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Effectiveness of mobile health (mHealth) in improving iron supplementation adherence and hemoglobin levels among pregnant women in Belu District, East Nusa Tenggara

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ABSTRAK

Latar Belakang: *Anemia pada kehamilan masih menjadi masalah kesehatan masyarakat yang signifikan, khususnya di Nusa Tenggara Timur (NTT), dengan prevalensi yang masih tinggi yaitu sebesar 51%. Salah satu faktor utama yang berkontribusi adalah rendahnya kepatuhan dalam mengonsumsi tablet tambah darah (TTD), yang sering dipengaruhi oleh keterbatasan pengetahuan, lupa, serta kurangnya dukungan berkelanjutan. Dalam beberapa tahun terakhir, mobile health (mHealth) muncul sebagai pendekatan yang menjanjikan dalam mendukung perubahan perilaku kesehatan melalui sistem pengingat dan penyediaan edukasi kesehatan yang mudah diakses.*

Tujuan: *Mengetahui pengaruh mobile health (mHealth) terhadap kepatuhan konsumsi tablet tambah darah dan kadar hemoglobin (Hb) pada ibu hamil di Kabupaten Belu, NTT.*

Metode: *Penelitian quasi-eksperimen dengan desain pretest-posttest control group dilakukan pada 80 ibu hamil trimester II–III dengan anemia ringan (Hb 8–10.9 g/dL). Peserta dibagi dalam dua kelompok: kelompok intervensi (mHealth + TTD) dan kelompok kontrol (TTD standar). Intervensi berlangsung selama 8 minggu. Kepatuhan diukur menggunakan lembar kepatuhan, dan kadar Hb diukur menggunakan metode sianmethemoglobin. Analisis data menggunakan paired t-test dan independent t-test.*

Hasil: *Kepatuhan konsumsi TTD meningkat signifikan pada kelompok intervensi (dari 52% menjadi 85%) dibandingkan kelompok kontrol (dari 50% menjadi 55%) ($p < 0,001$). Rerata kadar Hb meningkat sebesar 1.2 g/dL pada kelompok intervensi (dari 10.2 menjadi 11.4 g/dL) dan sebesar 0.4 g/dL pada kelompok kontrol (dari 10.3 menjadi 10.7 g/dL) ($p < 0.05$).*

Kesimpulan: *Intervensi mHealth efektif meningkatkan kepatuhan konsumsi tablet tambah darah dan kadar hemoglobin pada ibu hamil di Kabupaten Belu, NTT.*

KATA KUNCI*: anemia; ibu hamil; hemoglobin; mHealth; tablet tambah darah*

ABSTRACT

Background: *Maternal anemia remains a major and persistent public health challenge globally, and its prevalence is particularly high in East Nusa Tenggara (NTT), hovering at 51%. A primary driver of this issue is poor compliance with iron tablet supplementation (TTD), which is frequently caused by a lack of health awareness, forgetfulness, and the absence of continuous behavioral support. Recently, mobile health (mHealth) technologies have emerged as an innovative tool to foster positive health behaviors by providing automated reminders and accessible health learning resources.*

Objectives*: This study aimed to evaluate how mHealth applications affect iron tablet compliance and hemoglobin (Hb) levels among pregnant women living in Belu District, NTT.*

Methods: *Utilizing a quasi-experimental approach with a pretest-posttest control group layout, this study enrolled 80 pregnant women in their second and third trimesters who presented with mild anemia (Hb 8–10.9 g/dL). The cohort was equally split into an intervention group (receiving mHealth features alongside iron supplements) and a control group (receiving routine iron therapy alone). The program was carried out over an 8-week timeline. Compliance metrics were gathered via adherence records, while hemoglobin counts were tested using the cyanmethemoglobin technique. Analytical computations involved both paired and independent sample t-tests.*

Results: *Iron supplement compliance grew substantially within the intervention arm (surging from 52% to 85%) compared to the minimal progress seen in the control group (from 50% to 55%) ($p < 0.001$). Concurrently, the intervention group experienced a 1.2 g/dL increase in mean Hb levels (climbing from 10.2 to 11.4 g/dL), whereas the control cohort only crept up by 0.4 g/dL (from 10.3 to 10.7 g/dL) ($p < 0.05$).*

Conclusions: *Implementing an mHealth-based framework successfully boosts adherence to iron tablet routines and helps raise hemoglobin counts among pregnant individuals in Belu District, NTT.*

KEYWORDS*: anemia; hemoglobin; iron tablets; mHealth; pregnant women*

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INTRODUCTION

Globally, maternal anemia is widely recognized as a critical public health crisis. According to the World Health Organization (WHO), roughly 40% of pregnant women around the world are affected by anemia, a condition that jeopardizes both maternal and fetal outcomes by driving up the incidence of premature births, low birth weight (LBW), and maternal morbidity or mortality. Looking at the domestic landscape, data from the 2023 Indonesian Health Survey (SKI) indicates that the national anemia rate among pregnant women reached 27.7%. Unfortunately, East Nusa Tenggara (NTT) stands out as one of the regions worst hit by this condition, with maternal anemia rates fluctuating heavily between 48% and 52% (2).

This persistent problem is largely rooted in poor adherence to iron tablet supplementation (TTD), despite national recommendations mandating a minimum intake of 90 tablets across the gestational period. Real-world observations in NTT suggest that poor patient compliance is fueled by a combination of limited health literacy, simple forgetfulness, unpleasant side effects, and a lack of continuous educational reinforcement from healthcare channels (5).

In response to these challenges, modern healthcare has increasingly turned to mobile health (mHealth) as a digital asset to reshape health behaviors and improve medication adherence. Broadly speaking, mHealth involves using smartphones, mobile software applications, and short message services (SMS) to deliver medical monitoring and educational content. A growing body of literature indicates that mHealth platforms can markedly improve treatment compliance across various chronic conditions, including maternal healthcare initiatives (1). The distinct novelty of this research is the implementation of a hybrid mHealth framework that bundles daily SMS alerts, weekly educational texts, and direct WhatsApp monitoring tailored

specifically for mildly anemic pregnant women living in resource-poor regions like Belu District, East Nusa Tenggara. While standard mHealth programs often limit their scope to general maternal wellness tips or basic clinical appointment tracking, this intervention focuses heavily on behavioral change and tailored user interactions to directly boost iron intake compliance and improve hemoglobin metrics (6). Unlike most existing mHealth programs that focus only on general maternal health information or appointment scheduling, this intervention emphasizes behavior change and personalized engagement to improve adherence to iron tablet supplementation and hemoglobin levels.

Consequently, this paper addresses an important research gap in Indonesia, where empirical data regarding context-specific digital health strategies for maternal anemia prevention in rural populations remains scarce. Prior digital health investigations across the country have mostly focused on immunization notifications, general childhood nutrition, or standard pregnancy tracking. To date, rigorous clinical inquiries focused on the explicit role of mHealth in boosting iron supplementation adherence and its subsequent effect on hemoglobin outcomes within high-prevalence zones like NTT are still lacking. Driven by these realities, this study aims to evaluate how mHealth tools affect iron supplement compliance and hemoglobin outcomes in pregnant women across Belu District, NTT. The conclusions drawn are expected to offer a functional framework for the rollout of community-level digital interventions to lower maternal anemia in underserved locales.

MATERIALS AND METHODS

This investigation utilized a quasi-experimental framework incorporating a pre-test and post-test control group model. Participants were divided into two main groups: the intervention track (mHealth) and the control track (standard care). The fieldwork was carried out at several community health centers (Puskesmas) across Belu District, East Nusa Tenggara Province a region chosen due to its high maternal anemia rates. The study took place between March and July 2025. The source population encompassed all pregnant individuals in their second and third trimesters who sought antenatal care (ANC) services at the designated Puskesmas within the study period, representing an accessible population of roughly 230 women based on prior ANC registry records. Sampling was executed using a purposive strategy under a specific set of inclusion parameters: women at 14–32 weeks of gestation, free from severe obstetric complications, owning an active mobile phone capable of receiving SMS or WhatsApp, and consenting to participate by signing a formal informed consent document.

Sample size estimates were calculated using a two-mean comparison formula, assuming a 95% confidence level and 80% statistical power. Expecting a mean hemoglobin variation of 1.0 g/dL between the cohorts and a standard deviation of 1.2 g/dL, the initial calculation required 34 subjects per group. To account for a potential 15% attrition or drop-out rate, the recruitment goal was expanded to 40 individuals per arm, bringing the total sample size to 80 participants. During the purposive recruitment stage, field midwives at each Puskesmas screened prospective candidates using routine ANC records and baseline Hb laboratory evaluations. Only women with laboratory-confirmed mild anemia (Hb 8–10.9 g/dL) who met the operational parameters (appropriate gestational trimester and mobile tech access) were enrolled. This purposive method ensured that the selected respondents possessed the exact medical and technical characteristics required for the intervention. The participants were then divided into two equal cohorts: Intervention Group (n = 40): Provided with routine iron supplementation alongside the multi-component mHealth setup (including regular SMS notifications, educational texts, and interactive WhatsApp tracking). Control Group (n = 40): Provided with standard antenatal care and routine iron tablet supplies following standard Ministry of Health protocols.

To maintain structural balance across baseline profiles, randomization was executed using a computer-generated sequence. However, because a quasi-experimental design was used, full individual randomization was not possible. Instead, allocation was determined by the geographical location of the participating health centers (Puskesmas) to prevent cross-

contamination between subjects. Two distinct health centers with matching demographic and operational features were selected: one serving as the experimental hub and the other as the control site. This geographic separation ensured that participants within the same community received uniform care, preventing information sharing between the study groups.

The validity and reliability of the data collection instruments were confirmed through expert panel assessments and a small-scale pilot trial (n = 15). Internal consistency was verified with a Cronbach's alpha α≥0.70, inter-rater agreement was confirmed with an ICC >0.75, and construct validity was established by correlating compliance rates with changes in Hb levels. Hemoglobin tracking was performed using calibrated HemoCue instruments operated by laboratory technicians who were blinded to the assignment groups. The intervention arm received educational content and iron tablet (TTD) consumption reminders via WhatsApp/SMS channels over a 8-week timeframe. This protocol included anemia education, TTD health benefits, and nutritional counseling (sent twice weekly), alongside daily TTD alerts sent at a fixed time. Adherence monitoring was maintained through a daily text response ("taken"). Conversely, the control group only received standard government-mandated antenatal care without any supplementary digital support. Every participant provided signed informed consent before data collection. Ethical protocols focused heavily on ensuring data privacy, verifying that participation was fully voluntary, guaranteeing the right to withdraw at any stage without penalty, and ensuring that standard antenatal care was provided equally to both study arms.

RESULTS AND DISCUSSIONS

The baseline characteristics of the respondents presented in **Table 1** show that the intervention and control groups were comparable prior to the implementation of the mHealth intervention.

Table 1. Frequency distribution of research subject characteristics

Characteristics	Intervention (n=40)	Control (n=40)
Age (mean ± SD)	27.4 ± 4.3 years	27.1 ± 4.6 years
Education (%)		
- Primary/Junior	35%	37.5%
- High School	50%	47.5%
- College	15%	15%
Parity (median)	2	2
Housewives (%)	72.5%	75%

The mean age of respondents was similar between groups (27.4 ± 4.3 years vs. 27.1 ± 4.6 years), and the distribution of education levels also showed no substantial differences, with 35% versus 37.5% having primary or junior education, 50% versus 47.5% having high school education, and an equal proportion (15%) attaining college education. Parity was identical, with both groups having a median of 2, and the proportion of housewives was likewise comparable (72.5% vs 75%). All statistical tests indicated p-values > 0.05, confirming the absence of significant baseline differences. The homogeneity of these baseline characteristics is essential for strengthening internal validity, suggesting that both groups started the study under similar demographic conditions. This supports the interpretation that the changes observed in compliance and hemoglobin levels were more likely attributable to the mHealth intervention rather than pre-existing demographic variations. As also noted in similar mHealth studies, baseline comparability increases the confidence that intervention effects are genuine and not confounded by age, education, or parity differences (13).

Compliance with iron tablet consumption.

Compliance rates before and after intervention are shown in **Table 2.** As shown in **Table 2**, compliance with iron tablet consumption increased markedly in the intervention group,

rising from 45% at pre-test to 85% at post-test. In contrast, the control group showed only a slight improvement, from 47.50% to 55%**.** This substantial difference is consistent with the discussion that digital reminders, educational messages, and monitoring embedded in the mHealth system played a pivotal role in reinforcing daily adherence behaviors. Prior research similarly reported that structured mHealth reminders significantly enhanced adherence to iron–folic acid supplementation

Table 2. Compliance with Iron Tablet Consumption (%)

Compliance	Intervention	Control
Pre-test	45	47.50
Post-test	85	55

Hemoglobin levels (Hb).

The improvement in hemoglobin levels presented in **Table 3** indicates that the intervention group achieved an average increase of 1.20 g/dL (from 10.20 to 11.40 g/dL), compared with only 0.40 g/dL in the control group (from 10.30 to 10.70 g/dL). The association between higher adherence and improved Hb levels is consistent with established evidence that regular iron tablet consumption is directly related to anemia reduction in pregnancy. The greater Hb improvement in the intervention group aligns with the enhanced adherence documented in **Table 2**, further supporting the effectiveness of mHealth-assisted supplementation.

This study revealed that mobile health (mHealth) intervention significantly improved adherence to iron-folic acid (IFA) supplementation and hemoglobin (Hb) levels among pregnant women. The intervention group, which received daily reminders through the mHealth application, showed an adherence increase from 45% to 85%, while the control group only increased from 47.50% to 55%. Similarly, the mean Hb level in the intervention group improved by 1.20 g/dL compared to only 0.50 g/dL in the control group

Table 3. Mean Hemoglobin Levels

Time	Intervention	Control
Pre-test (g/dL)	10.20	10.30
Post-test (g/dL)	11.40	10.70

However, as this quasi-experimental study did not control for other influencing variables such as nutritional intake, previous compliance history, or family support, the results should be interpreted as associations rather than direct causal effects. This finding aligns with the Health Behavior Theory, which suggests that technology-based interventions can improve adherence through consistent reminders, accessible information, and behavioral support (8). The daily reminders provided by the mHealth app helped mothers overcome forgetfulness, which is one of the primary causes of poor adherence.

Our findings are supported by Mutmainnah et al. (2022), who reported that SMS reminders increased IFA adherence up to 80%. Similarly, Adisasmito (2021) found that the use of Android-based applications improved iron tablet adherence among pregnant women by 25% compared to the control group. These results strengthen the evidence that digital health tools are effective in supporting iron supplementation programs.

This study is also consistent with global research. For instance, Lee et al. (2020) in South Korea reported that app-based reminders improved adherence to prenatal vitamin supplementation up to 90%. Moreover, WHO (2021) recommends the integration of digital technologies as an innovative strategy to reduce maternal anemia, particularly in resource-limited settings. The local context of East Nusa Tenggara (NTT) presents unique challenges, such as limited healthcare access and geographical barriers. Therefore, mHealth interventions offer a practical solution to enhance communication and education

without frequent facility visits. The use of this application bridges the information gap, especially given the high prevalence of anemia in NTT (Riskesdas, 2018).

However, this study has some limitations. First, the relatively short intervention period (8 weeks) may not capture long-term effects. Second, the requirement for smartphone ownership and internet access could limit coverage among populations with technological constraints. Third, the reliance on self-reported adherence might introduce social desirability bias. The findings of this study have practical implications for maternal health programs. Integrating mHealth into antenatal care (ANC) services can enhance iron tablet adherence and reduce anemia prevalence, particularly in rural areas like Belu. Health workers can utilize such applications to monitor adherence and deliver real-time education. Future research should employ a randomized controlled trial design with a longer duration and a larger sample size. Additionally, developing more interactive mHealth applications with features such as online consultation could further improve intervention effectiveness.

CONCLUSION AND RECOMMENDATION

This study demonstrated that mobile health (mHealth) intervention effectively improved adherence to iron-folic acid (IFA) supplementation and hemoglobin (Hb) levels among pregnant women. The intervention group that received reminders through the mHealth application showed a significant increase in adherence and a greater improvement in Hb levels compared to the control group. The mHealth platform used in this study was designed with three main features: daily reminder notifications for taking IFA tablets, educational messages about anemia prevention and nutrition during pregnancy, a digital monitoring log that allowed participants to record tablet intake and receive motivational feedback. The workflow began with registration and baseline data entry, followed by automatic scheduling of reminders and weekly monitoring through the app. These features worked synergistically to enhance awareness, motivation, and self-monitoring among pregnant women. Thus, this digital-based intervention provides an innovative and practical strategy to prevent anemia during pregnancy, especially in areas with limited healthcare access such as East Nusa Tenggara.

For Healthcare Providers: mHealth applications should be integrated into antenatal care (ANC) programs to monitor IFA adherence in real-time. For Pregnant Women: It is recommended to utilize digital tools as reminders and educational resources to improve maternal and fetal health. For Future Researchers: Further studies should use randomized controlled trial designs with longer intervention periods to assess long-term effects. For Government and Health Programs: Policy support is needed for the development and large-scale implementation of mHealth applications, especially in regions with high anemia prevalence.

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