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## 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 onset of the COVID-19 pandemic has amplified anxiety and depression among pregnant women, posing a significant challenge to health workers in the early detection of these symptoms. Introducing an expert system, which transfers specialized intelligence into a computer, represents an innovative strategy for predicting and interpreting mental health screening outcomes. This expert system not only streamlines access to mental health services for pregnant women but also mitigates the workload for health workers. By doing so, it effectively addresses the hurdles impeding access to services during and post the COVID-19 pandemic.

**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:** Our study demonstrates that employing an expert system-driven mental health screening in pregnancy, utilizing EPDS, promises enhanced accessibility to health services, rapid and accurate results, a novel perspective in maternal mental health care, and offers potential directions for future research endeavors.

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

## BACKGROUND

Maternal mental health constitutes a crucial determinant in advancing the objectives outlined in the Sustainable Development Goals (SDGs), specifically those aimed at enhancing maternal health and curtailing premature mortality by one-third (Unicef, 2017). Despite concerted endeavors, Indonesia continues to grapple with maternal health challenges, a predicament further compounded by the advent of the COVID-19 pandemic. Recent data from the Indonesian Obstetrics and Gynecology Association (POGI) underscores the profound impact, revealing that 20% of maternal deaths over the past 17 months in Indonesia were attributable to COVID-19, with a staggering 52% of these cases being asymptomatic (Meaney et al., 2021).

In the pre-pandemic landscape, the World Health Organization (WHO) reported a prevalence range of 1%-37% for anxiety disorder and/or depression during pregnancy (Jha et al., 2018). The COVID-19 pandemic has heightened the vulnerability of pregnant women to anxiety disorder and depression (Lopez-Morales et al., 2021). Globally, disparate prevalence rates of anxiety and/or depression symptoms during pregnancy amid the pandemic are evident. Canadian statistics indicate 37% of pregnant women grappling with depression symptoms and 57% experiencing symptoms of anxiety. In Ethiopia, 32.2% of pregnant women exhibit anxiety symptoms. China reports 29.6% of pregnant women manifesting symptoms of depression, while Indonesia reports 31.4% displaying symptoms of anxiety (Kassaw & Pandey, 2020; Lebel et al., 2020; Wu et al., 2020; Zainiyah & Susanti, 2020). The imperative for vigilant mental health care for pregnant women is underscored by the potential escalation of maternal morbidity, mortality, and disability in the absence of timely intervention, thereby imposing a non-fatal burden on families and the nation (Bauer et al., 2016; Onah et al., 2017).

Pre-existing deficiencies in integrating maternal mental health within health programs in lower- to middle-income countries, predating the pandemic, have intensified the existing challenges. Health services have struggled to attain optimal capacities for screening and managing anxiety disorders and depression among pregnant women (Baron et al., 2016; Black et al., 2017). The limited capacity of health facilities to detect these conditions early stems from the absence of standardized screening in antenatal care (ANC), inadequate knowledge and skills among health workers, and insufficient health services (Kingston et al., 2015). Responding to this, the Indonesian government in 2021 enacted a regulation mandating mental health assessments as an ANC standard (Al-Hajji et al., 2019b). While laudable, the absence of a standardized instrument for early detection remains a significant impediment. Furthermore, health workers grapple with formidable workloads, constrained time resources, and energy, exacerbated by the COVID-19 pandemic, leading to restricted access to maternal health care.

In this milieu, addressing the critical need to establish practical standards for mental health care application in primary health care settings for pregnant women, both in regular circumstances and during pandemics, becomes imperative. Simultaneously, the exigencies of the COVID-19 pandemic have catalyzed the adoption of technology, with the digitalization of health information systems emerging as an essential component for seamless health service provision (Machmud et al., 2019; Zangmo et al., 2020). Among these technological advancements, the development of expert systems capable of assimilating expert knowledge and deploying algorithms for assessing mental health conditions, including anxiety and depression symptoms during pregnancy, represents a promising solution (Isinkaye et al., 2017).

The realization of such applications presents a transformative opportunity to surmount the challenges associated with accessing health services during the pandemic. It ensures the uninterrupted delivery of maternal health care, affords convenience, and concurrently alleviates the burden on health workers. This article endeavors to meet the pressing need for a meticulously derived conceptual model of an expert system, synthesized from a comprehensive systematic literature review. The primary focus lies in mental health screening during pregnancy amid the complex backdrop of the COVID-19 pandemic.

## **OBJECTIVE**

The primary aim of this research is to develop a comprehensive conceptual model facilitating the early detection of anxiety and depression symptoms in pregnant women. The focal point involves the implementation of a mental health screening framework driven by an expert system. This system will be intricately programmed to serve as a supportive tool for health workers, enhancing their capacity to deliver adept mental health care to pregnant women. Importantly, this model is designed to address the unique challenges posed by the COVID-19 pandemic, ensuring its relevance and effectiveness in both current and post-pandemic scenarios.

## **METHODS**

The initial phase of constructing the conceptual model involved a meticulous systematic literature review to discern the prevalent instruments and technologies employed for appraising anxiety and depression symptoms in pregnant women. Scrutinizing 15 studies that validated screening instruments, the Center for Evidence-based Medicine (CEBM) method was applied, culminating in the identification of 7 studies featuring 6 instruments aligning with predetermined criteria for anticipated outcomes. Additionally, an examination of 6 studies utilizing technology for assessing anxiety and depression symptoms in pregnant women was conducted.

Subsequently, the method proceeded to the development of a conceptual model for screening anxiety and depression symptoms based on an expert system, adopting the rules-based expert system (RBES) procedure. As elucidated by (Al-Hajji et al., 2019a), this procedural facet encompasses two pivotal dimensions:

1. Declarative method. This entails the meticulous formulation of a knowledge acquisition structure, a knowledge base, an inference engine, working memory, an explanation facility, and a user interface.
2. Procedural design. Adhering to the Expert System Development Lifecycle, this phase encompasses distinct stages such as problem definition, conceptual design, prototyping, system development, implementation, testing, and evaluation.

The method synthesizes a systematic exploration of existing literature with a methodical approach to conceptual model design. The incorporation of the RBES procedure provides a structured and systematic framework for crafting the expert system. It is essential to underscore the rationale for selecting the RBES procedure and articulate its advantages in the context of this study. Additionally, briefly expounding on the systematic literature review methodology, including search criteria and data extraction processes, would enhance the clarity of this comprehensive method.

## 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

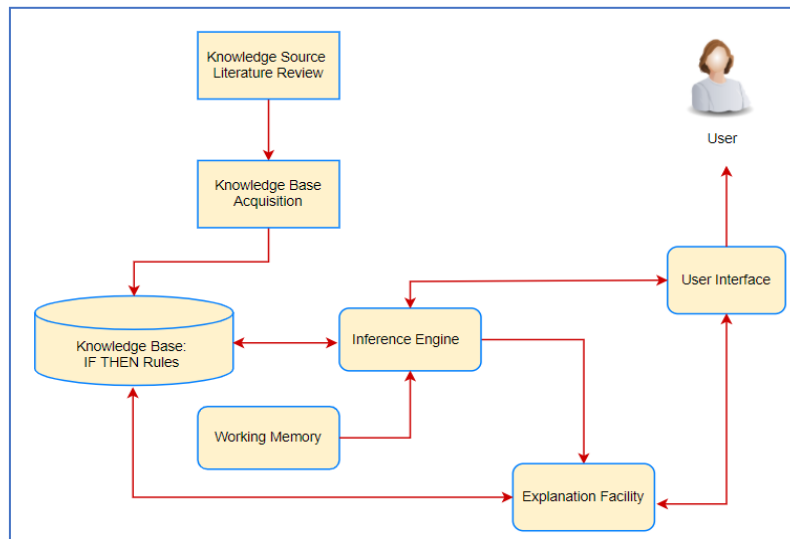
Authors	Assessment	Instruments	Technology	Strategies
Doherty et al., 2019	Depression	Ecological Momentary Assessment (EMA) and EPDS	Mobile app	Symptom assessment and monitoring
Porte et al., 2020	Depression, anxiety, mania, suicide	Computerized Adaptive Test-Mental Health (CAT-MH) and EPDS	Website and SMS	Symptom assessment, monitoring, 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)

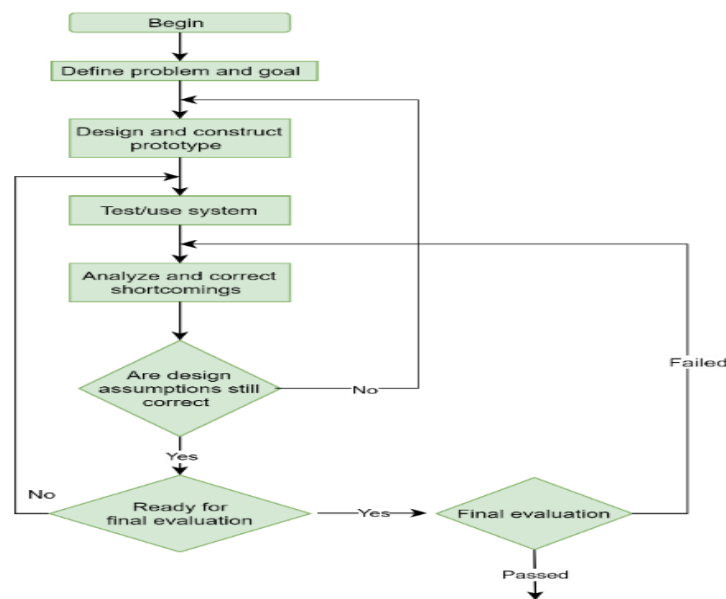
Knowledge is the key strength in the expert system, and it is gained from the knowledge and research of experts in various scientific journals and books. To begin developing the expert system, the EPDS instrument in English must be adapted into Indonesian (Windriyani et al., 2013b). Next, the Indonesian 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).

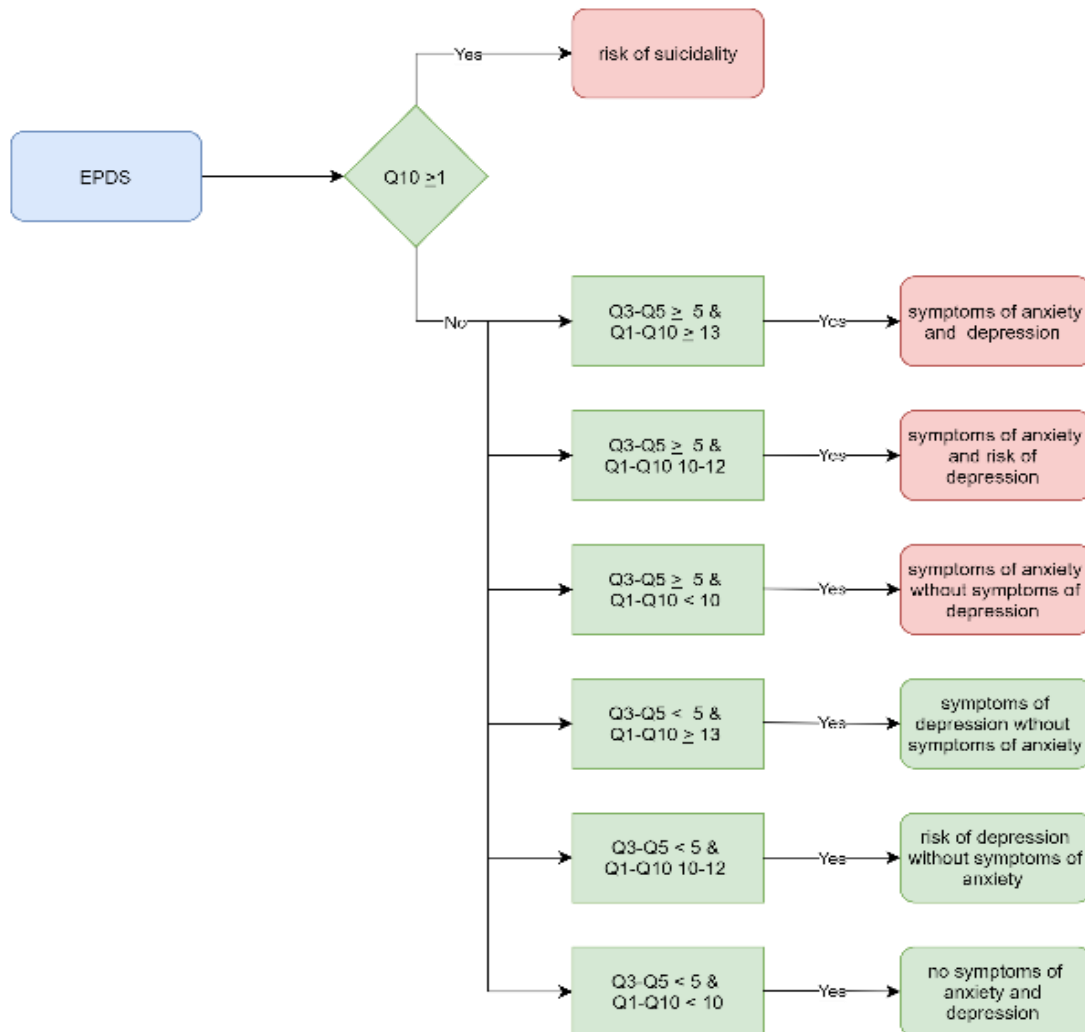
We conducted the assessment of symptoms of anxiety disorders and depression based on the structure of factors and rules of EPDS instruments displayed in the decision table (Table 3) (Nevid et al., 2014).

**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

In summary, the conceptual model incorporating an expert system for mental health screening in pregnancy, utilizing the EPDS instrument, emerges as a viable solution for providing essential mental health care to pregnant women amid the challenges posed by the COVID-19 pandemic. It is crucial to emphasize that this expert system is not intended to replace health workers but rather serves as a pivotal tool, offering valuable support in the decision-making process associated with screening within maternal and mental health programs. As a culmination, the proposed conceptual model, grounded in an expert system, warrants further development into a prototypical tool for the early detection of anxiety and depression symptoms in the unique context of pregnancy.

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