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Low-birth-weight scorecard for early prevention: the accuracy for predicting low-birth-weight infants based on maternal risk factor

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ABSTRACT

Introduction: Babies with low birth weight (LBW) have a risk of complications and health problems. One of the efforts to prevent LBW births is to detect risk factors in pregnant women. This study aimed to test the accuracy of an early LBW detection scorecard based on maternal risk factors.

Methods: The research design used was observational analytical. The sample in this study was 177 mothers who were registered and delivered at hospitals and public health centers in Surabaya and were selected using a purposive sampling method. The research instruments used were LBW scorecard, maternal medical records, and baby's scale. The accuracy of the scorecard was measured with Mann-Whitney test, and Receiver Operating Characteristic (ROC) curve.

Results: The LBW scorecard which was based on maternal factors analysis can significantly predict LBW births (p = 0.000). Based on the ROC curve analysis, it was known that the early detection scorecard has a cut-off point of 3.5, and an accuracy of 88.70%, which indicated that the scorecard has high accuracy in predicting LBW.

Conclusions: The LBW early detection scorecards is able accurately to predict the incidence of LBW births. Through analysis and calculation of maternal risk factor, it can be seen whether the mother is at risk of giving birth to a LBW or normal weight baby. Early detection of LBW can improve services for at-risk babies, resulting in a positive impact on their health outcomes.

Keywords: low birth weight, scorecard, maternal risk factors

Introduction

Children's growth and development can occur optimally if the mother has good physical and psychological conditions (Park *et al.*, 2018). A child's growth and development begin at the beginning of conception and pregnancy; therefore, the physical, psychological and nutritional conditions expended by the mother need to be maintained because they greatly influence the growth and development of the fetus (Suryati, 2014). Mothers who experience malnutrition during pregnancy have a greater risk of giving birth to LBW babies and having health problems. Apart from that, the incidence of LBW also has an impact on several other health problems and increases the neonatal mortality rate (Tadese *et al.*, 2021). The World Health Organization (WHO) defines LBW as a newborn with a body weight below 2,500 g (WHO, 2014). LBW is a public health problem at a global level that has short-term and long-term consequences. It is estimated that between 15% and 20% of all births in the world are LBW births. The target set by WHO by 2025 is to achieve a 30% reduction in the number of babies born with a body weight of less than 2500 g (WHO, 2014).

One of the risk factors for LBW babies is the mother's history of high-risk pregnancies. The estimated number of pregnant women at high risk or complications in the city of Surabaya in 2016 was 9,496 people. Meanwhile,

the coverage of high-risk pregnant women or complications treated at health facilities is 90.24% (City, 2016). The Infant Mortality Rate (IMR), Under-five Mortality Rate, and Maternal Mortality Rate (MMR) are important indicators to determine the level of public health. Indonesia is expected to be able to reduce MMR and IMR as an effort to support the achievement of the Sustainable Development Goals (SDGs) (Hapsari, 2019). There is a trend toward a decrease in the proportion of birth weights of less than 2,500 g. In 2013 the proportion of LBW decreased by 5.7% and in 2018 it was 6.2%. The 2019 RPJMN target is 8%; however, the results of the 2016 National Labor Force Survey are around 6.9% (Riskesdas, 2018), while the LBW percentage in Surabaya in 2018 is around 1.96 (Surabaya Health Office, 2018).

Babies with very low birth weight experience decreased cognitive, language and motor function (Endalamaw *et al.*, 2018). Previous research results explain that babies with low birth weight show an increased risk of death, growth retardation and neurodevelopmental delays, especially in children with very low birth weight (Hailu and Kebede, 2018). Additionally, newborns with low birth weight have a higher risk of stillbirth, low Apgar scores, admission to the neonatal intensive care unit, and early neonatal death (Wachamo, Bililign Yimer and Bizuneh, 2019). Apart from giving birth to LBW babies, pregnant women are at high risk, which can result in irregular/obstructed labor, fetuses dying in the womb, and pregnant women/mothers in labor dying (Utami, Purwanti and Aprilia, 2019). Several efforts have been made by the government to achieve child health targets from the time the fetus is in the womb until it is 18 years old. Some of these programs include integrated Antenatal Care (ANC), neonatal visits, immunizations, growth and development detection, and others. This effort aims to prepare healthy, intelligent and high-quality children. future generations and reduce child mortality (Riskesdas, 2018). Apart from that, various efforts are also made to prevent LBW births by controlling risk factors in pregnant women in the form of integrated ANC during pregnancy, providing additional food to pregnant women who experience chronic energy deficiency, and providing *roborantia*. Another effort that can be made is to detect pregnant women who are at risk of giving birth to LBW babies by scoring risk factors (Susilaningrum *et al.*, 2018).

Popular assumption states that LBW can be significantly reduced with special medical care during pregnancy. In previous study, risk factors in pregnant women that can be easily assessed using basic methods have been carefully examined throughout pregnancy and formed the basis of predictions. Early detection can help prevent the possibility of LBW and also provide several recommendations through diverse intervention mechanisms (Yarlapati, Dey and Saha, 2017; Porro *et al.*, 2020). Several risk factors in mothers that are considered to influence the occurrence of LBW are history of giving birth to LBW, maternal employment, parity status, gestational age < 37 weeks, gemelli pregnancy, educational history, experiencing pre-eclampsia or having levels of chronic hypertension history, maternal HB < 8 g /dl (Trimesters (TM) 1 and 3) or < 10.5 g/ dl (TM 2), and having a history of pre-gestational diabetes mellitus (Baker *et al.*, 2018; Wachamo, Bililign Yimer and Bizuneh, 2019). Early detection of LBW can improve services for at-risk babies, thereby having a positive impact on their health outcomes. Early detection of LBW helps mothers to better understand whether their condition during pregnancy is included in the risk category (Arsyi, 2021). The results of studies carried out at the previous stage found that there was potential for the developed scorecard to predict LBW in mothers through calculating risk factors (Utami *et al.*, 2023). However, the accuracy of low-birth-weight scorecard in predicting low-birth-weight infants is not yet known. This study aimed to test the accuracy of the LBW early detection score card based on maternal risk factor.

Materials and Methods

Design

This research used an observational analytical design to examine the accuracy of an early LBW detection scorecard based on maternal risk factors.

Sample

The research sample was 177 mothers who had registered and gave birth in hospitals or health centers in the city of Surabaya. Sample selection used a purposive sampling method based on inclusion and exclusion criteria. The inclusion criteria in this study

Table 1. Risk factor scorecard

Risk Factor	Score
There is past history of giving birth to LBW	10
Mother works (makes a living)	2
Current maternal parity status: Primipara (one delivery) or grande multi-para (≥5 times)	2
Gestational age at delivery <37 weeks	2
Gemelli/double pregnancy	1
Mother's last education < high school / equivalent	1
In this pregnancy experiencing pre-eclampsia	1
In this pregnancy, maternal HB levels < 8 g/dl (TM 1 and 3) or < 10.5 g/ dl (TM 2)	1
Have a history of chronic hypertension	1
Have a history of pre-gestational diabetes mellitus	1
Total Score	22

were 1) mothers who gave birth in a hospital or health center in the city of Surabaya, 2) willing to be respondents, and 3) cooperative. Meanwhile, exclusion criteria included 1) mothers whose babies died at birth, 2) mothers or babies experiencing serious complications and requiring intensive care.

Study Instrument

The instruments in this research were a demographic questionnaire and maternal medical records during pregnancy, infant weighing scale, and an early detection scorecard for LBW which had been developed in the previous study (Utami *et al.*, 2023).

Based on Table 1, the scorecard consists of several indicators, including history of giving birth to LBW, maternal employment, parity status, gestational age <37 weeks, gemelli pregnancy, educational history, experiencing pre-eclampsia or having levels of chronic hypertension history, maternal HB <8 g/dl (TM 1 and 3) or <10.5 g/dl (TM 2), and having a history of pre-gestational diabetes mellitus.

Data collection

The research began with the selection of research samples, namely mothers who gave birth in hospitals or health centers in the Surabaya City and were willing to be respondents. Mothers were assessed and scored on their maternal factors causing LBW based on several components on the scorecard. The scoring results were then adjusted to the cut-off point limit. If the risk factor scoring result was < 3.5 then the baby was predicted to have normal birth weight, whereas if the cut-off point result was ≥ 3.5 then the baby was predicted to experience LBW. The prediction results were then matched with the birth weight of the babies in each group. After that, the mother was followed until she gave birth, and the birth weight of the baby was measured using a scale. Mothers who had babies with a birth weight of < 2,500 grams were grouped in the LBW group, while mothers who had babies with a birth weight of ≥ 2,500 grams were grouped in the normal group.

Testing Scorecard Accuracy

At this stage, the researchers tested the accuracy of LBW scorecard in predicting LBW in 177 samples. The results of testing the accuracy of the scorecard are said to be effective if several calculation stages have been fulfilled: the results of the risk score comparison test between the LBW group and the non-LBW group were stated to be significantly different, the results of the ROC calculation using the AUC (Area Under Curve) graph have an Asymp. value. Sig (2-sided) less than 0.05, determines the cut off value, which produces a cut-off point number whereby sensitivity, specificity and accuracy values are close to 1.

Data Analysis

Analysis of the research data began by carrying out a normality test using the Kolmogorov Smirnov test with p value > 0.05. Next, the accuracy of the scorecard was tested by determining the cut-off point using the ROC curve. The ROC curve is a graphical representation of the relationship between sensitivity and 1-specificity. In medical research, ROC curves are widely used to describe diagnostic accuracy and determine optimal cut-off values. The accuracy of diagnosis is derived from the area under the ROC curve and optimal cut-offs are used to identify positive and negative conditions in diagnosis. ROC analysis is used to determine the ability of the score to classify or predict conditions (low birth weight or normal weight) (Ekelund, 2012). This analysis can also be used to determine the optimal cut-off point (optimal decision threshold). To find out whether this point is accurate, we also analyzed the area under the curve. The accuracy of the test depends on how well it separates the group being tested into low birth weight and normal birth weight groups. Accuracy is measured by the area under the curve, the ROC curve. Area 1 represents a perfect test; an area of 0.5 represents a worthless test. A rough guide to classifying the accuracy of a diagnostic test is the traditional academic point system: 0.90-1= excellent (A); 0.80-0.90 = good (B); 0.70-0.80 = sufficient (C); 0.60-0.70 = poor (D) and 0.50-0.60 = failed (F) (Nahm, 2022). The final stage of analysis is the effectiveness and sensitivity test employing the sensitivity and specificity diagnostic accuracy test using MedCalc. Next, the positive and negative predictive values (NPV and PPV) NPV and PPV are calculated, which are completed in the diagnostic accuracy test.

Ethical Clearance

It is confirmed that the research carried out has fulfilled several ethical principles and has received approval for ethical eligibility from the Health Research Ethics Commission dr. Mohamad Soewandie Hospital on June 7th, 2023, with ethical certificate number NO. 007/KE/KEPK/2023. Several ethical principles applied in this study were anonymity because we did not include the identity of the mother or baby in this study. Another principle is beneficence because we just included mothers and babies in a good condition and made sure that our study did not harm their health. The last principle is justice, whereby we made sure each

Table 2. Demographic characteristic of mothers (n= 177)

Indicators	LBW (n=59)		Not LBW (n=118)	
	n	%	n	%
Gestational Age				
< 37 weeks	32	54.2	0	0
> 37 weeks	27	45.8	118	100
Gemelli/Double Pregnancy				
Yes	3	5.1	0	0
No	56	94.9	118	100
History of LBW Birth				
Yes	10	16.9	4	3.4
No	49	83.1	114	96.6
History of Diabetes Mellitus				
Yes	8	13.6	0	0
No	51	86.4	118	100
History of Chronic Hypertension				
Yes	6	10.2	0	0
No	53	89.8	118	100
History of Pre-eclampsia				
Yes	11	18.6	5	4.2
No	48	81.4	113	95.8
Hemoglobin				
< 11 / < 10,5	16	27.1	26	22.0
> 10,5 / > 11	43	72.9	92	78.0
Educational History				
Under Senior High School	25	42.4	75	63.6
Senior High School/Equivalent	34	57.6	43	36.4
Job Status				
Working	24	40.7	45	38.1
Doesn't Work	35	59.3	73	61.9
Parity				
Primipara	28	47.5	35	29.7
Not Primipara	31	52.5	83	70.3

respondent in both groups received the same treatment.

Results

The research results include demographic data and risk factors for mothers, scorecard accuracy test results, and model accuracy test results, which are explained as follows.

Demographic Data and Maternal Risk Factors

Maternal demographic data. which include demographic characteristics and risk factor analysis based on components on the early detection scorecard, are displayed in Table 2.

Based on the results of the cross-tabulation analysis in Table 2, it is known that 59 mothers gave birth to babies with LBW, while 118 mothers gave birth to babies with normal weight. The majority of mothers with LBW babies have a gestational age of <37 weeks, apart from that, it is also found that mothers with LBW babies have a history of gemelli/double pregnancy, and a history of LBW birth in previous pregnancies. A history of diseases such as diabetes mellitus, chronic hypertension, and pre-eclampsia during pregnancy was also found in the group of mothers with LBW babies. Indicators of hemoglobin values for mothers that were below normal (< 11 g/dl) were also found to be the majority in the group of mothers with LBW babies. Meanwhile, indicators in the form of educational history, mother's type of employment, and parity number obtained equal results in both groups. The risk score comparison test from the score card between LBW and non-LBW subjects used the Mann Whitney test because the risk score data for the non-LBW group was not normally distributed. The following are the results of the risk score comparison test between LBW and non-LBW subjects.

Based on the risk score comparison test results in Table 3, it was found that for LBW subjects the risk score value was in the range 2 – 22 with a median of 10 and a mean ± SD value of 9.27 ± 4.34. Meanwhile, in the group of non-LBW subjects, the risk score value was in the range 1–4 with a median of 2 and a mean ± SD value of 2.25 ± 0.95. The results of normality test using Kolmogorov Smirnov test obtained that the p-value of the LBW group score was 0.062 which was stated to be

Table 3. Risk Score Comparison

Risk Score	LBW (n=59)	Not LBW (n=118)	p-value
Range (Median)	2 – 22 (10.00)	1 - 4 (2.00)	0.000
Mean ± SD	9.27 ± 4.34	2.25 ± 0.95	

Table 4. ROC calculation results

Area	Std. Error	Asymptotic Sig.	Asymptotic 95% CI	
			Lower Bound	Upper Bound
0.960	0.017	0.000	0.927	0.993

Table 5. LBW cut-off Point with LBW events

Cut-off point	Birth Weight		Total
	LBW	Not LBW	
	52	13	65.0
≥ 3.5 (LBW)	80.0	20.0	100.0
	88.1	11.0	36.7
	7	105	112.0
< 3.5 (Not LBW)	6.3	93.8	100.0
	11.9	89.0	63.3
	59	118	177.0
Total	33.3	66.7	100.0
	100	100	100.0

Table 6. Accuracy of test results of the LBW detection scorecard

Test	Value (%)	Confidence Interval (%)
Sensitivity	88.14	77.07 – 95.09
Specificity	88.99	81.90 – 94.00
Disease prevalence	33.33	26.44 – 40.80
Positive Predictive Value (PPV)	80.00	70.37 – 87.07
Negative Predictive Value (NPV)	93.75	88.18 – 96.79
Accuracy	88.70	83.09 – 92.96

normally distributed. Meanwhile, for the non-LBW group, the p-value was 0.000, which means it was not normally distributed. So, we used non parametric test (Mann-Whitney) to test the ability of the scorecard in predicting low-birth-weight. Based on the results of the comparison test using the Mann Whitney test, a p-value of 0.000 was obtained, which means there was a significant difference between LBW and non-LBW subjects based on the risk score obtained from the scorecard. The results of the analysis based on the mean value also showed that the risk score for LBW subjects was greater than the risk score for non-LBW subjects.

ROC Calculation for Determining Cut Off Point

Determination of cut-off points for risk classification were measured with the ROC curve. The results of the analysis using the ROC curve are shown in Table 4.

The test results in Table 4 using ROC obtained an AUC value of 0.960 with a significance of 0.000 ($p < 0.05$) with a positive curve direction, which means the top right point (1.1) represents a probability value that indicates a positive condition, namely the occurrence of LBW. The higher the AUC value indicates the greater the model accuracy. So, from the AUC value of 0.960, it can be said that the model produced by ROC is more accurate, as shown in Figure 1.

After the ROC calculation is carried out, the cut-off point value is determined, as shown in Figure 2.

In Figure 2, it is known that the results of calculations using a graph of the intersection between sensitivity and specificity values show that the cut-off point value is ≥ 3.50. The scorecard with a cut-off point value is 3.5, which means that if a mothers in her pregnancy has a risk score of <3.50 then her baby is not at risk of experiencing LBW. After classification is carried out, cross tabulation is shown in Table 5.

Based on the results of the analysis in Table 5, it is known that 105 mothers did not give birth to LBW as predicted (risk score < 3.50), and 52 mothers gave birth to LBW according to prediction (risk score ≥ 3.50). However, seven pregnant women who had a risk score of < 3.50 actually gave birth to LBW, and 13 mothers who had a risk score of ≥ 3.50 actually gave birth to babies with normal weight.

Model Accuracy Test

Calculation of model accuracy by calculating the sensitivity and specificity, and NPV and PPV values from the early detection scorecard for LBW incidents is described in Table 6.

Based on Table 6, it was found that the LBW scorecard had a sensitivity in predicting LBW births of 88.14%. The specificity result showed the ability of the scorecard to detect babies who are negative for LBW and the result showed that negative LBW is 88.99%. The PPV and NPV values showed that 80% of babies experienced LBW as predicted, while 93.7% of babies were proven not to experience LBW according to the results of the scorecard predictions. Overall, the scorecard had an accuracy of 88.70%. This value have a

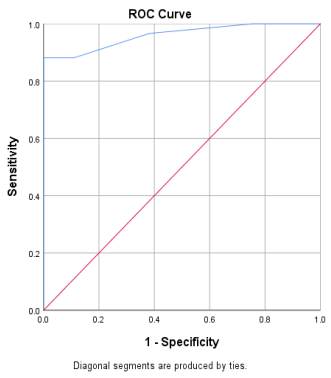

Figure 1. ROC Curve

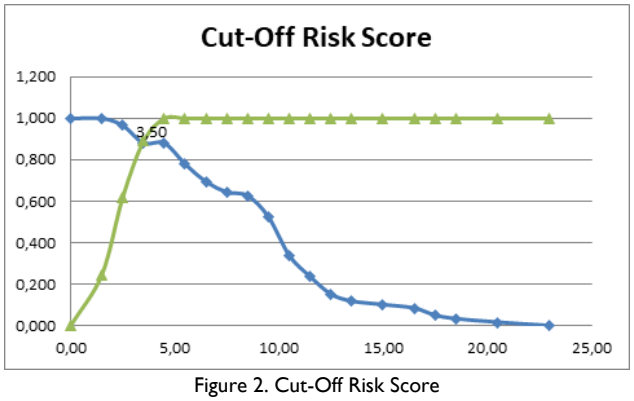

Figure 2. Cut-Off Risk Score

good interpretation because the percentage was more than 80% (Nahm, 2022).

Discussions

The application of the LBW early detection scorecard has high accuracy in predicting the incidence of LBW. Through analysis and calculation of risk factor scores for mothers, it is possible to determine the possibility of a baby being born with LBW. The results of the analysis of the LBW early detection scorecard that was developed also showed significant differences between the group of mothers with LBW babies and the group of mothers with normal birth weight babies. Several risk factors that are important to assess based on the score card developed include history of giving birth to LBW, mother's occupation, parity status, gestational age < 37 weeks, gemelli pregnancy, education history, experiencing pre-eclampsia or having chronic hypertension history, maternal HB levels <8 g/dl (TM 1 and 3) or < 10.5 g/dl (TM 2), and having a history of pre-gestational diabetes mellitus (Xi *et al.*, 2020; Utami *et al.*, 2023). Early detection of LBW can improve services for at-risk babies, thereby having a positive impact on their health outcomes. Early detection of LBW helps mothers to better understand whether their condition during pregnancy is included in the risk category (Bansal, Garg and Upadhyay, 2019; Toru and Anmut, 2020).

Midwifery services are an integral part of health services which focus on maternal, newborn and child health services in realizing quality family health (Ulita *et al.*, 2023). The state of maternal and child health is a national problem that needs to be given top priority because it determines the quality of human resources for the next generation. The high MMR and IMR figures and the slow decline in these two figures indicate that maternal and child health services are urgently needed to be improved both in terms of reach and services provided by health workers, especially midwives (Pramono and Paramita, 2015; Vos *et al.*, 2015). Obstetric services focus on prevention efforts, health promotion, assisting with normal childbirth, detecting complications in the mother and child, carrying out treatment according to authority or other assistance if needed, and carrying out emergency measures (Ford *et al.*, 2019). Through the development of an early LBW detection scorecard, health workers, especially midwives, have an important task in health counseling and education, not only for women but also for families and communities, especially in early detection of risk signs for LBW (Aryastami *et al.*, 2017; Ulita *et al.*, 2023).

Birth weight is an important indicator of a child's survival, future growth and overall development and, since it is not possible to provide expensive scales to community members and families, it is important to find alternative methods for estimating birth weight (Anil et al., 2020). Even though ultrasonic measurement techniques have been widely applied to measure fetal weight, only a small number of pregnant women are able to utilize maternity and child health program services due to limited economic resources and other social backgrounds (Rahfiludin and Dharmawan, 2018). Babies with a birth weight of less than 2,500 g can cause various health problems in the future. The high risk of death and health complications shows the importance of early prevention of LBW births (Huque and Hussain, 1991). ANC is a mandatory program in Indonesia with a minimum of four visits (Adawiyah *et al.*, 2021). The aims include preventing adverse birth outcomes, low birth weight, and detecting pregnant women who are at risk of giving birth to LBW babies by scoring. Many references state that pregnant women with anemia tend to give birth to LBW babies, but so far there has been no tool or scoring used to determine that pregnant women with a certain score are more at risk of giving birth to LBW babies (Kumalasari, Tjekyan and Zulkarnain, 2018). Through the development of this LBW early detection card, LBW births can be predicted more optimally (Utami *et al.*, 2023).

Efforts through ANC visits have not been able to predict LBW optimally, due to non-compliance with visits. Pregnant women make more antenatal visits when they have entered the third trimester; therefore, measuring body weight and risk factors in third trimester pregnant women is very important and plays a role in predicting LBW births. As a result of research that has been carried out, it is known that the early detection scorecard has a cut-off point of 3.5, which means that if the risk factor scoring results show a value of 3.5 or more, it can be predicted that the baby will be born LBW. By knowing the risk score, it is hoped that health workers can take optimal preventive and nursing steps for mothers and babies before delivery, to prevent worsening of the condition and death of the baby.

The study accurately reports the statistical significance of the data in predicting LBW through identification of maternal factors. The limitation of this study is that the sample of respondents is not representative and several other respondents are still needed. We recommend to do additional research to determine the best time to use this instrument to maximize its effectiveness in predicting the incidence of LBW and promoting healthier pregnancies.

Conclusions

The LBW early detection scorecard can accurately predict the occurrence of LBW births. Through analysis and calculation of risk factor scores for pregnant women, it can be seen whether the mother is at risk of giving birth to a LBW or normal weight baby. Early detection of LBW can improve services for at-risk babies, thereby having a positive impact on their health outcomes.

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Conflict of interest

There is no conflict of interest.

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