



Conceptual Model of an Expert System from Systematic Literature Review: Mental Health Screening in Pregnancy During the COVID-19 Pandemic

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ABSTRACT

Background: The COVID-19 pandemic has triggered increased anxiety and depression in pregnant women, while the ability of health workers to detect early symptoms of anxiety and depression in pregnancy remains poor. Expert system transfers expert intelligence into a computer to provide prediction and interpretation of mental health screening results. This expert system provides easy access to mental health services for pregnant women and reduces the workload for health workers so that obstacles to access to services during and after the COVID-19 pandemic can be resolved.

Objectives: We propose a conceptual model based on expert systems to allow early detection of anxiety and depression symptoms in pregnancy.

Methods: In this model, a systematic literature review was used to choose the instrument for the expert system. Next, to assess symptoms of anxiety and depression in pregnancy, we designed a decision table and produced an algorithm in a screening chart using the rule-based expert system procedure.

Results: Based on the results of the systematic literature review, there were 15 studies that had validated the screening instrument for symptoms of anxiety and depression in pregnant women. The results of the systematic review stated that the Edinburgh Postnatal Depression Scale (EPDS) had good sensitivity and specificity. Therefore, EPDS that be used in mental health screening based of expert system. Acquiring experts' knowledge into a computer program, seven algorithms were designed on screening chart to detect anxiety and or depression symptoms in pregnancy.

Conclusion: We illustrate that mental health screening in pregnancy using EPDS based on an expert system will provide accessibility of health services, accurate and fast results, a new approach for maternal mental health care, and avenues for future research.

Keywords: *pregnant women; screening; anxiety; depression; expert systems*

BACKGROUND

Maternal mental health plays an essential role in achieving the targets of Sustainable Development Goals (SDGs) related to improving maternal health and reducing premature deaths by one-third (Unicef, 2017). While the maternal health status in Indonesia remains below the target of the SDGs, the COVID-19 pandemic has further worsened maternal health. The Indonesian Obstetrics and Gynecology Association (POGI) reported that 20% of deaths among pregnant women over the past 17 months in Indonesia were due to COVID-19 infection, and 52% of these cases were asymptomatic (Meaney et al., 2021).

Before the COVID-19 pandemic, World Health Organization (WHO) had reported that the prevalence of anxiety disorder and/or depression in pregnancy about 1%-37% (Jha et al., 2018). The COVID-19 pandemic has increased the risk of anxiety disorder and depression for pregnant women (Lopez-Morales et al., 2021). The prevalence of anxiety and/or depression symptoms in pregnant women during the COVID-19 pandemic varies around the world. Canada reports that 37% of pregnant women suffer symptoms of depression, and 57% have symptoms of anxiety. In Ethiopia, 32.2% of pregnant women are experiencing anxiety symptoms. China reports that 29.6% of pregnant women show symptoms of depression, and Indonesia reports that 31.4% of pregnant women suffer symptoms of anxiety (Kassaw & Pandey, 2020; Lebel et al., 2020; Wu et al., 2020; Zainiyah & Susanti, 2020). Therefore, mental health care for pregnant women is particularly important during the COVID-19 pandemic. Untreated anxiety disorder and depression during pregnancy can increase maternal morbidity and mortality and well as maternal disability, which creates a non-fatal burden for the family and the country (Bauer et al., 2016; Onah et al., 2017).

Even before the COVID-19 pandemic, mental health tended to be neglected in maternal health programs in lower- to middle-income countries. Health services have yet to reach optimal capacity for screening and treatment of anxiety disorders and depression in pregnant women (Baron et al., 2016; Black et al., 2017). Thus, most health facilities are unable to screen for early detection of anxiety and depression symptoms in pregnant women under normal conditions, let alone during a worldwide pandemic (Unicef, 2017).

This low ability of health facilities to provide for early detection of anxiety and depression symptoms in pregnant women can be the result of several factors: the absence of standardized screening in antenatal care (ANC), a lack of knowledge and skills of health workers to identify anxiety disorders and depression in pregnancy, and inadequate health services (Kingston et al., 2015). The Indonesian government issued a new regulation in 2021 that established mental health assessments as an ANC standard (Al-Hajji et al., 2019b). Health workers in primary health care facilities should be prepared to assess the mental health of pregnant women. However, there is no standard instrument for early detection to assess the mental health of pregnant women in Indonesia. Moreover, health workers already have a heavy workload along with limited time and energy to give standardized antenatal care. These circumstances are exacerbated by the COVID-19 pandemic, which has also resulted in limited access to maternal health care.

Therefore, it is necessary to determine how practical standards of mental health care can be applied to pregnant women in primary health care both in normal circumstances as well as during pandemics. On the other hand, if such standard of mental health care is

applied in ANC, it must be one that does not create an excessive workload for health workers in either maternal or mental health programs.

At the same time, the COVID-19 pandemic has caused disruption in health services and forced every countries to utilize technology with the digitalization of health information systems in order to continue providing optimal health services (Machmud et al., 2019; Zangmo et al., 2020). One of the currently developing technologies is an expert system that can transfer expert knowledge into a computer and use algorithms to assess individuals' mental health conditions, including assessment of anxiety and depression symptoms in pregnancy (Isinkaye et al., 2017).

The development of this type of application could offer a solution to overcome the difficulty of accessing health services during the COVID-19 pandemic, ensure maternal health care continue without interruption, provide convenience, and reduce the workload of health workers in health programs.

OBJECTIVE

The aim of this study is to design a conceptual model for early detection of anxiety and depression symptoms in pregnant women. The screening mental health based on an expert system that is programmed to assist health workers in providing mental health care to pregnant women both during and after the COVID-19 pandemic.

METHODS

The first step toward designing this conceptual model was conducting a systematic literature review to identify what instruments and technologies are currently used to assess anxiety and depression symptoms in pregnant women. There were 15 studies that had validated the screening instrument for symptoms of anxiety and depression in pregnant women. We assessed the feasibility of 15 studies using the Centre for Evidence-based Medicine (CEBM) which obtained 7 studies with 6 instruments meeting the criteria of expected results. In addition, there were 6 studies had used technology to assess anxiety and depression symptoms in pregnant women.

The second step involved designing a conceptual model for the screening of symptoms of anxiety and depression based on an expert system using the rules-based expert system (RBES) procedure, which relies on interactive questions and answers. This RBES procedures consists of two aspects (Al-Hajji et al., 2019a):

1. Declarative method. This design includes the development of knowledge acquisition, a knowledge base, an inference engine, working memory, explanation facility, and a user interface.
2. Procedural design. This procedural design follows the Expert System Development Lifecycle, which consists of problem definition, conceptual design, prototyping, system development, implementation, testing, and evaluation.

RESULTS

1. Systematic Literature Review

The results of the systematic literature review identified several instruments that have been used and validated to assess anxiety and/or depression symptoms in pregnant women in low- and middle-income countries, as shown in Table. In this conceptual model, the expert system used the Edinburgh Postnatal Depression Scale (EPDS) instrument to

assess symptoms of anxiety and depression in pregnant women because of its sensitivity and specificity values.

Table 1. Instruments for screening for anxiety and/or depression symptoms in pregnancy

Instrument	Assessment	Countries that use and have validated	References
EPDS	Anxiety and/or Depression	India, South Africa, Malawi	(Joshi et al., 2020b; Marsay et al., 2017; Stewart et al., 2013)
Kessler-10	Anxiety and/or Depression	South Africa, India	(Fernandes et al., 2011)
DASS-21	Anxiety and/or Depression	Portugal	(Xavier, Bento, Azevedo, Marques, et al., 2016)
PHQ-9	Depression	Ethiopia	(Woldetensay et al., 2018)
SRQ	Depression	Malawi	(Stewart et al., 2013)
GAD-7	Anxiety	Peru	(Zhong et al., 2015)

In some countries, clinicians' assessment of anxiety and depression symptoms in pregnant women has relied on various types of technology, such as mobile or web applications and text messaging, as seen in Table 2.

Table 2. Overview of technology tools used to assess anxiety and/or depression symptoms

Authors	Assessment	Instruments	Technology	Strategies
Salvador et al., 2017	Depression	EPDS + 5 momentary questions + 2 contextual questions	Mobile app	Symptom assessment and monitoring
Faherty et al., 2017	Depression, Anxiety	PHQ-9 and GAD-7	Mobile app	Symptom monitoring and GPS movement tracking
Hantsoo et al., 2018	Depression, Anxiety	PHQ-9 and GAD-7	Mobile app and Telephone	Symptom monitoring and telephone calls from health provider
Ricketts et al., 2019	Depression	PHQ-8	Mobile app and telephone	Symptom assessment, monitoring, and health education
Doherty et al., 2019	Depression	Ecological Momentary Assessment (EMA) and EPDS	Mobile app	Symptom assessment and monitoring
Porte et al., 2020	Depression, anxiety,	Computerized Adaptive Test-Mental	Website and SMS	Symptom assessment,

mania,
suicideHealth (CAT-MH)
and EPDSmonitoring, and
psychoeducation

2. Rule-Based Expert System Design

The questions asked in this conceptual model of an expert system will consist of ten items from the EPDS instrument, which was developed by Cox et al (Cox et al., 1987).

1). Declarative method

The declarative method is used to discover whether something is right or wrong by considering of logic theory, as seen in Figure 1.

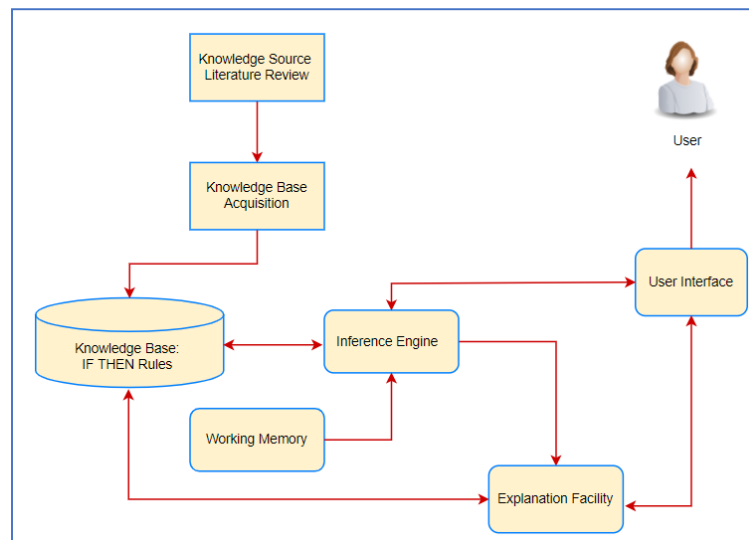


Figure 1. Expert system design (adapted from Gudu et al., 2012)

Knowledge is the key strength in the expert system, and it is gained from the knowledge and research of experts in various scientific journals and books. To begin developing the expert system, the EPDS instrument in English must be adapted into Indonesian (Windriyani et al., 2013b). Next, the Indonesian version of the EPDS will require assessment by qualified experts in their fields. The expert panel will generate a content validity index (CVI) to assess the relevance of the EPDS items.

Knowledge and the results of the expert panel will be acquired by transferring and transforming expertise at detecting symptoms of anxiety and depression in pregnant women into a computer program. This process is known as creating a knowledge base which is structured on two basic elements: facts and rules for understanding, formulating, and solving problems (Gudu et al., 2012a; Windriyani et al., 2013a).

The knowledge base cannot be separated from the inference machine that contains the mechanisms of mindset and reasoning used by the experts. The conceptual model designed in this expert system relies on a rules-based expert system using a modus ponens inference strategy. If there is an “IF A THEN B” rule, and, if it is known that A is true, then it can be concluded that B is also true. This approach to controlling inference in this expert system uses forward chaining, starting from gaining information about feelings experienced by a pregnant woman and ending by drawing a conclusion about her mental health (Awodele et al., 2016; Cox et al., 2010).

2). Procedural method

A flowchart of the procedural design based on the expert system development lifecycle can be seen in Figure 2.

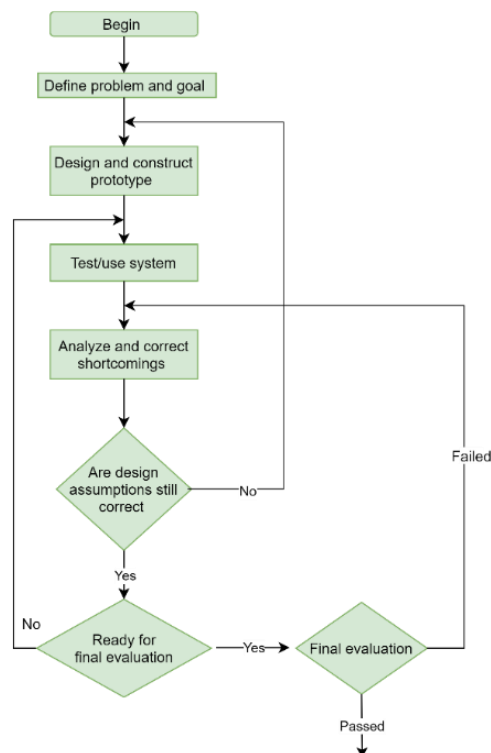


Figure 2. Flowchart of the expert system development lifecycle (adapted from (Al-Hajji et al., 2019a).

We conducted the assessment of symptoms of anxiety disorders and depression based on the structure of factors and rules of EPDS instruments displayed in the decision table (Table 3) (Nevid et al., 2014).

Table 3. Decision table

EPDS Item Label	Symptoms	Detection of
I have been able to laugh and see the funny side of things	Inability to experience pleasure	depression
I have looked forward with enjoyment to things	Inability to experience pleasure	depression
I have blamed myself unnecessarily when things no, not at all went wrong	Self-blame	anxiety and/or depression
I have been anxious or worried for no good reason	Anxious	anxiety and/or depression

I have felt scared or panicky for no very good reason	Scared	anxiety and/or depression
Things have been getting on top of me	Negative view of self, world, and future	depression
I have been so unhappy that I have had difficulty sleeping	Disturbance of sleep	depression
I have felt sad or miserable	hopelessness	depression
I have been so unhappy that I have been crying	Crying	depression
The thought of harming myself has occurred to me	Self-harm	depression

The decision table is used to acquire experts' knowledge into a computer program that produces a screening chart for the symptoms of anxiety and depression in pregnant women. Next, the assessment for screening for anxiety and depression will be developed using predefined algorithms (Figure 3).

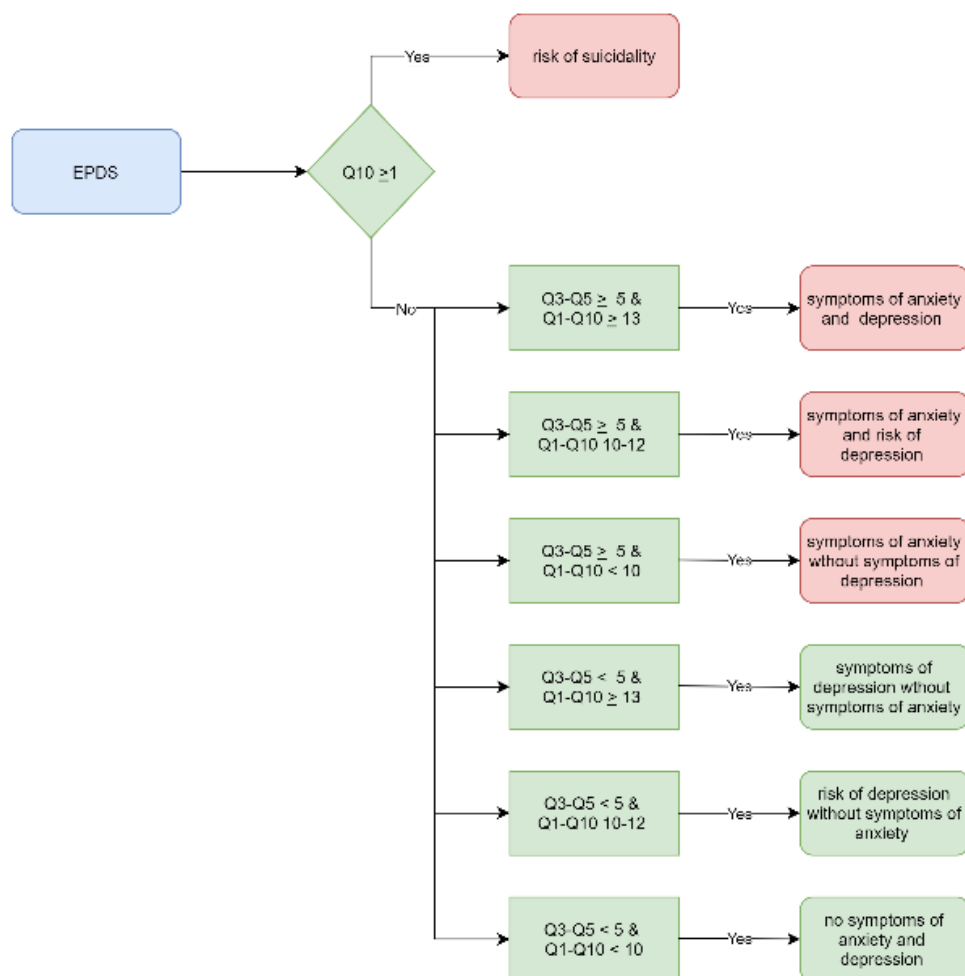


Figure 3. Screening chart for anxiety and depression symptoms in pregnancy (modified from (Joshi et al., 2020a))

In the test phase, the Indonesian version of the EPDS instrument will be tested in terms of its validity and reliability to be used for pregnant women in Indonesia. After that, the implementation and evaluation stage will be conducted as the final phase of the expert system development cycle. The algorithms that have been set in this expert system will be tested for sensitivity and specificity. Screening for symptoms of anxiety and depression in pregnant women based on the expert system is expected to have sensitivity and specificity values of more than 80%.

DISCUSSION

In the COVID-19 pandemic situation, increases in the numbers of pregnant women with anxiety disorder and depression must be addressed by early detection of symptoms of anxiety and depression in antenatal care to prevent their negative impact on maternal and child health.

This conceptual model of an expert system proposes a design of standardized mental health services for pregnant women that is practical for use in primary health care. This design is able to detect symptoms of anxiety and depression in pregnant women in both ordinary as well as extraordinary situations, such as the current pandemic, which will allow health workers, especially midwives, the ability to access the results of mental health screening assessments accurately, quickly, and continually. Moreover, screening for symptoms of anxiety and depression based on an expert system is expected to reduce the workload of health workers and overcome the lack of mental health professionals in primary health care. This screening system will allow for automatic assessment of pregnant women based on the knowledge and consistency of health experts' decisions.

The Indonesian EPDS used in this screening system is based on these considerations: self-reported, high accuracy, can assess not only depression symptoms but also anxiety symptoms, and can be used to assess post-partum depression in Indonesia (Marsay et al., 2017; Woldetensay et al., 2018; Xavier, Bento, Azevedo, & Marques, 2016). As such, it can provide for ongoing maternal mental health during the perinatal period.

Mental health assessments directly reported by pregnant women can produce good quality data, assuming that pregnant women are aware of their feelings and answer honestly. This assessment is administered easily and briefly (Demetriou et al., 2015). This simplicity is very helpful for midwives in primary health care because they are responsible for providing antenatal care to as many as 100 pregnant women during one scheduled ANC visit. Therefore, this expert system design for anxiety and depression symptom screening can make it easier and more effective to deliver antenatal mental health services because screening can be done anytime, anywhere. However, we must also be aware of the lack of assessment of self-reported anxiety and depressive symptoms by pregnant women. Misinterpretations may occur because pregnant women's abilities vary in terms of understanding and answering questions in this screening system (Fernandes et al., 2016).

The results of the screening chart presented in the conceptual model design may change according to the results of the validation tests (Stewart et al., 2013). The results of previous studies showed that expert systems can reduce errors in assessing pregnant women's mental health as conducted manually by health workers. The expert system also guarantees system security; only pregnant women and health workers who have valid

usernames and passwords can access this system. Most importantly, the accuracy of expert systems can reach 96% (Awodele et al., 2016; Gudu et al., 2012a; Isinkaye et al., 2017).

CONCLUSION

This conceptual model of an expert system for mental health screening in pregnancy using EPDS instrument is a potential solution to provide mental health care to pregnant women during and after the COVID-19 pandemic. It is important to understand, however, that this expert system does not replace health workers, but it is certainly an important tool that can support mental health care and the decision-making process involved in screening by health workers within maternal and mental health programs. Finally, this conceptual model based on an expert system deserves to be prototyped as a tool that can provide for early detection of symptoms of anxiety and depression in pregnancy.

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