in 2016. Healthcare messages that were supported by the evidence-based practice were selected from the World Health Organization's antenatal care guidelines. During phase two of the development of core healthcare reminder messages. the researcher along with the six midwives who administered the treatment (intervention and control) reviewed the components of the World Health Organization antenatal care guidelines incorporated into the local Liberian ANC guidelines. Phase two was intended to prevent giving health messages to the participants that were not approved by the Ministry of Health of Liberia. In Phase Three, the six midwives pretested the key health messages among 10 mothers (pregnant women) who were not part of the study but were recipients of ANC services at Phebe Hospital.

Data Collection

This study used several validated techniques to collect, measure, and analyze accurate insights. We supervised all stages of this research. In both hospitals, midwives were hired to administer the interventions. The researcher scrutinized every data report by the research assistants (midwives) for quality assurance purposes. In addition, the researcher hired laboratory technicians for blood sample collection and biochemical analysis, in consultation with the medical director of both participating hospitals. All data were collected using questionnaires for analysis. Filling out questionnaires was facilitated by the midwives. The questionnaires did not mention participants' names or personal identities which might raise concerns about stigmatization. At baseline, an assessment of the socio-demographic profiles of participants, along with dietary assessment using the qualitative food frequency questionnaire. Hemoglobin test before and after the treatment was measured using an automated hematology

analyzer designed for low-volume clinical settings, the CELL-DYN Emerald 22.

Blood Sample Collection

Blood specimens for anemia testing were collected from all pregnant women availing of antenatal care for the first time at the Phebe and Charles B. Dunbar Maternity Hospitals in Bong County, Liberia. Blood samples were drawn from a drop of blood taken from a finger prick and collected in a microcuvette.

Hemoglobin test before and after the treatment was measured using an automated hematology analyzer designed for low-volume clinical settings, the CELL-DYN Emerald 22. Each participant had their hemoglobin result recorded on their hospital cards. Those participants with hemoglobin less than 11g/dl, were referred to doctors for further intervention.

Data Quality Control

For quality assurance purposes, laboratory technicians were treated blinded. CELL-DYN Emerald 22, an automated hematology analyzer designed for low-volume clinical settings, was used for hemoglobin testing. Licensed laboratory technicians collected blood samples for hematological analysis. To ensure data quality control, a regular supervision visit was conducted to ensure that standard operating procedures were followed during blood sample collection. Blood specimens were transported in proper containers under the supervision and taken at the recommended time to the analyzer. To avoid negative impacts on test results, test materials were observed to ensure they were properly stored and cleaned. To avoid errors in the data recording process, all laboratory results were immediately entered into the laboratory request form of the participants.

Data Analysis Method

All available data were included in the analysis. The primary outcome was iron status. It was measured as hemoglobin level in g/dl. The secondary variable of interest included the consumption of 2-3 iron-rich foods per day, and adherence to IFA supplementation. Baseline data were analyzed using descriptive statistics (SPSS v. 25). Fisher's Exact test was used to determine whether two categorical variables were associated. A t-test (for continuous variables) was used to compare the mean of baseline data. The MacNemar test was used to analyze paired nominal data between two related samples. A logistic regression analysis based on longitudinal data was used to assess the treatment effects on secondary outcome measures, while an unpaired sample t-test was used to assess the treatment effects on the primary outcome measure. As facilities rather than individual pregnant women were randomized, a generalized estimating equation was used to account for within-cluster correlation coefficients.

RESULTS

Age and Pregnancy Profile

Participants range in age from 23 to 24 years old. There was no statistically significant difference between the ages of participants in the intervention group and the control group. The majority of participants were in their first trimester of pregnancy (Table 3).

Table 3: Age and Pregnancy Profile of Participants at Baseline

Variables	Intervention group n = 75	Control group n = 75	Independent Sample T-Test p-value
	Mean ±SD	Mean ±SD	
Age of participants	24.57 ± 6.280	23.45 ± 6.803	0.297
Age in months of pregnancy	3.15 ± 1.245	3.27 ± 1.044	0.513
Total pregnancy	2.11 ± 1.640	1.89 ± 1.956	0.470
Total living children	1.23 ± 1.341	1.16 ± 1.525	0.777
Age in the month of the last child	26.17 ± 28.974	20.75 ± 26.568	0.234

Trimesters and Health Profiles

A significant number of participants had positive malaria smear test results. Forty-three percent of those in the intervention and 45% in the control groups were malaria positive at baseline. In the past month, the majority of the participants did not have any history of illness in the past month (Table 4). There were no HIV/AIDS diagnoses among any of the participants in the study.

Table 4: Gestational and Health Profiles of Participants at Baseline

Variables and Category		Intervention group n = 75		Control group n =75		Fisher's Exact test p-value
		N	%	n	%	
Gestational period	First trimester	38	51	44	59	0.20
	Second trimester	37	49	31	41	
Malaria test result	Negative	43	57	41	55	0.43
	Positive	32	43	34	45	
Ill in the past month	Yes	24	32	27	36	0.36
	No	51	68	48	64	

Education and Marital Status

Participants have varying educational backgrounds. There were, however, a significant number of them who had at least a primary education. According to statistics (Table 15), there is no statistical difference between the groups when it comes to their educational attainment. Furthermore, more than half of the participants in the study are cohabiting couples.

Table 5: Educational level and Marital status, Baseline

Variables and Category		Intervention group n = 75		Control group n =75		Fisher's Exact test p-value
		N	%	n	%	
Highest Education Attainment	Primary education	54	72	53	70	0.500
	Secondary education	21	28	22	29	
Marital status	Cohabiting	51	68	54	72	0.361
	Not married	24	32	21	28	

Treatment Effect on Iron Status

The result showed that pregnant women assigned to the intervention group had a significantly greater mean hemoglobin level after the two interventions, t (2.4) = 445, p<0.013; d = 0.23. The effect size of the analysis (d = 0.23) was found to be small (Table 6). These results indicate that pregnant women in the intervention group (M = 12.8, SD = 0.71) experienced a small increase in hemoglobin levels than did pregnant women in the control group (M =11.7, SD = 0.63).

Table 6: Effects of Treatment on Iron Status Measured in Hemoglobin (Primary Outcome)

Hemoglobin Level in g/dl	Intervention group (Mean ± DS)	Control group (Mean ± DS)	Independent Sample T-test p-value
Baseline	10.9 ± 0.94	10.8 ± 0.92	0.108
Endline	12.8 ± 0.71	11.7 ± 0.65	0.013
Paired T-test (p-value)	0.047	0.000	Cohen's d Test: 0.23
Anemia Prevalence	Intervention group n (%)	Control group n (%)	Fisher's Exact Test (p-value)
Baseline	36 (48)	39 (52)	0.37
Endline	3 (4)	10 (13)	0.039
McNemar Test P value	0.000	0.000	Odds Ratio (Binary Logistic Regression): 0.27 (0.07- 1.03)

Anemia Prevalence among Participants with Malaria and History of Past Illnesses

At baseline, 66 participants had malaria infection and 34 participants had history of past illnesses. Based on Table 7, 27% of intervention participants and 20% of control participants with malaria at baseline had anemia. Participants were asked at baseline whether they had experienced any illness in the past month. As a result, 18% of participants in the intervention group and 15% of participants in the control group who experienced illness in the past month had anemia at baseline.

Table 7: Anemia Prevalence Among Participants with Malaria and History of Past Illnesses at Baseline

Treatment Groups	Prevalence of anemia among those with a malaria infection at baseline n = 66	Prevalence of anemia among those with a history of past illnesses at baseline n = 34
	n (%)	n (%)
Intervention Group	18 (27)	6 (18)
Control Group	13 (20)	5 (15)
Total Anemia cases	31	11

Adherence to IFA Supplementation

Data were adjusted for the level of education of participants. The odds of completing the monthly iron and folic acid supplementation (≥28 days) were significantly different between pregnant women who received the intervention and those who did not (Adjusted odds ratio "aOR" 5.0; 95% CI, 1.29-19.42). This result indicates that pregnant women in the intervention group adhered to the monthly prescribed dose of IFA tablets at a higher rate than those in the control group (96 vs. 84%). The prevalence of those who adhered to taking one IFA tablet per day in the intervention group was higher than those in the control group (95% vs. 85%). This means the odds of adhering to 1 IFA tablet per day were 3 times

Table 8: Impact of Treatment on Adherence to Iron and Folic Acid Supplementation

	Intervention groups n (75)	Control group n = 75	Unadjusted OR*(95% CI)	Adjusted OR** (95% CI)	Logistic Regression p-value
	n (%)	n (%)			
Acknowledged that Iron and folic acid supplements can prevent and treat anemia in pregnancy	73(97)	71(95)	2.05 (0.36-11.58)	2.05 (0.36-11.56)	0.416
Adhere to taking one IFA supplement (tablet)/per day	71(95)	64(85)	3.05 (0.92-10.06)	3.04 (0.92-10.08)	0.068
Adhere to taking ≥28 tablets/supplement of IFA/Month	72 (96)	62(84)	4.5 (1.23-16.93)	5.0 (1.29-19.42)	0.020
Did not take IFA tablet a day due to perceiving risk of side effects	71 (95)	68 (91)	1.8 (0.51-6.52)	1.8 (0.50-6.50)	0.35

higher among the intervention group compared with the control group (Adjusted odds ratio "aOR" 3.04; 95% CI, 0.92-10.08). Women in the intervention group were twice as likely to be aware of the importance of IFA supplementation during pregnancy than women in the control group (adjusted odds ratio, 2.05; 95% confidence interval, 0.36-11.56). According to Table 7, 95% of participants in the intervention group and 91% of participants in the control group missed at least one day without taking IFA tablets due to a perceived risk of side effects. Despite this, there was no statistically significant difference between the two groups (Adjusted odds ratio = 1.8; p>0.35).

Consumption of Iron Rich Food

Pregnant women in the intervention group consumed more fruits per day when exposed to mobile phone tele-reminder every two weeks (91% compared to 72%, adjusted odds ratio "aOR", 3.77, 95%CI, 1.49-9.54). In the intervention group, there were significant odds in the consumption of 2-3 fish/meat/poultry products compared to the control group (93% versus 83%,

Table 9: Treatment Effects on Daily Iron-Rich Food Consumption Between Treatment Groups

	Intervention group N (%)	Control group N (%)	Fisher's Exact Test p-value	Adjusted Odds Ratio (95% CI) Binary Logistic Regression
2-3 fruits consumption/day				
Baseline	12 (16)	10 (13)	0.40	3.77 (1.49- 9.54)
Endline	68 (91)	54 (72)	0.003	
Consumption of 2-3 vegetables/per day				
Baseline	53 (71)	57 (76)	0.29	3.69 (0.97-14.00)
Endline	72 (96)	65(87)	0.039	
Consumption of 2-3 meat/fish/poultry products per day				
Baseline	31 (41)	35 (47)	0.31	2.93 (0.99- 8.70)
Endline	70 (93)	62 (83)	0.038	

adjusted odds ratio, 2.93; 95% CI, 0.99-8.70). According to Table 8, pregnant women in the intervention group consumed 2-3 types of vegetables per day more than pregnant women in the control group. (96% compared with 87%, Adjusted odds ration "aOR", 3.69; 95%CI, 0.97-14.00).\

DISCUSSION

In this study, the null hypothesis stated that, compared to women in the control group, there were no significant changes in the mean hemoglobin level of pregnant women availing of antenatal care services who received mobile phone tele-reminder. On the other hand, the alternative hypothesis stated that, compared to women in the control group, there was a significant difference in the mean hemoglobin level of pregnant women availing of antenatal care services who received mobile phone tele-reminder. Since the p-value = .013 is less than the a = 0.05, the study rejects the Ho. It is now concluded in this study that at a = 0.05, there is sufficient evidence to say that integrating mobile phone tele-reminder into existing antenatal care is associated with increased iron status among pregnant women availing antenatal care services at the Phebe and Charles B. Dunbar hospitals. According

to the study, integrating mobile phone tele-reminders into existing ANC services appeared to improve iron status significantly. Hemoglobin levels in pregnant women in the intervention group were higher than those in the control group. A simple mobile phone audio call and SMS were used to address irregular attendance and inadequate utilization of essential antenatal care services.

It is essential to utilize all antenatal care services appropriately throughout pregnancy to identify health problems that may contribute to anemia during pregnancy. We found significant improvement in the consumption of iron-rich foods that include vegetables and meat/fish/poultry products among participants in the intervention group compared with those in the control group. Vitamin C in fruits enhances the absorption of iron in food. It has been found that tele-reminder can greatly increase the consumption of vitamin-rich foods during pregnancy. Red meat, fish, and poultry products are some of the animal products that contain hemoglobin. Heme-based sources of iron are the most readily absorbed by the body Participants in the intervention group again were more likely to adhere to IFA supplementation, compared with those in the control group. We agree with Lund and others (2014) that integrating mobile phone technology into existing ANC protocol, may increase ANC visits and improve quality care with more pregnant women receiving quality preventive health services. In accordance with Wagnew and others (2018), this study found that sending short message services on focused antenatal care to pregnant women increased the likelihood that they would adhere to antenatal care. In addition, the study agrees with Bangal and others (2017) that pregnant women who use mobile phones during ANC have a higher likelihood of taking IFA tablets, which can help prevent pregnancy-related anemia.

CONCLUSION

It is imperative to place anemia in pregnancy on the local and international health agendas. A lack of reduction or prevention of anemia during pregnancy may result in impaired health and quality of life for millions of women, as well as adverse effects on children's development and learning. The world must take action now to prevent the death of many pregnant women in developing countries due to anemia, which can be realistically prevented by national and international consensus.

Anemia in pregnancy is defined by the World Health Organization (WHO) as hemoglobin levels of less than 11 grams per deciliter. A person with anemia has fewer red blood cells or a lower hemoglobin concentration than normal. If a pregnant woman has too few or abnormal red blood cells, or not enough hemoglobin, the blood can't carry oxygen to the tissues of the body. The most common causes of anemia during pregnancy are nutritional deficiencies, particularly iron deficiency, but also folate, vitamin B12, and vitamin A deficiency. Other causes of anemia in pregnancy include infectious diseases, such as malaria, tuberculosis, HIV, and parasitic infections. During three months, a two-arm, double-blinded cluster randomized control trial was conducted in two referral hospitals. In Bong County, Liberia, the study was conducted at the Phebe and Charles B. Dunbar hospitals. The purpose of this study was to determine whether mobile phone tele-reminder affects iron status and diet quality of pregnant women seeking antenatal care for the first time. Randomly assigned to intervention and control groups were 150 pregnant women. There were six clusters of midwives caring for pregnant women in the study. Among the six clusters, three were randomly assigned to provide the mobile phone tele-reminder and the remaining three to provide control treatment. Each cluster had 25 participants, respectively. Participants in both groups were followed up every month. Participants in the intervention group were contacted every two weeks by telephoning and as well as sending SMS messages. To collect baseline, midline, and end-line data, questionnaires were used throughout the study.

To analyze baseline data, descriptive statistics (mean, SD, percentage, and frequency) were used. At baseline, two categorical or nominal variables were tested for independence by using Fisher's Exact test. Intent-to-treat analysis was used to analyze the findings. An independent sample t-test was used to determine the effect of the treatment on the primary outcome of the study. The longitudinal data were analyzed using binary logistic regression to determine the effect of the treatment on the secondary outcomes.

Based on baseline data, both groups had similar ages, gestational ages, number of pregnancies, number of living children, and last child's age in month. The majority of participants in both groups had completed primary education. The majority of participants in both groups were still cohabiting. Clinical findings indicated a high prevalence of malaria at baseline. Both groups had more than half of their participants in their first trimester. In both groups, the hemoglobin level was below 11 grams per deciliter. HIV/AIDS was not present in any of the participants. A few of the participants consumed 2-3 fruits per day on average at baseline. In both groups, more than half of the participants consumed 2-3 vegetables per day, and most consumed more fish, meat, and poultry products. As far as iron status is concerned, Mobile Phone Tele-Reminder significantly increases iron status measured in hemoglobin (g/dl). Despite this, the intervention had a small effect size on hemoglobin levels. The intervention significantly increased the likelihood of pregnant women taking their iron and folic acid supplements regularly. The intervention increased the consumption of iron and vitamin-rich foods during pregnancy.

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Abbreviation

ANC: Antenatal Care, g/dl: gram per deciliter, IFA: Iron, SMS: Short Message Services

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