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Risk prediction instrument for premature rupture of membranes based on clinical parameters and obstetric history

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ABSTRACT

Background: *Premature rupture of membranes is one of the most significant obstetric complications, with a direct impact on increasing the risk of infection, preterm labor, and perinatal mortality. In Indonesia, the main challenge in managing premature rupture of membranes is the late identification of at-risk pregnant women due to the unavailability of objective and practical screening instruments.*
Objective: *This study aims to develop and test the validity of a clinical and obstetric history-based early rupture risk prediction instrument that can be widely applied in primary health care.*
Methods: *The research design used a case control approach with a total of 450 respondents, consisting of case and control groups. Data were obtained from medical records and analyzed through chi-square test and logistic regression to identify significant risk factors. A score prediction model was then developed and validated using ROC curve, Youden index, and sensitivity-specificity analysis.*
Results: *Four variables proved significant in the final model: age beyond 20-35 years, at-risk parity (primipara or grandemultipara), anemia, and fetal abnormality. The prediction score constructed based on these four factors had an Area Under the Curve value of 0.887, with a sensitivity of 82.4% and specificity of 84.8% at a cut-off point of >2.50. The overall accuracy of the model reached 0.86, indicating excellent classification performance.*
Conclusions*: This score-based prediction model was shown to be valid and can be used as a practical screening tool to detect early risk of premature rupture of membranes. Its application is expected to strengthen efforts to prevent obstetric complications and improve the quality of maternal care in Indonesia.*

KEYWORD: *obstetric history; premature rupture of membranes; prediction instruments; risk score; clinical parameters;*

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INTRODUCTION

Premature rupture of membranes is an obstetric condition that requires serious attention because it has direct implications for increasing the risk of complications for both mother and baby (1). Premature rupture of membranes, characterized by the rupture of the amniotic membrane before the onset of labor, can occur at any gestational age and can lead to severe complications such as intrauterine infection (chorioamnionitis), preterm labor, neonatal sepsis, and high rates of perinatal morbidity and mortality (2). Globally, premature rupture of membranes is the leading cause of preterm birth, which indirectly contributes to high neonatal mortality rates, including in Indonesia (3).

In the national effort to reduce maternal and infant mortality, early detection of premature rupture of membranes is not only important, but a crucial component of the maternal healthcare system (4). However, the main challenge in the field is the limited identification of pregnant women at high risk of premature rupture of membranes, as the methods used so far tend to be subjective and not standardized. The risk of premature rupture of membranes is often related to clinical and obstetric factors that can be measured, such as blood pressure, infection, multiple pregnancies, or a previous history of premature rupture of membranes (5)(6).

Inaccuracy in the identification of this risk has the potential to cause delays in handling which can be fatal (7). Given these conditions, the development of a risk prediction instrument for premature rupture of membranes based on clinical parameters and obstetric history is a very urgent need. Such an instrument will be an important tool for health workers, especially midwives, in conducting risk screening systematically, objectively, and evidence-based (8). Not only does it play a role in more optimal prevention and management of CPD, but it can also support more targeted education to pregnant women, and improve the overall quality of maternal and child health services (9).

More than just a clinical tool, it has strategic potential as a data-driven preventive intervention in national maternal and child health programs (10). Thus, research to develop a risk prediction instrument for premature rupture of membranes is not only relevant, but also very urgent to address actual challenges in the field and contribute significantly to reducing maternal and infant mortality in Indonesia (11).

MATERIALS AND METHODS

The research design used a case control approach, with a 2:1 ratio of case and control groups. This study was divided into 3 phases. Phase I is the preparatory phase, phase II is the instrument development phase, and phase III is the instrument testing phase. The preparatory phase focused on instrument conceptualization through a comprehensive literature review of peer-reviewed journals, national maternal health guidelines, and previous studies on PROM risk prediction, followed by the formulation of

operational definitions and expert consultations with obstetricians, midwives, and public health specialists to ensure clinical relevance and feasibility. In the instrument development phase, the preliminary checklist and scoring sheets were designed based on findings from the preparatory phase, with each risk factor clearly defined as “present” or “absent.” This stage also included pilot testing on a small group of respondents outside the main study sample to assess clarity, relevance, and practicality, after which feedback was incorporated to refine wording, scoring rules, and usability. The final testing and validation phase involved the full-scale application of the instrument and statistical validation using data from the target population.

The population for instrument development in this study were laboring mothers from January 1, 2024 to December 31, 2024, while the population for hypothesis testing were laboring mothers from January 2 - May 5, 2025. The inclusion criteria in this study were laboring mothers with pregnancy > 28 weeks , no documented congenital fetal anomalies in the medical record prior to labor, no history of significant abdominal trauma during pregnancy, no diagnosis of placenta previa or placental abruption prior to onset of labor.The exclusion criteria in this study were incomplete maternal medical record data. The sample size for hypothesis testing was carried out using power and sample size software based on research conducted by Malesse, et al (2023) totaling at least 50 respondents. The sampling technique used is purposive sampling. Data collection for instrument development used secondary data with medical record data sources, while to test the validity and reliability of the instrument using scoring sheets and checklist sheets. The data analysis used was bivariate analysis with chi square test, multivariate with logistic regression test, then continued with efficacy/usability test which includes positive predictive value and negative predictive value. This research has received ethical clearance from the Research Ethics Committee of RSUD R.T. Notopuro Sidoarjo,Number 000.9.2/071/438.5.2.1.1/ 2025

RESULTS AND DISCUSSION

RESULTS

Descriptive analysis was conducted to describe the distribution of characteristics of pregnant women in relation to the incidence of premature rupture of membranes. There were 450 respondents in this study, who were classified into two groups based on the presence or absence of premature rupture. Each characteristic studied reflects risk factors that clinically and theoretically have the potential to influence the occurrence of premature rupture of membranes.

The characteristics analyzed included maternal age at pregnancy, number of parities, multiple pregnancies, anemia status, history of infection during pregnancy, maternal employment status, fetal position abnormalities in the uterus, distance between pregnancies, body mass index status, history of premature rupture of membranes in

previous pregnancies, presence of diabetes mellitus that occurred during pregnancy, and the presence of a mismatch between the size of the fetal head and maternal pelvis (cephalopelvic disproportion). The results of the analysis in **Table 1** show that several

Table 1. Characteristics distribution of respondents

Characteristics	n = 450				
	Premature rupture of membranes		OR	95% CI	*p value*
	Yes (%)	No (%)			
Age					
At risk (< 20 and > 35 years)	37 (44.6%)	46 (55.4%)	1.81	1.11 – 2.94	0.023
Not at risk (20 - 35 years)	113 (30.8%)	254 (69.2%)			
Parity					
At risk (primipara/ grandemultipara)	29 (53.7%)	25 (46.3%)	2.63	1.48 – 4.69	0.001
Not at Risk (Multiparous)	121 (30.6%)	275 (0.94%)			
Gemelli					
Yes	6 (19.4%)	25 (80.6%)	0.46	0.18 – 1.14	0.13
No	144 (34.4%)	275 (65.6%)			
Anemia					
Yes	31 (44.9)	38 (55.1)	1.8	1.07 – 3.03	0.037
No	119 (31.2)	262 (68.8)			
Infection					
Yes	24 (46.2%)	28 (53.6%)	1.85	1.03 – 3.32	0.054
No	126 (31.7%)	272 (68.3%)			
Occupation					
Working	18 (41.9%)	25 (58.1%)	1.5	0.79 – 2.85	0.281
Not working	132 (32.4%)	275 (67.6%)			
Abnormality of fetal position					
Yes	38 (44.2%)	48 (55.8%)	1.78	1.10 – 2.88	0.025
No	112 (30.8%)	252 (69.2%)			
Pregnancy distance					
At risk (< 18 months)	34 (36.6%)	59 (63.4%)	1.19	0.74 – 1.93	0.537
Not at risk (?18 months)	116 (32.5%)	241 (67.5%)			
Body Mass Index					
At risk (< 18.5 and > 30)	30 (30.9%)	67 (69.1%)	0.87	0.54 – 1.41	0.656
Not at risk (18.5 – 30)	120 (34.0%)	233 (66.0%)			
History of premature rupture of membranes					
Yes	31 (40.3%)	46 (59.7%)	1.44	0.87 – 2.38	0.199
No	119 (31.9%)	254 (68.1%)			

Gestational diabetes mellitus					
Yes	29 (38.7%)	46 (61.3%)	1.32	0.79 – 2.21	0.348
No	121 (32.3%)	254 (67.7%)			
Cephalopelvic Disproporion					
Yes	34 (47.2%)	38 (52.8%)	2.02	1.21 – 3.37	0.01
No	116 (30.7%)	262 (69.3%)			

* chi-square test

characteristics of pregnant women have a significant association with the incidence of premature rupture of membranes, characterized by a p value <0.05, namely age outside the safe range, risky parity, anemia, infection, fetal position abnormalities, and cephalopelvic disproportion. In addition, variables with a p value <0.2 such as multiple pregnancies, history of premature rupture, and gestational diabetes mellitus will also be included in the multivariate analysis model to identify independent risk factors in more depth.

Based on the results of multivariate

Table 2. First multivariate analysis model for predicting early rupture of membranes

Characteristics	Model 1		
	Adjusted OR	95% CI	*p* value
Age			
At risk (< 20 and > 35 years)	1.71	1.03 – 2.84	0.038
Not at risk (20 - 35 years)			
Parity			
At risk (primipara/ grandemultipara)	2.12	1.16 – 3.88	0.014
Not at Risk (Multiparous)			
Gemelli			
Yes	0.47	0.18 – 1.18	0.107
No			
Anemia			
Yes	1.82	1.05 – 3.14	0.032
No			
Infection			
Yes	1.68	0.91 – 3.11	0.097
No			
Abnormality of fetal position			
Yes	1.66	1.01 – 2.74	0.049
No			
History of premature rupture of membranes			
Yes	1.44	0.85 – 2.43	0.177
No			

Cephalopelvic Disproporion			
Yes	1.32	0.77 – 2.27	0.307
No			

*Logistic regression test

analysis in **Table 2**, there were five factors that were significantly associated with an increased risk of premature rupture of membranes, namely maternal age outside the safe range (< 20 years or > 35 years), at-risk parity status (primipara or grande-multipara), anemia, fetal abnormality, and pregnancy with infection that approached significance. These variables showed p values <0.2 and remained included in the model for further analysis. Age, parity, anemia, and fetal abnormality had p values < 0.05, indicating that these factors were significant independent predictors of premature rupture after controlling for other variables.

Table 3 shows the final results of the multivariate analysis that identified four significant factors for the incidence of premature rupture of membranes: maternal age outside the safe range, at-risk parity (primipara or grandemultipara), anemia, and fetal abnormality, each with a p value <0.05. These four variables were included in the prediction model and scored as 1 if the risky condition was present and 0 otherwise, based on the transformed adjusted odds ratio. This score aims to simplify the application of the model in clinical practice, the total minimum score value is 0, and the maximum score is 4.

Table 3. Final multivariate analysis model for predicting early rupture of membranes

Characteristics	Model final				
	Adjusted OR	95% CI	*p* value	Transformed adjusted OR	Skor
Age					
At risk (< 20 and > 35 years)	1.77	1.07 - 2.91	0.025	1.07	1
Not at risk (20 - 35 years)					0
Parity					
At risk (primipara/ grandemultipara)	2.28	1.26 - 4.12	0.006	1.38	1
Not at Risk (Multiparous)					0
Anemia					
Yes	1.79	1.04 - 3.05	0.033	1.08	1
No					0
Abnormality of fetal position					
Yes	1.65	1.01 - 2.71	0.048	1	1
No					0

*Logistic regression test

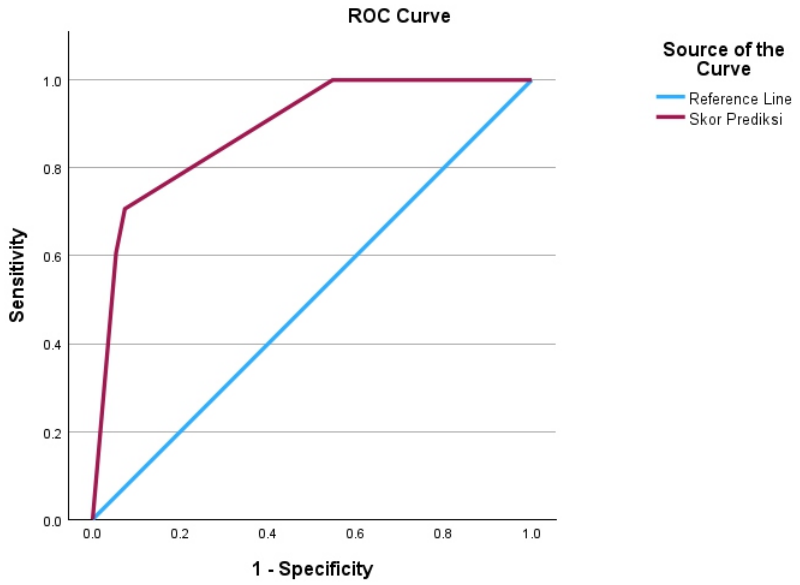

Figure 1. ROC Curve for Predicting Early Rupture of Membranes

Figure 1 shows the ROC (Receiver Operating Characteristic) curve of the predictive score model for premature rupture of membranes. The red ROC curve shows the model's performance in discriminating between pregnant women who do and do not experience premature rupture of membranes, with the area under the curve (AUC) visually appearing quite high, indicating good discriminatory ability of the model.

The curve is well above the blue diagonal reference line, which represents random classification. Thus, the developed prediction model showed adequate sensitivity and specificity, and is feasible for practical use in clinical risk assessment. **Table 4** shows the discriminative performance of the premature rupture prediction score model based on ROC curve analysis. The Area Under the Curve (AUC) value of 0.887 with a p value <0.001 indicates that the model has excellent classification ability and is statistically significant.

The Gini Index of 0.773 and the maximum Kolmogorov-Smirnov (K-S) value of 0.633 also corroborated the validity of the model in distinguishing risk groups. Based on the Youden index, the optimal cut-off point was determined at a score of 2.50, which is the threshold for accurately distinguishing between pregnant women at risk and those not at risk of premature rupture of membranes.

Table 4. AUC values and youden index cut off points

Category	Area	p value	Gini Index	Max K-S	*Cut Off*
Premature rupture of membranes prediction score	0.887	0	0.773	0.633	2.5

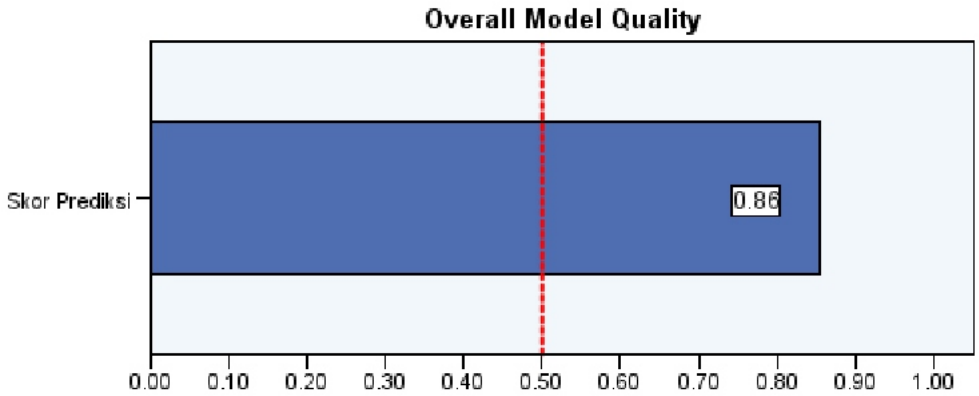

Figure 2. Quality of the Predicting Early Rupture of Membranes

Table 5. Sensitivity and specificity analysis of the predicting early rupture of membranes

Prediction Score	n = 50				
	Premature rupture of membranes		*p value*	Sensitivity (%)	Specificity (%)
	Yes (%)	No (%)			
At risk (score > 2.50)	14 (73.7)	5 (26.3%)	< 0,001	82.40%	84.80%
Not at risk (score ? 2.50)	3(9.7%)	28 (90.3%)			

Figure 2 shows a visualization of the overall quality of the premature rupture prediction model based on the developed prediction score. The value shown is 0.86, which illustrates the overall accuracy or predictive ability of the model. This is well above the reference line of 0.50 indicating that the model performs very well and is far superior to random predictions. Overall, this graph confirms that the developed prediction model has high classification quality and is reliable in a clinical context.

Table 5 shows that the premature rupture prediction score with a cut-off point > 2.50 had a sensitivity of 82.4% and a specificity of 84.8%, with a p value < 0.001. This indicates that the model was able to accurately and significantly identify at-risk pregnant women in distinguishing between those who did and did not experience premature rupture of membranes.

DISCUSSION

The results of this study showed that maternal age, parity, anemia, and fetal abnormality were factors that significantly increased the risk of premature rupture of membranes (**Table 1**). This finding is consistent with obstetric theory which states that extreme age (<20 or >35 years) is associated with immaturity or degeneration of cervical tissue and amniotic membrane, which increases susceptibility to early rupture. Physiologically, these age groups also tend to have higher rates of pregnancy complications than optimal reproductive age

(12). At-risk parity, i.e. first pregnancy (primipara) or fourth or more pregnancy (grande-multipara), also proved significant in the final model. This is consistent with the study by Raghupathy et al. (2021) who stated that primiparas tend to have higher intrauterine pressure due to lack of uterine elasticity, while grandemultiparas experience decreased tissue tone due to repeated pregnancies. Both conditions increase the risk of premature amniotic membrane rupture. This study reinforces the importance of close observation of pregnant women with these parity statuses(13)(14).

Anemia during pregnancy, which was also significant in the prediction model, can cause tissue hypoxia, including in the amniotic membrane, which accelerates structural degradation and increases its susceptibility to rupture. The study by Ziaei et al. (2015) found that severe anemia was directly associated with increased risk of intrauterine infection and premature rupture of membranes. Therefore, these findings confirm the importance of monitoring hemoglobin levels as part of obstetric risk screening(15)(16).

Fetal abnormality, such as transverse or breech presentation, creates abnormal pressure on the lower part of the uterus and cervix, which can accelerate the tension and tearing of the amniotic membrane (17). This result is in line with the findings of Suwal et al. (2022), who noted that unphysiological fetal position increases the risk of preterm labor and premature rupture of membranes. These findings strengthen the argument that antenatal check-ups with routine fetal position evaluation should be standard in pregnancy monitoring(18).

As shown in **Table 2**, the initial multivariate logistic regression model identified several variables with p-values <0.2—maternal age, parity, anemia, fetal abnormality, and infection. These were retained in the preliminary model to assess their adjusted influence on PROM. However, only four variables remained significant in the **final model** (**Table 3**): maternal age outside the safe range, at-risk parity, anemia, and fetal malpresentation. Each of these variables was assigned a binary score (1 for risky, 0 for non-risky), resulting in a practical scoring system with a total possible score ranging from 0 to 4.

In terms of model validity (**Table 4**), the Area Under the Curve (AUC) value of 0.887 indicates that the prediction score has excellent discriminatory ability in distinguishing between pregnant women at risk and those not at risk of premature rupture of membranes (19). This is reinforced by the sensitivity value of 82.4% and specificity of 84.8% at a cut-off point of 2.50, indicating that the model has a high balance of accuracy in risk classification (20). As demonstrated in the study conducted by Malesse et al. (2023), this model exhibits better performance than many comparable predictive models, which typically have an average AUC ranging between 0.70 and 0.80 (21). The final model developed in this study simplifies the use of risk scores by assigning a value of 1 to each

risky variable and 0 to non-risky conditions. This scoring scheme is not only practical, but also statistically sound, as each variable is selected based on significance in multivariate analysis. The total score ranges from 0 to 4, with an optimal cut-off point at 2.5. The use of this score allows health workers to quickly identify pregnant women who need early attention and intervention without having to rely on entirely subjective assessments (22)(23).

The model's predictive accuracy was validated using ROC curve analysis. As depicted in **Figure 1**, the ROC curve lies well above the diagonal reference line, demonstrating strong discriminatory capability. **Figure 2** illustrates the model's overall prediction quality, with an accuracy value of **0.86**, reinforcing its robustness as a classification tool. External validity test results through ROC curve and Youden Index analysis reinforce the reliability of this score in practice. The AUC of 0.887 indicates that the prediction model is excellent in its classification accuracy.

This means that in more than 88% of cases, the model can correctly distinguish between individuals who do and do not experience premature rupture of membranes. This value is even higher than some obstetric risk models developed in other countries, whose average AUC is in the range of 0.75-0.85. Thus, the statistical validity of the model has been very well tested (24). In terms of practical predictive accuracy, the prediction score also showed high sensitivity and specificity in testing on 50 subjects (**Table 5**). At a score > 2.50, the model was able to identify 82.4% of cases of premature rupture of membranes with a specificity of 84.8%. This indicates that the model is not only sensitive in detecting risk, but also specific enough to avoid misclassification in the non-risk group (25). The p value <0.001 in this test indicates that the difference between the high and low risk groups is highly statistically significant, making the model feasible to implement in healthcare facilities (26).

When compared to previous studies, these results represent an important advance in the development of localized and contextualized premature rupture risk screening tools. In contrast to approaches in developed countries that often rely on high technology and complex laboratory parameters, this model emphasizes clinical parameters that are easily obtained from history taking and routine antenatal examinations (27) (28). This approach is in line with the principles of primary health care, namely affordability, simplicity, and effectiveness (29).

Considering these findings, it can be concluded that the score-based prediction model developed in this study is not only statistically robust, but also applicable in the context of maternal health services in Indonesia (30). The use of this score can be part of routine antenatal screening protocols, enabling health workers to conduct early detection and more appropriate interventions. This study also addresses the

urgent need for an objective tool to identify the risk of premature rupture of membranes, thereby contributing significantly to efforts to reduce maternal and infant mortality at the national level.

CONCLUSION AND RECOMMENDATION

The study concluded that maternal age outside the 20-35 years range, risky parity, anemia, and fetal abnormality were significant factors for the incidence of premature rupture of membranes. The score-based prediction model developed from these four variables proved to have excellent classification performance, with an AUC value of 0.887 and sensitivity and specificity above 80%. The model is considered effective, practical and feasible to implement in midwifery services as it only requires basic clinical data.

It is recommended that this score instrument be used as a routine screening tool in antenatal examinations, especially in primary care facilities. The use of this model is expected to help early detection, accelerate intervention, and strategically support efforts to reduce maternal and infant morbidity and mortality in Indonesia. Further validation in different populations is needed to strengthen its widespread application.

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