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EARLY STRESS DETECTION DURING PREGNANCY USING E-HEALTH IN THE PANDEMIC

Deteksi Dini Stres Selama Masa Kehamilan dengan E-Health pada Masa Pandemi

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Abstract

Background: Women are more prone to stress during pregnancy than during the postpartum period. Stress during pregnancy is correlated with pregnancy and birth outcomes. Early detection using the e-Health system is an alternative to health services during the pandemic.
Aims: The research objective was to produce innovation in early stress detection using an information system based on the e-Health system.
Methods: This study was conducted in the Ngaliyan Primary Healthcare Centre with 34 pregnant women. This study utilized both qualitative and quantitative research. Qualitative research was done using the System Development Life Cycle (SDLC), while quantitative research was done using an experimental design with a one-shot case study approach.
Results: The e-Health system could automatically identify stress during pregnancy with the TAM questionnaire yielding a very effective result of 85.4%. The average time needed to detect pregnant women's stress was 230.94 seconds. This system can analyze 374 pregnant women within one day (24 hours), provide services, and report pregnant women's stress detection results.
Conclusions: The e-Health system effectively in conserves time and can be used to record and report early stress in pregnant women.

Keywords: early detection, information system, pregnancy, smartphone, stress

Abstrak

Latar Belakang: *Stres rentan terjadi pada masa kehamilan dibandingkan selama masa postpartum. Stres selama kehamilan berhubungan dengan luaran kehamilan dan persalinan. Deteksi dini dengan sistem e-Health sebagai alternatif pelayanan kesehatan pada masa pandemi.*
Tujuan: *Penelitian ini bertujuan untuk menghasilkan inovasi upaya deteksi dini stres dengan sistem informasi menggunakan sistem e-Health yang dapat digunakan secara efektif dalam mengidentifikasi stres ibu hamil.*
Metode: *Jenis penelitian ini adalah penelitian kualitatif dan kuantitatif. Penelitian kualitatif menggunakan* Sistem Development Life Cycle (SDLC) *dan penelitian kuantitatif menggunakan rancangan experimental dengan pendekatan* one-shot case study*.*
Hasil: *Sistem e-Health secara otomatis dapat mengidentifikasi stress selama kehamilan dengan kuesioner* Technology Acceptance Model (TAM) *yang menunjukkan hasil yang sangat efektif 85.4%. Rerata kecepatan waktu yang dibutuhkan mendeteksi status stres ibu hamil adalah 230,94 detik. Sistem ini dapat menganalisis 374 orang ibu hamil dalam satu hari (24 jam) dan juga menyediakan layanan dan melaporkan hasil deteksi stress pada ibu hamil.*
Kesimpulan: *Sistem e-Health dapat mendeteksi stress dalam kehamilan secara efektif. Sistem informasi e-Health juga efektif secara waktu pengisian dan dapat digunakan sebagai pencatatan dan pelaporan terkait deteksi dini stress dalam kehamilan.*

Kata kunci: *kehamilan, stres, deteksi dini, sistem informasi,* smartphone

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Introduction

The gestation period is prone to stress. Stress is defined as an emotional experience that is uncomfortable and accompanied by physiological, biochemical and behavioral changes. Some situations in life that can trigger stress are social support, a low quality of life physical and psychological health, environment, and social relationships (Kashanian *et al*., 2021). Pregnant women must be able to adapt to these physiological and psychological changes (Kharaghani *et al*., 2020). Physiological and psychological adaptations are interrelated (Pangesti, 2018). Pregnancy causes women to become prone to stress. However, the overall prevalence of stress remains unclear. A study in the United States found that approximately 84% of pregnant women experienced stress, with 6% experiencing high levels of stress (Corbijn van Willenswaard *et al*., 2017). A study in Indonesia found that 78% of pregnant women experienced low to moderate stress, and as many as 6% experienced severe stress. Women are more susceptible to stress during pregnancy than during the postpartum period (Runjati *et al*., 2017).

The consequences of stress during pregnancy can lead to decreased cognitive development, autism, and schizophrenia, and have a negative effect on motor development, as well as greater difficulty in behavior (Huizink *et al*., 2016; Corbijn van Willenswaard *et al*., 2017). Stress during pregnancy is associated with the risk of postpartum depression and also has an impact on worse pregnancy outcomes such as fewer months and low birth weight (Urizar *et al*., 2019). The results of a previous study proved that stress can affect delivery outcomes in pregnant women (Zijlmans *et al*., 2017). Efforts have been made to maintain maternal health during pregnancy by providing antenatal care (ANC) (Ministry of Health, 2023) Researchers have suggested that ANC should be able to meet pregnant women's needs using strategies to deal with psychological health problems related to anxiety and stress (Tsai *et al*., 2018). However, psychological problems for pregnant women still exist in the absence of routine and standardized early detection/ screening related to community-based services in health facilities. Previous studies have shown that 80% of psychological health issues during pregnancy go undetected and untreated (Kingston *et al*., 2017).

There are many barriers pregnant women face in accessing healthcare and getting treatment, such as lack of time, cost, geographic distance to health services, and transportation (Loughnan *et al.*, 2018). It is recommended that the public reduce visits to hospitals or other health facilities during the pandemic. However, certain categories of patients, such as pregnant women, still have to go to the hospital regularly to monitor fetal growth (Chang, 2020). Thus, innovations are needed to modify health services using information technology. In recent years, the use of information systems technology in health services (e-Health) has grown rapidly. Information system technology allows flexible access to health services, which can be accessed anywhere and anytime. Additionally, it saves travel costs, facilitates care, minimizes stigmatization, is more anonymous, and is more private, thereby increasing honest answers. In addition, information system technology can support patients' decisions to seek health-related information, help them communicate more efficiently, and reduce the error rate in diagnosing (Livingston, 2019; Martinez-Borba *et al*., 2018) The use of information system technology, especially smartphones, has been debated when it comes to overcoming obstacles in providing early detection of psychological health such as stress problems (Motosko *et al*., 2017). Thus, it is necessary to research the early detection of maternal stress during pregnancy with a smartphone-based information system. The study aims to develop an information system to detect stress, analyzes effectiveness, and find out time consuming to detect stress in pregnant women.

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Method

Information system development method

The stages of developing an information system using the Software Development Life Cycle (SDLC) waterfall were planning, analysis, design, implementation, testing, and maintenance. SDLC is a logical process to develop information systems involving requirements, validation, training and system owners (Raharjana, 2017). With TAM, user perceptions were evaluated from two variables, ease of use and usefulness, and thus TAM can explain and predict user acceptance of information technology. In terms of TAM score criteria, 0%–20% was categorized as ineffective; 21%–40% was categorized as less effective; 41-60% was categorized as quite effective; 61%–80% was categorized as effective; and 81%–100% was categorized as very effective.

Information system design

The main function of information is to increase knowledge. The information submitted to the recipient of the information is data that has been processed and decisions taken (Lukoff *et al*., 2018). An information system is a unity of interconnected elements that can collect (input), manipulate (process), store, distribute (output) information and provide feedback to achieve goals. (Raharjana, 2017). The information system design is shown in Figure 1.

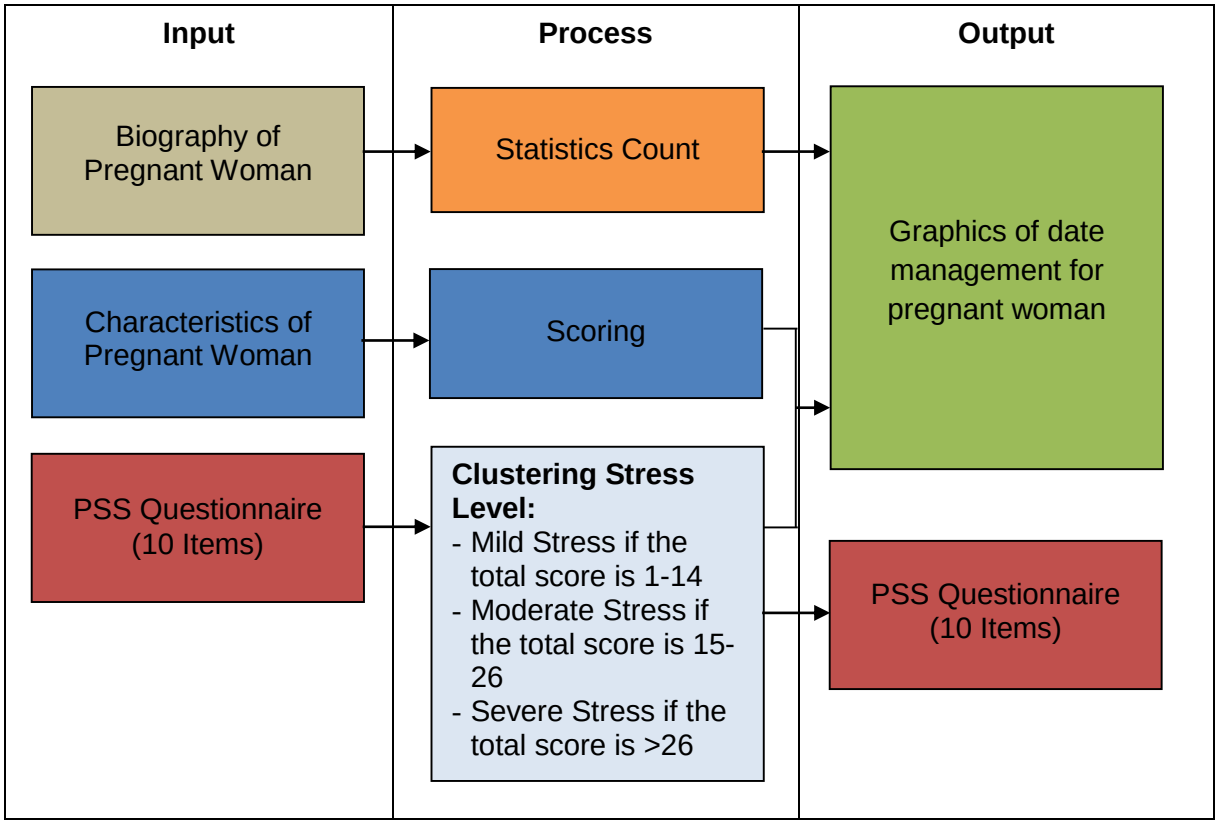

Figure 1. Information system design

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Research Methods

This study utilized quantitative research using the pre-scheduled design experiment with the one-shot case study approach. There was one intervention, followed by a post-test. The sample in this study was pregnant women in the working area of the Ngaliyan Primary Healthcare Centre between February and May 2021. The purposive sampling technique was used with a sample of 34 respondents. The instrument used in this study was the PSS (Perceived Stress Scale) questionnaire to measure stress. The stress level assessment scores were 1–14 categorized as mild stress; 15–26 categorized as moderate stress; and >26 categorized as severe stress. Pregnant women were asked to use a smartphone that had been installed for screening stress (Perceived stress scale) to detect stress during pregnancy. The implementation of an information system using smartphone tools to detect maternal stress during pregnancy is divided into two: the first is a website that will be accessed by the midwife as an admin and the second is an application link that can be accessed by pregnant women via a smartphone. Smartphone design developed and evaluated by experts. Data analysis used descriptive statistics to describe stress levels and TAM analysis to analyze the effectiveness of information systems to detect stress.

Results and Discussion

Maternal stress detection using smartphones

Maternal anxiety identification during pregnancy was established based on the results of the PSS questionnaire. The pregnant women's stress scores can be seen in Table 1.

Based on Table 1, 16.55 was the average PSS score for stress detection with the e-Health system with, a minimum score of 6 and a maximum score of 24. When viewed by stress category, the results show that ten mothers experienced mild stress (29.4%), and the remaining 24 experienced moderate stress (70.6%). None of the respondents experienced severe stress. Stress in pregnant women can affect the development of the fetus in various channels. First exposure to stress hormones to the fetus through the placenta. In pregnancy, the placenta serves as a barrier to protect the baby from harmful substances, but the hormone cortisol (the hormone released during stress) can pass through it so that it can provide changes to intraunterine conditions (Glover, 2019; Berthelon *et al*., 2018). Thus, it can result in premature birth and interfere with fetal development. In addition to exposure to stress hormones through the placenta, stress can also ingest the mother's immune system. Mothers who feel depressed are more susceptible to infections and complications during pregnancy. Mothers' behavior changes easily in response to stressful situations, particularly high-risk behaviors such as smoking, drinking, and poor diet (Berthelon *et al*., 2018).

The e-Health system used in this study was able to process data and make a stress diagnosis based on pregnant women's characteristics as shown in Table 2.

Based on the data from Table 1 and Table 2, the e-Health system with smartphone tools was able to diagnose stress in pregnant women. It could be used as an innovation that makes it easier for users to detect stress in pregnant women independently. The use of e-Health has spread, making it possible to provide remote, low-cost, and easy-to-use services to a larger number of patients. The mobile application can process health problems, including mental health problems, with efficient services (Gomez de-Regil *et al.*, 2020). Information systems can provide more sources of data and more complete information. With a storage information system, the report will be more integrated. However, health workers must first understand how to access the information system properly according to the expected objectives (Simbolon *et al.*, 2019).

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Table 1. Pregnant women's stress scores

Variable	PSS Score with Information System (n = 34)
PSS Score	
Mean±SD	16.55 ±4.53
Minimum	6
Maximum	24
Stress Category	
Mild stress	10 (29.4)
Moderate stress	24 (70.6)
Heavy stress	0 (0)

Table 2. Stress diagnosis results based on pregnant women's characteristics

Variable	Mild Stress n (%)	Moderate Stress n (%)
Age		
Teenagers (12-16 years)	0 (0)	0 (0)
Adolescents (17-25 years)	1 (2.9)	5 (14.7)
Young Adults (26-35 years)	6 (17.6)	18 (52.9)
Older Adults (36-45 years)	2 (5.9)	2 (5.9)
Elderly (46-55 years)	0 (0)	0 (0)
Education		
Elementary school	0 (0)	2 (5.9)
Junior high school	0 (0)	1 (2.9)
Senior high School	5 (14.7)	9 (26.5)
Higher education	4 (11.8)	13 (38.2)
Profession		
Employed	6 (17.6)	13 (38.2)
Unemployed	3 (8.8)	12 (35.3)
Family support		
Always	8 (23.5)	22 (64.7)
Often	1 (2.9)	3 (8.8)
Sometimes	0 (0)	0 (0)
Never	0 (0)	0 (0)
Parity		
Primipara	3 (8.8%)	11 (32.4)
Multipara	6 (17.6%)	14 (41.2)
History of a past pregnancy, childbirth, postpartum		
First-time pregnancy	3 (8.8)	11 (32.4)
Normal delivery history	6 (17.6)	6 (17.6)
Miscarriage history	0 (0)	1 (2.9)
History of premature delivery	0 (0)	1 (2.9)
History of delivery with surgery	0 (0)	6 (17.6)
History of complications	0 (0)	0 (0)
Gestational age		
First trimester (1-12 weeks)	1 (2.9)	0 (0)
Second trimester (13-28 weeks)	4 (11.8)	12 (35.3)
Third trimester (29-40 weeks)	4 (11.8)	13 (38.2)

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Table 3 Information System TAM Score

Variable	Number of Respondents	Score Average	Presentation (%)
Perceived ease of use	34	4.24	84.8
Perceived usefulness	34	4.19	83.8
Attitude toward using	34	4.20	84
Behavioral intention	34	4.31	86
Actual usage	34	4.41	88.2
Overall average		4.27	85.4

The Effectiveness of Smartphone

The system was tested using the technology acceptance model (TAM) questionnaire which were perceived ease to use, perceived usefulness, attitude toward using, behavioral intention and actual usage. The information system's TAM score is shown in Table 3.

In this study, the overall average value was 4.27 with a presentation of 85.4% for the five variables, which means it was very effective. The results showed that the respondents accepted the e-Health system on smartphones to detect maternal anxiety during pregnancy. During the COVID-19 pandemic, people have been encouraged to reduce visits to the hospital or other health facilities. However, patients such as pregnant women still have to go to the hospital regularly to monitor fetal growth (Chang, 2020). The acceptance of the use of information technology (TAM) has five concepts that can influence a person in the use of information technology, namely perceived usefulness, perceived ease of use, user attitude (Attitude Toward), behavior intention, and actual use (Wu *et al*., 2017). The Technology Acceptance Model (TAM) questionnaire was used. TAM places user perceptions with two variables, namely ease of use (Perceived ease of use) and benefit (Perceived usefulness) so that TAM can explain and predict user acceptance of information technology. Adaptability and simplicity make TAM one of the most commonly used models for measuring Information Systems (Al-Emran *et al*., 2018). The TAM concept explains that five concepts influence a person's use of information technology. The study found that the TAM of smartphone system information was proven to be effective detecting stress in pregnant women. It is also useful to provide psychologically care for pregnant women during the pandemic. A meta-analysis shows that giving psychological interventions using smartphone aids can reduce stress. Smartphones offer a variety of novel self-management strategies for people with stress disorders both clinical and sub-clinical. Smartphones provide mobile services to millions of people around the world who need psychological support but struggle to access regular healthcare (Firth *et al*., 2017; Linardon *et al*., 2019).

Service Speed with Smartphone Tools

The information system for early maternal stress detection during pregnancy with smartphone tools was able to detect stress in pregnant women automatically. The results showed that the average stress diagnosis could be done in 230.94 seconds using the information system. In just 230.94 seconds, pregnant women can find out the level of stress they are experiencing. Thus, e-Health can provide services quickly. This information system's detection speed is very dependent on an internet connection. The faster the internet connection, the faster it will take to detect. Conversely, the worse the internet connection, the longer it will take to evaluate pregnant women's anxiety. The development of information systems has reduced health workers' clinical decision-making time. In addition, the information system can provide convenience in accessing patient data, allowing this to be done more quickly as well. The duration of the detection process affects its handling and subsequent actions (Aini, Widyawati, and Santoso, 2019).

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Number of Services from Health Workers

This study's results indicate that early detection with an information system can be done within 230.94 seconds (3.849 minutes); thus, the number of pregnant women undergoing early anxiety detection in one day can be calculated as follows:

$$number\ of\ pregnant\ women = \frac{60\ minute}{time\ to\ detect\ (minute)} \times 24\ hour$$

$$number\ of\ pregnant\ women = \frac{60\ minute}{3{,}849\ minute} \times 24\ hour$$

$$number\ of\ pregnant\ women = 15.59 \times 24\ hour$$

$$number\ of\ pregnant\ women = 374.12$$

$$number\ of\ pregnant\ women = 374\ women$$

Based on these calculations, it is known that the e-Health system can detect 374 pregnant women in one day (24 hours) with the assumption that data is filled out at alternating times. This information system can be used for large amounts of data. Thus, this information system can increase the number of services provided by health workers. It can also help health workers overcome the obstacles in conducting early detection of anxiety. Information technology utilization can improve performance more quickly, precisely, and accurately, which in turn can increase productivity. This information system can also overcome obstacles in early detection of the stress status of pregnant women. This information system uses smartphone tools because smartphones can provide convenience to be used anytime and anywhere so as to increase the efficiency of use; lightweight and can be stored in bags or pockets, can optimize work to be more punctual, health workers can quickly and easily get references in the health sector.

Recording and Reporting Early Stress Detection

The smartphone tool as a platform for e-Health has developed a new method to facilitate the report-making process. It provides real-time results displayed in the questionnaire menu. The screen displaying anxiety diagnosis results is shown in Figure 2.

Data on the prevalence and incidence of maternal stress during pregnancy can be seen in the dashboard menu. This dashboard menu displays a diagram showing the number of pregnant women who have received mild stress (green color), moderate stress (purple color), and heavy stress (blue color) diagnoses. The number of pregnant women diagnosed with stress is displayed based on the women's characteristics. This includes age, education, occupation, family support, parity, gestational age, past pregnancy history of parturition, and past/current illness history. The screen displaying the number of pregnant women with anxiety in terms of maternal age is shown in Figure 3.

Based on Figure 2 and Figure 3, the e-Health tool tested in this study could be used as a means of recording and reporting systems regarding pregnant women's anxiety. This can be useful for monitoring and evaluation activities. Based on the requirements analysis results, there was no system for recording and reporting stress in pregnant women. This was reported using the Maternal and Child Health Management Information System (MCH MIS). After completing data management, midwives must report daily and monthly to the local Health Office. However, in reality, there will be occasional delays in the timeliness of recording and reporting. This can happen when there is no internet connection and MIS user officers are on duty outside the public health center. The utilization of e-Health with this smartphone tool makes it easier for health workers to get information on pregnant women's anxiety incidence in one area.

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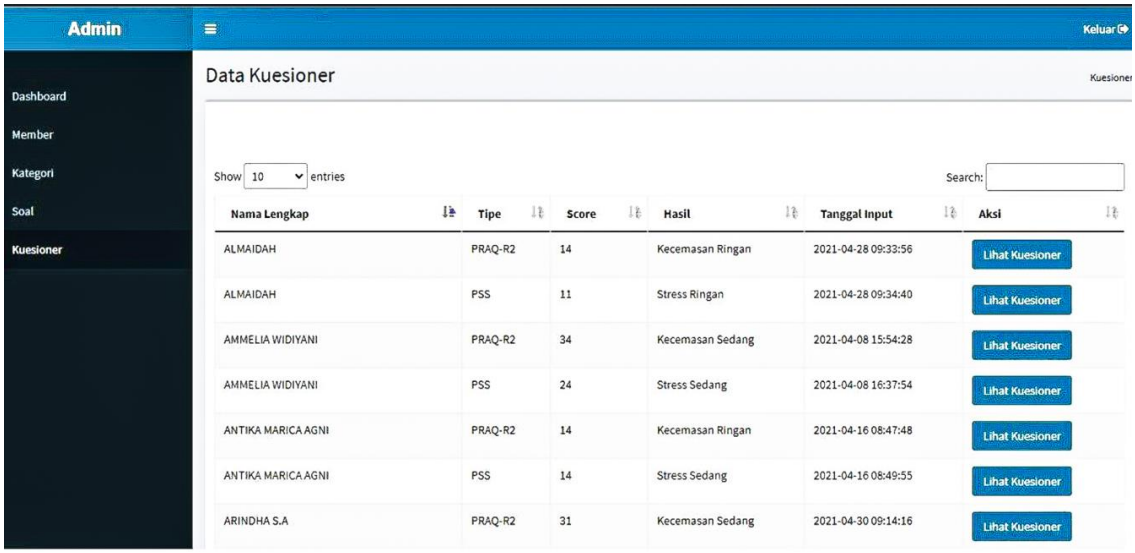

Figure 2. Display of stress diagnosis results

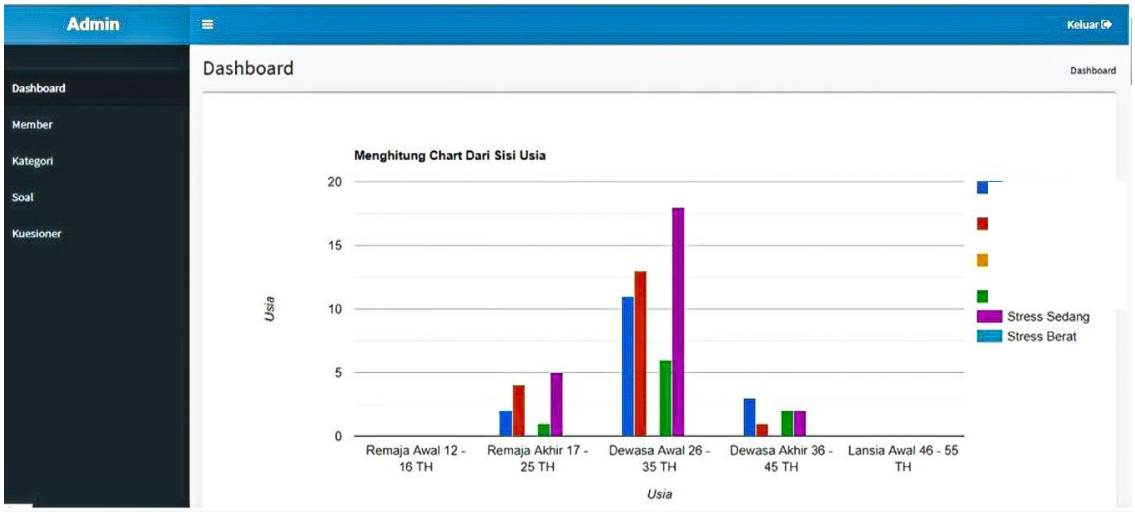

Figure 3. Number of anxiety cases based on maternal age

This is in accordance with previous research, which found that the information system allowed users to fill out questionnaires faster, more concretely, and accurately. Additionally, it provides a precise copy of the report as well (Simbolon *et al.,* 2019). The speed of the implementation of the examination results can affect the quality of the health service place. The speed of reporting will have an impact on faster decision-making changes. This information system can be a solution to the problem of the speed of reporting time. With a reporting information system, it becomes faster and can save transportation costs if reporting has to be done with a manual system. Information systems are able to ease the work of health workers. Rapid reporting can make policymakers quick to act in making decisions to issue policies to address health concerns.

Conclusion

The results showed that the e-Health information system was able to automatically identify stress during pregnancy with very effective acceptance. TAM analysis should be effective in detecting stress. The TAM score indicates a very effective e-health system at 85.4%;

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thus, this system is recommended to evaluate the effectiveness of a system. This system can analyze 374 pregnant women in one day (24 hours). This system is also capable of providing services and reporting stress detection results for pregnant women. Based on these findings, this e-Health system can be beneficial as an early detection tool during pregnancy and prevent harmful stress effects during pregnancy. It is recommended that the information system for early detection of stress with smartphone tools is expected to be part of midwifery services as a choice in monitoring the psychological well-being of pregnant women.

Abbreviations

MCH MIS: Maternal and Child Health Management Information System; TAM: Technology Acceptance Model; SDLC: Software Development Life Cycle.

Declaration

Ethics Approval and Consent Participant

This study was conducted by all necessary ethical principles and approved by the Bioethics Commission for Medicine/Health Research, Faculty of Medicine, Sultan Agung Islamic University, Semarang, with number No. 125/IV/2021/Bioethics Commission. Respondents were informed of the survey's objectives and purposes, and verbal consent to participate in the study was taken from them before their involvement.

Conflict of Interest

The authors declare that there were no significant competing financial, professional, or personal interests that might have affected the study.

Availability of Data and Materials

Not applicable.

Authors' Contribution

R and SR conceptualized the study, created the methodology, and wrote, reviewed, and edited the manuscript and original draft.

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