Research Paper:
The Impact of an Android Application on Compliance With Iron Supplementations in Pregnant Women

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ABSTRACT

Background: Monitoring the adherence of pregnant women to taking iron supplements indicates controlling the appropriateness of taking a certain number of supplements. This increases the odds of effective iron absorption; a process that occurs by consuming at least 30 iron pills a month to prevent gestational anemia. This study aimed to determine the effects of monitoring pregnant women's compliance in taking up iron supplements through an Android application in Jambi City, Indonesia.

Methods: This was a quasi-experimental single group study with a pre-test-post-test design. The study subjects included a convenient sample of women in their third trimester referring to 3 maternity Hospitals in Jambi City, Indonesia, in 2020. Initial data were obtained through Hemoglobin (Hb) measurements before being given a monitoring application and subsequent Hb level checks after giving the application. The obtained data were analyzed by t-test and Mann-Whitney U test in SPSS 16. A significance level of 5% was considered.

Results: The results obtained in the initial examination indicated that the minimum Hb level was equal to 7.3 g/dL and the maximum level was measured as 11.2 g/dL. After the intervention, the Hb level increased to a minimum of 7.6 g/dL and a maximum of 12.2 g/dL. The Mann-Whitney U test data suggested a significant difference in the degree of compliance of pregnant women with iron supplementation (P=0.010).

Conclusion: Monitoring through the Android application increased pregnant women's compliance with taking iron supplements and presented a linear impact on increasing their Hb level.

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Highlights

- Failure to take iron supplements during pregnancy increases the incidence of pregnancy anemia.
- Anemia in pregnant women brings consequences and complications, such as the high risk for miscarriage, bleeding, low birth weight, uterine atony, uterine inertia, and retained placenta.
- The purpose of the smartphone application is to monitor pregnant women's compliance with taking iron supplements to prevent anemia.
- The study findings indicated that using a smartphone application increases Hb levels by increasing the adherence of pregnant women to taking iron supplements.

Plain Language Summary

Monitoring hemoglobin levels is essential in pregnant women. This is because the lack of hemoglobin can negatively impact the health of the mother and fetus in the womb. Having a smartphone application to monitor the compliance of pregnant women with taking iron supplements is effective. It can be used as a reminder for the regular use of iron supplements; thus, reducing the incidence of anemia in pregnancy. According to the present study findings, using a smartphone application increases hemoglobin levels by improving the adherence of pregnant women to taking iron supplements.

1. Introduction

Maternal Mortality Rate (MMR) is an indicator of community health (Sajedinejad et al. 2015). The World Health Organization (WHO) has reported the prevalence of MMR as 239 deaths for every 100000 live births in the Least Developed Countries (LDCs), compared to 124 deaths for every 100000 live births in Developed Countries (DC), in 2015. The difference in these ratios is 115 between regions, countries, different socio-economic strata, as well as rural and urban populations (World Health Organization 2018). Based on the Indonesian Demographic Health Survey (IDHS) in 2015, Maternal Mortality Rate (MMR) in Indonesia has been reported as 305/100000 live births (Badan Pusat Statistik 2017).

The cause of the high MMR in Indonesia is inseparable from the complications during pregnancy, childbirth, and puerperium. The causes of high MMR include bleeding (28%), eclampsia (24%), and infection (11%). However, other indirect causes, such as nutritional problems leading to anemia in pregnancy (40%), chronic energy deficiency (27%), and consumption patterns below the minimum requirement (44.2%) should also be considered (Kemenkes 2018). Approximately 48.9% of pregnant women in Indonesia experience anemia. Accordingly, it remains a community problem, because the proportion is higher than the primary health research results in 2013, i.e., 37.1% (Kemenkes 2018).

In 2016, the local government published the results of a statistical study. According to this, the frequency of anemias in pregnant women equaled 1261 (9.38%) mothers, and in 2017, it increased to 1338 (11.4%). Therefore, all 20 Public Health Centers (PHC) in Jambi City were covered by the supply of 90 tablets of iron supplements with coverage of >90% (Kota Jambi 2018).

According to Radkar and Parasuraman (2007), the anemia-induced maternal mortality rate is 19.7% of total MMR in India (2007). Approximately 15%-20% of maternal deaths are directly or indirectly due to anemia. Additionally, increased maternal morbidity is also associated with anemia. The main cause of anemia in pregnant women is an iron deficiency; however, pregnant women rarely develop iron deficiency anemia due to nutritional problems (Kautshar, Suriah & Jafar 2013).

Pharmacological treatment for anemia is taking one iron supplement a day during pregnancy (Dahlan & Ardhi, 2021). Anemia, in all countries, particularly the developing regions, is mainly caused by iron deficiency (Gedefaw et al. 2015; Noronha et al. 2012; Plante et al. 2011). Inadequate iron intake, high iron absorption during pregnancy, iron loss due to bleeding, and infectious diseases are considered as the leading causes of iron deficiency (Gedefaw et al. 2015).

The nationally developed Anemia Prevention Program provides iron supplements for pregnant women with at

least 90 tablets during pregnancy (Agustina 2019). A study in Pageraji Village Cilongok, the District of Banyumas Regency, Indonesia, found a significant difference between pregnant women who were adherent to taking iron tablets (50.9%), compared to non-adherent women (49.1%), with a 50% anemia incidence. Therefore, compliance with consuming iron supplements significantly affects the incidence of anemia in pregnant women (Anasari & Tri, 2012). Non-Compliance with taking iron supplements increases the risk of anemia during pregnancy fourfold (Wiradnyani , Khusun & Achadi 2013).

Therefore, pregnant women need to become familiar with the benefits of regular consumption of iron supplements through an efficient monitoring system. In this study, an online Android system was used to monitor iron supplementation in pregnant women, with the expectation that this mechanism will increase mothers' adherence to iron supplementation. An overgrowing media that can easily and attractively present guidelines is an Android-based smartphone (Intan Trivena Maria Daeng, Mewengkang & Kalesaran 2017). The capabilities of Android smartphones, including multimedia capabilities, high portability, and local data storage, can help healthcare workers by providing information about case management and decision support applications that impact improving service quality (Florez-Arango et al. 2011). This study aimed to determine the effects of monitoring pregnant women's compliance with taking up iron supplements through an Android application in Jambi City, Indonesia.

2. Materials and Methods

This was a quasi-experimental single group study with two Hb measurements before and after the intervention. Fifty mothers in their third trimester of pregnancy were conveniently recruited as the sample at the visit to Obgyn Hospitals in Jambi City, Indonesia, in 2020. The inclusion criteria were being in the third trimester of pregnancy, to participate in the study and have an android cell phone.

Initially, an intervention called process (X) (i.e., using an Android application) was performed at the input (O_1) and after output (i.e., the determination of compliance), the result of treatment and test (O_2) (i.e., changes in Hb) were compared. Accordingly, the necessary data were collected based on the results of Hb measurements before and after being given the Android application. The study participants' Hb levels were measured using Sahli's Hb method before and after the intervention. Adherence was monitored by a smartphone application; it was assessed by checking the number of consumed iron supplements for 30 days using observation sheets. If the number of iron tablets taken was <30, it was rated as 0=non-adherence; ≥30 was rated as 1=adherent. To use the application, the respondents were requested to install it on their smartphones. Then, the research team explained how to work with it. To measure compliance, the explored mothers were requested to click on the program on a specific day and date after taking each iron supplement and continue the same measure for a full 30 days. Not clicking on the data on the app indicates that the respondent is not taking iron supplements. The Android app also has a standby operator to recapitulate the respondents' data. The respondents were reminded via WhatsApp at 3 Obgyn Hospitals in Jambi. A group of enumerators assisted research data collection. The data were analyzed by t-test and Mann-Whitney U test in SPSS 16, at a significance level of 0.05.

3. Results

The demographic characteristics of the study subjects are presented in Table 1. Based on Table 2, the distribution of the data was not normal; therefore, non-parametric tests were applied to analyze the collected data. Table 3 suggests that before monitoring compliance with the intake of iron supplements through the application, the minimum Hb of the respondents equaled 7.3 g/dL and the maximum was measured as 11.2 g/dL. After using the application, Hb levels reached a minimum of 7.6 g/db and a maximum of 12.2 g/dL.

Table 4 demonstrates that most women (78%) were adherent to taking iron supplementations. The relationship between monitoring the compliance of pregnant women with taking iron supplementations via an Android application with an increase in Hb is presented in Table 5.

Table 5 reveals that the mean value equaled 30.06, indicating that adherent women had more influence on the increase in Hb levels (P=0.010).

4. Discussion

Anemia is a condition of decreased red blood cells or Hb which results in a lack of oxygen-carrying capacity for the needs of vital organs in pregnant women and the fetus (Widness 2008). An indication for anemia is if the Hb concentration is <10.5 to 11.0 g/dL (Lumbanraja et al. 2019). Supplementation with iron tablets is a valuable approach to treat anemia; using tablets containing 60 mg/day can increase Hb levels. Iron supplementation has long been routinely given to pregnant women at PHC,

Table 1. Frequency distribution of respondents' characteristics

Characteristics		No. (%)
Age (y)	20-29	37(74.0)
	30-40	13(26.0)
Education Level	High (> High School)	14(28.0)
	Low (< High School)	36(72.0)
Occupation	Housewives	39(78.0)
	Civil servant	4(8.0)
	Entrepreneur	7(14.0)
Parity	Primiparous	20(40.0)
	Multiparous	30(60.0)

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and Health and Nutrition Integrated Service Center (Posyandu) in Indonesia (Shanti et al. 2017).

The Mann-Whitney U test provided a P=0.010; thus, there existed differences in Hb levels before and after monitoring using a smartphone application, with changes in Hb levels from 11.2 g/dL to a maximum of 12 g/dL. Monitoring the respondents' Hb levels significantly impacted pregnant women's compliance in taking iron supplements.

The obtained results were in line with those of several research that illustrated the significant impact of smartphone-based applications on the quality of antenatal care. MnNabb et al. (2015) argued that "the change Antenatal Care (ANC) application" can increase the ANC service quality score, especially the health education domain, which had the highest quality score increase from 5.45 at the beginning to 8.67 points (P<0.001). Likewise, client satisfaction increased from 75% to 83% (P<0.05) (McNabb et al. 2015).

Our results were also in line with a study at Al-Yamamah Hospital, Riyadh, Saudi Arabia. They found that the non-adherence of pregnant women to taking iron supplements was significantly associated with an enhanced anemia rate from 29.6% in the first trimester to 34% in the third trimester (Habib et al. 2009) since usually no basic changes occur in the composition of the diet. A retrospective cohort study was carried out in Al-Yamamah Hospital, Riyadh, Saudi Arabia, to compare the outcome of hemoglobin levels in 308 pregnant women near term with compliance to iron supplementation during the preceding pregnancy stages. Data were collected using an interview-based questionnaire for assessment of supplementation compliance and the women were divided into three categories: strictly compliant; partially compliant; and non-compliant. Hemoglobin levels were extracted from the medical records for the first antenatal visit (before 13 weeks' gestation. It was turned out that smartphone-based application is effective on pregnant women's compliance with taking iron tablets (Rukmaini, Sapurti & Aisyiah 2018).

Similar to our results, there was a mean adherence to the asthma treatment of 82% in patients receiving daily SMS reminders, compared to 70% in the group that received no reminders (Strandbygaard, Thomsen & Backer 2010). In another study, text messages improved adherence to immunosuppressant treatment in the liver transplant recipients as measured by blood medicine concen-

Table 2. The results of data normality test related to the effect of compliance through Android application on Hb increase

Outcome Measure	Kolmogorov-Spirnov			Shapiro-Wilks		
	Statistic	df	Sig.	Statistic	df	Sig.
Hb (Pre-test)	0.192	50	0.000	0.926	50	0.004
Hb (Post-test)	0.161	50	0.002	0.897	50	0.000

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Table 3. Hb levels of the examined pregnant women before and after iron supplements monitoring through the Android application (N=50)

Hb Measurement	N	Min.	Max.	Mean±SD
Before being monitored	50	7.3	11.2	9.640±0.928
After being monitored	50	7.6	12.2	10.376±0.920

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trations (Miloh et al. 2009). Studies involving patients with Human Immunodeficiency Virus (HIV) revealed the following information: significantly higher adherence in patients who received daily mobile reminders, compared to patients alerted by pagers; >95% adherence in patients receiving SMS reminders, compared to the group that received no reminders (Pop-Eleches et al. 2011).

Based on brief interviews between the researchers in a study and several respondents, pregnant women had received iron supplements during antenatal care; however, they had not taken them regularly and often forgot to take the blood-boosters. Therefore, it is necessary to have an application to monitor the activities of pregnant women in taking vitamins or supplements (Wang et al. 2019).

One strategy to improve patient behavior in treatment is to provide controlled treatment services to patients at home based on mobile technology (Vervloet et al. 2012). A subject is said to be obedient if the provided medicine is used up or reduced according to the predetermined schedule and is willing to follow the physician's or other healthcare staff's recommendations. The individual is said to be disobedient if they neglect obligations to perform the recommendations of physicians/healthcare workers (Putri et al. 2020).

Formally, a tool or job guide is defined as an external device that provides direct knowledge and information to help, direct, guide, and improve the performance of individuals in their tasks (Florez-Arango et al. 2011).

At the end of the intervention, the explored non-compliant women stated that in addition to forgetting, their non-compliance was also because of complications, such as nausea, constipation, or difficulty in defecating; consequently, they discontinued taking iron supplementations. The present study explicated the apparent efficacy of using an android-based application as a reminder with actual results. This is because the impact of increasing maternal compliance in taking iron supplements is evident from the lack of anemia in pregnant women and an increase in their Hb levels.

This smartphone application was not equipped with a menu to upload documents or jpg files. Therefore, the limitation of this study was the absence of complete documentary evidence in the application that presents if the respondent is taking iron supplements. For example, by sending photo documentation through this application when taking iron supplements.

Table 4. Describing the status of the examined women concerning compliance with taking iron supplementation

No	Compliance	No. (%)
1	No	11 (22.0)
2	Yes	39 (78.0)
Total		50 (100)

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Table 5. Differences in the mean adherence values of respondents in taking iron supplementations with increased Hb after monitoring (N=50)

Adherence	Mean±SD	P
Adherent	30.06±3.679	0.010
Not adherent	9.32±0.911	

*Mann-Whitney U test.

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5. Conclusion

The current research data indicated that monitoring the consumption of iron supplements using an Android application improves pregnant women's compliance with taking iron supplements and leads to increasing their Hb levels. Using such an application is recommended for improving pregnant women's compliance with iron supplementations by healthcare workers and midwives.

Ethical Considerations

Compliance with ethical guidelines

The study was approved by the Health Research Ethics Committee of Health Polytechnic of Jambi (Reference number LB.02.06/2/136/2020). The subjects sought their signed informed consent for participation in the study.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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