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Effectiveness and quality of mobile applications in pregnancy monitoring: A systematic review

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ABSTRACT

Background: Technology is now increasingly developed and widely used in the world of health. This condition triggers the use of mobile applications for monitoring the health of pregnant women. However, the effectiveness of using applications for pregnancy monitoring still needs to be studied more deeply.

Method: This article is a literature study on the use of mobile applications for pregnancy monitoring. This systematic review aims to identify research published from January 2011 to December 2024 by searching in four databases (PubMed, Science Direct, Scopus, ProQuest). The included study addresses the effectiveness and quality of the use of mobile apps for health monitoring of pregnant women and this study is the primary study. Data extraction was carried out by 3 researchers with screening and discussion methods.

Results: A total of 3130 articles have been screened, 8 articles are included in the inclusion criteria. A total of 7 articles were randomized controlled trials and only 1 article was a quasi-experiment. The grouping category is 4, namely 2 articles providing health information, 1 article discussing pregnancy counselling, 2 articles discussing decision making and mental support, and three articles discussing pregnancy management.

Conclusion: Mobile applications for pregnancy monitoring have an effective function in four categories of use, namely provide health information, pregnancy counselling, decision-making and mental support, and pregnancy care management.

Keywords: ***pregnant women, mobile health, medical informatics, application, maternal care pattern***

INTRODUCTION

The use of information and communication technology is increasing rapidly. There are so many uses of technology in the health sector, such as the use of applications for pregnant women [1]. The increasing number of application users by pregnant women can improve maternal knowledge, maternal health services, important information available, and online consultation media[2]. The use of mobile applications by pregnant women is high, allowing for the provision of health education to women during pregnancy and monitoring of maternal health conditions. Approximately 60% of the 140 million women who give birth globally each year download pregnancy-related mobile apps. These apps serve various purposes, including providing health information, tracking fetal development, and offering telemedicine consultations. Many also include social features that connect users with other pregnant women, as well as educational resources such as tutorials and expert workshops [3]. The right application can be utilized for pregnancy care and structured perinatal care[4]. Currently, there are many applications developed for maternal health monitoring that provide online consultation services, online training, and significantly affect the healthier lifestyle of pregnant women [5]

Mobile apps are included in mHealth (mobile health). Mobile health is defined as the use and utilization of technology such as apps, video messaging, and online consultations to support the achievement of health goals. Digital health services have been widely applied in various health sectors with various variations that are tailored to the purpose of use in the health sector [6]. Digital applications are growing which has an impact on increasing the use of applications by pregnant women. The use of digital applications among pregnant women has significantly increased, especially during the COVID-19 pandemic. Over 50% of pregnant women use pregnancy-related apps, and the pandemic led to a 25% increase in mobile health app downloads. These apps provide various features, including fetal development tracking, nutrition guidance, and antenatal care information [7].

Pregnant women who use the application feel facilitated in monitoring their health conditions. Many health apps are focused on maternal and child health. The application has appeared in the android market and app store with diverse and interesting features ranging from free to paid [8].

The use of digital applications in pregnancy certainly has several challenges. One of the challenges is the maintenance of the application and cooperation between users such as patients and doctors [9]. Cultural and socio-economic factors are factors that have a great influence on the use of mobile applications, so when creating an application, it is important to pay attention to the needs of users and adjust to the demographic background[10]. Based on current conditions, it is necessary to conduct a systematic review of the effectiveness and quality of mobile applications for pregnancy monitoring. This aims to identify the effectiveness of the use of the application and map the functionality of each application.

METHODS

1. Search Strategy

Preparation of systematic review using PRISMA protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and has been registered PROSPERO with the number **CRD42022367615**. Search for articles to be reviewed using four electronic databases (ProQuest, Scopus, Science Direct, PubMed). The search is limited to articles published from January 2011 to December 2021. We also use PICO (Population, Intervention, Comparison, and Outcomes) in determining search keywords. The search was carried out using MeSH terms identified in order to

reach more results. The following terms were included: pregnant women, mobile health, medical informatics, application, maternal care pattern. Keyword terms that have been obtained are entered into the search in ProQuest, Scopus, Science Direct, and PubMed. The definitions of which are presented below.

Table 1. Search terms and search strategy

No	Keywords	Database
1	(pregnant women AND pregnancy care AND maternal & child health care AND pregnancy monitoring AND midwifery care AND pregnancy complications AND mobile application)	ProQuest
2	(pregnant AND women, AND mobile AND applications, AND pregnancy AND care)	Scopus
3	((Pregnant women) AND ((mobile application) AND (Pregnancy care))	Science Direct
4	((((pregnant women) OR (maternal care pattern)) AND (medical informatics application)) AND (mobile health)) OR (mobile health unit)	Pubmed

2. Inclusion Criteria
   Study inclusion criteria were: (1) full-text journal article; (2) primary research; (3) published in English; (4) published in a recent year period (2011–2024); (5) reported use of mobile applications in pregnancy monitoring (6) Experimental research design.
3. Exclusion Criteria
   (1) protocol; (2) duplicate publication; (3) small sample sizes; (4) high risk of bias; (5) Do not focus on the target population (non-pregnant women).
4. Study Selection
   The first step is to identify duplicate articles in 4 databases using the Zotero 6.0.20 application. If there is a duplicate of the article, we use the most recent article. The second step is to identify the abstract and title carried out by the two researchers. Third, articles that have been obtained in full text are filtered by the two researchers based on the inclusion criteria and exclusion criteria that have been set. If there is a difference of opinion from the two researchers, then involve a third researcher through discussion.
5. Data Extraction
   Implementation of extraction data is to ensure the reliability of the information collected. The process of data extraction using automatic tool Zotero 6.0.20. The first author determined search keywords, selected the articles, and assessment the collected articles according to the effectiveness and quality of the mobile application used for pregnancy monitoring (RP). The second author then verified the accuracy of the data that has been extracted and assessed the article using the Critical Appraisal Tool (PDR). The third author prepared the manuscript of the article to be published. The different opinion were discussed together by involving the third author (AHH). Based on the results of discussions between authors, there are 4 categories of application use implemented for pregnancy monitoring, namely mobile applications as information providers, pregnancy consultations, decision-making and mental support, and pregnancy care management. Each application is classified into four main categories based on their functionality and effectiveness of use.

RESULT

1. Study selection

   The total number of articles that have been obtained from 4 databases is 3130: 272 in ProQuest, 144 in Scopus, 1622 in Science Direct, and 1092 in Pubmed. All titles and abstracts are imported into Zotero 6.0.20 and 167 duplicate abstracts are excluded. There are 2936 articles that are not filtered abstract and title. As a result of the screening, there were 1961 articles that were not the results of a review or conference. There are 728 articles that have the potential to comply with the inclusion and exclusion criteria and can be accessed in full text. Of the 728 articles, 82 articles were not

pregnancy applications, 290 were not mobile applications, 343 were not intervention studies, and 117 were not pregnancy monitoring. In addition, there were 27 articles that were not studies related to the effectiveness of using the app for pregnancy monitoring. The final result was 8 articles that met the inclusion criteria for the agreed systematic review [11–18] **(Figure 1).**

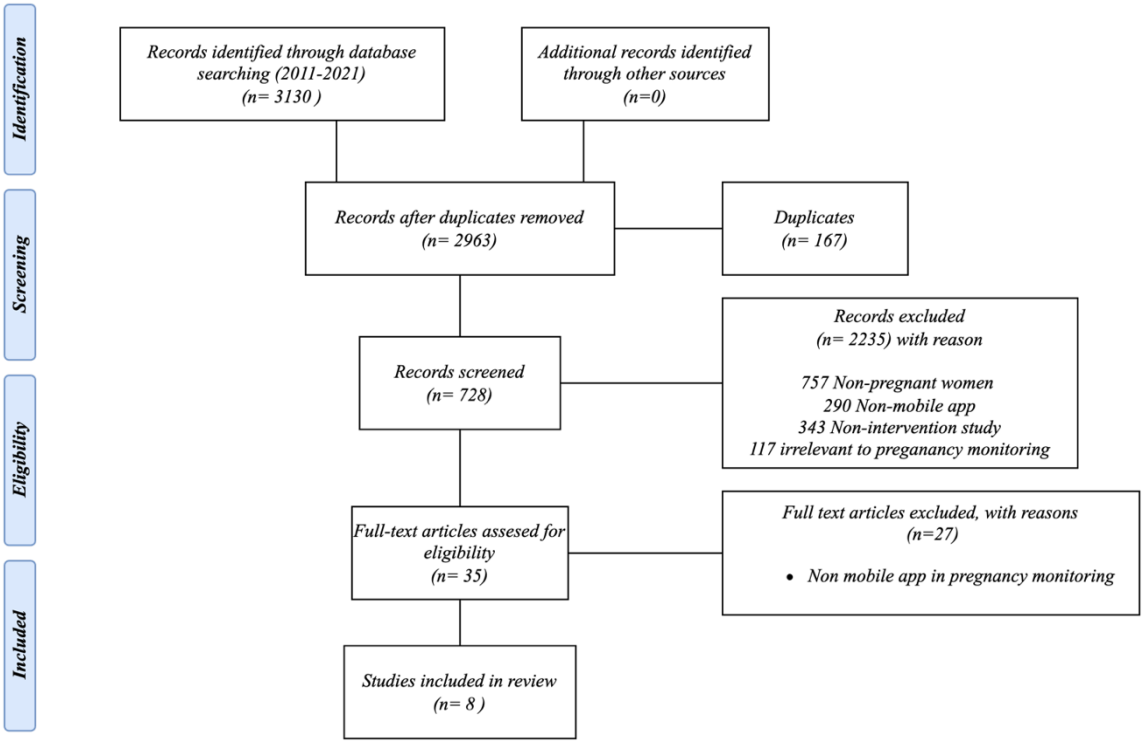

Figure 1. Article screening flowchart

2. Assessment of study quality

   Assessment for critical appraisal uses JBI Critical Apraisal Tools. The total results of the articles obtained for review are 8 articles. The quality assessment of articles using JBI Critical Apraisal Tools for randomized controlled trials was 7 articles [8,10–15] and 1 quasi-experimental studies article [9]. The following is a table of results from the quality evaluation **(Table 2 and 3).**
3. Use of mobile applications for pregnant women

   We found that mobile applications were used for pregnancy monitoring and have a several function. Each function from the use of mobile application grouped into provide health information, provide pregnancy counseling, decision making and mental support, pregnancy care management. Two articles provide health information [8,9], one article provide pregnancy counseling [10], two articles in decision making and mental support [11,12], and three articles in pregnancy care management [13–15]. The specific information extracted from the studies is summarized in **Tables 4.**

   a. Mobile application provide health information

Mobile applications have an important role in providing information for pregnant women. In this context, pregnant women find it helpful to use mobile applications that are used to provide information related to the health of their pregnancy. Pregnant women can use the application starting from the beginning of pregnancy or pregnancy in the third trimester. The results of the

RTC study [8,9] showed that the intervention group that used mobile applications to obtain information related to their pregnancy proved to be richer in information than the control group that used standard
methods of obtaining information.

b. Mobile application provide pregnancy counseling

The use of mobile applications is used to provide structured counseling to pregnant women. Pregnant women are given vouchers for online counseling to health workers. Counseling can be done starting from the first antenatal care visit up to 42 days of the mother's postpartum. Pregnant women can do counseling independently by making an agreement with health workers. Counseling conducted for information on vaccine consultation, antenatal care, childbirth, postpartum complications [10].

c. Mobile application help decision making and mental support

Mobile apps are proven to be effective using mobile apps to reduce anxiety and help get mental support. Mothers with indications of premature delivery can
take advantage of mobile applications to get support from health workers and Community Health Workers (CHW). The app used by Community Health Workers (CHWs) is used to provide support and assist mothers in maternity health facilities. There were 74% of mothers in the intervention group who were successfully treated and gave birth in health facilities compared to 63% in the control group. Mobile apps are quite helpful to aid decision making and mental support [11,12].

d. Mobile application for pregnancy care management

Pregnant women who use the application for pregnancy care management have the ability to schedule antenatal care, monitor the health condition of the mother and fetus. The use of the application can also continue until the baby is born. So that the use of this application helps pregnant women do self-monitoring and understand the condition of pregnancy well. In the studies carried out there were intervention and control
groups. The intervention group proved to be better prepared for her pregnancy [13–15].

Table 2. Critical Appraisal Checklist for Quasi Experiment

Item	Liu
1. It clear in the study about ‘cause’ and ‘effect’	√
2. Similar participants included	√
3. The participants included in any comparisons receiving similar treatment/care	√
4. There was control group	√
5. There multiple measurements of the outcome	√
6. Complete follow-up and if not, adequately explained and analyzed	√
7. The outcomes of participants measured in the same way for comparisons	√
8. Outcomes measured in a reliable way	√
9. Appropriate statistical analysis	√
Overall appraisal	Include

Table 3. Critical Appraisal Checklist for RCT

Item	Buchanan	Carlisle	Hackett	Ledford	Lund	Modi	Souza
1. True randomization used for assignment of participants	√	√	√	√	√	√	√
2. Allocation to treatment groups concealed	√	√	√	√	√	√	√
3. Similar at the baseline	√	√	√	√	√	√	√
4. Blind participants to assignments	√	√	√	√	√	√	√
5. Blindness in assignees	√	√	√	No	√	√	No
6. Outcomes assessors blindness	Unclear	No	√	√	√	√	√
7. Treatment groups treated identically	√	√	√	√	Unclear	No	Unclear
8. Complete follow-up strategies to address incomplete follow-up	√	√	NA	√	√	√	√
9. Participants analyzed in the groups to which they were randomized	√	√	√	√	√	√	√
10. Outcomes measured in their treatment groups	√	√	√	√	√	√	√
11. Outcomes measured in a reliable way	√	√	√	√	NA	√	√
12. Appropriate statistical analysis	√	√	√	√	√	√	√
13. The trial design appropriate	√	√	√	√	√	√	√
Overall appraisal	Include	Include	Include	Include	Include	Include	Include

Table 4. Review study information

Study	Country	Subject	Intervention	Function	Result	Conclusion	Kategories use of app
Buchanan[11]	Australia	Third trimester pregnant women (28-34 weeks), sample: 1155	Use of Communicating Healthy Beginnings Advice by Telephone (CHAT)	Providing health information to mothers and providing information on newborn health and parenting by phone and SMS (Short Message Service)	The main sources of health information most often trusted by mothers are from midwives or health workers as many as 81%, 77% from family or friends, 75% from magazines or books, and 73% from their mother's experience.	Mobile applications have an important role for pregnant women by involving the role of health workers and reliable sources of information in channeling information through mobile applications. Although this is influenced by economic background and language skills, based on the interest in using this application, pregnant women are desirable.	provide health information
Carlisle[14]	United Kingdom	Women at risk of premature birth, sample: 221	Application for pregnant women "QUiPP app"	Provide support to women in decision-making on conditions at risk of premature labor. Reduce anxiety and provide mental support to women at risk of preterm labor.	There were 23% of women who used the QuiPP App to have a high level of conflict in decision-making compared to women who did not use the app, which was 77% conflict in decision-making. The Chi-squared test was used with results that were not statistically significant.	The QUiPP application has a role in reducing anxiety and decision-making conflicts in pregnant women. This application makes it easier for pregnant women who are at risk of giving birth prematurely to be calmer. It is hoped that doctors can use this application optimally in providing counseling to pregnant women.	help decision making and mental support
Hackett[15]	Tanzania	Mothers aged 16–49 years old, sample: 572	SP+	Facilitate CHWs (community health workers) in sending pregnant women to health facilities, including for proper care for the survival of newborns.	Smartphone use intervention (SP+) by CHW increased maternal referral to health facilities by 74% compared to 63% in the control group.	Smartphone-based support for Community Health Workers (CHWs) has a high impact on counseling for primary mothers, especially helping in sending to health facilities for mothers with low ANC absorption. This study was proven to increase the positive effects of counseling by CHW on pregnant women	help decision making and mental support

Ledford[16]	USA	pregnant mothers, sample: 173	mobile application	Education to patients about what is experienced during pregnancy, recording for patient experiences during pregnancy, including to record weight, blood pressure, and conditions experienced during pregnancy.	Patients in the intervention group (using the app) recorded their pregnancy information more often (p=0.04) and had pregnancy check-ups more often (p=0.02) than patients in the control group (using a notebook).	Mobile apps successfully convince patients that self-management for the benefit of health is important.	pregnancy care management
Lund[13]	Tanzania	Pregnant women, sample: 2550	Telephone-based text messaging and voucher usage	Two-way communication provided by primary health facilities by using SMS or messages via telephone and direct communication by giving vouchers for health consultations.	In the intervention group (telephone use), antenatal visits were more than four times (44%) compared to the control group (consultation vouchers) who had antenatal visits more than four times (37%) (OR, 2.39; 95% CI, 1.03-5.55)	The use of mobile apps contributes to the improvement of maternal and newborn health through optimal care. This needs to be considered by policymakers to implement the use of applications, especially the constraints due to limited resources.	provide pregnancy counseling
Modi[17]	India	Primary Health Centers (PHCs) staff, sample: 22 and Accredited Social Health Activists (ASHAs), sample: 561	ImTeCHO	The ImTeCHO application provides facilities for scheduling home visits, screening for complications during pregnancy, providing counseling during home visits, and supportive supervision by PHC staff	The coverage of home visits in the first week after birth was carried out twice in the mHealth intervention group (32.4%) and in the control group (22.9%). The coverage of services in MNCH (Maternal, Newborn and Child Health) related to primary health services reached 43.0% in the intervention group and 38.5% in the non-intervention group.	The use of the ImTeCHO application as a tool for ASHA and PHC in improving the health status and quality of maternal, newborn and child health (MNCH) health services has proven to be effective and important to be applied	pregnancy care management

Souza[12]	Brazil	pregnant women, sample: 98	Healthy Gestation application	Provides information about pregnancy care, childbirth, postpartum, and breastfeeding. The mobile application provides a virtual booklet, an alarm to perform a pregnancy check as scheduled.	Pregnant women in the intervention group (using a pregnancy app) had prenatal consultations more often than pregnant women in the control group. There was a significant relationship between the use of the app and the number of prenatal consultations in pregnant women ($p<0.05$)	The Healthy Gestation app has proven to be effective in improving prenatal care, having a major contribution to pregnancy care and maternal health information. This application can be used by health professionals to improve maternal health indicators at the primary health service level.	provide health information
Liu[18]	China	pregnant women, sample: 200	Health assistant app	Provides an overview of the management of examinations in pregnant women. Assisting in recording the patient's examination history or medical records containing data related to follow-up, evaluation, and appointments. The app also manages the schedule of newborn visits.	The knowledge possessed by the intervention group in terms of pregnancy, perinatal, childbirth, and adherence was higher than that of the control group. The use of the application helps in determining the actions that must be taken appropriately according to the mother's condition.	The use of the application improves health management by pregnant women, which affects the health status of the women. Women who gave birth in health facilities also increased in the intervention group.	pregnancy care management

DISCUSSION

The systematic review aimed to identify the effectiveness and quality of mobile app use on pregnancy monitoring. Each included study had different goals and uses in monitoring pregnancy with measurable results. Of the 8 articles included, 5 articles concluded that the use of the app is effective for monitoring the health of pregnant women, while 3 articles have not assessed its effectiveness but it has been proven that the use of the app for pregnancy monitoring is beneficial for pregnant women and health workers.

The results of the article review indicate that the 8 articles obtained have benefits for the mental health of pregnant women [14,15]. Mental disorders in the mother such as depression and anxiety can have a negative effect on the baby's health[19]. Depression often occurs up to 20% of pregnant women must have experienced depression during their pregnancy. Maternal depression is more common in mothers with low income levels [20]. Given the impact of depression that can interfere with the health of babies, it is important to prevent this condition in prenatal period. Mobile applications also play a role in prenatal mental health care. Pregnant women who use mobile applications for pregnancy care that are equipped with mental health care will be monitored by the health care team. There is a notification that the health care team will receive if the mood deteriorates during the prenatal visit [21]. Pregnant women who do not report their pregnancy conditions to health workers become less attention, feel unsupported, and lack confidence. Therefore, mobile applications can be a tool that can affect the experience and well-being of mothers who are reluctant to report their pregnancies. The use of mobile applications can be used to access information about pregnancy and counseling with health workers[22].

Mobile applications can facilitate mothers in providing support and help to make the right decisions. The features used in the mobile application are tailored to the needs of pregnant women and are designed to make it easier for users. There is a guide included in the application to help overcome problems experienced by pregnant women. Physical activities recommended for pregnant women can also be accessed through the application, making it easier for health service providers in the limitations of providing health services for pregnant women's physical activities [23]. The application used is also equipped with videos that can help pregnant women in obtaining information as well as increasing access to consultation with health workers[24]. Apps for pregnant women can track the use of educational materials remotely. Mobile applications can be a forum for consultation on childbirth preparation with the condition of babies at risk of prematurity [25].

ANC visits in rural areas are still uneven, so information and consultations held online will help overcome these problems. Pregnancy conditions become easier to monitor [26,27]. Seeing the impact on quality, efficiency, and problems of using mobile applications as healthcare providers is a potential strategy to strengthen the health system [28]. The use of technology that is easily accessible to all parties provides significant benefits in the pregnancy care system[29]. The use of health application systems for pregnancy care is influenced by women's knowledge. High knowledge will be easy to adapt using mobile applications[30]**.** The use of applications for pregnancy management provides many benefits, but nutritional consultation activities for pregnant women physical activity, and physical examination are still recommended using face-to-face methods. Mobile applications effectively manage pregnancy care [31].

Mobile apps used in the healthcare sector are advised to engage healthcare professionals who are tech-savvy for the purpose of accuracy and trust in existing content. Low-income pregnant women

have a desire to improve the quality of pregnancy care by using mHealth. The results of the research that have been carried out show that the use of mobile-based applications is effective in increasing maternal knowledge and anticipating complications in pregnancy. Some studies showed that the use of mobile apps made a significant improvement of 63% in maternal knowledge in the treatment group and a 1% increase in the control group [32].

Pregnant women said that after using the mobile application, they experienced an increase in knowledge in accordance with the purpose of using the mobile application. Important aspects of pregnancy such as healthy behavior during pregnancy become an important point in daily pregnancy. Applications related to maternal health have great potential for health promotion activities, making application users more aware and responsible for implementing a healthy lifestyle [5]

The long review process may result in outdated findings by the time it is published. Despite standardized protocols (e.g., PRISMA guidelines), subjective decisions in study selection, data extraction, and interpretation may introduce bias. A systematic review of mobile apps for pregnancy monitoring can provide important insights into how digital health interventions are impacting maternal and fetal health. Assisting policymakers in determining the right health program related to health digitalization. For future researchers, it should be a reference to develop the required application model.

CONCLUSION

This systematic review found that mobile app-applied pregnancy monitoring is primarily used for health information, pregnancy counseling, decision-making, and pregnancy care management. Pregnant women and health workers assume that the use of mobile applications has quality and effectiveness for pregnancy monitoring. There are several obstacles faced, namely adaptation to the use of the application and the language used in the application. Overall, it is considered effective and helps facilitate health monitoring in pregnant women.

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