

Review of Android Apps for Monitoring Pregnancy Symptoms and Care

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ABSTRACT

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monitoring 1, pregnancy symptom 2, self-care 3, mHealth 4, pregnancy care 5, Android mobile application

A scarcity of apps for high-risk pregnancy detection motivated researchers thoroughly to evaluate the various Android mobile applications to unveil the gaps in accuracy, functionality, and usability. This review provides crucial recommendations for future investigations in pregnancy monitoring app development. The current study systematically assesses Android mobile applications deploying Mobile Application Rating Scale (MARS) for engagement, functionality, aesthetics, and information evaluation. Additionally, app characteristics, pregnancy monitoring features, guidance, and minor pregnancy disorder monitoring were assessed. A total of 1,176 mobile apps are reviewed, with a mere 18 (1.53%) meeting inclusion criteria. 17 (94.44%) of these focus on assessing pregnancy-related concerns, and exceptional MARS grade of 4.29 out of 5. Notably, the app functionality evaluation received the maximum score of 4.72. Furthermore, 7 (27%) track particular pregnancy issues, while 16 (88.88%) apps track tiredness. In addition, 14 applications (77.78%) are dedicated to monitoring minor pregnancy problems. Pregnancy Tracker, Pregnancy App, and Baby Tracker have a commendable 4.7-star rating and provide thorough pregnancy information. Minor disorders are tracked by Mylo Pregnancy, Pregnancy Track, Maternal Care, Pregnancy Calculator, and Ovia Pregnancy. What to Expect, Healofy, Amma Pregnancy, and My Pregnancy outshine with MARS scores above 4.75 to 5, confirming best user experiences. Due to certain security and privacy considerations, the study was limited to evaluate selective applications. This review findings guide future mobile health research in a moving context.

1. INTRODUCTION

Maternal health is critical in ensuring the fetus's immediate and long-term well-being. Each pregnancy is different, with its own set of physical and psychological obstacles. According to research, mother's well-being has a considerable effect on pregnancy outcomes and subsequent child development [1]. Complications such as pregnancy-induced hypertension, gestational diabetes, and bleeding disorders jeopardize successful results [2]. Preventing such problems and preserving long-term health requires accurate maternity care. Regular monitoring and health check-ups detect high-risk pregnancies, which reduces maternal and neonatal morbidity and mortality [3]. Yoga, lifestyle changes, psychotherapies, and mindfulness are all complementary methods that improve maternal well-being [4, 5]. However, access barriers, particularly for disadvantaged women, prevent effective usage of such programs [6, 7]. Considering the limitations in resource-limited settings, poor adherence to prenatal treatment among identified women highlights the need for more accessible and comprehensive healthcare [8, 9].

Antenatal mothers popularly use pregnancy monitoring apps to track their symptoms, obtain individualized information, and communicate with healthcare experts. These applications may give invaluable assistance and guidance throughout the pregnant experience, particularly for high-risk

pregnancies that need closer monitoring. Several researches demonstrated the advantages of utilizing pregnancy monitoring apps [10] mHealth platforms have been shown to improve the health of both the mother and the fetus throughout pregnancy. One of the primary benefits of mHealth technology is the ability to enable remote monitoring, which allows for the early detection of negative pregnancy events [11]. Furthermore, mHealth applications provide a quick and easy platform for recording and retrieving health and behavior information. Pregnancy monitoring apps can provide individualized information and services based on the user's unique needs and stage of pregnancy [12]. These programs frequently include features that enable users to swiftly communicate with their healthcare experts, hence boosting the quality of treatment and help they get [13]. Pregnancy monitoring applications allow women to track their symptoms and gain insights into their health and pregnancy progress. These apps contain educational tools including articles and videos to assist women understand pregnancy, childbirth, and postpartum care. These apps help women stay educated and make wise decisions by offering simple access to a wealth of information. Furthermore, pregnancy monitoring apps offer remote health monitoring by allowing users to track indicators such as blood pressure and glucose levels. This remote monitoring capacity is notably beneficial for treating disorders such as gestational diabetes or hypertension, as well as

increasing mother care and general well-being [10]. Furthermore, mHealth applications can help obstetricians and midwives overcome time and geographical restrictions so that they can provide better care to pregnant women.

Furthermore, research has shown that using pregnancy monitoring apps and mHealth technologies might result in more effective and fair prenatal care. They have been shown to be useful in lowering prenatal weight gain, treating diseases such as gestational diabetes and asthma, increasing general physical and nutritional health, and enhancing mental health and pregnant awareness [13]. Additionally, using online applications and queries can be especially advantageous for pregnant women with high-risk pregnancies that require further monitoring. Online applications that give information on monitoring newborns' sleeping, growth, development, and feeding can provide these mothers with crucial data and assistance [14].

Researchers found only a few number of mobile applications specialized to identifying, analyzing, and categorizing high-risk pregnancies throughout their study of literature. Due to the rareness, numerous Android mobile applications were thoroughly evaluated. Extensive testing indicated severe inadequacies in critical areas such as accuracy, functionality, and usefulness in pregnancy monitoring. The analysis not only highlights existing research gaps, but it also makes critical recommendations for future researchers. The identified gaps show the critical need for innovations in app development, highlighting the need of fine-tuning features for precision and user experience. As technology advances, resolving these gaps will be critical to improving the overall efficacy of pregnancy monitoring apps and assuring adequate support for pregnant mothers and healthcare providers.

The objective of this review is to thoroughly evaluate Android applications meant to track pregnant symptoms and care. This study highlights gaps in critical areas such as accuracy, functionality, and usability by finding and assessing current apps. Additionally, it provides significant insights into the limits of current apps and their consequences for pregnancy monitoring. Furthermore, the purpose of this study is to provide essential recommendations for future studies in the field, directing the creation of more effective and user-friendly Android apps for pregnancy monitoring. This study encourages future researchers to contribute to the growth of technology in maternal healthcare by providing increased support and care for pregnant women by updated mobile apps.

2. METHOD

2.1 Selection of the apps by systematic search criteria

An extensive search was carried out from 22nd January 2023 to 25th February 2023, by the researchers over the Google Play Store in order to identify the applications linked to the current study. The keywords used were as follows: "Physical health," "Pregnancy check-up," "Health in Pregnancy," "Gestation," "Pregnancy symptoms" and "Pregnancy monitoring". The researchers obtained similar results with the use of the keywords "Health in Pregnancy", "Pregnancy Symptoms", and "Physical Health". Improved search results were obtained after using the keywords "Health in Pregnancy," "Gestation," "Pregnancy Symptoms," and "Pregnancy Monitoring".

The selection of the apps was done in three phases based on

the collected data using the above mentioned keywords. During the first phase of the screening, the title and screen shots were used to exclude apps that calculated only Last Menstrual Period (LMP) and Expected Date of Delivery (EDD). However, these apps did not take into consideration to track physiology of pregnancy or minor disorders of pregnancy. The apps in which the researchers were unable to be registered or log in, or which were not available in languages other than English and Hindi, had only clinical guidelines for practitioners, and contained too many games, were excluded in this study. The descriptions and screenshots of the applications were examined in the second phase of the study to exclude apps that were too generic, did not collect as much information about pregnancy, and did not track minor pregnancy diseases. The third phase involved the exclusion of those apps which required University login credentials and finally the selected 18 apps were downloaded to carry out the study.

2.2 Evaluation measures or rating tools

In the current study, all apps were systematically evaluated by deployment of the Mobile Application Rating Scale (MARS) and defined IQVIA for Health Information performance scoring system.

2.2.1 Mobile Application Rating Scale (MARS)

MARS is an effective framework intended for an in-depth assessment of mobile applications, particularly those in the health and well-being domains. MARS was designed by Stoyan R Stoyanov and collaborators which consists of six key elements. The engagement metric measures user involvement and interest, whereas the functional metric measures the app's usability and performance. Aesthetics dives into visual design components, whereas Information Quality assures data correctness and dependability [14]. The App-specific dimension tailors the evaluation to the app's special function, whereas Subjective Quality assesses overall user satisfaction. Each dimension has a rating scale, which provides a quantifiable measure for a more in-depth examination. MARS serves as great tool for academics, developers, and users, providing insights about app strengths and areas for improvement, finally contributing to the advancement of mobile app quality and user experience [15].

2.2.2 IQVIA functionality

The IQVIA functionality score is the only metric developed to evaluate the functioning of mobile applications [16]. IQVIA is not an acronym; it represents the combination of two companies, IMS Health and Quintiles. The applications were assessed based on seven functions: informing, teaching, recording, presenting, guiding, recalling, and permitting the exchange of data [17].

Inform: Provide information in a variety of media such as text, photographs, and videos.

Instruct: Provide suggestions and instructions to the user.

Record: Capture data entered by the user by recording it.

Display: Showcase user-entered or produced data graphically.

Directing: Provide advice based on user input, such as a diagnosis or suggestions for consultation with a physician or a specific course of treatment.

Remind/Alert: Send the user reminders.

Communicate: Establish connection with healthcare

professionals or patients, and/or give ties to social networking sites [17, 18].

This section contains broad data on each app. The app quality module considers 19 characteristics grouped in four different parameters: engagement, information quality, usefulness and aesthetics. A 5-point Likert Scale was employed for rating the items in the MARS tool (1 indicates inadequate, 2 indicates poor, 3 indicates acceptable, 4 indicates good, and 5 indicates excellent). The final MARS results comprise the average score of four mentioned parameters. Furthermore, the MARS contains a subjective quality rating in addition to an app-specific subscale that analyses the observed influence on the individual's consent, attitudes, and intents to improve, along with the probability of altering the stated targeted behaviours. The functionality subdomain assesses if an app is simple to use, facilitates easy navigation, promotes logical sequence, and looks at the physical layout of the app. The engagement score considers if the app is enjoyable, intriguing, customizable, and collaborative (e.g., provides notifications, messages, recalls, feedback, and allows sharing), and if it is properly suited to the desired demographic data.

This comprehensive review delves to assess the characteristics of mobile applications including commencement date, updating date, overall user ratings, download availability, affiliation status, online access requirement, reminder feature, and accessibility to relevant information. Furthermore, this review accurately observes the pregnancy-related features of the applications, these include last menstrual period (LMP) and estimated due date (EDD) advice, a functioning weight tracker, exercise and sleep monitoring facilities, a foetal movement counter, contraction counter, calendar, diary, and an extensive diet plan. The app's ability to detect high-risk pregnancies, gestational diabetes, and hypertension (HTN) is impressive. Furthermore, the study examines the monitoring of minor pregnancy diseases such as tiredness, nausea, and discharge, as well as mood changes, anemia, and blood pressure.

2.3 Data extraction and evaluation

The instrument included items from the MARS questionnaire [19], IQVIA functioning recommendations [17], WHO, and FOGSI pregnancy guidelines. For calculating the interrater reliability, a four reviewers independently rated four randomly selected apps using a data extraction form, which was found to be within acceptable limits (0.75-0.83). During the evaluation procedure, four random submissions were scored on a scale of 1 to 10 by these four reviewers. Following, reviewer 1/reviewer 2, reviewer 1/reviewer 3, reviewer 2/reviewer 3, and reviewer 3/reviewer 4 were added as new columns. each pair received a "1" for agreement opinions and a "0" for disagreement viewpoints. For example, reviewer 1/reviewer 2 expressed disagreement (0) for 2nd app, reviewer 1/reviewer 3 expressed agreement (1) for all apps, reviewer 2/reviewer 3 expressed disagreement (0) for 2nd app, and reviewer 3/reviewer 4 concurred (1) for 4th app. For the current review, the interrater reliability was 0.83.

The following applications were examined individually by more than one researchers. Mean, total score of MARS, and IQVIA functioning scores are stated in result's section.

2.4 Ethical code and ethical considerations

Concerns with ethics (plagiarism, misconduct, data falsification and fabrication, multiple publishing and submission and so on) are strictly adhered to.

3. RESULTS

3.1 Results

Figure 1 presents that total number of apps obtained in the search resulted in the discovery of 1176 Android applications in the Google Play store that were potentially related to the current study. 920 applications (78.23%) were excluded in the first round because their characteristics did not fulfil the study's inclusion requirements. 178 (78.23%) and 59 (15.13%) applications were rejected during the second and third levels of screening, respectively. Finally, 18 (1.53%) applications satisfied the inclusion requirements in our study. Previous studies have evaluated various apps in Google play and Café Bazaar to check the functionalities of apps that monitor the pregnancy self-care [1].

Table 1 shows, in total, 99% (n=17) of applications were rated with the above four stars, 55% (n=10) of apps had a private affiliation, the remainder did not specify their affiliation, 66.66% (n=12) apps required internet connectivity to operate, and 99% (n=17) apps had the feature of sending reminders. The majority of the applications in the present study monitored the pregnant symptoms, minor complications, prenatal nutrition, immunization, travel, and fitness guidance. To comprehend the functionality of the applications, a study categorized the content of the apps into four categories: pregnancy complications, pregnancy guidance, maternity care, and postpartum care [20]. However, no provision for live interaction between health care providers and users was observed in the apps listed below. The interaction between health care experts and pregnant women can get quick advice. Future app developers can use artificial intelligence (AI) to initiate this provision.

Table 2 illustrates all apps in the current review track the LMP, EDD, and body weight of pregnant women while 88.88% (n=16) of apps provide advice on dietary and pregnancy fitness, 61.11% (n=11) apps monitor foetal movements whereas 55.5% (n=10) apps track contraction, and 66.66% (n=12) track high risk pregnancies for hypertension and diabetes. These apps made it possible for antenatal women to self-monitor their pregnancy characteristics and receive guidance. A review published by Lazarevic N et al, assessed the quality of 31 self-monitoring pregnancy apps, by deploying a digital health scorecard. The results reveal that digital health scorecard display could reinforce the pregnant women to take decision appropriately based on their needs [20]. Chan KL et al. conducted a meta-analysis to understand the effectiveness of the pregnancy apps on outcomes in antenatal and postnatal women. Authors reported that maternal women have potential benefits of well-being by using the mHealth apps. This study recommends that use of large clinical trials focusing on different health outcomes will be beneficial in future studies [21].

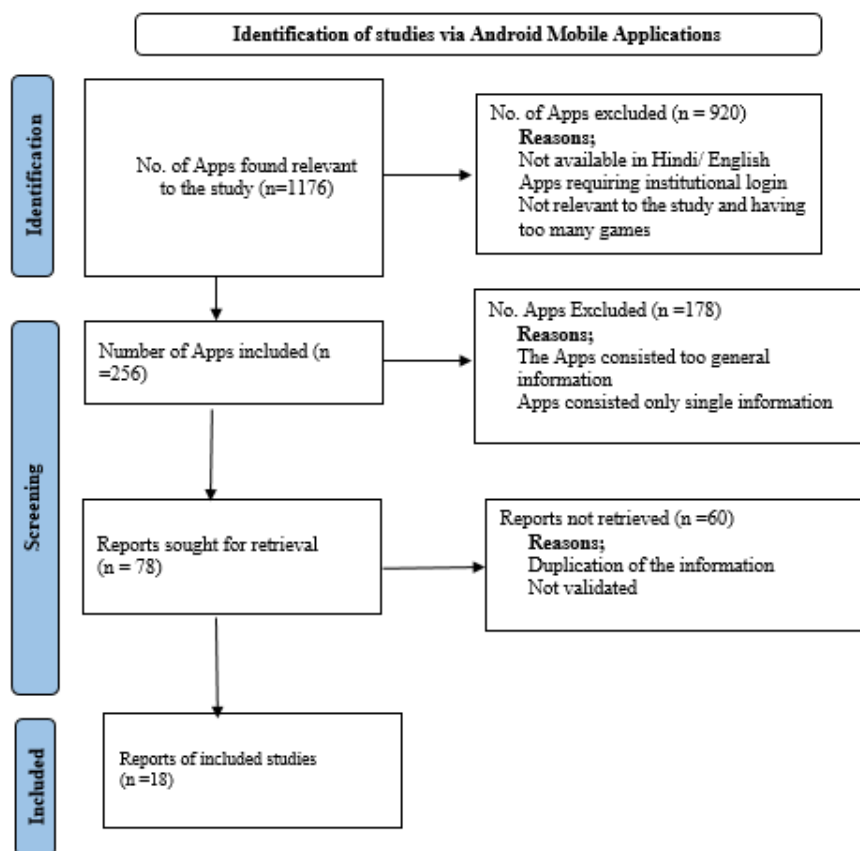


Figure 1. The PRISMA flowchart was used to describe the filtering procedure, which complies with the Preferred Reporting Items for Systematic Reviews criteria. MARS was used to assess the applications for mobile devices

Table 1. Characteristics of individual apps included

| App | Start Date | Last Update | Rating | Downloads | Affiliation | Requires Web Access | Requires Login / Password | Reminders | Available Information |
|-------------------------------------|-------------------------------|--------------------------------|--------|-------------|----------------------|---------------------|---------------------------|-----------|---|
| Pregnancy Tracker | 4 th May 2016 | 16 th Dec 2022 | 4.7 | 5 millions | Private organisation | Yes | No | Yes | Antenatal diet and Exercises |
| Pregnancy App and Baby Tracker | 11 th March 2011 | 10 th Jan 2023 | 4.7 | 10 lakhs | Baby center. Com | Yes | Yes | No | Pregnancy events and breast feeding |
| What to Expect | 26 th October 2010 | 13 th Jan 2023 | 4.7 | 5 millions | Private | Yes | Yes | Yes | Pregnancy care, breastfeeding, baby care, diet, and milestones tracking |
| Healofy Pregnancy and Parenting | 31 st May 2019 | 16 th December 2022 | 4.6 | 10 millions | Commercial | Yes | Yes | Yes | Monitoring of movements of the baby and dietary plan |
| Pregnancy Journey | 8 th June 2021 | 22 nd June 2022 | 3.4 | 10000 | Private, Bangladesh | Yes | Yes | Yes | Diet, vaccine, BP, meditation, exercise, and pregnancy warning sign tracking |
| Pregnancy Tracker, Maternity | 9 th June 2022 | 7 th December 2022 | 4 | 1 million | - | Yes | Yes | Yes | Antenatal diet and exercises |
| Pregnancy Baby Mom, Diet and Yoga | 10 th May 2019 | 7 th Nov 2021 | 4.2 | 50000 | Babyindian.com | No | No | Yes | Diet, Yoga, Baby Connect, Progress, and Baby Care. |
| Hello Belly | 3 rd Feb 2017 | 16 th June 2022 | 4.2 | 1 lakh | Hello baby Inc | Yes | No | Yes | Nutrition in pregnancy, health check-ups, baby requirements |
| Pregnancy, Care, Diet and Nutrition | 11 th May 2016 | 30 th Nov 2022 | 4.5 | 1 lakh | Recovery Bull.com | No | No | Yes | Trimester care, diet, precautions for high/low BP, constipation prevention tips |
| Ovulation Calendar and Fertility | 16 th Aug 2018 | 20 th April 2021 | 4.3 | 1 million | - | Yes | Yes | Yes | Tracking of the pregnancy |
| Amma | 25 th May | 12 th Jan | 4.3 | 10 million | - | Yes | No | Yes | Complications, preeclampsia, |

| | | | | | | | | | | |
|--------------------------------|----------------------------|----------------------------|-----|-------------|-------------|-----|-----|-----|--|---|
| Pregnancy & baby tracker | 2015 | 2023 | | | | | | | | bleeding, antenatal care, and debunked myths covered |
| Pregnancy Day by Day | 1 st Nov 2017 | 30 th July 2021 | 4.7 | 5 lakhs | - | Yes | No | Yes | | Childbirth, fertility, fitness, postnatal wellbeing, preconception, life, online consultation, live interaction |
| iMumz- Pregnancy and Parenting | 5 th April 2019 | 23 rd Nov 2022 | 4.3 | 50000 | - | No | No | Yes | | Stress relief, natural delivery preparation, yoga, pelvic exercises, music therapy, breathing, communication |
| Mylo Pregnancy & Parenting App | 7 th Jan 2017 | 14 th Jan 2023 | 4.6 | 5 million + | - | Yes | Yes | Yes | | Pregnancy diet, music, mamasutra, tests, milk bank, baby sleep, names, memories |
| My Pregnancy –Pregnancy Track | 11 th Sep 2019 | 25 th Aug 2021 | 4.6 | 1million + | - | No | No | Yes | | Antenatal care, foetal growth, contractions, do's and don'ts, visits, screening, baby care, hospital bag |
| Maternal Care /Mother and Baby | 29 th Sep 2021 | 29 th Sep 2021 | 4 | 50000+ | Private | No | No | Yes | | Maternity safety, BMI calculators, language change, antenatal hygiene, postpartum care |
| Pregnancy Calculator Symptoms | 3 rd June 2019 | 22 nd Nov 2022 | 4.3 | 50000+ | | Yes | No | Yes | | Weight tracker, kick counter, and Kegel exercises |
| Ovia Pregnancy & Baby Tracker | 14 th July 2014 | 4 th Jan 2023 | 4.3 | 1 million + | Ovia Health | Yes | Yes | Yes | | Kegel, BP tracking, nutrition, sleep, mood. Questionnaire for health advice |

Table 2. Monitoring of pregnancy features, advices provided by various apps

| App | LMP & EDD | Weight Tracker | Exercises/ Sleep | Foetal Movement Counter | Contraction Counter | Calendar & Diary | Diet Plan | High Risk Pregnancy Detection | GDM/ HTN |
|-------------------------------------|-----------|----------------|------------------|-------------------------|---------------------|------------------|-----------|-------------------------------|----------|
| Pregnancy Tracking App | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | |
| Pregnancy App and Baby Tracker | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | |
| What to Expect | Yes | Yes | Yes | No | No | Yes | Yes | No | |
| Healofy Pregnancy and Parenting | Yes | Yes | Yes | Yes | No | Yes | Yes | No | |
| Pregnancy Journey | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | |
| Pregnancy Tracker, Maternity | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | |
| Pregnancy Baby Mom, Diet and Yoga | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | |
| Hello Belly | Yes | No | Yes | No | No | No | Yes | No | |
| Pregnancy, Care, Diet and Nutrition | Yes | Yes | Yes | No | No | No | Yes | Yes | |
| Ovulation Calendar and Fertility | Yes | Yes | Yes | No | No | Yes | Yes | Yes | |
| Amma Pregnancy & Baby Tracker | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | |
| Amma Pregnancy & Baby Tracker | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | |
| Pregnancy Day by Day | Yes | Yes | No | Yes | No | Yes | Yes | Yes | |
| iMumz- Pregnancy and Parenting | Yes | Yes | Yes | No | - | Yes | Yes | Yes | |
| Mylo Pregnancy & Parenting App | Yes | Yes | Yes | No | - | Yes | Yes | Yes | |
| My pregnancy – Pregnancy Track | Yes | Yes | - | Yes | Yes | Yes | Yes | Yes | |
| Maternal Care /Mother and Baby | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | |
| Pregnancy Calculator Symptoms | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | |
| Ovia Pregnancy & Baby Tracker | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | |

As shown in Table 3, 88.89% of apps track tiredness, while 77.78% monitor nausea, white/brown discharge, frequent urination, heart burn, body image alterations, and oedema. 50% to 55.56 % apps monitor blood pressure and anemia in antenatal women. In the apps described below, pre-structured advices or therapies have been configured to tackle minor disorders of pregnancy. However, the interaction between health care experts and pregnant women is critical to the success of any app's function [3]. The applications ought to additionally incorporate predictive models, and recommendations should be made based on antenatal women's risk factors for high-risk pregnancies and predictive results.

Table 4 shows that in the area of engagement, 38.88% (n=7) applications had high ratings ranging from 4.8 to 5, indicating that these apps appear to be successfully attracting the attention of users when it comes to app functionality. 90% (n=18) applications received more than 4 ratings, indicating that these apps are successful in tracking the pregnant journey. Moving on to aesthetics, every app obtained an average rating of greater than 4, indicating that they had an interesting design and an aesthetically acceptable user experience. In regards to information, 14 apps obtained average ratings over 4, indicating that the majority of them provide thorough and significant information to pregnant women. Apps, on the other hand, have not mentioned the validating entities from whom the data was collected.

Figure 2 presents quality scores of apps, Pregnancy Calculator Symptoms app scored highest mean values. In Figure 3, box plot depicts the deviation of the values of Global Rating Scale which is less deviated as compared to the deviation of the MARS quality score. The mean is near 4.3 and the deviation for Global Rating Scale is within the maximum and minimum limits 4.7 and 4 respectively. Whereas for the MARS quality score the mean is 4.3 and the maximum and minimum limits are 5.4 and 3.4. There is more deviation for the MARS quality score. Figure 4 shows a linear regression of the MARS score and globally app ratings revealed a significant association $R^2 = 0.13$, $F = 1.67$, $p = 0.003$, indicating that greater global app ratings had a substantial influence on better MARS quality scores.

3.2 Discussion

Due to low cost and ease of use, regardless of time or geographical location, mHealth apps have been widely used [22]. The usage of social media and mobile applications by pregnant mothers and their partners are increasing as they seek health information and become more aware of risky behaviours and warning signs of pregnancy. The aim of the current study was to evaluate the quality and functionality of the pregnancy self-monitoring apps using MARS [16] and defined IQVIA for health information performance scoring system. Majority of the pregnancy monitoring apps focus on tracking the pregnancy characteristics and features of LMP, EDD, body weight, foetal movement counts, pregnancy dairy, identification of high risk pregnancy, and complications. Majority of the apps track the minor disorders of pregnancy that include fatigue, nausea, white/brown discharge, frequency of urination, heart burn, tumbler and tired, body image changes, oedema, palpitations/brittleness, anemia, and blood pressure. Majority of the apps provide the advices regarding pregnancy care, breast feeding, baby care, antenatal diet, monitoring of growth of the baby, and minor ailments of pregnancy, complications of pregnancy including preeclampsia, vaginal bleeding, antenatal care, pregnancy myths and milestones tracking. In general, the applications scored well for quality, with the majority of prevalent functionality being directions on what to do in reaction to symptoms.

Surprisingly, the number of functions contained in an app had a positive relationship with the overall category rating. Furthermore, the entire scorecard (domain scores + overall global scores) was strongly associated with the app's worldwide rating from users on the Google Play Store, demonstrating that many of the characteristics evaluated by the MARS technique are valued by users. These results demonstrate the applicability of the "MARS" strategy and its potential to assist end-users in selecting the best app for their needs by giving thorough information about app features and quality in a manner that is simple to understand.

Table 3. Monitoring of minor disorders of pregnancy

| | A | B | C | D | E | F | G | H | I | J | K | L | Total |
|-------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Pregnancy Tracker | √ | | | | | | | | | | | | 1 |
| Pregnancy App and Baby Tracker | √ | √ | | | | | | | | | | | 8 |
| What to Expect | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | 12 |
| Healofy Pregnancy and parenting | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | 6 |
| Pregnancy Journey | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | 12 |
| Pregnancy Tracker, Maternity | | | | | | | | | | | | | 0 |
| Pregnancy Baby Mom, Diet and Yoga | | | | | | | | | | | | | 0 |
| Hello Belly | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | 6 |
| Pregnancy, care, diet and nutrition | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | 11 |
| Ovulation calendar and fertility | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | 9 |
| Amma Pregnancy & baby tracker | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | 7 |
| Pregnancy Day by Day | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | 11 |
| iMumz- Pregnancy and Parenting | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | 11 |
| Mylo Pregnancy & Parenting App | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | 12 |
| My pregnancy –Pregnancy track | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | 12 |
| Maternal Care /Mother and baby | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | 12 |
| Pregnancy Calculator Symptoms | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | 12 |
| Ovia Pregnancy & Baby Tracker | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | 12 |
| % | 88.89 | 77.78 | 77.78 | 77.78 | 77.78 | 66.67 | 61.11 | 77.78 | 72.22 | 50.00 | 55.56 | 66.67 | |

A=Fatigue, B= Nausea, C= White/brown discharge, D=Frequency urination, E= Heart burn, F=Tumbler and tired, G=Body image changes, H=Oedema, I=Mood swings/Depression/ Anxiety, J=Palpitations/Brittleness, K=Anaemia, L=BP; √Green indicates 'yes', app has the monitoring mechanism and light pink indicates 'no', app does not have the monitoring mechanism. Around 12 monitoring mechanisms were identified throughout the reviewed apps.

Table 4. Quality scores of Mobile Application Rating Scale (MARS)

| Name of the App | Engagement | Functionality | Aesthetics | Information | Overall Mean Score |
|-------------------------------------|------------|---------------|------------|-------------|--------------------|
| Pregnancy Tracker | 4.8 | 3.75 | 4.67 | 4.14 | 4.34 |
| Pregnancy App and Baby Tracker | 3.6 | 4.25 | 4.67 | 4.29 | 4.20 |
| What to Expect | 4 | 4.5 | 5 | 4.29 | 4.45 |
| Healofy Pregnancy and parenting | 4.6 | 4.5 | 4.33 | 4.57 | 4.50 |
| Pregnancy Journey | 4.2 | 4 | 4 | 5 | 4.30 |
| Pregnancy Tracker, Maternity | 3.8 | 4 | 3 | 3 | 3.45 |
| Pregnancy Baby Mom, Diet and Yoga | 4 | 4 | 4 | 3.86 | 3.97 |
| Hello Belly | 4 | 4 | 4 | 4 | 4.00 |
| Pregnancy, care, diet and nutrition | 4 | 4 | 4 | 4 | 4.00 |
| Ovulation calendar and fertility | 4.6 | 4.5 | 4.67 | 4.29 | 4.52 |
| Amma Pregnancy & baby tracker | 5 | 5 | 5 | 4.29 | 4.82 |
| Pregnancy Day by Day | 5 | 4 | 4 | 4.43 | 4.36 |
| iMumz- Pregnancy and Parenting | 4 | 4.5 | 4 | 4 | 4.13 |
| Mylo Pregnancy & Parenting App | 5 | 4 | 5 | 4 | 4.50 |
| My pregnancy –Pregnancy track | 5 | 5 | 5 | 3.86 | 4.72 |
| Maternal Care /Mother and baby | 4 | 4 | 3 | 5 | 4.00 |
| Pregancy Calculator Symptoms | 5 | 5 | 5 | 5 | 5.00 |
| Ovia Pregnancy & Baby Tracker | 5 | 4 | 4 | 3 | 4.00 |

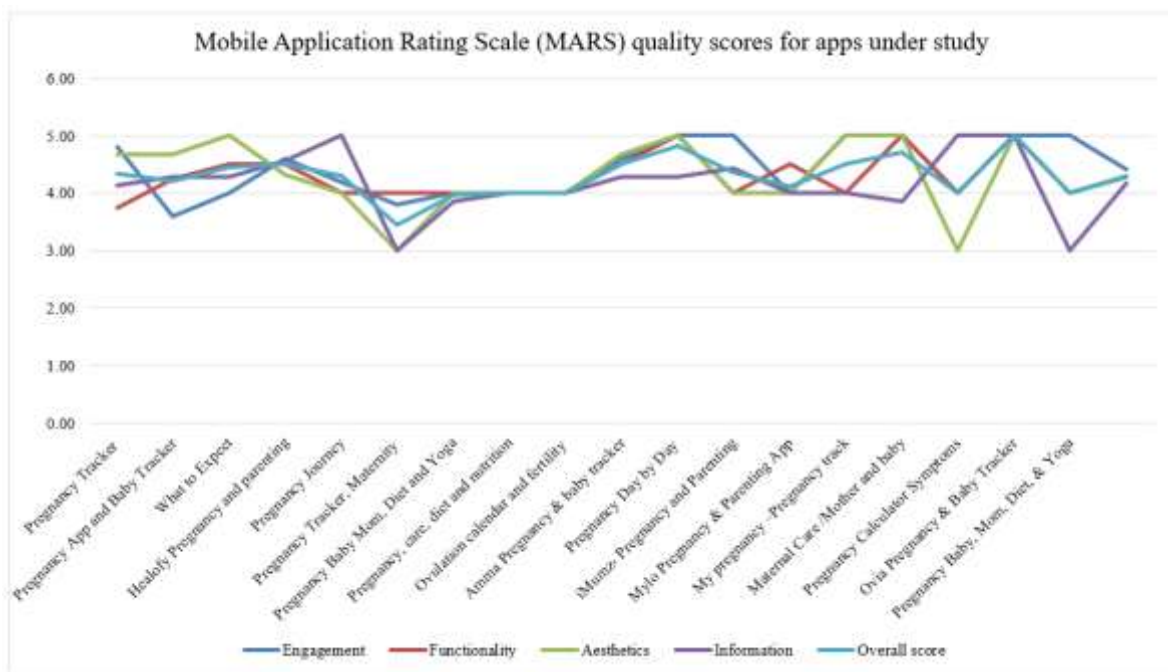


Figure 2. The quality scores of the apps under study

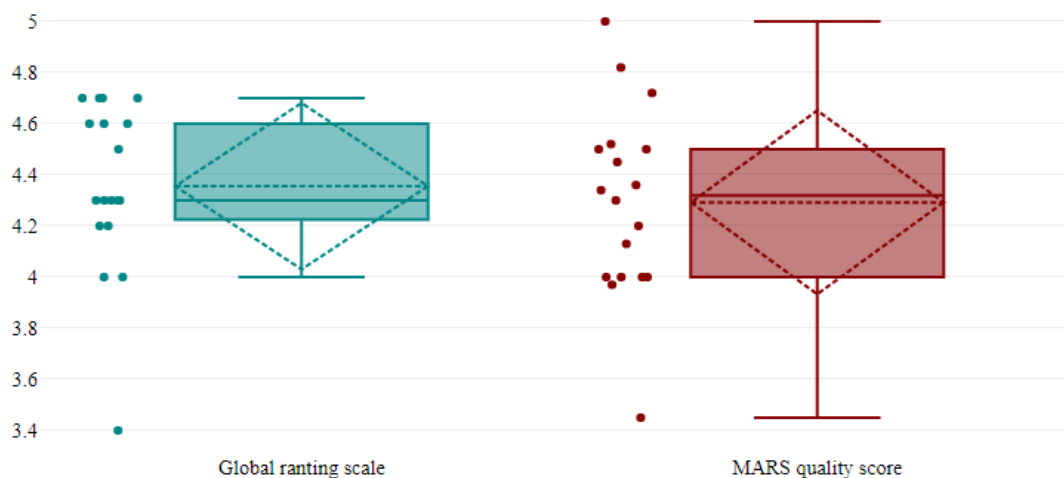


Figure 3. Box plot shows the overall mean values, SD of MARS score and global score for individual apps

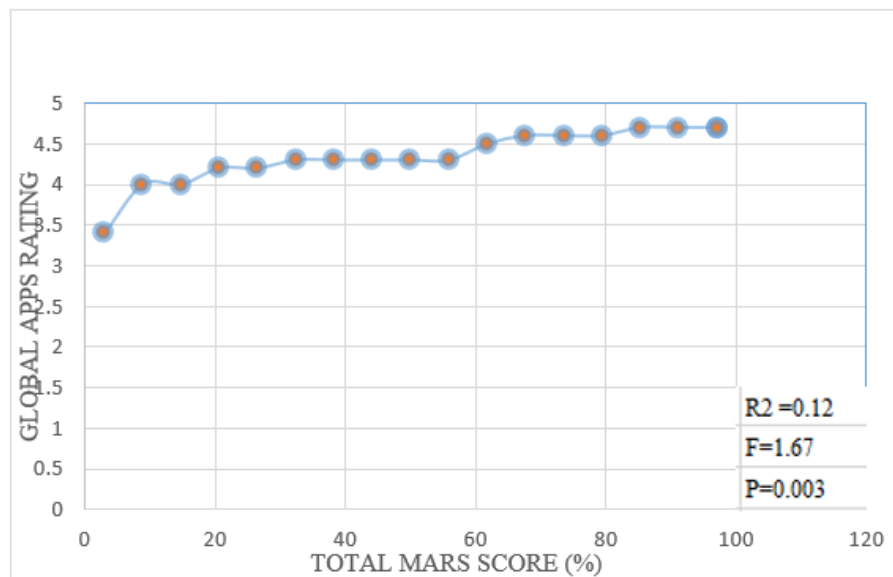


Figure 4. Linear regression between total MARS score and the global app ratings for all 18 apps

Pregnancy care requires a comprehensive strategy that includes both medical and psychological assistance. As a result, it is critical for pregnancy-related applications to cover all elements of self-care, including family, social, psychological, religious, and traditional medical needs. User training is one of the features of pregnancy self-care applications, and it includes many areas of maternal, foetal, and infant, postnatal care, and father education. According to Leiferman et al. online training has the potential to improve prenatal depression therapy by enhancing communication between patients and healthcare professionals. Furthermore, Alio et al. observed that parental involvement can lower infant mortality by increasing mother's availability of resources, assistance, and overall well-being [23, 24].

Self-care applications also have the power to improve maternal perception of foetal development and create bonding with the unborn baby. This capability, as observed by Warrander et al. [25], has the potential to minimize the incidence of stillbirth and foetal development limitation. According to Alam et al. [26], mobile consultation is a significant resource for pregnant women, providing them with important medical information and provision.

Medical non-compliance is a big concern for pregnant women, and it can have a substantial influence on their well-being. Pregnancy self-care apps, according to Saghaeianjad-Isfahani et al. [27], can play an important role in addressing this concern by providing reminders for medical visits, medication regimens, testing, and note-taking.

According to Wulff et al. [28] studies, stress and problems in mother-foetus bonding might have harmful implications for both the mother and the unborn baby. Music has been shown to improve maternal mood, general well-being, and develop a closer link between the mother and the foetus throughout pregnancy. Self-care apps for pregnancy can help with this by including elements that stimulate the foetal heart rate and encourage endorphin release in the mother through music.

Pregnancy brings with it a slew of transformational events that might lead to health hazards such as excessive weight gains and obesity [29]. Weight retention after childbirth is a common problem for women [30]. However, due to a lack of information about physical activity and food intake, women find it difficult to manage their weight throughout the prenatal

and postnatal periods [7, 31]. This study focuses on the availability of several mHealth applications that provide advice on maternal weight control and encourage lifestyle changes in terms of nutrition and physical activity, hence assisting in self-monitoring.

Managing gestational diabetes mellitus (GDM) is similar to controlling maternal weight that requires self-monitoring and making required changes to unhealthy lifestyle patterns while adhering to physician guidelines. Mothers' cooperation is critical in this respect [32]. According to the current review, mHealth applications play an important role in providing information and supporting in the control of GDM by promoting good lifestyle modifications. However, accuracy of this information is questionable.

Psychological support interventions offered via mHealth applications have been shown to successfully lower sadness and anxiety levels [33]. However, it is unknown if the information supplied in pregnancy applications is useful to pregnant or postpartum women. Furthermore, several applications provide relaxation techniques that can assist lower stress levels, especially among primiparous women.

Maintaining a recorded history of maternal care, as indicated by Dawod et al. [34], might help attenuate some risk factors and promote parental bonding. As a result, it is clear that including this function into pregnant self-care applications is critical.

Pregnancy self-care applications, such as other user-friendly self-care apps created for pregnancy, include user interface (UI) elements. According to Zargarzadeh's [35], certain UI features, such as settings customization, feedback mechanisms, user ratings, data sharing and backup functionalities, offline usability, regular updates, the option to receive daily and weekly emails, and a search feature, are considered important.

4. CONCLUSION

The selected applications mostly provided prenatal self-monitoring with great evaluations, and performed variety of functions. The research additionally, highlights engaging designs, comprehensive information, and unnamed validating

bodies. Global rating scale values deviated less from MARS quality ratings (5.4 to 3.4). Regression revealed a statistically significant relationship between greater worldwide ratings and higher MARS quality scores ($R^2=0.13$, $p=0.003$), highlighting the importance of user ratings. These findings highlight the wide range of pregnant applications available and their potential consequences for maternal health monitoring. Despite the variety of capabilities available in pregnancy apps, the study finds a significant gap in their capacity to detect high-risk pregnancies and give decision-making support. According to the present assessment, a small number of applications are dedicated to addressing the intricacies of high-risk pregnancies, possibly leaving users in critical situations without enough assistance and information. This indicates an area where app developers might improve their applications to meet the special demands of high-risk pregnancies, underlining the significance of more comprehensive and tailored functions in the arena of maternal health applications.

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