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Maternal Characteristics, Malnutrition, and Pregnancy Complications with the Incidence of Low Birth Weight in an Industrial Environment

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Abstract

Low Birth Weight is one of the leading causes of under-five deaths during the neonatal period. In Indonesia, the infant mortality rate is in the top 7 in the world. The industrial environment, where air pollution is high, is one of the factors causing LBW. The study aimed to identify the factors that influence the incidence of LBW in an industrial environment. Using data from a cohort of pregnant women in 2023, the study used a nested case-control design at Bergas Community Health Centre. The study population included all mothers who delivered live infants in 2023, totalling 832 respondents. Data from the study were analysed using Chi-Square for bivariate analysis and logistic regression for multivariate analysis. The results showed a relationship between maternal age, parity, maternal nutritional status, hypertension, preeclampsia, and anaemia with the occurrence of LBW with $p < 0.0001$. The multivariate analysis indicated a significant relationship between maternal age (OR 3.233, 95% CI 1.557 – 6.714), parity (OR 2.567, 95% CI 1.382 – 4.767), maternal nutritional status (OR 7.905, 95% CI 3.472 – 17.998), preeclampsia (OR 28.090, 95% CI 9.894 – 84.468), and maternal hemoglobin levels (OR 10.883, 95% CI 5.736 – 20.649) with the incidence of LBW. The most influential factor in LBW is the occurrence of preeclampsia in mothers.

Introduction

Low birth weight (LBW) infants weigh less than 2,500 grams. The most severe risks for LBW infants include death and disability (Osuchukwu & Reed, 2024; UNICEF & WHO, 2019, 2020; WHO, 2011, 2022). It is estimated that around two million neonatal deaths occur, with approximately two million attributed to low birth weight. Infants with LBW face higher risks of mortality, growth delays, lower intelligence levels, and chronic diseases in adulthood (UNICEF & WHO, 2019). In addition to mortality, about a million LBW infants live with long-term disabilities, including cerebral palsy and cognitive delays. Besides the risks of death, disabilities, and long-term illnesses, families with infants weighing less than 2,500 grams are at increased risk of experiencing psychological and long-term financial issues (UNICEF & WHO, 2020).

Some research found that very preterm birth, defined as a gestational age of less than 32 weeks and very low birth weight (< 1,500 grams), had several effects, including a higher risk of experiencing conception or fertility problems, complications during pregnancy, three times the risk of developing pregnancy-related hypertension, lower IQ levels, and poorer physical health quality in early adulthood. This can cause issues with vision, mobility, dexterity, and cognition as well, compared to term infants, and weighing 2500 grams or

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more (Bolbocean *et al*., 2023; Eves *et al*., 2021; Van Der Pal *et al*., 2021). Premature babies are also prone to experiencing difficulties in oral motor skills, breathing, and fulfilling their nutritional needs (Mauliza *et al*., 2023). Infants with very low birth weight are more vulnerable to metabolic syndrome later on. Very low birth weight also predisposes individuals to coronary heart disease because these infants are small and thin at birth, followed by a rapid growth spurt during childhood and an increased risk of type 2 diabetes, resulting from an accelerated growth phase in the first year of life (Barker *et al*., 2009; Eriksson, 2006, 2011, 2016; Jebasingh & Thomas, 2022).

The infant mortality rate in Indonesia was the 7th highest in the world in 2020. The trend in infant mortality rates for deaths of toddlers in Indonesia in 2023 experienced improvement compared to 2022, and death is the most common in the neonatal age. The three reasons for death are Respiratory and Cardiovascular (1%), LBW (0.7%), and congenital abnormalities (0.3%). The causes of neonatal deaths in Central Java are the highest at 38.44% LBW. LBW infant trends for those born in Central Java for 4 years keep increasing, with an incidence of 5.2% in 2023. Semarang Regency occupies ranking 7th rank in Central Java in the incidence of LBW, namely by 6.6%, and the Bergas Health Community Centre is ranked first in the incidence of LBW in Semarang Regency in 2023, namely 8.89% of total deliveries alive. LBW babies who experience complications until they die by 8.1%. Various efforts have been made in the Semarang district for the management of LBW from the start of pregnancy until management when it is born, but LBW incidents continue to increase (BPS Kabupaten Semarang, 2024). Characteristics of female workers in Semarang Regency are in the processing sector or laboring by 41.15%. This is because the education level is still low and medium, as well as the number of factories in the Semarang area (BPS Kabupaten Semarang, 2022). The Bergas sub-district is a densely populated area with industries, which causes many mothers to become industrial workers. This environment can also affect mothers' nutritional patterns and consumption habits, as they usually prefer fast food with minimal nutritional content. Industrial environments are also very susceptible to air pollution related to low birth weight (Trerotoli *et al*., 2021).

One of the attempts to reduce LBW is pregnancy mentoring for mothers at risk. Effective mentoring needs the existence of study-related factors that affect LBD incidence. Prior research stated that the determinants of BBLR include sociocultural factors, such as family income, education, location of residence, and the number of family members (3-4 people). Maternal factors consist of age at delivery, height, maternal illness during pregnancy, maternal BMI, weight gain of less than 6.5 kg during TM 2 and TM 3, consumption of iron tablets of less than 180 during pregnancy, the distance between pregnancies, regularity of antenatal care (ANC) visits, and a bicornuate uterus (Helmizar *et al*., 2024). Environmental factors include distance from home to health services, use of firewood for cooking, washing hands with water only, and kitchen space within the house, which are related to air pollution, one factor causing LBW. Factors of the female fetus, factor placenta, the incidence of premature rupture of membranes, gestational hypertension, dental health in the last 1-3 years, working hours more than 6 hours, passive smokers, and consumption of peanut oil. Factors that can prevent LBW or are protective include weight gain in pregnant women, daily milk consumption, and folic acid supplementation (Demelash *et al*., 2015; Khayati *et al*., 2016; Shen *et al*., 2019). This research aimed to identify the factors causing LBW in the work area of Bergas Community Health Centre in 2023, based on cohort data from mothers. The variables studied in this study were gender of the baby, the mother's age, the mother's parity, the distance of pregnancy, the mother's nutritional status, hypertension, haemoglobin status, diabetes, hepatitis, and preeclampsia (Aini & Kurniawan, 2023; Oktriyanto *et al*., 2022).

Methods

The study used the Nested Case-Control design and was implemented at Bergas Community Health Centre. Mothers who delivered live infants recorded at the Bergas Community Health Centre in 2023 were

involved in this study, with 832 participants. The current study used recorded respondent data from cohort mothers at village midwives. Then, it was reported and documented at the community health centre. The measurement used documentation results from the cohort mothers and matched the available data from the midwives and the community health centre. The data collection was compiled using a master table. The retrieval sample in this study used total sampling. This study has been declared ethically feasible by the Health Research Ethics Commission of the Faculty of Medicine, Universitas Negeri Semarang, with number 206/KEPK/FK/KLE/2024. The characteristics of the respondents were analysed using univariate analysis with frequency distribution. Bivariate analysis was carried out using Chi-Square or alternative tests. Multivariate analysis was performed using logistic regression with IBM SPSS 25.0 version. The results of the multivariate analysis were then used to calculate the probability of low birth weight (LBW) using the formula:

$$p = \frac{1}{(1 + exp^{(-y)})}$$

Results And Discussion

The Maternal Characteristics Of Respondents In This Study, Presented In Table 1, Showed That Out Of 832 Respondents, 74 (8.9%) Gave Birth To Low-Birth-Weight Infants. Mothers Who Delivered Female Infants Totalled 386 Respondents (46.4%), At Risk Due To Age (Under 20 And Over 35 Years) Amounted To 99 Respondents (11.9%), And With High Parity (Primipara) Were 251 Respondents (30.2%). The Number Of Respondents With A Risky Pregnancy Interval (Less Than 2 Years) Was 4 (0.5%), With Chronic Energy Deficiency (Ced) Totalled 46 Respondents (5.5%), Experienced

Table 1. Maternal Characteristics of Respondents, Bergas 2023

Variable	Frequency (N)	Percentage (%)
Low Birth Weight		
Yes	74	8.9
No	758	91.9
Baby gender		
Woman	386	46.4
Man	446	53.6
Mother's age		
At risk	99	11.9
No risk	733	88.1
Maternal parity		
At risk	251	30.2
No Risk	581	69.8
Pregnancy interval		
At risk	4	0.5
No Risk	828	99.5
Maternal nutritional status		
Chronic Energy Deficiency	46	5.5
Good	786	94.5
Maternal Hypertension		
Yes	36	4.3
No	796	95.7
Maternal Anaemia		

Variable	Frequency (N)	Percentage (%)
Yes	94	11.3
No	738	88.7
Maternal Diabetes Mellitus		
Yes	2	0.2
No	830	99.8
Yes	6	0.7
No	826	99.3
Preeclampsia		
Yes	22	2.6
No	810	97.4
Job		
Laborer	538	64.7
Unemployed	169	20.3
Trader	26	3.1
Teacher	72	8.7
Civil Servant	20	2.4
Doctor	1	0.1
Farmer	6	0.7

Hypertension 36 Respondents (4.3%), With Anaemia Were 94 Respondents (11.3%), With Diabetes Were Two Respondents (0.2%). Those With Hepatitis Were Six Respondents (0.7%). Those Who Experienced Preeclampsia And Eclampsia Were 22 Respondents (2.6%).

Maternal Characteristics With Low Birth Weight (Lbw) At Bergas Community Health Centre Are Shown In Table 2. Out Of 10 Variables, Six Are Associated With Lbw, Including Mothers Aged Less Than 20 Years And More Than 35 Years (Or: 3.742; 95% Ci: 2.156-6.494); Primiparous Mothers (Or: 2.701; 95% Ci: 1.667-4.376); Chronic Energy Deficiency (Ced), (Or: 17.906; 95% Ci: 9.364-34.238); Hypertension (Or: 6.810; 95% Ci: 3.287-14.111); Preeclampsia And Eclampsia (Or: 17.736; 95% Ci: 7.290-14.149); And Anemia (Or: 16.527; 95% Ci: 9.663-28.226). The Results Of Bivariate Analysis Were Presented In Table 2.

Table 2. Maternal Characteristics with Low Birth Weight

Variables	Birth Weight				p	OR (CI 95%)
	LBW		BBLN			
	n	%	n	%		
Baby gender [b]						
Woman	34	45.9	352	46.4	1.000	0.980
Man	40	54.1	406	53.6		(0.607-1.583)
Mother's age [b]						
Less than 20 and more than 35 years	22	29.7	77	10.2		3.742
20-35 years	52	70.3	681	89.8		(2.156-6.494)
Maternal parity [b]						
Nulliparous	38	51.7	213	28.1		2.701
Multipara	36	48.6	545	71.9		(1.667-4.376)

Pregnancy interval [a]						
<2 years	1	1.4	3	0.4	0.312	3.447
>2 years	73	98.6	755	99.6		(0.354-33.567)
Maternal nutritional statu[s] a						
Chronic Energy Deficiency	25	33.8	21	2.8		17.906
Good	49	66.2	737	97.2		(0.354-33.567)
Maternal Hypertension [a]						
Yes	13	17.6	23	3.0		6.810
No	61	82.4	735	97.0		(3.287-14.111)
Preeclampsia [a]						
Positive	13	17.6	9	1.2		17.736
Negative	61	82.4	749	98.8		(7.290-14.149)
HB mother [b]						
Anaemia	41	55.4	53	1.2		16.527
No anaemia	33	44.6	705	98.8		(9.663-28.266)
Maternal Diabetes [a]						
Yes	0	0	2	1.8	1.000	1.099
No	74	100	756	99.7		(1.076 – 1.123)
Maternal Hepatitis [a]						
Yes	2	2.7	4	0.5	0.093	5.236
No	72	97.3	754	99.5		(0.943-29.081)

[a]Analyzed using Fisher's Exact
[b] Analyzed using Chi-Square
*Statistically significant at p=0.05

Table 3. Relationship between Age, Parity, Nutritional Status, Preeclampsia, and Anaemia with the incidence of LBW

Variables	**B**	**Wald**	**p**	**OR (CI 95%)**
Mother's Age	1.174	9.912	0.002	3.233 (1.557 – 6.714)
Mother's Parity	0.943	8.913	0.003	2.567 (1.382 – 4.767)
Maternal Nutritional Status	2.067	24.252	<0.0001	7.905 (3.472 – 17.998)
Preeclampsia	3.364	37.816	<0.0001	28.090 (9.894 – 84.468)
Anaemia	2.387	53.362	<0.0001	10.883 (5.736 – 20.649)
Constant	-4.047	200.097	<0.0001	0.017

Multivariate Analysis With Logistic Regression Was Conducted To Determine The Risk Factors For Lbw, The Result Of Which Was Presented In Table 3. Preeclampsia Was The Most Influential Factor In The Incidence Of Lbw, With An Or Of 28,090 (95% Ci: 9,894-84,468). It Indicated That Mothers With Preeclampsia Had An Increased Risk Of Giving Birth To Lbw By 28 Times Compared To Mothers Without Preeclampsia Table 3.

Analyzed Using Multiple Logistic Regression. The Effect Of Each Variable Is Adjusted For The Effect Of The Other Variables. Using The Results Of Multivariate Logistic Regression, The Probability Of Lbw Could Be Calculated Using The Formula As Follows.

Y= -4.047+1.174 (Mother's Age < 20 Years Old And > 35 Years Old) + 0.943 (Parity

Table 4. Results of Probability Calculations in Several Scenarios

Respondent	Mother's age	Parity	Nutritional status	Pree clam psia	Anaemia	Probability of LBW Incident (%)
Respondent A	<20 and >35 Years	Multigravida	Good	No	No	5,352
Respondent B	20-35 years	Primipara	Good	No	No	4,292
Respondent C	20-35 years	Multigravida	Chronic Energy Deficiency	No	No	12,134
Respondent D	20-35 years	Multigravida	Good	Yes	No	33,560
Respondent E	20-35 years	Multigravida	Good	No	Yes	15,978
Respondent F	20-35 years	Multigravida	Good	No	No	1,718
Respondent G	<20 and >35 Years	Primipara	Chronic Energy Deficiency	Yes	Yes	99,723
Respondent H	<20 and >35 Years	Primipara	Chronic Energy Deficiency	Yes	No	97,070
Respondent I	<20 and >35 Years	Primipara	Chronic Energy Deficiency	No	Yes	92,578
Respondent J	<20 and >35 Years	Primipara	Good	Yes	Yes	97,855
Respondent K	<20 and >35 Years	Multigravida	Chronic Energy Deficiency	Yes	Yes	99,292
Respondent L	20-35 years	Primipara	Chronic Energy Deficiency	Yes	Yes	99,110

Nulliparous Mothers) + 2,067 (Chronic Energy Deficiency (Ced) Mothers) + 3,364 (Preeclampsia Mothers) + 2,387 (Anemic Mothers).

Based On The Probability Calculations, Mothers Aged 20-35 Yo, Multigravida, With Good Nutritional Status, No Preeclampsia, And No Anemia Had A Chance Of Giving Birth To Lbw Infants Of 1.718%. In Comparison, Mothers Who Were Less Than 20 Years Old And More Than 35 Years Old, With Primipara, Chronic Energy Deficiency, Preeclampsia, And Anemia, Had A Chance Of Giving Birth To An Lbw Baby Of 99.723%. The Results Of Several Scenarios Were Presented In Table 4.

Mothers With Solely An Age-Related Risk Would Have A 5.352% Probability Of Delivering Low Birth Weight Infants. This Was More Likely Than The 4.292% Possibility For Mothers Who Were Only At Risk Of Parity. The Highest Chance Of Delivering Lbw Infants Was 3.560% For Mothers Who Had Pre-Eclampsia. Mothers With Preeclampsia Would Have Disorders Of Uteroplacental Blood Circulation That Would Interfere With The Supply Of Fetal Needs And Result In Stunted Fetal Growth. Our Study Found That Mothers Who Gave Birth In Bergas In 2023 Mostly Worked As Labourers (64.7%). There Were Many Factories In The Bergas Area And The Lowlands Of Community Education (Bps Kabupaten Semarang, 2022). Working As A Labourer Results In Limited Family Income, Leading To Low Socio-Economic Status, Which Causes Low Birth Weight (Mishra Et Al., 2021). Labour Workers With High Workloads And Low-Wage Incomes Use Their Nutritional Purchasing Power To The Fullest Rather Than Considering Its Nutritional Content. Short Rest Periods Also Make Labour Workers Buy Food Available Around The Factory, Which, On Average, Is Low In Nutritional Content. This Happens Every Day, Therefore Increasing The Incidence Of Malnutrition And Anaemia.

Our Research Findings Indicated That Preeclampsia Was The Highest Risk For Delivering Low Birth Weight Infants, With An Or Of 28.09. This Signified That Mothers With Preeclampsia Possess A 28 Times Greater Chance Of Giving Birth To An Lbw Infant Compared To Mothers Without Preeclampsia. This Study Supported Prior Research Indicating That Low Birth Weight Results From Childbirth

Complicated By Preeclampsia (Shulman Et Al., 2017). Research That Has Been Conducted In Ethiopia Also Found That Maternal Preeclampsia And Hiv Increased The Incidence Of Lbw (Ekubagewargies Et Al., 2019). The Condition Of Mothers With Preeclampsia Impaired Uteroplacental Blood Circulation, Resulting In Fetal Growth Abnormalities. Anaemia Status Was Also One Of The Factors That Would Result In Lbw Pregnancy Outcomes In This Study; The Results Obtained Were Or 10.883 (95% Ci: 5.736 - 20.649). This Means That Mothers Who Experience Anaemia Have A 10.88 Times Higher Risk Of Delivering Lbw Infants Compared To Mothers Who Are Not Anaemic. During Pregnancy, There Is An Increased Need For Hb For Fetal Growth And Preparation For Blood Loss During Childbirth. Fetal Growth Will Be Hampered If The Mother Is Anaemic (Anil Et Al., 2020; Chandran & Kirby, 2021). In Developing Countries, Lbw Is Often Caused By What Kind Of Status (Bhowmik Et Al., 2019). Anaemia In The Mother Greatly Influences The Incidence Of Lbe, Which Is Related To Fetal Growth In The Womb (Figueiredo Et Al., 2019).

Our Study Found That Mothers With Chronic Energy Deficiency (Ced) Status Have A Risk Of Giving Birth To Lbw Babies 7.9 Times Compared To Mothers With Good Nutrition, With Or 7.905 (95% Di: 3.472 - 17.998). A Mother's Nutritional Status Intake Pregnancy During Pregnancy Can Determine The Outcome Of Pregnancy, Namely The Infant. The Mother's Nutritional Status Before Pregnancy Greatly Influences The Outcome Of Pregnancy, One Of Which Is The Weight Of The Fetus (Retnakaran Et Al., 2021). During Pregnancy, The Health Of The Fetus Depends On The Mother; If The Mother Is Malnourished, The Fetus In The Womb Will Also Experience Malnutrition, Which Will Result In Lbw. The Results Of The Study Showed That The Poor Nutritional Status Of The Mothers Was 31.7 Times More At Risk Of Lbw (Mohamed Et Al., 2022). The Nutritional Status Of The Mother Before Pregnancy And Weight Gain During Pregnancy Are Related To The Incidence Of Lbw (Bhowmik Et Al., 2019). Maternal Malnutrition, Both Past And Present, Increases The Risk Of Lbw (Gokhale & Rao, 2020). Underweight Mothers Are At Risk Of Delivering Lbw Infants. Some Attempts To Overcome It Are Monitoring And Improving Nutritional Status During Pregnancy To Increase Fetal Weight And Have It Born With A Normal Weight (He Et Al., 2018). Women Who Experience Malnutrition During Pregnancy, Aged Less Than 20 And More Than 35 Years, And Have Low Parity Are At Greater Risk Of Having A Pregnancy Outcome With Lbw. To Prevent The Occurrence Of Labour With Lbw Babies, Regular Prenatal Checkups Are Necessary To Monitor The Baby's Growth And Improve The Nutritional Status Of The Mother During Pregnancy. Maternal Age And Parity Are The Causes Of Lbw (Kaur Et Al., 2019). The Results Of This Study Showed That Maternal Age At Risk, Namely Less Than 20 Years And More Than 35 Years, Could Increase The Risk Of Giving Birth To An Lbw Baby By 3,233 Times Compared To Maternal Age 20-35 Years With

Conclusion

The factors related to the incidence of LBW were maternal age, maternal parity, maternal nutritional status, preeclampsia, and maternal HB Status. Preeclampsia had the most influence on the incidence of LBW. It is advisable to implement stringent treatment and oversight of pregnancies in mothers who are either very young or older, primiparous, have chronic energy deficiency, are experiencing preeclampsia, or are afflicted with anaemia to reduce the incidence of low birth weight (LBW).

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