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Prediction instrument for obstructed labor

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ABSTRACT

Background: *Obstructed labor is a complication during childbirth that can increase maternal and neonatal mortality and morbidity, making early detection crucial for prevention. However, currently, no instrument is available to predict the occurrence of obstructed labor.*
Objectives: *This study aims to develop an effective prediction instrument for the early identification of obstructed labor, enabling timely interventions to reduce associated risks.*
Methods: *The study employs a case-control design for the development of the instrument and a cohort design for its testing. The research is conducted in three phases: Phase I involves a literature review to identify risk factors, Phase II focuses on the initial testing of the instrument, and Phase III includes the validation of the instrument in a clinical setting. The study population consists of 360 women in labor for instrument development and 40 women for instrument testing. Bivariate analysis is conducted using chi-square tests, while multivariate analysis is performed using logistic regression, followed by ROC curve analysis to determine the optimal cutoff point.*
Results: *The results indicate significant associations between obstructed labor and factors such as infant birth weight, maternal height, age, obesity, upper arm circumference, anemia, history of abdominal surgery, and weight gain during pregnancy. The final predictive model demonstrated an AUC of 0.908, indicating excellent predictive performance with a sensitivity of 85.7% and specificity of 80.8%.*
Conclusions: *This study highlights the importance of early risk detection and intervention and contributes to the literature by providing an instrument capable of predicting the risk of obstructed labor.*

KEYWORD: *obstructed labor; prediction; score*

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INTRODUCTION

Obstructed labor is a critical issue in the childbirth process that can potentially endanger both the mother and the baby (1). In various regions of Indonesia, this condition frequently occurs and is one of the leading causes of complications during childbirth (2). This situation necessitates the development of an effective prediction instrument to identify the potential for obstructed labor early on, allowing for timely and efficient interventions to reduce the associated risks (3). Obstructed labor occurs when the childbirth process does not progress as expected, increasing health risks for both the mother and the baby (4). Intrauterine hypoxia, or oxygen deficiency in the baby, can lead to brain damage or even death (5). Additionally, the mother is at risk of experiencing birth canal tears, severe bleeding, and infections (1). Although several studies have explored the risk factors for obstructed labor, they often lack the translation into effective, practical, and validated prediction instruments that can be integrated into routine clinical assessments (6). The dangers of obstructed labor are not limited to the childbirth process itself but also extend to long-term consequences for both the mother and the baby (7). Mothers are at high risk of physical and psychological trauma, including Post-Traumatic Stress Disorder (PTSD) and postpartum depression. At the same time, babies may suffer long-term neurological damage due to hypoxia (8). Most current studies rely on retrospective data and traditional statistical models, with minimal exploration of dynamic or real-time predictive systems that could inform clinical decision-making before complications arise. Previous research on prediction methods and management of obstructed labor remains limited, and most studies have not yet produced practical and accurate prediction instruments for everyday clinical use (9).

Understanding and managing obstructed labor has become increasingly urgent, given the high rates of morbidity and mortality associated with this condition (10). Factors such as limited access to quality healthcare facilities and delays in receiving appropriate medical interventions exacerbate the situation (8). The development of early prediction strategies and effective management of obstructed labor is essential to reduce maternal and neonatal mortality and morbidity rates and improve the quality of maternal and neonatal healthcare services (11). Therefore, this study aims to develop a prediction instrument that can be effectively used in various regions of Indonesia, addressing the current gaps in literature and obstetric practice.

MATERIALS AND METHODS

Research design

The research design for instrument development employs a case-control approach, while the design for instrument testing utilizes a cohort approach. The study is divided into three phases. Phase I is the preparation phase, involving a literature review to identify risk factors for obstructed

labor that will be used in developing the instrument. Phase II involves the initial testing of the instrument, and Phase III includes further testing of the instrument.

Setting and samples

The population for instrument development in this study consisted of women in labor between January 1, 2023, and December 31, 2023. The period for conducting validity and reliability testing of the instrument was from March 5, 2024, to June 16, 2024. The inclusion criteria are women in labor with a gestational age of over 36 weeks and without labor induction, while the exclusion criterion is incomplete maternal medical records.The sample size for instrument development consists of 360 women in labor, while the sample size for hypothesis testing includes 40 women. The sample size calculation was performed using Power and Sample Size software based on the study conducted by Melesse et al. (2023). The sampling technique used in this study is purposive sampling.

Measurement and data collection

Data collection for instrument development was conducted using medical records, while data collection for the validity and reliability testing of the instrument was carried out through direct observation, with findings recorded on a structured data collection sheet.

Data analysis

The data analysis involved bivariate analysis using the chi-square test, multivariate analysis using logistic regression, and determination of the cutoff point with ROC curve analysis. This was followed by an efficacy test, which included evaluating the positive and negative predictive values. Data analysis was performed using SPSS version 29.

Ethical considerations

This study has received ethical approval from the Health Research Ethics Committee of RSUD R.T. Notopuro Sidoarjo, under the recommendation number 000.9.2/059/438.5.2.1.1/2024 dated July 10, 2024.

RESULTS AND DISCUSSION

RESULTS

The bivariate analysis of the relationship between maternal and neonatal characteristics and the incidence of obstructed labor is summarized in Table 1. This includes assessments of anthropometric indicators, maternal medical history, and pregnancy-related conditions. Each variable is evaluated for its statistical relevance using odds ratios (OR), confidence intervals (CI), and p-values to determine the strength and significance of its association with obstructed labor.

Table 1 factors such as baby's weight, mother's height, age, obesity, upper arm circumference, anemia, history of abdominal surgery, and weight gain during pregnancy are associated with obstructed labor. Risk factors with a p-value < 0.2 were included in

Table 1. Characteristics distribution of respondents

Characteristics	n = 360				
	Obstructed Labor		OR	95% CI	*p-value*
	Yes (%)	No (%)			
Baby's weight					
> 3500 gram	44 (24.4)	21 (11.7)	2.5	1.4 – 4.3	0.003
≤ 3500 gram	136 (75.6)	159 (88.3)			
Mother's height					
≤ 145 cm	35 (19.4)	9 (5.0)	4.6	2.1 – 9.9	< 0.001
> 145 cm	145 (80.6)	171 (95.0)			
History of obstructed labor					
Yes	10 (5.6)	18 (10.0)	0.5	0.2 – 1.2	0.168
No	170 (94.4)	162 (90.0)			
Age (year)					
At risk (< 20 and > 35)	40 (22.2)	15 (8.3)	3.1	1.7 – 5.9	< 0.001
Not at risk (20 – 35)	140 (77.8)	165 (91.7)			
Obesity					
Ya	31 (17.2)	13 (7.2)	2.7	1.3 – 5.3	0.006
Tidak	149 (82.8)	167 (92.8)			
Upper arm circumference					
< 23,5 cm	23 (12.8)	9 (5.0)	2.8	1.2 – 6.2	0.016
≥ 23,5 cm	157 (87.2)	170 (94.4)			
Anemia					
Yes	50 (27.8)	20 (11.1)	3.1	1.7 – 5.4	<0.001
No	130 (72.2)	160 (88.9)			
Parity					
At risk (primigravida and grandemultigravida)	44 (24.4)	31 (17.2)	1.6	0.9 – 2.6	0.092
Not at risk (multigravida)	136 (75.6)	149 (82.8)			
Premature rupture of membranes					
Yes	39 (21.7)	37 (20.6)	1.1	0.6 – 1.8	0.897
No	141 (78.3)	143 (79.4)			
History of abdominal surgery					
Yes	39 (21.7)	21 (11.7)	2.1	1.2 – 3.7	0.016
No	141 (78.3)	159 (88.3)			
Birth interval					
At risk (nulliparous and < 2 years)	35 (19.4)	24 (13.3)	1.6	0.9 – 2.8	0.155
Not at risk (≥ 2 years)	145 (80.6)	156 (86.7)			
Weight gain during pregnancy					
Abnormal	39 (21.7)	19 (10.6)	2.3	1.3 – 4.3	0.006
Normal	141 (78.3)	161 (89.4)			

* chi-square test

Table 2. First multivariate analysis model for predicting obstructed labor

Characteristics	Model 1		
	Adjusted OR	95% CI	*p*-value
Baby's weight	2.6	1.3 – 4.5	0.009
> 3500 gram			
≤ 3500 gram			
Mother's height	3.6	1.6 – 8.1	0.003
≤ 145 cm			
> 145 cm			
History of obstructed labor	0.5	0.2 – 1.1	0.078
Yes			
No			
Age (year)	3.7	1.8 – 7.5	<0.001
At risk (< 20 and > 35)			
Not at risk (20 – 35)			
Obesity	2.6	1.2 – 5.7	0.014
Ya			
Tidak			
Upper arm circumference	3.4	1.4 – 8.7	0.008
< 23,5 cm			
≥ 23,5 cm			
Anemia	3.3	1.8 – 6.2	<0.001
Yes			
No			
Parity	1.6	0.9 – 2.9	0.097
At risk (primigravida and grandemultigravida)			
Not at risk (multigravida)			
History of abdominal surgery	2.1	1.1 – 3.9	0.031
Yes			
No			
Birth interval	1.7	0.9 – 3.2	0.104
At risk (nulliparous and < 2 years)			
Not at risk (≥ 2 years)			
Weight gain during pregnancy	2.1	1.1 – 4.1	0.029
Abnormal			
Normal			

*Logistic regression test

the logistic regression analysis to develop the prediction model.

Table 2 represents the initial model of the prediction instrument for obstructed labor. According to the table, the risk factors associated with obstructed labor include the baby's weight, mother's height, age, obesity, upper arm circumference, anemia, history of

abdominal surgery, and maternal weight gain during pregnancy. Subsequently, risk factors with a p-value < 0.05 were included in the multivariate analysis, constituting the final model for developing the prediction instrument.

Table 3 represents the final model of the prediction instrument for obstructed labor, consisting of 7 risk factors. Each risk factor is scored between 0 and 2, resulting in a minimum total score of 0 and a maximum total score of 11 across all risk factors.

Table 3. Final multivariate analysis model for predicting obstructed labor

Characteristics	Model final				
	Adjusted OR	95% CI	*p*-value	Transformed adjusted OR	Score
Baby's weight	2.3	1.2 – 4.3	0.01	1.2	
> 3500 gram					1
≤ 3500 gram					0
Mother's height	3.6	1.6 – 8.1	0.002	1.9	
≤ 145 cm					2
> 145 cm					0
Age (year)	3.7	1.8 – 7.3	<0.001	1.9	
At risk (< 20 and > 35)					2
Not at risk (20 – 35)					0
Obesity	2.4	1.1 – 5.1	0.023	1.2	
Ya					1
Tidak					0
Upper arm circumference	3.1	1.2 – 7.5	0.015	1.6	
< 23,5 cm					2
≥ 23,5 cm					0
Anemia	3.2	1.7 – 5.8	<0.001	1.7	
Yes					2
No					0
History of abdominal surgery	1.9	1.1 – 3.8	0.035	1	
Yes					1
No					0
Weight gain during pregnancy	2.1	1.1 – 4.2	0.023	1.1	
Abnormal					1
Normal					0

*Logistic regression test

Based on **Figure 1**, it can be concluded that the tested model or scoring system exhibits good predictive performance, as indicated by the ROC curve being well above the reference line. This suggests that the model has high sensitivity and specificity and effectively distinguishes between positive and negative events in the tested data. In other words, the model effectively predicts the occurrence of obstructed labor.

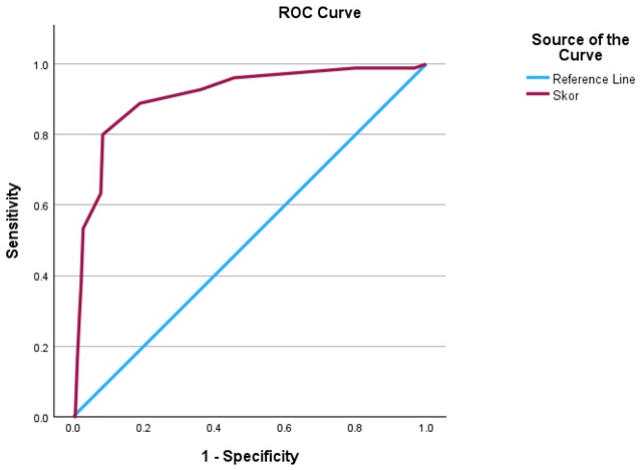

Figure 1: ROC Curve for Predicting Obstructed Labor

Table 4. AUC values and youden index cutoff points

Category	Area	p-value	Gini Index	Max K-S	*Cut Off*
Obstructed labor prediction score.	0.908	0	0.815	0.717	5.5

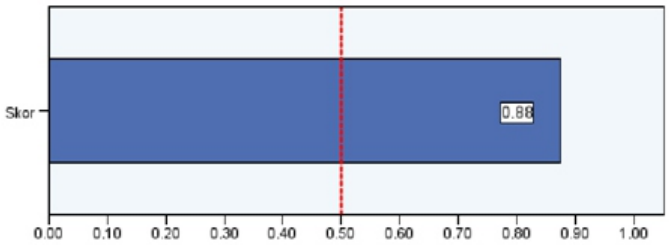

Figure 2. Quality of the Prediction Instrument Model for Obstructed Labor

Table 4 shows that the obstructed labor prediction score demonstrates excellent performance with a high Area Under Curve (AUC), strong statistical significance, and good discriminatory ability, as indicated by the Gini Index and Max K-S. This prediction model uses a cutoff score of 5.50 for optimal classification.

Figure 2 shows that the prediction model used has an AUC value of 0.88, indicating that the model performs very well in distinguishing between cases predicted to occur and those not predicted to occur. A cutoff at the value of 0.50 marks the point where the model differentiates between predictions classified as positive or negative. Its performance is both high and consistent, suggesting that the model is reliable within the context of the analyzed predictions.

Based on **Table 5,** among the at-risk group, 85.7% experienced obstructed labor, while 19.2% of those predicted to be at risk did not experience obstructed labor. In the non-risk group, 14.3% experienced obstructed labor despite being predicted as not at risk, while 80.8% truly did not experience obstructed labor. The sensitivity value of 85.7% indicates that this prediction

Table 5. Sensitivity and specificity analysis of the prediction instrument for obstructed labor

Prediction Score	n = 40				
	Obstructed Labor		*p-value*	Sensitivity (%)	Specificity (%)
	Yes (%)	No (%)			
At risk (score > 5.50)	12 (85.7)	5 (19.2%)	< 0.001	85.7	80.8
Not at Risk (score ≤ 5.50)	2 (14.3%)	21 (80.8%)			

instrument correctly identifies 85.7% of all obstructed labor cases, demonstrating a good ability to detect obstructed labor in at-risk individuals. The specificity value of 80.8% indicates that the prediction instrument correctly identifies 80.8% of the cases that did not experience obstructed labor.

DISCUSSION

The development of the prediction instrument for obstructed labor in this study is based on theories emphasizing the importance of early detection and immediate management of high-risk labor conditions (12). These theories state that various maternal factors, such as excessive baby weight, short maternal height, and maternal health conditions like obesity and anemia, can significantly affect the course of labor **(Table 1)** (13). The developed instrument aligns with the existing literature, where these factors have been identified as key determinants of obstructed labor. For example, a previous study by Desta et al. (2022) also found that maternal height and obesity are significant predictors of dystocia, supporting this prediction model's findings (14).

Additionally, this study reinforces the concept that the overall health condition of the mother, including nutritional status as measured by upper arm circumference and health history such as previous abdominal surgeries, has a significant impact on the risk of obstructed labor (15). This aligns with the study conducted by Musaba et al. (2021), which demonstrated that maternal medical history and nutritional status contribute to suboptimal labor outcomes (16). The prediction model developed in this research quantifies these factors and integrates them into a coherent scoring system **(Table 2, Table 3)** (17).

This prediction instrument incorporates widely recognized risk factors from the literature and simplifies them into a practical form that can be applied in various clinical settings, bridging the gap between theory and clinical practice. Its performance, based on ROC curve analysis, confirms the model's robustness in distinguishing between at-risk and non-risk cases **(Figure 1)** (18). The AUC value presented confirms the model's high discriminatory power. The final analysis also demonstrates substantial sensitivity and specificity, proving the model's effectiveness in clinical screening **(Table 4, Table 5)** (12).

In the context of clinical application, this study integrates an evidence-based approach with everyday practice needs, providing an instrument that healthcare

professionals can use for better clinical decision-making. The performance evaluation further supports this with a high AUC, reinforcing the instrument's utility. This prediction model relies on existing theoretical findings and contributes to the literature by offering an instrument that can help reduce maternal and neonatal morbidity and mortality rates (**Figure 2**).

In relating the findings of this study to a broader theoretical framework, it is important to consider the principles of risk management in obstetrics, which emphasize the importance of identifying modifiable risk factors (19). The prediction instrument developed in this study offers a more systematic approach to managing obstructed labor, enabling healthcare professionals to identify mothers at higher risk and allocate available resources more efficiently (20).This aligns with risk management theory, which suggests that timely and evidence-based interventions in high-risk groups can significantly reduce complications and adverse outcomes (21).

Additionally, this study contributes to the growing topic of using technology and data-driven instruments in maternal healthcare (22). By employing advanced statistical analyses, such as logistic regression and ROC curves, this instrument bases its predictions on known risk factors and validates its accuracy through a robust quantitative approach (23). This reflects a global trend in healthcare that is increasingly shifting towards more data-driven and predictive approaches. It demonstrates that, with appropriate analytical technologies, prediction instruments can become reliable tools for making more accurate clinical decisions (24).

This prediction instrument also highlights the need for local adaptation in applying research findings (25). Although this model was developed with the Indonesian maternal population in mind, there is a need for external validation in various settings and other populations to ensure the generalizability of the results (26).This is important given the demographic and epidemiological differences that may affect labor outcomes across different regions (27). Adapting the instrument based on local context can enhance its relevance and effectiveness and support broader adoption across healthcare systems (28). Further development may include adjustments for populations with different risk levels, including mothers with more complex comorbid conditions or in resource-limited settings, so that this instrument can truly become a universally applicable and widely beneficial predictive tool.

CONCLUSION AND RECOMMENDATION

This study successfully developed and validated a prediction instrument for obstructed labor, demonstrating excellent predictive performance with a sensitivity of 85.7% and specificity of 80.8%. The instrument includes key risk factors such as baby's weight, mother's height, age, obesity, upper arm circumference, anemia, history of abdominal surgery, and weight gain during pregnancy, all of which were found to

contribute to the risk of obstructed labor significantly. This instrument supports existing obstetric theories on the importance of early detection and prompt intervention in preventing labor complications and offers a practical solution that can be applied in various clinical settings, including those with limited resources.

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