Development of early detection of low-birth-weight instrument based on maternal risk factors: A mixed-methods study

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Abstract

Background: Babies born with low birth weight (LBW) are at a higher risk of experiencing health problems. The absence of quick and reliable instruments to detect LBW conditions can significantly impact the growth and development of newborns.
Purpose: This study aims to develop an instrument to detect the incidence of LBW based on mother's risk factor.
Methods: In this study, mixed-methods research was conducted, consisting of qualitative and quantitative stages. A total of 20 participants participated in Focus Group Discussions (FGDs) during the qualitative stage, and 321 respondents took part in the quantitative stage. During the qualitative stage, the process of labeling, synthesizing significant codes, and theoretical integration was carried out. Furthermore, at the quantitative stage, the calculation of the cut-off point using receiver operating characteristic (ROC) analysis was performed.
Results: Four indicators were added in newly developed instrument; there are currently ten indicators based on results of our FGD with the experts (OR/score: 74.395/10, 15.557/2, 13.877/2, 9.952/2, 7.203/1, 2.756/1, 2.532/1, 1.280/1, 1.268/1, and 1.163/1). Instrument was tested on 321 samples; it was able to detect 111 (88.1%) cases from a total 123 (38.3%) cases of LBW (p=0.000). Cut-off point determination used Receiver Operating Characteristic (ROC) curve; any score greater than 3 was predicted with LBW incidence (AUC=0.952, 95% CI 0.923-0.973).
Conclusion: LBW could be predicted by our newly developed instrument. These finding could help health workers or policy makers to reduce the LBW incidence by early detection. Further study is needed to determine the ideal screening time to maximize the usage of this instrument.

Keywords: early detection evaluation; low birth weight; instrument; mixed-method study

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Introduction

Child development begins from the occurrence of conception or early pregnancy. From this point, mothers need to maintain their physical and psychological conditions so that the fetus they contain can grow and develop optimally. Maternal nutrition is very influential on fetal growth and development (Klankhajhon & Sthien, 2022; Lowensohn et al., 2016). Undernourished mothers before or during pregnancy more often give birth to LBW (low birth weight) babies or they are born with health problems. LBW is a baby whose birth weight is less than 2500 grams (Cutland et al., 2017). The incidence of LBW contributes to the neonatal mortality rate because of the various problems it causes. Babies with LBW are more at risk of experiencing health problems than term babies, so efforts are needed to prevent the occurrence of LBW. The WHO also defines low birth weight

(LBW) as a newborn with a weight below 2500 g (World Health Organization, 2014). This institution defines very LBW as being less than 1500 g, and extreme LBW when it is below 1000 g. LBW is a public health problem at a global level with short- and long-term consequences. Low birth weight is usually the consequence of PTB, growth retardation, or both, and it may occur in preterm or term newborns. It is estimated that between 15% and 20% of all births in the world are LBW births. The goal of the WHO is to achieve a 30% reduction in the number of babies born weighing less than 2500 g by 2025 (World Health Organization, 2015).

Since the fetus is in the womb until it is 18 years old, the government has carried out child health efforts with integrated ANC programs, neonatal visits, immunizations, growth and development detection, etc. This effort aims to prepare healthy, intelligent, and quality future generations and to reduce child mortality (Ministry of Health Republic of Indonesia, 2019). Child health efforts have shown good results as seen from the child mortality rate from year to year which shows a decline. The results of the Indonesia Demographic and Health Survey (IDHS) in 2017 showed AKN of 15 per 1,000 live births, IMR of 24 per 1,000 live births, and AKABA 32 per 1,000 live births. The Toddler Mortality Rate has reached the 2030 Sustainable Development Target (TPB/SDGs) which is 25/1,000 live births and it is hoped that AKN can also reach the target of 12/1,000 live births (Ministry of Health Republic of Indonesia, 2019).

Infant Mortality Rate (IMR), Under-five Mortality Rate and Maternal Mortality Rate are important indicators to determine the health status of the community. Indonesia is expected to suppress MMR and IMR as an effort to support the achievement of the SDGs (Sustainable Development Goals), namely ending preventable maternal, infant and under-five mortality, which is targeted for a Maternal Mortality Rate of 70 per 100,000 live births; for infants 12 per 1,000 live births and under-five mortality rate 25 per 1,000 live births (Pramono & Paramita, 2015). There is a tendency to decrease the proportion of birth weight less than 2,500 grams. In 2013 the proportion of LBW was 5.7, in 2018 it was 6.2. The National Medium-Term Development Plan target in 2019 is 8%, but the 2016 National Labor Force Survey results are around 6.9% (Ministry of Health Republic of Indonesia, 2018), while the percentage of LBW in Surabaya in 2018 was around 1.96 (Surabaya Health Office, 2018). One of the risk factors for the occurrence of LBW babies is a history of high-risk maternal pregnancies. Estimates of pregnant women at high risk of complications in the city of Surabaya in 2016 amounted to 9,496 people. The coverage of high risk pregnant women or complications treated in health facilities is 90.24% (Rosnani & Mediarti, 2022; Surabaya City Government, 2016). In addition to giving birth to LBW babies, pregnant women are at high risk, which can lead to uneven / stuck delivery, dead fetuses in the womb, pregnant women/maternal deaths, and so on.

Various efforts have been made by the government to prevent the birth of LBW babies including integrated ANC during pregnancy, giving meals to pregnant women who have Calorie Protein Malnutrition (CPM), and giving vitamins. Another effort that can be done is to detect pregnant women who are at risk of giving birth to LBW babies by scoring. Many references have mentioned that pregnant women who are CPM or anemic tend to give birth to LBW babies, but so far there is no such tool or scoring used to determine that pregnant women with a certain score are more at risk of giving birth to LBW babies. If a scoring method can be found, it can be anticipated that pregnant women will not give birth to LBW babies. The aim of the present study was to develop early detection instruments of low birth weight based on risk factors.

Materials and Methods

This research was mixed methods research using a sequential explanatory study design (Ivankova et al., 2006). The sequential explanatory study design is characterized by two distinct phases: a quantitative data collection phase and an analysis phase, followed by a qualitative phase. The purpose of the qualitative phase is to help explain or elaborate the quantitative results obtained in the first phase (Creswell & Creswell, 2018; Ivankova et al., 2006). For this study, the first phase consisted of analyzing routinely collected patient data to map variations between hospitals, followed by focus groups with health experts to gain their perspective on the reasons for variation. A mixed methods approach was used to engage health professionals to reflect on their own data and identify explanations for variation, and in turn, implement quality improvement initiatives to address this. Participating hospitals are actively involved in the partnership with researchers and have agreed that this is a priority area for investigation.

Qualitative phase

The qualitative phase of this study was carried out to create an instrument that could predict LBW using a descriptive approach through discussion with the experts. This phase was conducted to summarize and determine the corresponding score of each factor that could lead to LBW in infants.

Participants and settings

Study population consisted of health experts to gain their perspective or the reasons for variation that arose from collected patient data. Focus group discussion with the experts was conducted in 2021 and located in Health Polytechnic of the Surabaya Ministry of Health.

Data Collection

Data were collected through in-depth semi-structured interviews with midwives, obstetrics-

Table 1. Risk Factor Score Based on Risk Factor Improvement

Risk Factor	OR	Score
There is a history of giving birth to LBW before	74.395	10
Mother works (make a living)	15.557	2
Current maternal parity status: Primipara (one delivery) or grande multi-para (≥5 times)	13.877	2
Gestational age at delivery <37 weeks	9.952	2
Gemeli Pregnancy	7.203	1
Mother's last education < high school / equivalent	2.756	1
In this pregnancy experiencing pre-eclampsia	2.532	1
In this pregnancy, maternal HB levels < 8 g/dl (TM 1 and 3) or < 10.5 g/dl (TM 2)	1.280	1
Have a history of Chronic Hypertension	1.268	1
Have a history of pre-gestational diabetes mellitus	1.163	1
Total score		**22**

gynecology specialists, and pediatricians. Sixteen events of 90-minutes FGD were conducted and attended by 20 physicians, each with separated sessions for medical and midwifery staffs at each of the three participating hospitals. FDG was aimed to summarize all knowledge about early detection of LBW based on mother's risk factors. Participants were recruited via email invitations, distributed by maternity managers at each participating hospital to all doctors and other health professionals, consent of agreement was also included. Using an inductive approach, FGD was manifested by systematical guided conversations to develop an understanding of local cultures, practices, processes, problems, and challenges that can help explain any variations identified in hospitals (Turner et al., 2021). After the presentation of previous study findings, the focus group began with open-ended questions such as *"What do you think about these findings?", "Are you surprised by these findings – why or why not?", "How can we explain this variation from your point of view?"*. These questions were used to explain the perspectives and experiences of the participants and identify important issues (Mohamad & Despois, 2022; Mohamed et al., 2022; Turner et al., 2021). These broad questions generated conducive discussion, interspersed with occasional encouragement from the facilitator to seek clarification or explore observations deeply. The focus groups were audio-recorded, facilitated by the lead author and resumed by the second researcher. Data of the interviews were analyzed using a conventional qualitative content analysis method. In this qualitative study sample size was unsettled, thus sampling was continued until data saturation occurred.

Data Analysis

Data were analyzed inductively by two investigators using Word (Luo & Lim, 2022). It involved an ongoing, recursive process of reading, discussing and reflecting on the collected data, followed by coding using Microsoft Word to identify similarities, inconsistencies, tensions and ambiguities (Turner et al., 2021). Coding consisted of three phases 1) an initial phase of labelling each data segment, 2) a focused phase selecting the most significant initial codes, to sort and synthesize the large dataset collected, and 3) a theoretical integration phase to restore coherence to the fractured story. Results of the discussion were analyzed in terms of a correlation between presumed risk factor and LBW using odds ratio; any result that yielded odds ratio more than one was considered a significant factor and thus added to the previously made instrument, followed by determining the score of each indicator based on the odds ratio score.

Quantitative Phase

Study design

This phase of the study was conducted to test the effectiveness of early detection LBW using our newly developed instrument. Quasi-experimental approach was conducted between October 31, 2021 and 1 November, 2021 in three participating general hospitals from two health districts in Surabaya Indonesia. Research was conducted by collecting data of delivery including both the outcome (LBW or non-LBW) and risk factor related to it, determining their correlation using bivariate statistical analysis.

Participants and data collection

Population used in this study were pregnant women that had visited in the three participating general hospitals from two health districts in Surabaya Indonesia; we used purposive sampling technique to obtain patient data from records and included 321 women who delivered between 31 October, 2021 and 1 November, 202. Data were recorded by midwives and doctors in an electronic records system during pregnancy, birth, and the immediate postpartum period. Data obtained e included maternal demographic and pregnancy characteristics, information on pre-existing and

Table 2. Distribution of Respondents Based on Risk Factors with a Large Sample (n=321)

Criteria	LBW		NOT LBW		Total	
	n	%	n	%	n	%
Mother's Age at Childbirth (years)						
20 or >35	21	35.6	38	64.4	59	100
20 – 35	105	40.1	157	59.9	262	100
Baby Gender						
Man	68	38.2	110	61.8	178	100
Woman	58	40.6	85	59.4	143	100
How to give birth						
Spontaneous	42	28.6	105	71.4	147	100
SC	84	48.3	90	51.7	174	100
Place of Delivery						
Public health center	2	7.1	26	92.9	28	100
Hospital	116	41.9	161	58.1	277	100
Maternity Clinic	8	50	8	50	16	100
ANC						
Public health centre	25	25	75	75	100	100
Hospital	83	43.7	107	56.3	190	100
Maternity Clinic	18	58.1	13	41.9	31	100
History of LBW Birth						
Not	86	30.6	195	69.4	281	100
Yes	40	100	0	0	40	100
Job status						
Doesn't work	68	28.9	167	71.1	235	100
Working	58	67.4	28	32.6	86	100
Parity						
Primipara	72	55	59	45	131	100
Multipara	54	29.2	131	70.8	185	100
Grande multipara	0	0	5	100	5	100
Gestational Age						
< 37 Weeks	40	83.3	8	16.7	48	100
37 Weeks	86	31.5	187	68.5	273	100
Gemelli/Double Pregnancy						
Not	125	39.3	193	60.7	318	100
Yes	1	33.3	2	66.7	3	100
Mother's Last Educational History						
Elementary	5	14.7	29	85.3	34	100
junior high school	14	51.9	13	48.1	27	100
High school/equivalent	107	41.3	152	58.7	259	100
Diploma/S1	0	0	1	100	1	100
PreEclamsia						
Not	122	39.5	187	61.5	309	100
Yes	4	33.3	8	28.6	12	100

Cont. Table 2. Distribution of Respondents Based on Risk Factors with a Large Sample (n=321)

Criteria	LBW		NOT LBW		Total	
	n	%	n	%	n	%
Anemia						
Not	121	38.5	193	60.5	314	100
Yes	5	71.4	2	70	7	100
History of Chronic Hypertension						
Not	123	39.5	188	60.5	311	100
Yes	3	30	7	100	10	100
History of Pre Gestational Diabetes						
Not	126	39.5	193	60.5	319	100
Yes	0	0	2	100	2	100

current medical and obstetric conditions, antenatal and intrapartum care and birth outcomes (LBW or non-LBW). The instrument used to detect the incidence of LBW was arranged based on the predictor index of risk factors from previous step.

Data analysis

Collected data were analyzed its correlation using bivariate analysis with significance value of $p<0.05$, followed by calculation of cut-off point using receiver operating characteristic (ROC).

Ethical clearance

Ethics approval was given by the Research Ethics Committee of the Health Polytechnic of the Surabaya Ministry of Health Number: No. Etik: No.EA/1181/KEPK-Poltekkes_Sby/V/2022.

Results

Analysis of qualitative data

From the result of sixteen events of our FGD, four indicators were added in our newly developed instrument; 1) gemelli pregnancy, 2) in this pregnancy, maternal HB levels < 8 g/dl (Trimester 1 and 3) or < 10.5 g/dl (Trimester 2 and 3) have a history of chronic hypertension, and 4) have a history of pre-gestational diabetes mellitus. As shown in Table 1, 10 consecutive values of odds ratio from the highest to lowest indicators were 74.395, 15.557, 13.877, 9.952, 7.203, 2.756, 2.532, 1.280, 1.268, and 1.163. Any value of odds ratio greater than one is considered as a significant finding. Data were then analyzed further to determine the score based on the odds ratio value, using five standardized steps: 1) determine the lowest peak of odds ratio score (1.163), 2) determine the highest peak of odds ratio score (74.395), 3) calculate the class range between those two scores (73.232), 4) calculate the class interval by dividing the class range with the sum of indicators (7.323), 5) determine each indicator's score value based on the previous interval and odds ratio value; each multiple of interval that was previously calculated (7.323) is considered as a score of 1.

Analysis of quantitative data

The instrument was tested on 321 samples; it was able to detect 111 (88.1%) cases from a total 123 (38.3%) cases of LBW (p=0.000). Cut-off point determination used Receiver Operating Characteristic (ROC) curve, any score greater than 3 was predicted with LBW incidence (AUC=0.952, 95% CI 0.923-0.973). Based on Table 2, it shows that the proportion of LBW was much greater in the age group of 20-35 years than the other groups, much greater in female infants, much greater in SC, and much greater in those who born in the clinic and performing ANC at the clinic. Moreover, the proportion of LBW is mostly found in mothers who had a history of low birth weight, working mothers, primipara, gestational age <37 weeks, pregnant with gemelli, junior high school education, not having pre-eclampsia, experiencing anemia during pregnancy, experiencing chronic hypertension, and not suffering from hypertension or pre-gestational diabetes mellitus.

Discussion

Identification of risk factors for LBW in pregnant women is very useful in prioritizing treatment for high-risk women and allows early intervention. Previous LBW history, premature gestational age < 37 weeks, low HB levels, maternal occupation/career, primiparous pregnancy, educational status, pre-eclampsia, chronic hypertension, pregestational diabetes mellitus, and gestational diabetes are risk factors that are strongly associated with the high incidence of LBW infants, which will be discussed in this section.

Previous LBW history

This is one of the most important predictors of LBW or low birth weight, with the finding that 40

out of 40 (100%) samples with a history of previous LBW experienced LBW in the current birth. This finding is in line with other studies which say that previous LBW birth history also affects subsequent pregnancies (Nair & Devi, 2015). Based on birth records (n=98,776) reported on the electronic registration system of vital statistics in Nebraska from 2005 to 2014, mothers with a history of LBW were more likely to experience recurrence than those without a history of LBW (Su et al., 2018). Identifying mothers who are at risk of experiencing LBW in the future is very helpful in carrying out early detection and immediate treatment.

Gestational age at delivery <37 weeks

The findings were 40 out of 48 (83.3%) samples with a history of preterm pregnancy, which is the second most common risk factor in this study after a previous history of pregnancy with LBW. This can be associated with a period of fetal growth that is not yet fully mature. The findings of this study revealed a strong association between LBW and gestational age less than 37 weeks. According to a recent study in Surabaya, 30.48% of births were categorized as preterm pregnancies, much higher than in developed countries (1.8%-2.1%). This is also related to mothers aged 14–19 years who have not yet fully matured in their reproductive organs (Wibowo et al., 2022). Preterm pregnancy also increases the likelihood of LBW 4.1 times higher than term pregnancy (DeMarco et al., 2021). In general, in the third trimester, the ideal weight gain target for pregnant women and babies every week is around 200 grams, with the decreasing gestational age due to preterm pregnancy, the baby's weight at birth will certainly be lower than it should be.

In this pregnancy, maternal HB levels < 8 g/dl (TM 1 and 3) or < 10.5 g/dl (TM 2)

A total of 5 out of 7 (71.4%) samples with anemia experienced births with LBW. These findings are in line with the cross-sectional study by Kumari et al. (n = 515), which said that anemia in pregnant women can cause preterm labor followed by LBW. Another study also mentions cases of anemia in pregnant women with 90% of premature deliveries (Mohamed et al., 2022). The association between Hb levels and LBW can be explained by poor gestational nutritional status due to uteroplacental circulation disorders that cause adverse pregnancy outcomes.

Current maternal parity status

Parity is defined as the number of children born either live or stillborn to a mother. In this study, it was found that 72 out of 131 (55%) samples with primiparous pregnancies had LBW births. Another study states that babies born to nulliparous women are more likely to experience LBW due to various factors (Patel et al., 2021). The average birth weight of babies increased up to the third parity, but with a smaller difference (Hinkle et al., 2014). Similar findings were also published by Borah and Agarwalla (2016) (n = 450) . Recent studies have shown that the experience or incomplete feedback of physiological changes after the first pregnancy provides a better facilitative environment in the uterus in subsequent pregnancies, including uteroplacental blood flow. In addition, other studies mention that there are structural factors that limit the capacity of the uterus in the first pregnancy (Hinkle et al., 2014).

Mother's last education < high school / equivalent

A total of 14 of 27 (51.9%) mothers with LBW pregnancies had a history of education at the elementary level, followed by a history of education at the high school level as many as 107 of the 259 (41.3%) sample. Educational factors are identified as one of the important factors in determining the level of maturity of a mother in understanding and solving health problems; women who have higher education will be more concerned about their health during pregnancy compared to those with low education. Women with low education tend to be less concerned about their own health because they think pregnancy is a natural thing, so that complications during pregnancy are difficult to detect early because these women tend not to have pregnancy visits. This is in line with research in Nepal, Iran and Africa, which says that education and knowledge are important factors that can reduce the incidence of LBW. These findings are also in line with studies in Ethiopia, Kenya, and Nepal and Africa (Bansal et al., 2019; Momeni et al., 2017; Moreira et al., 2018; Muchemi et al., 2015; Tessema et al., 2021). Literacy often links good knowledge of nutritional practices with health-seeking behavior during pregnancy, which can affect birth outcomes. Education determines many attitudes and actions in dealing with various problems, including food arrangements for pregnant women to prevent the emergence of LBW. From the description above, it can be concluded that a low level of knowledge is a risk factor for LBW.

Pre-eclampsia, chronic hypertension, and pre-gestational diabetes mellitus

A total of 7 out of 24 (29%) samples with a history of chronic disease had a pregnancy with LBW. Maternal disease and obstetric complications during pregnancy cause LBW because it increases the risk of preterm delivery and poor fetal growth. Studies have shown that maternal blood pressure level is associated with neonatal birthweight. This study is supported by previous research which stated an association between gestational hypertension or pre-eclampsia and the increased risk of LBW. The overall incidence of LBW was 2.25%. The incidences of LBW were 3.58% and 6.02% for gestational hypertension and pre-eclampsia group, relative to 2.11%/5.68% and 2.16%/5.74% for normal group (Liu et al., 2021). The early onset of gestational hypertension/pre-eclampsia appeared to be a relatively more detrimental exposure window

for both LBW.

Gemelli pregnancy

In this study, it was found that 1 out of 2 samples with smooth pregnancies experienced LBW (33.3%); other studies stated that having LBW pregnancies was one indicator of the occurrence of LBW. In addition, the findings in this study were lower when compared to global studies which estimated 16.7% (Tessema et al., 2021). This can happen due to demographic, social and economic conditions and healthcare systems that are different from other countries which have a higher percentage of LBW births with a history of grace.

Conclusion

The study highlights the potential of the newly developed instrument in predicting LBW, which can significantly benefit healthcare workers and policy makers. Early detection of LBW can lead to improved care for at-risk infants, positively influencing their health outcomes. However, additional research is needed to determine the best timing for using the instrument to maximize its effectiveness in reducing LBW incidence and promoting healthier pregnancies.

Declaration of Interest

None.

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Data Availability

None.

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