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ORIGINAL RESEARCH

Optimizing Antenatal Care: The Effects of a Holistic Nursing Android Application for Pregnant Women

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Abstract

Background: During the COVID-19 pandemic, face-to-face antenatal care (ANC) services were limited. Therefore, we developed the Android digital application "Guide Me" with a holistic care concept for optimizing ANC.
Purpose: This study aimed to evaluate the effect of the Android digital application "Guide Me" on optimizing ANC.
Methods: The present study used an experimental research design. The participants included 302 pregnant women selected through block randomization, with 160 in the intervention group and 142 in the control group. The intervention involved providing ANC services using a digital Android application at home, with health services visited only when treatment was necessary. The intervention group received usual care along with the Android application, "Guide Me", which included a holistic nursing concept program, while the control group received only the usual care. Data were collected three times, and the ANC scale was used to measure ANC optimization. Repeated measures ANOVA was used to analyze the data.
Results: There were significant differences in the optimization of ANC ([F=96.887, df (1,300), p<0.001]) between the intervention and control groups. The target of 14 T in the intervention group showed significant statistical differences over three times ([F=118.35, df (1,308), p<0.001]) compared to the control group, with optimization of ANC increasing from 45.79 to 59.16 in the intervention group and from 44.09 to 45.77 in the control group.
Conclusions: The program effectively increased ANC optimization. Pregnant women feel more at ease in their own homes and have less time to visit a hospital. Therefore, they may accept and even appreciate online apps and telemonitoring as alternatives to ANC checks.

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1. Introduction

The majority of pregnant women express concern about COVID-19 exposure during pregnancy care at health services (Schwartz, 2020), despite the fact that neonates are generally safe from mothers with COVID-19 (DeNicola et al., 2020). A study in Chicago reported that 43.5% of pregnant women with COVID-19 exhibited no signs or symptoms during the early stages of infection. Other studies have found the COVID-19 virus in the placenta (Hosier et al., 2020) and shown that vertical transmission from mother to neonate can occur during the third trimester (Hu et al., 2020). Additionally, pregnant women have reported high levels of fear related to COVID-19 (Lebel et al., 2020; Nausheen et al., 2020; Zainiyah & Susanti, 2020), with Goldfarb et al. (2020) emphasizing the need for support and routine consultations throughout pregnancy. Given these concerns, routine consultations for pregnant women using online services are crucial to prevent complications for both mothers and their fetuses (Miller et al., 2020), particularly during the pandemic.

In response to this need, health services have rapidly adapted by offering online consultations (Rasmussen & Jamieson, 2020). These services allow pregnant women to consult healthcare providers from home, reducing their risk of COVID-19 exposure while enhancing accessibility, especially in the context of restricted mobility (Brunelli et al., 2021).

Telemedicine applications, including mobile health (mHealth) apps, have emerged as vital tools for addressing the healthcare needs of pregnant women during the pandemic. Research highlights the potential of mHealth apps and social media to significantly enhance maternal well-being (Chan & Chen, 2019). However, most applications offer limited features for pregnant women (Choi et al., 2016; Zairina et al., 2016), focusing, for example, on video calls (Borrelli et al., 2023) and video chat (Shi et al., 2023) or addressing singular issues like asthma (Zairina et al., 2016) or physical activity (Choi et al., 2016). Furthermore, the majority of research on mHealth apps to support lifestyle and healthcare in high-income nations highlights the effectiveness of these apps for reducing gestational weight gain, increasing fruit and vegetable intake, and supporting healthcare for the prevention of infections and asthma during pregnancy (Carter et al., 2019). However, these apps often fail to address the comprehensive, multifaceted needs of pregnant women, especially those in low- to middle-income settings.

Our preliminary study revealed that most pregnant women in the study area use Android mobile phones (Desmawati et al., 2020). This indicates a significant opportunity to develop Android-based digital health services tailored for Antenatal Care (ANC). While many telemedicine applications focus on specific health issues or limited maternal health education, they often do not provide holistic care addressing physical, emotional, psychological, cultural, and spiritual well-being. This gap underscores the need for a more comprehensive approach to ANC, particularly in resource-limited settings.

The "Guide Me" application seeks to address this gap by providing a holistic approach to ANC based on Holistic Nursing Theory (HNT), which recognizes the interconnected needs of pregnant women. The application includes features such as a question-and-answer platform, chat, video calls by appointment, and scheduling in-person consultations. It also offers perinatal education resources to enhance pregnant women's knowledge about pregnancy and childbirth preparation. While the app does not provide direct physical services, such as ultrasonography (USG), blood pressure monitoring, or laboratory tests, it allows users to schedule appointments for these services. This feature ensures that pregnant women can receive necessary physical care without long waits at healthcare facilities. Additionally, the application incorporates non-pharmacologic education modes to manage pregnancy holistically, addressing physical, psychological, emotional, cultural, and spiritual needs to optimize ANC (Tendean et al., 2021). It also includes independent nurse-midwifery interventions (Desmawati et al., 2019) and offers education classes for ANC and childbirth preparation (Desmawati et al., 2020).

This study aimed to evaluate the effectiveness of the "Guide Me" Android application in optimizing ANC. The intervention involves delivering ANC services through the app, with in-person visits to healthcare facilities limited to cases requiring physical examination or treatment.

2. Methods

2.1. Research design

The design of the study was experimental. This design fits the aim of the study, which is to test the effect of the Android digital application "Guide Me" on optimizing ANC. The intervention results were compared between the intervention group and the control group. The study was conducted at antenatal clinics in four Community Health Centers (CHCs) across two districts in Indonesia.

2.2. Setting and samples

The study was conducted from July to December 2022. The sample size was calculated using G*Power version 3.1.9.7 (Faul et al., 2007), with medium effect size, power = 0.80, and a level of significance = 0.05 (Cohen, 1988). At least 84 pregnant women were needed for each CHC. With four CHCs included, a total of 336 respondents participated in the study and met the inclusion criteria at antenatal clinics. These criteria included mothers and fetuses without complications, singleton pregnancies, 12–36 weeks of pregnancy, and willingness to follow the research guidelines until the program's completion. The exclusion criteria included not planning the baby's delivery outside the research areas. Pregnant women who met the inclusion criteria and were willing to participate in the study provided informed consent and their mobile phone numbers.

Participants were randomly assigned to either the intervention group (IG) (n=168) or the control group (CG) (n=168) using an application that generated a specified sequence based on the block randomization formula. Pregnant women in the IG received the usual care during

pregnancy and used the "Guide Me" application. During the study, respondents were excluded if: (1) the mother developed any adverse medical conditions or psychological depression, or (2) they had to undergo a cesarean section or natural labor before completing the program and questionnaire.

2.3. Intervention

The respondents were divided into the intervention and control groups. The control group received the usual ANC, while the intervention group received the usual ANC and used an Android digital application, "Guide Me," developed by the researcher. The application was developed based on a focus group discussion with 30 pregnant women representing four health centers in Indonesia (Cinere, Limo, Pamulang, and Ciputat). Correspondingly, the focus group discussion (FGD) results were used as references for creating the application, which was supplemented with content from related materials. After the application was completed, it was tested on ten pregnant women at a public health center. The results indicated that the application significantly helped optimize pregnant women's ANC targets.

The application includes five features: (1) read feature, (2) question-and-answer feature, (3) chat feature, (4) video call feature, and (5) appointment scheduling feature. For the intervention group, routine ANC services included the "10 T" in Indonesian, consisting of ten items: (1) *Timbang berat badan dan tinggi badan* (weight and height measurement), (2) *Tekanan darah diperiksa* (blood pressure measurement), (3) *Tetapkan status gizi* (nutritional status assessment), (4) *Tinggi fundus uteri diperiksa* (uterine fundal height measurement), (5) *Tentukan presentasi janin dan detak jantung janin* (fetal presentation and heart rate monitoring), (6) *Tetanus vaksin* (tetanus toxoid vaccination), (7) *Tablet zat besi* (iron supplementation), (8) *Tes laboratorium rutin dan khusus* (routine laboratory tests, e.g., urine and sexually transmitted disease (STD) tests), (9) *Temu wicara* (counseling), and (10) *Tatalaksana kasus* (case management for individual pregnancy issues via the digital ANC application to reduce worry) (Rohmawati et al., 2020). With the additional program in the application, the "10 T" was expanded to "14 T" with the addition of: (11) *Senam hamil* (pregnancy exercise), (12) *Perawatan payudara* (breast care), (13) *Berikan Yodium untuk daerah gondok* (iodine supplementation for goiter-endemic areas), and (14) *Anti malaria untuk daerah endemik* (malaria prophylaxis for endemic areas).

The control group received the usual care provided by CHCs, which included measuring height and weight, blood pressure, uterine fundal height, fetal presentation and heart rate, tetanus toxoid vaccination, iron supplementation, and routine laboratory tests, e.g., urine tests and STD tests upon request. Meanwhile, respondents in the intervention group were asked to install the application and were provided with instructions on how to use it. The study was conducted over six months, with measurements taken at three points (pre-, mid-, and post-test).

2.4. Measurement and data collection

The 14 T of ANC was used to measure targets in the optimization of ANC implementation (Rohmawati et al., 2020). The study was evaluated at three points: pre-test, mid-test, and post-test. The scale was scored from 1 to 5 (1=never, 2=seldom, 3=sometimes, 4=often, 5=always), with total scores ranging from 14 to 70. A lower score indicated poor ANC practices, while a higher score reflected better ANC adherence. The reliability of the instruments used in the study was tested, with the ANC scale showing a reliability coefficient of 0.75. The Content Validity Index (CVI) for the content within the application (program) was 0.83. Participants were provided with a manual to guide them in using the home application. At the end of the study, data from 302 respondents were analyzed, including 142 respondents in the control group (CG) and 160 respondents in the intervention group (IG) (Figure 1). Data collection was conducted by the principal investigator and a research assistant.

2.5. Data analysis

Data analysis was conducted using IBM SPSS Statistics for Windows, Version 25.0 (Armonk, New York). Repeated Measures Analysis of Variance (ANOVA) was used to evaluate within-group effects before and after the intervention, while independent t-tests were performed to compare the program's effects between the intervention and control groups. A significance level of $p<0.05$ (two-tailed) was considered statistically significant. In this study, potential confounding factors

included the possibility of respondents using other mHealth applications and instances where pregnant women in the intervention group might discuss the "Guide Me" application with those in the control group. Although the researcher could not fully control these confounding variables, efforts were made to minimize bias by requesting participants in the intervention group to refrain from sharing information about the application with others and advising respondents not to use other mHealth applications during the study.

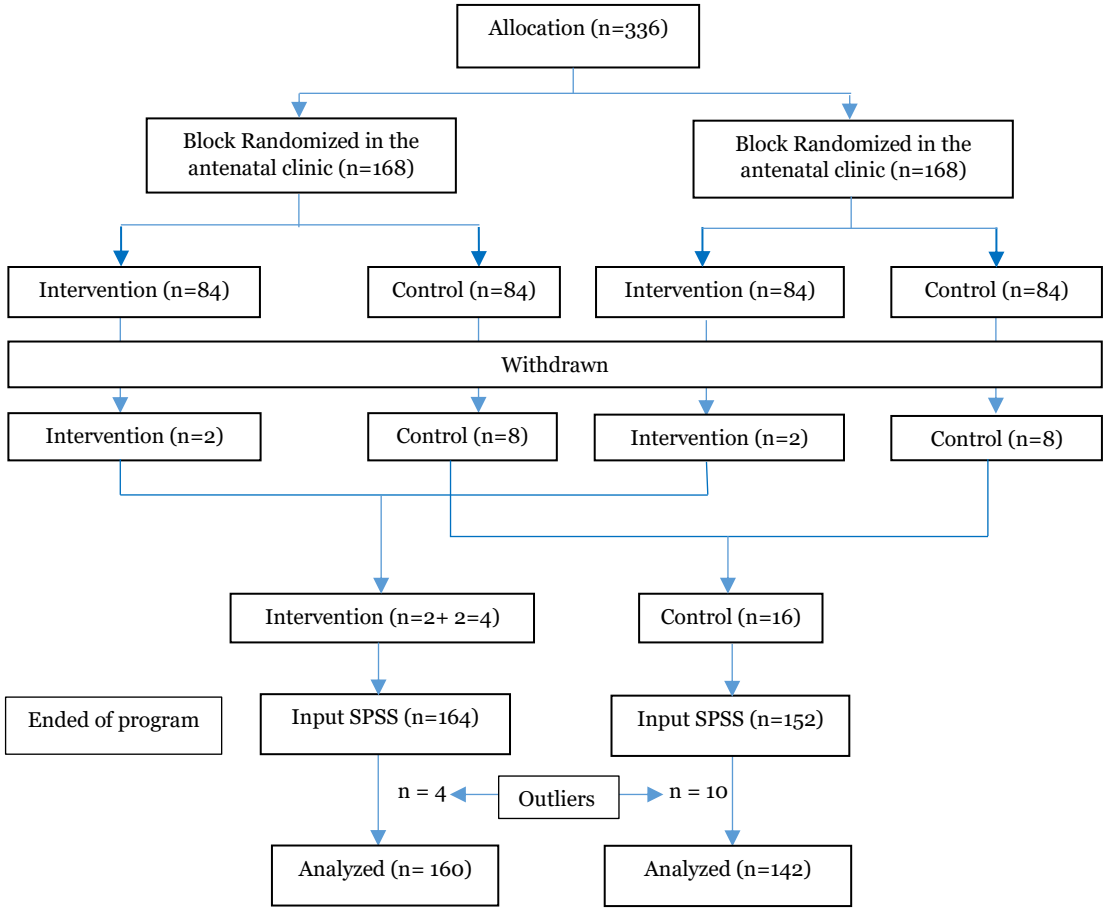

Figure 1. Flow diagram of participants during the study

2.6. Ethical considerations

This study obtained ethical approval from the ethics review boards at the University of Jember, Indonesia (reference number 137/UB25.1.14/KEPK/2022). Furthermore, pregnant women were provided with information about the study and signed a consent form. They were free to withdraw from the study at any time, and the confidentiality of their data was ensured.

3. Results

3.1. Demographic data of the respondents

Of the 336 pregnant women (n=168 in the control group [CG] and n=168 in the intervention group [IG]) with their family involvement from data collection until the completion of the study, 20 respondents dropped out (16 pregnant women in the CG and 4 in the IG) (Figure 1). They withdrew for various reasons, such as normal delivery or cesarean section, and did not complete the program. During data analysis, some outliers were found (n=10 in the CG and n=4 in the IG), resulting in a total sample of 302 respondents (160 in the intervention group and 142 in the control group). The mean age of respondents in the intervention and control groups was 28.9 and 28.2 years, respectively. Most respondents had elementary, junior, or senior high school education levels (75% in the intervention group and 80.3% in the control group). Additionally, a higher proportion of respondents in the intervention group had completed higher education

(25%) compared to those in the control group (19.7%). Furthermore, most respondents were not working (76.25% in the intervention group and 81.69% in the control group) (Table 1).

Table 1. Demographic data of the respondents in the intervention and control groups (n=302)

Variables	Intervention Group (n=160)	Control Group (n=142)
	f (%)	f (%)
Mean age (years), M(SD)	28.9 (5.26)	28.22 (5.29)
Ethnicity		
Betawinese, Sundanese, Javanese	98 (61.25)	92 (64.78)
Minangnes and others (non-Java islands)	62 (38.75)	50 (35.21)
Educational level		
Elementary, Junior, Senior High School	120 (75)	114 (80.3)
Diploma, Bachelor, Master	40 (25)	28 (19.7)
Occupation		
Not working	122 (76.25)	116 (81.69)
Working	38 (23.75)	26 (18.31)
Family's income per month (IDR), M(SD)*	4,182.92 (1,808.85)	3,809.52 (1,909.38)
Gestational Status (trimester), M(SD)	2.10(1.17)	2.02(1.01)

Note: M=Mean, SD= Standard Deviation, f=Frequency, *IDR in thousands

3.2. ANC scores of pregnant women

At the end of the study, data from 302 respondents were analyzed, including 142 pregnant women in the control group (CG) and 160 pregnant women in the intervention group (IG). All pregnant women in both groups met the assumptions for the independent t-test and repeated measures ANOVA. The distribution of the data was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests, and the result showed that the data were normally distributed. Homogeneity was confirmed by Levene's test for ANC optimization scores (p=0.056). The baseline demographic and obstetric data of both groups were similar. No significant differences were found in demographic and obstetric data between the control and intervention groups (maternal age p=0.212, gestational age at the start of using the application p=0.572, educational level p=0.760, occupation p=0.091, and gestational status p=0.721). Thus, randomization and confounding factors were controlled with a fairly homogenous sample.

As presented in Table 2, this study indicated a significantly different optimization of ANC between the CG and IG [F=96.887, df(1, 300), p<0.001]. Furthermore, there were significant statistical differences over three time points for ANC optimization [F=118.35, df(1, 308), p<0.001]. This revealed that the ANC score significantly increased after the program was conducted. Using repeated measures ANOVA with Greenhouse-Geisser correction, a significant difference in ANC optimization scores over the three time points was reported [F (1.028, 1.028) =175.797, p<0.001, with partial η^2=0.369].

Table 2. Comparison of optimization ANC score of pregnant women during using ANC digital android application of the two groups (n=302) using repeated measure ANOVA

Sources of variance	Sum of Squares	Df	Mean Square	F	*P*-value	Partial η^2
Between-respondents						
Group(intercept)	2109876	1	210987.20	23150.63	0.000**	0.987
Group	8829.972	1	8829.972	96.887	0.000**	0.244
Error	27341.05	300	91.137			
Within respondents						
Time	8762.545	1.028	8524.313	175.797	0.000**	0.369
Group x time	5899.189	1.028	5738.805	118.352	0.000**	0.283
Error (time)	14953.37	308.3	48.489			

Note. ** p<0.001

A post hoc test using the Bonferroni correction showed that the mean ANC target score at the mid-test (M=49.45, SD=4.49) was more optimal than at the pre-test (M=45.79, SD=7.10), with a significant difference (p<0.000). The ANC target score at the post-test (M=59.16, SD=4.57) was more optimal than at the mid-test, and this improvement also resulted in a significant difference (p<0.000) (Table 3).

Table 3. Comparisons of mean differences in ANC optimization across the three time points using the Bonferroni correction in the repeated measure ANOVA

Comparison	Mean(Standard Deviation)				Mean difference	p
	Pre-test	1st month	2nd month	SE		
Pre-test and 2nd trimester	45.79(7.10)		-	0.496	-2.666	0.000**
Pre-test and 3rd trimester	-	49.45(4.49)		0.497	-7.526	0.000**
2nd and 3rd trimester		-	59.16(4.57)	0.068	-4.859	0.000**

Note. **p<0.001

Table 4 presents the mean, standard deviation, and p-value of the total ANC optimization scores at each time point for the IG and CG. The mean ANC scores at the pre-test, mid-test, and post-test in the IG were higher than those in the CG. An independent t-test demonstrated that the mean and standard deviation of ANC scores in the IG were as follows: pre-test, 45.79(7.10); mid-test, 49.45(4.49); and post-test, 59.16(4.57). In comparison, the CG scores were: pre-test, 44.09 (8.25); mid-test, 45.77(8.01); and post-test, 45.77(8.01). A significant difference was found between the two groups at the mid-test (t=4.987, p<0.001) and post-test (t=18.082, p<0.001). However, there was no significant difference between the two groups at the pre-test (t=1.917, p=0.058). The study indicated significant differences in ANC optimization at the mid-test and post-test compared to the pre-test.

Table 4. Comparisons of mean scores and standard deviations of optimization ANC

Antenatal Care	Intervention Group (n=140)		Control Group (n=162)		T	*p*-value
	M	SD	M	SD		
Optimization ANC at pre-test	45.79	7.10	44.09	8.25	1.917	0.058
Optimization ANC at mid-test	49.45	4.49	45.77	8.01	4.987	0.000**
Optimization ANC at post-test	59.16	4.57	45.77	8.01	18.08	0.000**

Note. ** p<0.001, M=Mean score, SD=Standard deviation

4. Discussion

This study aimed to evaluate the effect of the Android digital application "Guide Me" on optimizing antenatal care (ANC). The findings demonstrate the application's effectiveness in enhancing ANC for pregnant women, as ANC targets significantly increased and became more optimal after the program's implementation. These results align with previous research, which found that most women experience positive pregnancy outcomes when using online consultations (van den Heuvel et al., 2020b). Online apps and telemonitoring are widely regarded as convenient and valuable tools for ANC, as they enable women to remain comfortable at home while minimizing the need for hospital visits. Such digital tools also contribute to maintaining, optimizing, and improving the frequency and outcomes of ANC. Additionally, remote and digital consultations, as well as home-based electronic fetal monitoring, have been shown to support quality midwifery care during the pandemic and beyond (van den Heuvel et al., 2020b).

During the COVID-19 pandemic, most countries reduced face-to-face antenatal clinic visits for pregnant women. For instance, in Italy, women found online apps useful for ANC checks except when direct treatment was required (Coxon et al., 2020; Renfrew et al., 2020). Similarly, many health services in France and the United Kingdom replaced in-person visits with virtual support. In the Netherlands, mobile or phone consultations continued for blood tests and early ultrasounds at 10–12 weeks of pregnancy, while in Spain, some hospitals transitioned to phone

consultations (Coxon et al., 2020; Renfrew et al., 2020). The current study provides a set of core principles as solutions for pregnant women during and after the pandemic. Mobile health (mHealth) apps promote healthy lifestyles and support medical care by helping prevent excessive weight gain during pregnancy, encouraging the consumption of fruits and vegetables, and assisting with smoking cessation. These apps also support healthcare efforts to prevent infections during pregnancy (Coxon et al., 2020; Overdijkink et al., 2018). Studies with large sample sizes have demonstrated the significant outcomes of digital health services. For instance, Zairina et al. (2016) reported that mHealth apps improved asthma control during pregnancy. Additionally, the Management of Maternal Obesity through Mobile Technology (MOMTech) program effectively managed maternal obesity during pregnancy, showing feasibility in clinical settings and acceptance by women, though slight modifications to recruitment, text messages, and consultation logistics may be necessary for broader implementation (Soltani et al., 2015).

This study found that after six months of using the "Guide Me" program, ANC optimization improved by 13.49%. This finding aligns with a previous study reporting that lifestyle behaviors improved by 26.3% after six months of coaching, with the platform showing high compliance and usability, and users demonstrating improvements in nutrition and lifestyle behaviors (Choi et al., 2016). Another study in the Netherlands demonstrated that the SAFE@HOME app reduced face-to-face visits while enhancing ANC services through a digital platform, resulting in increased healthcare utilization through additional digital antenatal visits (van den Heuvel et al., 2020a). The present study highlighted the application's features, including (1) reading material, (2) a question-and-answer section, (3) chat functionality, (4) video calls, and (5) scheduling face-to-face appointments. These findings support previous studies reporting two modes of application use: (1) asynchronous, where patient information is stored and reviewed later by a nurse-midwife, similar to this study's reading and Q&A features, and (2) synchronous, involving live interactive consultations where pregnant women interact remotely with nurse-midwives in real-time to maintain physical distancing (DeNicola et al., 2020). This synchronous approach is comparable to the chat and video call features (available with prior agreement) in the current study, which have been particularly effective during the COVID-19 pandemic.

Since the onset of the COVID-19 pandemic in 2020, the global perspective on telehealth has shifted. The world has benefited more from its use, including in pregnancy care. The American College of Obstetrics and Gynecology (ACOG) recommended the use of telehealth in February 2020 (Dosaj et al., 2021). Following this, it was reported in New York that the implementation of telehealth reduced more than half of face-to-face visits for low-risk patients (Sumarsono et al., 2023). Similarly, virtual prenatal care visits and consultations have been reported to replace most in-person visits (Zork et al., 2020). Many regimens, such as nutrition counseling, weight gain management, risk factors, vitamins, breastfeeding education, pre-term labor, preeclampsia precautions, family planning counseling, and physical exercise, can be done virtually. A study in the UK showed that implementing a remote monitoring system replaced 800 in-person appointments and achieved better compliance with ANC targets (Aziz et al., 2020). In another country, Cairo, the implementation of telehealth in maternity nursing care helped reduce the maternal mortality rate. The digital application had positive impacts, such as increased maternal knowledge, motivation, and health behavior, which helped guide pregnant women in practicing physical activities and detecting high-risk pregnancies, all while providing affordable home-based services (Kamel & El Toukhi, 2020).

Nowadays, the acceptance of telehealth services is high and continues to be appropriate post-COVID-19. Telehealth flexibilities have expanded access to care through digital means. This condition provides an opportunity to expand access to pregnancy and provide holistic nursing care for pregnant women after COVID-19.

5. Implication and limitations

The findings of this study have significant implications for nursing practice, particularly in the delivery of antenatal care (ANC). The successful implementation of the "Guide Me" Android application demonstrates the potential of digital health solutions to optimize ANC, especially when face-to-face interactions are limited, such as during pandemics or for women in remote areas. This approach offers nurses a new model of care that integrates holistic nursing concepts, enabling them to remotely monitor and guide pregnant women while still providing personalized support. The increased acceptance of telehealth services post-COVID-19 has expanded access to

care through digital platforms, creating an opportunity to improve pregnancy care and offer holistic nursing support to pregnant women beyond the pandemic.

This study has certain limitations. It focused only on normal pregnancies, which limits the generalizability of the findings to women with high-risk pregnancies. Since the intervention (the "Guide Me" Android application) was designed for home use, its effectiveness may differ for women who require more frequent in-person visits of ANC. Aditionally, subjects using the app for self-practice at home could not be directly monitored by researchers. It is important to note that the study began in the second trimester of pregnancy. Antenatal care (ANC) should ideally start in the first trimester to detect and prevent complications early, including providing guidance on nutrition, controlling chronic diseases, treating infections, and managing risk factors to prevent complications such as pre-term birth, low birth weight, and maternal and infant mortality.

6. Conclusion

This study concluded that the Android digital application "Guide Me," with a holistic care concept, effectively optimizes ANC. This app is a holistic nursing program that addresses physical, psychological, social, cultural, and spiritual needs through digital means. The program is effective and efficient in terms of time, cost, and ease of use. Moreover, women feel more at ease in their own homes, spend less time visiting hospitals, and may find online apps and telemonitoring to be acceptable and valuable alternatives to ANC checks. They can maintain, optimize, and improve ANC numbers and target checks. It is affordable, simple to use, timely, and effective. Additionally, policymakers and healthcare providers should consider implementing the program in all antenatal clinics in Indonesia. Future research should focus on developing apps to test their effectiveness for high-risk pregnancies, particularly in the field of community healthcare.

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Author contribution

All authors (DD, RI) contributed to the conceptualization of the study, data collection and processing, and manuscript preparation and revision. All authors have read and approved the final manuscript.

Conflict of interest

There is no conflict of interest among authors.

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