



Pregnancy Risk, Neonatal Factors, and Health Care Services on Low Birth Weight Mortality

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Revised: 31 July 2026 Accepted: 26 September 2026 Published: 30 September 2026 How to cite : Irawati, S. A., Sutrisno, S., & Handono, K. (2026). Pregnancy Risk, Neonatal Factors, and Health Care Services on Low Birth Weight Mortality. <i>Contagion: Scientific Periodical Journal of Public Health and Coastal Health</i>, 8(3), 682–695.	<i>Low birth weight (LBW) infants are highly vulnerable to death during the first 28 days of life. However, evidence from primary care settings that simultaneously examines pregnancy related, neonatal, and health service factors remains limited. This retrospective case control study used secondary records for LBW infants born between 2018 through 2022 at six public health centers in X city, Indonesia. The analytical sample comprised 86 infants, including 43 neonatal deaths (cases) and 43 controls who survived beyond 28 days. Data were extracted from Perinatal Verbal Autopsy forms, delivery registers, and medical records. Bivariate associations were assessed using Pearson's chi-square test or Fisher's exact tests, and crude odds ratios (cORs). Six non-separated predictors were subsequently entered into a multivariable binary logistic regression model. Maternal anemia (hemoglobin <11 g/dL) occurred in 29/43 cases (67.4%) and 9/43 controls (20.9%) and was associated with neonatal death in bivariate analysis (cOR 7.83; 95% CI 2.96-20.70; $p<0.001$). Respiratory compromise showed complete separation: all 43 infants with abnormal respiratory status were cases (Fisher $p<0.001$), so a conventional OR could not be estimated. Delivery facility type, breastfeeding, neonatal follow-up, and referral status also contained zero cells. The six predictor model was significant overall ($p=0.002$); maternal anemia remained the only independently significant predictor (aOR 8.94; 95% CI 2.95-27.09; $p<0.001$). The complete separation observed for several neonatal and service variables suggests strong distributional differences between cases and controls; however, these findings should be interpreted cautiously because of potential severity related referral bias, reverse causality, and survivor bias. Maternal anemia was the most consistent independent factor associated with neonatal death among LBW infants. Strengthening antenatal screening and treatment for maternal anemia, improving immediate respiratory assessment, enhancing referral documentation, and ensuring linkage between maternal and infant health records may contribute to better prevention and surveillance efforts.</i> Keywords: <i>Low Birth Weight, Neonatal Mortality, Case-Control Study, Maternal Anemia.</i>

INTRODUCTION

The neonatal period remains the most vulnerable phase of child survival. Updated global estimates indicate that 2.3 million neonatal deaths occurred in 2024, representing 47% of all deaths among children younger than 5 years of age (World Health Organization, 2026). Infants born too soon or too small are disproportionately vulnerable to early death and long-term impairment, making low birth weight (LBW) an important marker of biological vulnerability and health system performance (Lawn, 2023). Global estimates for 2020 indicated

that 14.7% of live births were LBW, with the greatest burden concentrated in Southern Asia and sub-Saharan Africa (Okwaraji, Krasevec, et al., 2024).

In Indonesia, neonatal mortality reflects the interaction of maternal, neonatal, and health service determinants rather than a single causal pathway. A national analysis involving 10,838 newborns found that low birth weight (LBW), delivery complications, and low participation in postnatal care were associated with an increased risk of neonatal mortality (Sampurna et al., 2023). A multicenter study conducted across 12 Indonesian hospitals further identified LBW, referral status, respiratory distress, asphyxia, major congenital abnormalities, and feeding problems as important correlates of neonatal death throughout the neonatal period (Haksari et al., 2025). Population based evidence from Indonesia has also identified maternal and socioeconomic factors as important determinants of LBW (Wulandari, F., 2022), while the main reviews highlighted anemia, hypertensive disorders, nutritional factors, and other maternal exposures as recurring determinants of LBW (Arabzadeh et al., 2024). These findings support the need to examine pregnancy-related exposures, the infant's immediate clinical condition, and health care processes within a unified analytical framework.

The local primary care context provides an additional rationale for this integrated approach. The 2024 health profile for the study area documented 107 infant deaths among 11,664 live births across 16 public health center catchment areas and identified low birth weight (LBW) as one of the direct causes of infant mortality (X city Health Office, 2025). Public health centers play a central role in antenatal risk detection, delivery and referral documentation, neonatal follow-up, and mortality surveillance; therefore, routine records from these facilities can provide health system relevant evidence that may not be captured in hospital based studies alone. Evidence from low and middle income countries indicates that stronger coverage and continuity of maternal and newborn health services across the antenatal, delivery, and postnatal periods are associated with improved survival outcomes (Hone et al., 2024; Zelka et al., 2023), while a recent scoping review emphasizes that neonatal mortality during the postnatal period is influenced by both proximate and distal determinants (Izulla et al., 2023). However, integrated evidence derived from routine primary care records in Indonesia remains limited.

The analytical framework of this study positions pregnancy related risk factors as antecedent determinants, neonatal characteristics as more proximal determinants, and health care services as factors that may modify risk across the continuum from pregnancy through the neonatal period. Pregnancy risk factors included maternal age, maternal nutritional status as measured by mid upper arm circumference (MUAC), blood pressure, and maternal anemia.

Neonatal factors included gestational age, plurality, gender, and respiratory status, whereas healthcare-related factors included antenatal care (ANC), type of delivery facility, breastfeeding status, neonatal follow-up, and referral status. The study outcome was neonatal death among low birth weight (LBW) infants within the first 28 days of life. We hypothesized a priori that higher risk categories within these three domains would be associated with increased odds of neonatal death among LBW infants. Because this was a retrospective study based on a relatively small secondary dataset, the analyses were also considered exploratory, particularly for variables with sparse data or complete separation.

METHOD

Study Design, Setting, and Period

This study employed a retrospective case control design using secondary data. The source population comprised 2,200 low birth weight (LBW) infants recorded in X city between 2018 and 2022. Of the 16 public health centers in the area, six centers with records that met the study eligibility criteria were included and were coded as Public Health Centers to ensure blinded review. Data abstraction was conducted from February to May 2025. The primary data sources were Perinatal Verbal Autopsy (PVA) forms, delivery registers, and medical records. Ethical approval for this study was obtained from the Ethics Committee of Universitas Brawijaya (Ethical Clearance No. 45/ EC / KEPK - S2 / 2025).

Case and Control Definitions and Sample Selection

Cases were defined as live born infants with a birth weight $<2,500$ g who died within the first 28 days of life. All 43 eligible LBW neonatal deaths recorded between 2018 and 2022 were included through total sampling. Controls were LBW infants who survived beyond 28 days and were selected purposively from delivery registers and medical records from the same study period. A total of 43 controls were selected to achieve a 1:1 case-control ratio.

Eligible cases and controls had a gestational age >28 weeks, were born in participating health facilities, and had sufficiently complete records for the primary pregnancy, neonatal, and health service variables. Exclusion criteria included major congenital anomalies incompatible with life, birth outside participating facilities, and incomplete records for key study variables. For controls, survival beyond the first 28 days was required. The sample size was not determined through a formal statistical power calculation; the case group comprised all available eligible deaths, whereas the control group was selected at a 1:1 ratio for analytical efficiency. This sampling strategy and its implications for statistical power are acknowledged as limitations. Overall, the final analytic dataset comprised 86 LBW infants (43 cases and 43

controls) with no listwise missing data. Data analysis proceeded from univariate descriptive statistics to bivariate analyses using Pearson's chi-square test or Fisher's exact test, with crude odds ratios (95% CIs) calculated for each predictor. Eligible variables were subsequently entered into a binary logistic regression model.

Operational Definitions and Data Sources

Table 1. Operational definitions of study variables and data sources.

Domain	Variable	Operational definition	Data source
Outcome	LBW neonatal mortality	Birth weight <2,500 g and death at 0-28 days (1) versus survival beyond 28 days (0).	PVA, delivery register, medical record
Pregnancy	Maternal age	At-risk age <20 or >35 years versus 20-35 years.	PVA, delivery register, medical record
Pregnancy	Maternal nutritional status / MUAC	Nutritional risk when mid-upper arm circumference (MUAC) <23.5 cm in the available early-pregnancy record versus ≥23.5 cm.	Delivery register, medical record
Pregnancy	Blood pressure	High when systolic ≥140 mmHg and/or diastolic ≥90 mmHg versus below these thresholds.	PVA, medical record
Pregnancy	Maternal anemia	Hemoglobin <11 g/dL versus ≥11 g/dL. The final analytic coding consistently used the <11 g/dL threshold for the available pregnancy Hb record.	PVA, delivery register, medical record
Pregnancy	Active or passive smoking exposure	Recorded active smoking and passive tobacco-smoke exposure.	PVA, medical record
Neonatal	Gestational age	Preterm <37 weeks versus term ≥37 weeks.	PVA, delivery register, medical record
Neonatal	Plurality	Twin pregnancy versus singleton.	PVA, delivery register, medical record
Neonatal	Gender	Male versus female.	PVA, delivery register, medical record
Neonatal	Congenital anomaly	Recorded congenital anomaly; major anomalies incompatible with life were excluded.	PVA, medical record
Neonatal	Respiratory status	Respiratory compromise / not breathing / gasping after birth versus normal breathing.	PVA, medical record
Health care	ANC visits	<4 visits versus ≥4 visits according to the categories available in the historical study instrument.	PVA, delivery register, medical record
Health care	Delivery facility type	Hospital versus clinic/midwife; all subjects were born in participating health facilities.	PVA, delivery register, medical record

Domain	Variable	Operational definition	Data source
Health care	Breastfeeding	Exclusive breastfeeding without formula/alternative during the available neonatal observation period versus not; measured until day 28 or before death.	PVA, medical record
Health care	Neonatal follow-up	Complete when KN1 (6-48 hours), KN2 (days 3-7), and KN3 (days 8-28) were recorded; otherwise incomplete.	PVA, delivery register, medical record
Health care	Referral status	Final categories: referral not performed versus referral not required. No “referral performed” category was present in the final analytic dataset.	PVA, medical record

Data Quality, Bias, and Missing Data

Data were abstracted using the same variable list and coding framework for all subjects and were checked for completeness and internal consistency before analysis. Full blinding of data abstractors to case control status was not feasible because Perinatal Verbal Autopsy (PVA) records inherently identified deaths, whereas control data were obtained from delivery registers and medical records. This difference in data sources may have introduced variations in information quality between cases and controls. Selection bias was also possible because controls were selected purposively, and inclusion was restricted to records with complete data.

The final analytical dataset comprised only complete case records. The case processing summary indicated 86 valid subjects and no listwise missing observations. Variables that could not be estimated were affected by homogeneous categories, zero cell counts, or complete separation rather than missing data. Because health service variables were measured during or after clinical deterioration, they were also considered susceptible to confounding by indication, reverse causality, or survivor bias.

Table 2. Missing data, homogeneity, and complete separation in the final dataset

Variable	Analytic issue	Missing	Implication
Active smoking	0/86 yes; 86/86 no	0	Homogeneous; not tested inferentially
Passive smoke exposure	86/86 yes	0	Homogeneous; not tested inferentially
Gestational age category	86/86 term (>37 weeks)	0	Homogeneous; not tested inferentially
Congenital anomaly	0/86 major anomaly; major anomalies excluded	0	No analyzable variation in the final dataset
ANC category	86/86 >4 visits	0	Homogeneous; not tested inferentially
Respiratory status	43 compromised; all were cases	0	Complete separation; conventional OR not estimable

Variable	Analytic issue	Missing	Implication
Delivery facility type	Hospital: 43 cases vs 3 controls; clinic/midwife: 0 vs 40	0	Complete separation
Breastfeeding	Not exclusive: 42 cases vs 0 controls	0	Complete separation; vulnerable to reverse causality
Neonatal follow-up	Incomplete: 43 cases vs 0 controls	0	Complete separation; vulnerable to survivor bias
Referral status	Not performed: 43 cases vs 0 controls	0	Complete separation; clinical comparison categories are non-equivalent
Other model variables	Age, MUAC, blood pressure, Hb, plurality, gender	0	Variable and eligible for multivariable modeling

Statistical Analysis

Univariate analysis summarized categorical variables as frequencies and percentages and continuous variables as means and standard deviations when relevant. Bivariate associations were assessed using Pearson's chi-square when expected frequency assumptions were satisfied and Fisher's exact tests for sparse data or zero cells. Crude odds ratios (cORs) with 95% confidence intervals (CIs) were reported when estimable. A two-sided $p < 0.05$ was considered statistically significant.

Binary logistic regression using the Enter method was used to control potential confounding among six predictors that occurred before the outcome and did not show complete separation: maternal age, MUAC, blood pressure, maternal anemia, plurality, and gender. Respiratory status and the health service variables with zero cells were not entered into the conventional logistic model because maximum likelihood estimates would be unstable or non estimable and because several occurred close to or after deterioration. Model performance was summarized using the omnibus likelihood ratio test, Nagelkerke R-squared, Hosmer Lemeshow goodness of fit test, classification accuracy, and area under the receiver operating characteristic curve (AUC). Analyses were conducted using IBM SPSS Statistics version 25.

RESULTS

Sample Characteristics and Data Completeness

A total of 86 LBW infants were analyzed, comprising 43 neonatal deaths and 43 controls who survived beyond 28 days. All 86 records were complete for variables used in the final analytic data set (0% listwise missing). Maternal anemia was present in 38/86 infants overall; 29 of 43 cases (67.4%) were born to mothers with anemia compared with 9 of 43 controls (20.9%).

Bivariate Analysis

Table 3. Bivariate analysis of pregnancy, neonatal, and health care factors associated with LBW neonatal mortality

Variable	Comparison	Cases n1/n0	Controls n1/n0	cOR (95% CI)	p-value	Test
Maternal age	At-risk vs 20-35 y	24/19	21/22	1.32 (0.57-3.09)	0.517	Chi-square
MUAC	<23.5 vs ≥23.5 cm	24/19	19/24	1.60 (0.68-3.74)	0.281	Chi-square
Blood pressure	High vs not high	6/37	5/38	1.23 (0.35-4.39)	0.747	Chi-square
Maternal anemia	Hb <11 vs ≥11 g/dL	29/14	9/34	7.83 (2.96-20.70)	<0.001	Chi-square
Plurality	Twin vs singleton	4/39	2/41	2.10 (0.36-12.14)	0.676	Fisher exact
Gender	Male vs female	23/20	19/24	1.45 (0.62-3.40)	0.388	Chi-square
Respiratory status	Compromised vs normal	43/0	0/43	Not estimable	<0.001	Fisher exact
Delivery facility type	Hospital vs clinic/midwife	43/0	3/40	Not estimable	<0.001	Fisher exact
Breastfeeding	Not exclusive vs exclusive	42/1	0/43	Not estimable	<0.001	Fisher exact
Neonatal follow-up	Incomplete vs complete	43/0	0/43	Not estimable	<0.001	Fisher exact
Referral status	Not performed vs not required	43/0	0/43	Not estimable	<0.001	Fisher exact

Within the pregnancy domain, maternal anemia was the only factor significantly associated with neonatal death in the bivariate analysis. The odds of death among LBW infants born to mothers with anemia were 7.83 times the odds among infants born to mothers without anemia (95% CI 2.96-20.70; $p<0.001$). Maternal age, MUAC, and blood pressure were not statistically significant.

Within the neonatal domain, respiratory compromise showed complete separation: 43/43 infants with respiratory compromise were in the case group and none were in the control group (Fisher $p<0.001$). This represents an extreme distributional difference, but a conventional odds ratio could not be estimated because one or more cells were zero. Plurality and gender were not statistically significant.

Within the health service domain, delivery facility type, breastfeeding, neonatal follow-up, and referral status also contained zero cells and yielded Fisher $p<0.001$. These findings should not be interpreted as direct causal effects of the services. Hospital delivery may reflect referral of more severely ill infants, breastfeeding and complete follow up require survival long

enough for exposure to be observed, and referral status was coded using categories that are not clinically equivalent.

Multivariable Analysis

Table 4. Multivariable binary logistic regression

Predictor	B	SE	aOR	95% CI	p-value
At risk maternal age	0.256	0.528	1.29	0.46-3.63	0.628
Nutritional risk (MUAC <23.5 cm)	-0.121	0.541	0.89	0.31-2.56	0.823
High blood pressure	-0.908	0.896	0.40	0.07-2.34	0.311
Maternal anemia (Hb <11 g/dL)	2.191	0.566	8.94	2.95-27.09	<0.001
Twin pregnancy	0.733	1.060	2.08	0.26-16.62	0.489
Male gender	-0.003	0.520	1.00	0.36-2.76	0.995

The six-predictor logistic regression model was significant overall (chi-square=20.981; df=6; p=0.002). The Hosmer-Lemeshow test did not indicate lack of fit (chi-square=9.649; df=8; p=0.291). Overall classification accuracy was 73.3%, Nagelkerke R squared was 0.289, and the AUC was 0.747. After adjustment for the five other predictors, maternal anemia was the only independently significant factor (aOR 8.94; 95% CI 2.95-27.09; p<0.001).

DISCUSSION

The principal finding of this study was that maternal anemia was the factor most consistently associated with neonatal death among LBW infants. This association was evident in the bivariate analysis (cOR 7.83; 95% CI 2.96-20.70) and remained strong after adjustment for maternal age, MUAC, blood pressure, twin pregnancy, and infant gender (aOR 8.94; 95% CI 2.95-27.09). These findings directly address the study objective and warrant a revision of the earlier interpretation that no factors were statistically significant associated with neonatal death.

The finding regarding maternal anemia is both biologically and epidemiologically plausible. The World Health Organization (WHO) currently defines anemia during pregnancy using trimester specific hemoglobin thresholds of <11.0 g/dL in the first and third trimesters and <10.5 g/dL in the second trimester (World Health Organization, 2024). In the present study, the historical dataset employed a single analytical threshold of Hb <11 g/dL because information on the timing of hemoglobin measurement by trimester was not consistently available. A global systematic review found that low maternal hemoglobin levels were associated not only with low birth weight (LBW) but also with preterm birth, perinatal mortality, and neonatal mortality (Young et al., 2023). More recently, an analysis of 45 national datasets from low- and middle-income countries reported that maternal anemia was associated with increased risks of neonatal and infant mortality (Tsamantioti et al., 2025). Prospective

evidence from Uganda likewise demonstrated an association between maternal anemia and adverse neonatal outcomes (Edelson et al., 2023), while recent evidence syntheses continue to identify maternal anemia and related pregnancy conditions as important contributors to adverse birth outcomes (Arabzadeh et al., 2024).

Respiratory compromise exhibited the strongest distributional pattern among the neonatal factors, as all infants with abnormal respiratory status were cases. This finding is consistent with the well established clinical importance of respiratory morbidity in vulnerable newborns. The Indonesian multicenter study by Haksari (Haksari et al., 2025) identified respiratory distress as an important risk factor for mortality during the early neonatal period, while a 2026 systematic review and meta analysis identified respiratory distress syndrome as a significant predictor of mortality among LBW neonates (W T Wondie et al., 2026). Earlier retrospective studies of LBW infants likewise reported substantial early mortality and a high burden of respiratory morbidity (Genie & Kebede, 2022; Wubet Tazeb Wondie et al., 2023). In a multicenter cohort of LBW infants, prematurity, multiple birth, low Apgar score, and very low or extremely low birth weight were significant predictors of respiratory distress syndrome (Mukosha et al., 2023). Recent evidence syntheses similarly identify respiratory distress syndrome, sepsis, prematurity, and very low birth weight as recurrent predictors of neonatal mortality (Kefale et al., 2025). Nevertheless, the present dataset exhibited complete separation, precluding the estimation of a conventional odds ratio (OR). Thus, this finding should be interpreted as a strong signal of association rather than as a precise effect estimate.

The pronounced bivariate differences observed for delivery facility type, breastfeeding, neonatal follow-up, and referral status require careful temporal and clinical interpretation. All cases were recorded as hospital deliveries, whereas most controls were delivered in clinics or midwifery facilities. This pattern may reflect confounding by indication, whereby more severe cases are more likely to be referred to and managed in hospitals. Evidence from other low and middle income settings similarly suggests that associations between place of birth or provider type and neonatal mortality are context dependent and should not be interpreted as simple facility effects (Dixit et al., 2023; Lin et al., 2023). Exclusive breastfeeding and completion of neonatal follow-up also depend on an infant surviving long enough for these processes to occur, creating potential for reverse causality and survivor bias. The broader literature indicates that feeding practices in the first days of life are associated with neonatal survival, while targeted hospital based interventions can improve breastfeeding outcomes among preterm and LBW infants (Mal & Ram, 2023; Song et al., 2023). The referral categories, namely *not referred* and *referral not required*, represent distinct clinical circumstances and should not be considered

interchangeable levels of exposure. For these reasons, service related variables exhibiting complete separation were not interpreted as evidence of causal effects and were not included in the conventional multivariable model.

No statistically significant associations were detected for maternal age, MUAC, blood pressure, plurality, or infant gender. These findings should not be interpreted as evidence that these factors are clinically irrelevant. Confidence intervals were wide for several estimates, particularly for twin pregnancy, indicating limited precision. Studies of preterm and high risk neonatal populations have shown that mortality is often influenced by multiple interacting maternal and proximal neonatal factors rather than by a single background characteristic (Aynalem et al., 2022; Kefale et al., 2025). Furthermore, the case control sample was relatively small, and numerous bivariate tests were performed, increasing both the likelihood of type II error for moderate associations and the chance of false positive findings across multiple comparisons.

Several potential sources of bias should be considered. The purposive selection of controls and the requirement for complete records may have introduced selection bias, as controls with more complete documentation may have been more closely engaged with routine health services than the underlying source population. The use of different data sources for cases and controls may also have introduced differential misclassification. Perinatal Verbal Autopsy (PVA) records are inherently more detailed with respect to deaths than routine records for surviving infants, potentially exaggerating apparent differences in certain clinical or service related variables. In contrast, nondifferential measurement error arising from incompletely documented maternal exposures may have attenuated true associations toward the null. These concerns are consistent with international assessments that have identified important limitations in the completeness and quality of routine birth weight and preterm birth data (Okwaraji, Bradley, et al., 2024).

Generalizability is also limited. The sample was drawn from six public health centers in X city and included births between 2018 and 2022; therefore, the findings are most applicable to primary care networks with similar referral pathways and routine health information systems rather than to all settings in Indonesia. The inability to estimate the effects of several clinically important variables resulted from restricted variation or complete separation, rather than missing data. Future studies should employ prospective multicenter designs, prespecified sample size calculations, standardized longitudinal mother infant records, and statistical approaches appropriate for sparse data, particularly when predictors prone to separation are central to the research question.

The most immediate programmatic implication of these findings is the need to strengthen prevention, detection, and management of maternal anemia during pregnancy, including routine hemoglobin testing and appropriate follow up of treatment. For newborn care, priority should be given to immediate respiratory assessment and the standardized documentation of stabilization and referral processes. Linking antenatal, delivery, neonatal care, referral, and mortality records through the first 28 days would further enhance both continuity of care and the quality of local neonatal mortality surveillance.

CONCLUSION

In this case-control study of LBW infants in X city city, maternal anemia was the most consistent independent predictor of neonatal death (aOR 8.94; 95% CI 2.95-27.09; $p < 0.001$). Respiratory compromise and several healthcare service variables showed marked bivariate differences; however, conventional odds ratios (ORs) could not be estimated because of complete separation, and the temporal relationship of these variables to clinical deterioration limits causal interpretation. Non significant findings for other predictors should be interpreted in the context of the small sample size and restricted variation rather than as evidence of a lack of clinical relevance.

Maternal and child health programs in X city should prioritize the screening, prevention, and management of maternal anemia during pregnancy, immediate neonatal respiratory assessment, strengthened referral documentation, and longitudinal mother-infant and neonatal mortality recording at public health centers. Larger prospective multicenter studies with adequately powered sample sizes and statistical methods capable of handling sparse or separated data are needed to better quantify these associations.

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CONFLICT OF INTEREST

The authors declare no conflict of interest related to this study.

ETHICAL CONSIDERATIONS

This study used secondary data and received ethical approval from the Ethics Committee of Universitas Brawijaya (Ethical Clearance No. 45/ EC / KEPK - S2 / 2025).

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