Determinant of Neonatal Mortality in Rural Gorontalo: A Population-Based Case Control Study

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ABSTRACT

Background: *Neonatal mortality remains a significant public health challenge, particularly in rural areas, where multiple maternal, perinatal, and neonatal risk factors contribute to adverse outcomes. This study aims to identify the determinants of neonatal mortality in a rural setting.*
Method: *A case–control design was employed involving 224 participants (56 neonatal deaths and 168 surviving controls). Data were obtained from maternal and child health records and structured questionnaires. Descriptive, bivariate, and logistic regression analyses were performed to assess factors associated with neonatal mortality.*
Result*: Significant determinants of neonatal mortality included maternal undernutrition (AOR = 3.54), low birth weight (AOR = 6.77), pregnancy complications (AOR = 8.04), intrapartum complications (AOR = 7.39), and neonatal complications (AOR = 9.17). Meanwhile, variables such as maternal age, education level, socioeconomic status, parity, antenatal care attendance, maternal anemia, interpregnancy interval, referral delay, healthcare access, exposure to cigarette smoke, and clean and healthy living behavior were not significantly associated with neonatal mortality. Neonatal mortality in rural areas is primarily influenced by maternal and neonatal factors related to nutrition and complications. Preventive efforts should focus on improving maternal nutritional status, strengthening early detection of pregnancy and intrapartum complications, and enhancing the management of neonatal complications to reduce neonatal mortality.*

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INTRODUCTION

Neonatal mortality refers to the death of an infant within the first 28 days of life. According to the World Health Organization, neonatal deaths remain a substantial global health burden. In 2022, an estimated 2.3 million neonatal deaths occurred worldwide. Approximately 6,500 newborns die each day, accounting for about 47% of all deaths among children under five years of age. In Central and Southern Asia, the reported neonatal mortality rate remains high, with approximately 21 deaths per 1,000 live births.(1)

According to the Directorate of Family Health, in 2020, 72.0% (20,266 deaths) of the 28,158 deaths among chidlren under-five occurred during the neonatal period. In 2022, The Global Economy reported an that Indonesia's neonatal mortality rate was approximately 11 deaths per 1,000 live births.(2) At the subnational level, Gorontalo Province recorded 244 infant deaths, including neonatal deaths, in 2020. These figures demonstrate that neonatal mortality remains a significant public health concern requiring sustained attention and targeted interventions.

Neonatal mortality remains the largest contributor to under-five deaths globally, primarily due to risk factors directly caused by perinatal conditions.(3) The main determinants are prematurity low birth weight, intrapartum asphyxia, neonatal infections (including sepsis and pneumonia), and congenital anomalies.(4–6) Maternal obstetric complications, such as preeclampsia, antepartum hemorrhage, and premature rupture of membranes, also increase the risk of neonatal morbidity and mortality by impairing placental perfusion and heightening susceptibility to infections.(7,8) Moreover, the quality of intrapartum care, including the competency of healthcare providers, the timeliness of resuscitation interventions, and the availability of essential neonatal care facilities, plays a critical role in determining survival during the first 24 hours of life, the most vulnerable period for newborns.(9,10)

On the other hand, several indirect factors contribute to disparities in neonatal mortality. Low to middle socioeconomic status, low maternal educational attainment, limited access to quality antenatal care services, and geographic barriers to accessing health facilities have consistently been associated with an increased risk of neonatal mortality, particularly in low- and middle-income countries.(11,12) These conditions indicate that reducing neonatal mortality requires not only clinical interventions targeting biological risk factors but also systemic approaches that address social determinants and improve equity in access to healthcare services.

Neonatal death not only causes profound grief for families but also has serious implications for social dynamics, psychological well-being, and the economic welfare of families and communities. Previous studies have shown that perinatal death affects the social functioning of families, as those who experience infant loss may face deterioration in their social relationships.(13) In addition, families often bear a substantial economic burden, as costs related to intensive neonatal care, medical treatment, transportation, and indirect expenses, such as loss of parental productivity frequently exceed household financial capacity. Consequently, neonatal death or prolonged neonatal intensive care can result in significant financial strain on affected families.(14) Furthermore, at the population level, high neonatal mortality reflects the loss of potential human capital for future generations, exacerbates social inequalities, increases the burden on health systems, and ultimately hinders long-term health development and societal well-being.(15)

Although numerous studies have identified the major determinants of neonatal mortality, a substantial knowledge gap remains regarding how these factors operate specifically in rural settings, which have distinct social, geographic, and health system contexts compared with urban areas. In rural regions such as Gorontalo, contextual factors, including distance to and affordability of health facilities, reliance on primary healthcare services, and the role of family and community in health-related decision-making have not been sufficiently examined in isolation or in depth. This lack of locally contextualized evidence creates a critical gap in understanding the specific mechanisms influencing neonatal mortality in rural areas, resulting in interventions that are often not fully aligned with local needs. Therefore, using a case–control approach, this study aims to assess demographic characteristics, maternal and obstetric factors, neonatal conditions, as well as behavioral and environmental factors as determinants of neonatal mortality in rural Gorontalo.

METHOD

Study design

This study employed a population-based case–control design to identify determinants of neonatal mortality in rural Gorontalo. This design was selected because it allows assessment of multiple risk factors for a relatively rare outcome, such as neonatal death. The population-based approach ensured that both cases and controls were drawn from the same source population, enhancing internal validity and and allowing the findings to more accurately represent the underlying population.

Population and sample

The target population of this study comprised all neonates aged 0–28 days whose mothers resided in rural areas. Cases consisted of neonates who died during the neonatal period (0–28 days), as identified from records of primary health centers, village midwives, and/or death registration systems. Controls were neonates who survived at least until 28 days of life. The case-to-control ratio was set at 1:3, following previous studies, to increase statistical power for this relatively rare outcome (16). Controls were not individually matched to cases. However, they were selected from birth registries of the same primary health centers as the cases to ensure representation of the same source population and same birth period, thereby minimizing selection bias. In addition, the study was restricted to singleton births.

The inclusion criteria for cases were neonates who died between 0 and 28 days of life and had verifiable birth and death records from primary health centers or village midwives. The inclusion criteria for controls were neonates who survived beyond the 28 days of life and resided in the same geographic area as the cases at the time of birth. Exclusion criteria for both groups included extreme gestational age (<25 weeks), refusal by the mother or family to participate in the interview, and families who had relocated outside the study area.

Variables and data collection

The variables measured in this study included maternal age, maternal education, household income (as an indicator of socioeconomic status), parity, interpregnancy interval, history of miscarriage, maternal nutritional status (chronic energy deficiency), antenatal care visits, pregnancy-related anemia, comorbid conditions, pregnancy complications, type of delivery, birth attendant, intrapartum complications, low birth weight (LBW), neonatal complications, delays in referral, access to health services, exposure to tobacco smoke, and household sanitary and hygiene practices.

Clinical variables routinely recorded during pregnancy, intrapartum, and the neonatal period were extracted directly from the Maternal and Child Health Book, whereas the remaining variables were collected using a structured questionnaire. To enhance data accuracy and minimize missing data, cross-verification was conducted between records from the Maternal and Child Health (MCH) Handbook and other available sources, such as maternal and infant cohort registers.

Statistical analysis

Data were analyzed in several stages, beginning with descriptive analysis to summarize the characteristics of each variable. Bivariate analysis was then conducted to assess the association between each independent variable and neonatal mortality using the chi-square test, yielding crude odds ratios with 95% confidence intervals (CIs). Variables with a P-value <0.25 in the bivariate analysis were included in the multivariate analysis using logistic regression to obtain adjusted odds ratios (ORs). A stepwise backward likelihood ratio (LR) method was employed to generate a parsimonious model and identify the significant determinants of neonatal mortality.

Ethical clearance

This study received ethical approval from the Health Research Ethics Committee of Universitas Negeri Gorontalo, with ethical clearance number 183C/UN47.B7/KE/2025.

RESULT AND DISCUSSION

Table 1. Demographic and bivariate analysis of maternal, pregnancy, intrapartum, neonatal, and environmental factors associated with neonatal mortality

Variabel	Cases		Controls		Total		OR	95% CI	P-value
	f	%	f	%	f	%			
Maternal age (years)									
<20 atau ≥ 35	12	21.4	9	5.4	21	9.4	4.82	1.908-12.169	0.001
20-34	44	78.6	159	94.6	203	90.6			
Maternal education									
Low	24	60.7	111	66.1	145	64.7	0.79	0.425-1.481	0.519
High	22	39.3	57	33.3	79	35.3			
Socioeconomic status									
Lower–middle	38	67.9	120	71.4	158	70.5	0.84	0.439-1623	0.615
Upper–middle	18	32.1	48	28.6	66	29.5			
Parity									
Primiparous	22	39.3	72	42.9	94	42.0	0.86	0.465-1.599	0.755
Multiparous	34	60.7	96	57.1	130	58.0			
Interpregnancy interval (years)									
<2 atau > 5	8	14.3	9	5.4	11	4.9	2.94	1.077-8.049	0.040
2-5	48	85.7	159	94.6	213	95.1			
History of Miscarriage									
Yes	11	19.6	15	8.9	26	11.6	2.49	1.070-5.811	0.051
No	45	80.4	153	91.1	198	88.4			
Maternal nutritional status									
Chronic energy deficiency (CED)	14	26.8	24	14.3	39	17.4	2.19	1.055-4.566	0.042
Normal	41	73.2	144	85.7	185	82.6			
Antenatal care (ANC) visits									
Incomplete	5	8.9	6	3.6	11	4.9	2.65	0.775-9.037	0.148
Complete	51	91.1	162	96.4	213	95.1			
Pregnancy-related anemia									
Yes	9	16.1	9	5.4	18	8.0	3.38	1.270-9.010	0.020
No	47	83.9	159	94.6	206	92.0			
History of comorbid conditions									
Yes	9	16.1	6	3.6	15	6.7	5.17	1.751-15.268	0.003
No	47	83.9	162	96.4	209	93.3			
Pregnancy complications									
Yes	8	14.3	5	3.0	13	5.8	5.43	1.699-17.380	0.004
No	48	85.7	163	97.0	211	94.2			
Type of delivery									
Operative/assisted	13	23.2	21	12.5	34	15.2	2.12	0.979-4.574	0.083
Spontaneous	43	76.8	147	87.5	190	84.8			
Birth attendant									
Non–health professional	1	1.8	0	0.0	1	0.4	4.05	3.223-5.100	0.250
Health professional	55	98.2	168	100.0	223	99.6			
Intrapartum complications									
Yes	9	16.1	7	4.2	16	7.1	4.40	1.557-12.458	0.006
No	47	83.9	161	95.8	208	92.9			

Low birth weight (LBW)									
Yes	7	12.5	6	3.6	13	5.8	3.86	1.238-12.016	0.021
No	49	87.5	162	96.4	211	94.2			
Neonatal complications									
Yes	19	33.9	12	7.1	31	13.8	6.67	2.980-14.957	0.000
No	37	66.1	156	92.9	193	86.2			
Delay in referral									
Yes	10	17.9	9	5.4	19	8.5	3.84	1.473-10.015	0.010
No	46	82.1	159	94.6	205	91.5			
Access to health services									
Not accessible	3	5.4	11	6.5	14	6.3	0.81	0.217-3.006	1.000
Accessible	53	92.6	157	93.5	210	93.8			
Exposure to tobacco smoke									
Yes	33	58.9	93	55.4	126	56.3	1.16	0.627-2.136	0.756
No	23	41.1	75	44.6	98	43.8			
Healthy living behavior									
Poor	5	8.9	9	5.4	14	6.3	1.73	0.555-5.404	0.347
Adequate	51	91.1	159	94.6	210	93.8			

Table 2. Determinants of neonatal mortality in rural Gorontalo

Variabel	AOR	95% CI	P-value
Maternal nutritional status			
Chronic energy deficiency vs normal	3.54	1.493-8.419	0.004*
Low birth weight (LBW)			
Yes vs no	6.77	1.899-24.180	0.003*
Interpregnancy intervals (years)			
<2 atau > 5 vs 2-5	3.27	0.961-11.102	0.058**
Maternal complications			
Yes vs no	8.04	2.156-30.014	0.002*
Intrapartum complications			
Yes vs no	7.39	2.254-24.216	0.001*
Neonatal complications			
Yes vs no	9.17	3.699-22.715	0.000*

Note: *Significant at p<0.05, **significant at p<0.1

Among the 224 mothers and newborns included in the analysis, most mothers were aged 20–34 years (94.2%), had low educational attainment (64.7%), and came from lower–middle socioeconomic families (70.5%). Approximately 58.0% were multiparous, and the majority had an interpregnancy interval of 2–5 years (95.1%). A history of miscarriage was reported by 11.6% of mothers, while 17.4% were classified as having chronic energy deficiency. Complete ANC visits were recorded for 95.1% of participants, whereas pregnancy-related anemia was observed in 8.0%. Pregnancy complications were documented in 5.8% of mothers. Most deliveries were spontaneous (84.8%) and assisted by health professionals (99.6%).

Among newborns, 9.4% were classified as low birth weight, 13.8% experienced neonatal complications, and referral delays occurred in 8.5% of cases. Although physical access to health services was generally adequate for 93.8% of respondents, household exposure to tobacco smoke remained high (56.3%). Clean and healthy living practices were adequate in 93.8% of households. Overall, neonatal mortality in this sample reached 25.0%, indicating a substantial burden among the rural population studied.

Table 1 presents the bivariate associations between maternal, obstetric, neonatal, and health-system–related characteristics and neonatal mortality. Maternal age showed a strong and statistically significant association, with mothers in the extreme age groups (<20 or ≥35 years) having markedly higher odds of neonatal death compared with those aged 20–34 years. Interpregnancy intervals of <2 or >5 years were also associated with an increased risk.

Maternal nutritional status demonstrated a significant effect, with mothers with chronic energy deficiency (CED) having more than double the odds of neonatal mortality. Pregnancy-related anemia similarly elevated the risk. A history of maternal comorbidities showed one of the strongest associations, increasing the odds more than fivefold, while pregnancy complications were also significantly associated. Although a history of miscarriage showed a borderline association, it did not reach statistical significance.

Intrapartum-related factors also contributed to neonatal outcomes. Intrapartum complications significantly increased the odds of neonatal mortality. Operative or assisted delivery showed an elevated risk, although the association was not statistically significant. Births attended by non–health professionals showed a high odds ratio However the association was not statistically significant due to the very small number of cases. Infant characteristics showed some of the strongest associations. Low birth weight (LBW) significantly increased the likelihood of neonatal death. Neonatal complications exhibited the highest risk observed in this analysis, with affected newborns experiencing more than sixfold higher odds of mortality. Delayed referral was also significantly associated with an increased risk of mortality. Based on the bivariate results, variables with $p < 0.25$ were selected for inclusion in the multivariate logistic regression model. These variables comprised high-risk maternal age, extreme interpregnancy interval, history of miscarriage, chronic energy deficiency, maternal anemia, pre-existing medical conditions, pregnancy complications, mode of delivery, labor complications, low birth weight, neonatal complications, and delays in referral. Variables that did not show significant bivariate associations, such as maternal education, socioeconomic status, parity, access to healthcare services, household exposure to tobacco smoke, and clean and healthy living behavior were excluded from the final model to minimize the risk of overfitting and ensure that the analysis focused on independent determinants of neonatal mortality.

The multivariate logistic regression analysis revealed several factors that remained independent determinants of neonatal mortality after controlling other variables. Chronic energy deficiency increased the risk of neonatal death by 3.5 times compared with mothers with normal nutritional status (AOR = 3.54), highlighting the critical role of maternal nutrition on neonatal outcomes. Low birth weight (LBW) was a strong risk factor, with LBW infants being 6.8 times more likely to die than infants with normal birth weight (AOR = 6.77).

Reproductive factors, such as extreme interpregnancy intervals (<2 or >5 years), tended to increase the risk of neonatal mortality (AOR = 3.27), although this association was only significant at the 10% level ($p < 0.1$). Maternal complications during pregnancy and labor also substantially contributed to neonatal death. Mothers who experienced pregnancy complications had an eight-fold higher risk of neonatal death (AOR = 8.04), while intrapartum complications increased the risk nearly 7.4 times (AOR = 7.39). Furthermore, neonatal complications exhibited the strongest effect, with affected infants having a 9.2-fold higher likelihood of dying compared with those without complications (AOR = 9.17).

Pregnant women with chronic energy deficiency (CED) have more than a threefold increased risk of neonatal mortality compared with those with normal nutritional status. CED contributes to abnormal placental development, as the placenta plays a critical role in the transfer of nutrients and oxygen from mother to fetus. This condition is associated with reduced maternal blood volume, decreased cardiac output, and impaired uteroplacental blood flow, resulting in a smaller and less efficient placenta.(17) Consequently, the fetus may experience hypoxia and intrauterine growth restriction (IUGR), which ultimately increase the risk of neonatal complications.(18) Studies in Indonesia have shown that women with chronic maternal undernutrition are more likely to experience adverse neonatal outcomes, including low birth weight (LBW) and neonatal mortality.(19)

Furthermore, analyses of the maternal nutrition landscape in Indonesia indicate that maternal malnutrition, including CED, frequently coincides with high rates of neonatal morbidity and mortality rates, underscoring maternal nutritional status as a key determinant of perinatal health.(20) CED is a modifiable risk factor that can be addressed through health promotion interventions, including nutrition education and strengthened maternal health services. Improvements in maternal nutrition achieved through these strategies contribute to better pregnancy outcomes and may ultimately reduce the risk of infant mortality.

The increased risk of mortality among low birth weight (LBW) infants can be explained by several biological mechanisms. LBW is frequently associated with surfactant deficiency, leading to neonatal respiratory distress syndrome, which substantially increases early neonatal morbidity and mortality.(21) In addition, LBW infants have immature immune systems, making them more susceptible to severe infections and sepsis. They are also prone to hypothermia and hypoglycemia due to limited energy and fat reserves, conditions that further compromise hemodynamic stability and immune responses.(22,23)

Consistent with these mechanisms, a multicenter study conducted across several islands in Indonesia demonstrated that LBW infants had a markedly higher risk of neonatal death compared with infants of normal birth weight.(24) Similarly, a meta-analysis synthesizing multiple studies from low- and middle-income countries in Africa also demonstrated that infants with low birth weight had a significantly increased risk of neonatal mortality (PHR = 4.37 (95% CI: 2.62–7.29).(25)

Extreme interpregnancy intervals, whether too short or too long, are associated with an increased risk of neonatal mortality. A very short interpregnancy interval may lead to “maternal depletion,” a condition in which the mother’s body has not fully recovered physiologically, particularly in terms of nutritional reserves, iron, folate, and hormonal balance before the subsequent pregnancy begins.(26) Conversely, excessively long interpregnancy intervals may result in the loss of beneficial physiological adaptations acquired during the previous pregnancy, including adaptations in the cardiovascular, immunological, and uteroplacental vascular systems, leading to suboptimal placental development and fetal perfusion in the subsequent pregnancy.(27) These conditions may impair placental and fetal growth and increase the risk of preeclampsia, fetal malnutrition, intrauterine growth restriction (IUGR), and preterm birth. Consistent with these mechanisms, a recent meta-analysis from the Asia–Pacific region reported that short interpregnancy intervals were consistently associated with higher neonatal mortality (OR = 1.78; 95% CI: 1.25–2.55) as well as early neonatal death.(28)

Furthermore, a cohort study conducted in rural India found that interpregnancy intervals of less than 18 months were associated with a markedly increased risk of neonatal death (OR = 4.12; 95% CI: 3.74–4.55), while intervals of 18–35 months also showed elevated risk compared with the reference interval of 36–59 months.(29) These findings underscore the role of maternal biological recovery and reproductive behaviors in shaping the relationship between interpregnancy interval and neonatal mortality.(29) In general, interpregnancy interval is a modifiable factor that can be addressed through health promotion efforts, particularly family planning counseling and comprehensive reproductive health education for prospective couples. Achieving an optimal birth spacing improves maternal and infant health conditions, thereby contributing to a reduction in the risk of infant mortality.

Pregnancy complications significantly increase the risk of neonatal mortality. Complications such as preeclampsia/eclampsia and placental vascular disorders directly impair uteroplacental perfusion and lead to fetal hypoxia, thereby restricting fetal growth and increasing the likelihood of preterm birth.(21) Intrauterine hypoxia and prematurity result in the immaturity of vital neonatal organs, including the lungs and immune system, which heightens susceptibility to respiratory disorders, infections, and failure of postnatal physiological adaptation, all of which contribute to increased neonatal mortality.(30) A prospective study conducted in Indonesia reported that obstetric complications, including malpresentation, maternal near-miss events at hospital admission, and complications during obstetric care, were associated with higher perinatal mortality, including neonatal death.(31) Similarly, a study from the United States demonstrated that hypertensive disorders of pregnancy were linked to poorer pregnancy outcomes, including neonatal mortality.(32) By promoting changes in maternal health behaviors and enhancing family support to recognize and respond to complications early, the impact of maternal complications on infant outcomes can be minimized, thereby reducing the risk of neonatal mortality.

Intrapartum complications are associated with an increased risk of neonatal mortality. These complications may lead to neonatal death through major disruptions in oxygen supply and fetal circulation during the intrapartum period.(33) Impaired placental perfusion or umbilical cord compression during labor can result in acute intrapartum hypoxia, triggering metabolic acidosis, organ failure, and tissue injury.(34) A recent meta-analysis conducted in developing countries reported that intrapartum neonatal encephalopathy resulting from birth asphyxia or delivery-related trauma was associated with high neonatal mortality rates across multiple regions.(35)

In addition, a cohort study in a referral hospital in Uganda demonstrated that severe obstetric complications, including antepartum hemorrhage, placental abruption, uterine rupture, preeclampsia/eclampsia, and maternal sepsis significantly increased the risk of perinatal death, encompassing both stillbirths and neonatal mortality.(36) Neonatal complications are strongly associated with an increased risk of neonatal mortality. Severe conditions such as extreme prematurity, intrauterine growth restriction (IUGR), and low birth weight (LBW) contribute to neonatal death through multiple biological mechanisms. The immaturity of vital organs in these vulnerable neonates compromises their ability to adapt physiologically after birth, resulting in a higher incidence of respiratory disorders (e.g., surfactant deficiency), hypoxia-related brain injury or intraventricular hemorrhage, and increased susceptibility to infections and sepsis.(21)

In addition, conditions such as necrotizing enterocolitis and metabolic disturbances, including hypothermia and hypoglycemia, further worsen the clinical status of fragile neonates, cumulatively increasing the risk of death during the neonatal period. Consistent with these findings, a prospective hospital-based study in Indonesia reported that neonatal complications such as asphyxia occurring during or immediately after delivery significantly increased the risk of neonatal and overall perinatal mortality.(31) Similarly, a hospital-based study in Yemen demonstrated that most neonatal deaths among hospitalized infants were attributable to complications such as prematurity, asphyxia, sepsis, and respiratory disorders, all of which are classified as neonatal complications.(37)

This study has several strengths, particularly the use of a community-based case–control design in a rural setting, which enabled a comprehensive assessment of both proximal and distal risk factors for neonatal mortality. However, several limitations should be acknowledged. The study relied on health records and questionnaire-based data collection, which may be subject to recall bias and data incompleteness, particularly for variables not routinely documented in the Maternal and Child Health Handbook or hospital records. In addition, factors related to dietary patterns, high-risk behaviors, environmental exposures, or genetic predispositions that may influence neonatal mortality could not be fully controlled. Future studies conducted in broader populations beyond rural settings and with larger sample sizes may provide more statistically efficient and generalizable estimates of the associations.

CONCLUSION

The findings suggest that neonatal mortality in rural areas is largely influenced by maternal undernutrition and clinical complications occurring during pregnancy, childbirth, and the neonatal period. Conversely, maternal demographic characteristics, socioeconomic factors, and indicators of health service access were not independently associated with neonatal death in this rural population. By focusing on a rural population, this study provides context-specific insights that are often underrepresented in the neonatal mortality literature, which is largely dominated by urban or facility-based studies.

Health policies aimed at reducing neonatal mortality in rural areas should prioritize on strengthening behavior-based health promotion, with an emphasizes on improving maternal nutrition literacy, increasing awareness of the importance of early risk screening during pregnancy and childbirth, and encouraging essential newborn care practices. In addition, community-based health promotion policies should support the empowerment of families, community health workers, and community leaders in birth planning, enabling interventions to be implemented more effectively and sustainably.

Conflict of Interest

No potential conflicts of interest relevant to this article were reported.

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