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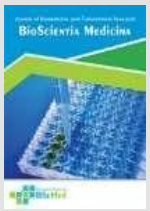

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Determinants of In-hospital Mortality in Preterm Neonates Admitted to a Tertiary Indonesian NICU: A One-Year Retrospective Cohort of 209 Infants

Komang Okky Maharani Ciptana Putri[1*], Putu Mas Vina Paramitha Cempaka[2], I Made Kardana[2], Made Sukmawati[2], Putu Junara Putra[2], I Wayan Dharma Artana[2]

[1]Medical Doctor, Assistant of Neonatal Intensive Care Unit, Prof. I.G.N.G Ngoerah Hospital, Faculty of Medicine, Udayana University, Denpasar, Indonesia

[2]Pediatrician, Consultant of Neonatology, Department of Child Health, Prof. I.G.N.G Ngoerah Hospital, Faculty of Medicine, Udayana University, Denpasar, Indonesia

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***Corresponding author:**
Komang Okky Maharani Ciptana Putri

E-mail address:
raniciptanaputri@yahoo.com

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A B S T R A C T

Background. Preterm birth is the largest single contributor to global neonatal mortality, and Southeast Asia carries a disproportionate burden, yet contemporary multivariable data from Indonesian tertiary neonatal intensive care units (NICUs) remain limited. We aimed to identify maternal, perinatal and neonatal determinants of in-hospital mortality among preterm neonates at the NICU of Prof. I.G.N.G Ngoerah Hospital, Denpasar, Bali. **Methods.** In a single-centre retrospective cohort, 209 preterm neonates (gestational age <37 weeks and birth weight <2500 g) admitted between September 2024 and September 2025 were enrolled by total sampling. Bivariate logistic regression with p<0.25 inclusion threshold was followed by multivariable binary logistic regression; intermediate-outcome variables (RDS and surfactant therapy) were excluded a priori to avoid over-adjustment bias. **Results.** In-hospital mortality was 42.1% (88/209) and decreased monotonically across birth-weight strata, from 75.0% in infants <1000 g to 41.9% in 1000–1499 g and 22.9% in ≥1500 g (Cochran–Armitage trend p<0.001). Sepsis (56.8%) and respiratory distress syndrome (30.7%) accounted for 87.5% of deaths. In the multivariable model, birth weight 1000–1499 g (adjusted odds ratio [aOR] 0.36, 95% CI 0.15–0.90; p=0.029) and ≥1500 g (aOR 0.17, 95% CI 0.06–0.51; p=0.001) and each 1-point increment in 5-minute Apgar score (aOR 0.81, 95% CI 0.67–0.98; p=0.031) were independently associated with lower mortality. Maternal urinary tract infection trended toward higher mortality (aOR 2.85, 95% CI 0.97–8.35; p=0.057). **Conclusion.** Birth weight and 5-minute Apgar score are independent, immediately measurable predictors of in-hospital preterm mortality in this Indonesian tertiary NICU. Combining bedside risk stratification with antenatal corticosteroid coverage audit and universal antenatal urine-culture screening offers a translational pathway to reduce neonatal mortality in resource-constrained Southeast Asian settings.

1. Introduction

Preterm birth, defined as delivery before 37 completed weeks of gestation, remains the largest single contributor to global neonatal mortality. Updated 2023 modelling places the worldwide preterm-birth burden at 13.4 million live births in 2020, with a global preterm-birth rate of 9.9%, and the gap between low- and middle-income countries (LMICs) and high-income countries has not narrowed since 2010.[1,2] Complications of prematurity together with intrapartum-related events and neonatal infections account for almost half of all deaths in children younger than five years, and the in-hospital phase is dominated by sepsis and respiratory distress syndrome (RDS). Indonesia ranks within the global top-ten for absolute preterm-birth burden,[3] with a national neonatal mortality rate of 15.7 per 1000 live births reported by the 2022 Indonesian Demographic and Health Survey; preterm complications account for an estimated 35–40% of these deaths.

The high in-hospital mortality of preterm infants is biologically anchored in multi-organ immaturity. Quantitative deficiency of surfactant proteins B and C, compounded by ABCA3 lamellar-body immaturity, generates alveolar instability and RDS, and antenatal corticosteroids exert a sizeable mortality benefit precisely by accelerating alveolar maturation and inducing surfactant synthesis.[4-6] Germinal-matrix capillaries are intrinsically fragile and cerebrovascular autoregulation is limited; recent mechanistic work has implicated immature neuronal salt and water transport in amplified hemorrhagic injury, providing a molecular substrate for the elevated intraventricular hemorrhage (IVH) risk in extremely preterm infants.[7,8] The innate-immune ontogeny of preterm infants — reduced neutrophil chemotaxis, defective monocyte cytokine production, and incomplete transplacental immunoglobulin transfer prior to approximately 32 weeks — explains the disproportionate vulnerability of very-preterm infants to nosocomial sepsis.[9,10]

Two robust and immediately measurable predictors anchor the contemporary evidence base for preterm mortality risk. The 5-minute Apgar score retains its prognostic value across the full score range, with each 1-point increment associated with a 12–22% relative reduction in death in recent Swedish national cohorts.[11] Birth-weight stratification at 1000 g and 1500 g continues to capture the steepest mortality gradient, with extremely-low-birth-weight (ELBW) mortality typically exceeding low-birth-weight (LBW) mortality by 4- to 6-fold even after adjustment. Antenatal corticosteroids reduce neonatal death by approximately 22% in the most recent Cochrane meta-analysis and by 16% in the WHO ACTION-1 LMIC randomized trial.[12,13]

A specific knowledge gap persists for Indonesia and Southeast Asia: the simultaneous quantification of adjusted associations between maternal, perinatal and neonatal exposures and in-hospital preterm mortality in a tertiary referral centre, together with an explicit cause-of-death decomposition to inform sepsis-prevention and respiratory-care bundles. This study addresses the gap by analysing 13 consecutive months of preterm admissions to the NICU of Prof. I.G.N.G Ngoerah Hospital — the largest tertiary referral centre in Bali. The novelty lies in three elements: a contemporary 2024–2025 effect-size profile for an Indonesian tertiary NICU, an integrated cause-of-death decomposition tied to actionable clinical bundles, and a translational synthesis converting the two strongest predictors into a parsimonious bedside risk-stratification framework. The aim of this study was to identify the maternal, perinatal and neonatal determinants of in-hospital mortality in preterm neonates and to quantify their adjusted associations using multivariable binary logistic regression with causal-pathway-aware exclusion of intermediate-outcome variables.

2. Methods

Study design and setting

This single-centre analytical observational study used a retrospective cohort design with consecutive medical-record review. The study was conducted at the NICU of Prof. I.G.N.G Ngoerah Hospital, Faculty of Medicine, Universitas Udayana, Denpasar, Bali, Indonesia, between 1 September 2024 and 30 September 2025. Prof. I.G.N.G Ngoerah Hospital is the largest tertiary referral teaching hospital in Bali and serves Eastern Indonesia for high-risk obstetric and neonatal care. Reporting follows the STROBE guideline for observational studies.

Participants and sample size

Inclusion criteria were gestational age <37 completed weeks, birth weight <2500 g, and admission to the NICU during the study period, either inborn or outborn. Exclusion criteria were incomplete medical records and stillbirth. Total sampling yielded 209 eligible neonates. With 88 deaths and seven candidate covariates in the multivariable model, an events-per-variable ratio of approximately 11 met the conventional Peduzzi threshold of ≥10 and supported stable parameter estimation.

Variables and definitions

Gestational age was determined by last menstrual period and first-trimester ultrasonography and categorised as extremely preterm (<28 weeks), very preterm (28 to <32 weeks), moderate preterm (32 to <34 weeks), and late preterm (34 to <37 weeks). Birth

weight was stratified as <1000 g (ELBW), 1000 to <1500 g (very low birth weight, VLBW), and 1500 to <2500 g (LBW). Small-for-gestational-age was defined as birth weight <10th percentile on the sex-specific Fenton growth curve. Apgar scores at 1 and 5 minutes were analysed as continuous variables. Maternal exposures comprised hypertensive disorders of pregnancy, preterm premature rupture of membranes, chorioamnionitis, urinary tract infection (UTI), diabetes mellitus, antenatal corticosteroids, and mode of delivery. Neonatal morbidities included RDS, patent ductus arteriosus, IVH (Papile classification), necrotising enterocolitis (NEC ≥ Bell stage II), bronchopulmonary dysplasia, retinopathy of prematurity, late-onset sepsis, and meningitis. The primary outcome was all-cause in-hospital mortality during the index admission.

Statistical analysis

Analyses were performed using SPSS Statistics version 27.0 (IBM Corp., Armonk, NY) and R version 4.3.2 with the rms and pROC packages. Normality was assessed by the Shapiro–Wilk test; data are presented as mean ± standard deviation or median (interquartile range, IQR) as appropriate, and categorical data as frequency (%). Bivariate associations with mortality were tested by univariate logistic regression. Variables with bivariate $p<0.25$ and those of a priori clinical relevance were carried forward into multivariable binary logistic regression. Intermediate-outcome variables on the causal pathway (RDS, surfactant therapy) were excluded a priori to avoid over-adjustment bias. Multicollinearity was assessed by variance inflation factor (VIF; threshold <10). Model fit was evaluated by the Hosmer–Lemeshow goodness-of-fit test and Nagelkerke R^2, and discrimination by the area under the receiver-operating-characteristic curve (AUC) with 95% confidence intervals by DeLong's method. All tests were two-sided with $\alpha=0.05$ and p-values reported to three decimal places.

Ethics

The study was approved by the Research Ethical Committee, Faculty of Medicine, Universitas Udayana/Prof. I.G.N.G. Ngoerah Hospital (approval number 1822/UN14.2.2.VII.14/LT/2026). As a retrospective study using anonymised medical-record data, the ethics committee waived the requirement for written informed consent. The study was conducted in accordance with the Declaration of Helsinki.

3. Results

Baseline characteristics

A total of 209 preterm neonates met the eligibility criteria. The median gestational age was 30 weeks (IQR 28–32) and the median birth weight was 1300 g (IQR 1065–1555). The largest gestational-age stratum was very preterm (28 to <32 weeks), comprising 100 infants (47.8%), followed by extremely preterm (53 infants, 25.4%), moderate preterm (45 infants, 21.5%) and late preterm (11 infants, 5.3%). By birth-weight stratum, 36 infants (17.2%) were ELBW, 112 (53.6%) were VLBW, and 61 (29.2%) were LBW. Female sex predominated (122/209, 58.4%). The median 5-minute Apgar score was 6 (IQR 5–8). Resuscitation at birth was required in 147 infants (70.3%), and surfactant was administered to 37 infants (17.7%). The cohort included 152 inborn (72.7%) and 57 outborn (27.3%) infants. The mean maternal age was 28.9 ± 6.1 years; hypertensive disorders of pregnancy occurred in 35 mothers (16.7%), urinary tract infection in 20 (9.6%), and antenatal corticosteroids were administered in 55.0% (Table 1).

Neonatal morbidity by birth-weight stratum

Neonatal morbidities followed the expected birth-weight gradient (Table 2; Figure 1). RDS was the most frequent morbidity overall (117/209, 55.9%) and its incidence decreased monotonically across birth-weight strata: 72.2% in <1000 g, 56.2% in 1000–<1500 g, and 45.9% in ≥1500 g. Patent ductus arteriosus was diagnosed in 30.1% (63/209). NEC of stage II or greater occurred in 16.7% (35/209), with the highest incidence (27.7%) in the <1000-g stratum. IVH was documented in 2.4% (5/209), late-onset sepsis in 9.0% (19/209), meningitis in 17.2% (36/209), retinopathy of prematurity in 8.6% (18/209), and bronchopulmonary dysplasia in 2.3% (5/209). The mean length of stay across the cohort was 27.0 ± 23.1 day.

Table 1. Baseline neonatal and maternal characteristics of preterm infants (N = 209)		
Variable	**Category**	**Value (n = 209)**
Neonatal characteristics		
Gestational age (weeks)	Median (IQR)	30 (28–32)
	Extremely preterm (<28)	53 (25.4%)
	Very preterm (28–<32)	100 (47.8%)
	Moderate preterm (32–<34)	45 (21.5%)
	Late preterm (34–<37)	11 (5.3%)
Birth weight (g)	Median (IQR)	1300 (1065–1555)
	ELBW <1000 g	36 (17.2%)
	VLBW 1000–<1500 g	112 (53.6%)
	LBW 1500–<2500 g	61 (29.2%)
Sex	Female	122 (58.4%)
	Male	87 (41.6%)
Apgar score, 1 min	Median (IQR)	5 (3–7)
Apgar score, 5 min	Median (IQR)	6 (5–8)
Resuscitation at birth	Yes, n (%)	147 (70.3%)
Surfactant therapy	Yes, n (%)	37 (17.7%)
Place of birth	Inborn	152 (72.7%)
	Outborn (referral)	57 (27.3%)
Maternal characteristics		
Maternal age (years)	Mean ± SD	28.9 ± 6.1
Hypertensive disorder of pregnancy*	Yes, n (%)	35 (16.7%)
Urinary tract infection	Yes, n (%)	20 (9.6%)
Preterm PROM	Yes, n (%)	69 (33.0%)
Antenatal corticosteroids	Yes, n (%)	115 (55.0%)
Mode of delivery	Caesarean section	140 (67.0%)
	Spontaneous vaginal	69 (33.0%)

*Notes: *Includes gestational hypertension, pre-eclampsia, superimposed hypertension and pregnancy-related renal disease. ELBW = extremely low birth weight; IQR = interquartile range; LBW = low birth weight; PROM = premature rupture of membranes; VLBW = very low birth weight.*

Table 2. Neonatal morbidity profile during NICU stay, stratified by birth-weight category				
Morbidity	**<1000 g (n = 36)**	**1000–1499 g (n = 112)**	**≥1500 g (n = 61)**	**Overall (n = 209)**
Respiratory distress syndrome	26 (72.2%)	63 (56.2%)	28 (45.9%)	117 (55.9%)
Patent ductus arteriosus	13 (36.1%)	38 (33.9%)	12 (19.6%)	63 (30.1%)
Late-onset sepsis	1 (2.7%)	12 (10.7%)	6 (9.8%)	19 (9.0%)
Meningitis	5 (13.8%)	23 (20.5%)	8 (13.1%)	36 (17.2%)
NEC (≥ stage II)	10 (27.7%)	19 (16.9%)	6 (9.8%)	35 (16.7%)
Intraventricular hemorrhage	3 (8.3%)	2 (1.7%)	0	5 (2.4%)
Retinopathy of prematurity	2 (5.5%)	11 (9.8%)	5 (8.1%)	18 (8.6%)
Bronchopulmonary dysplasia	2 (5.5%)	3 (2.6%)	0	5 (2.3%)
Outcomes				
Survival to discharge	9 (25.0%)	65 (58.0%)	47 (77.0%)	121 (57.9%)
All-cause mortality	27 (75.0%)	47 (41.9%)	14 (22.9%)	88 (42.1%)
Length of stay, days (mean ± SD)	24.9 ± 30.9	30.9 ± 23.6	20.9 ± 13.9	27.0 ± 23.1

Notes: NEC = necrotising enterocolitis. Percentages within columns refer to the column-stratum denominator.

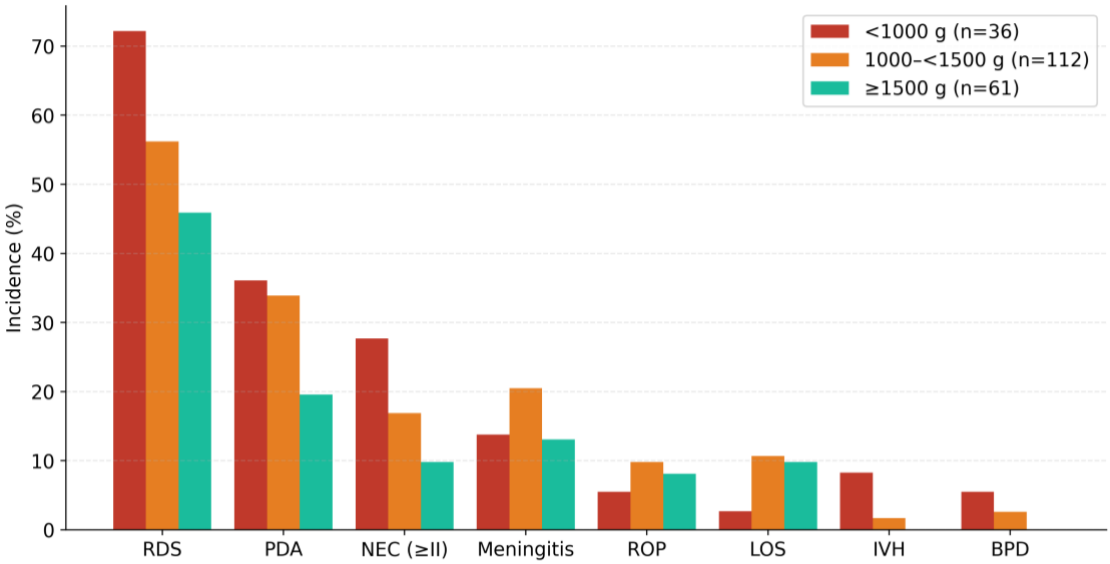

Figure 1. Incidence of neonatal morbidities by birth-weight stratum among 209 preterm infants. Bars represent within-stratum incidence (%). BPD = bronchopulmonary dysplasia; IVH = intraventricular hemorrhage; LOS = late-onset sepsis; NEC = necrotising enterocolitis; PDA = patent ductus arteriosus; RDS = respiratory distress syndrome; ROP = retinopathy of prematurity.

In-hospital mortality and cause-of-death distribution

Overall in-hospital mortality was 42.1% (88/209). Mortality was strongly and monotonically related to birth weight: 75.0% (27/36) in infants <1000 g, 41.9% (47/112) in 1000–1499 g, and 22.9% (14/61) in ≥1500 g (Figure 2). The leading causes of death were neonatal sepsis (50/88; 56.8%) and RDS (27/88; 30.7%), together accounting for 87.5% of all deaths, followed by congenital anomalies (4.5%), gastrointestinal complications (2.3%), prematurity itself (2.3%), central-nervous-system disorders (2.3%) and cardiovascular causes (1.1%) (Figure 3).

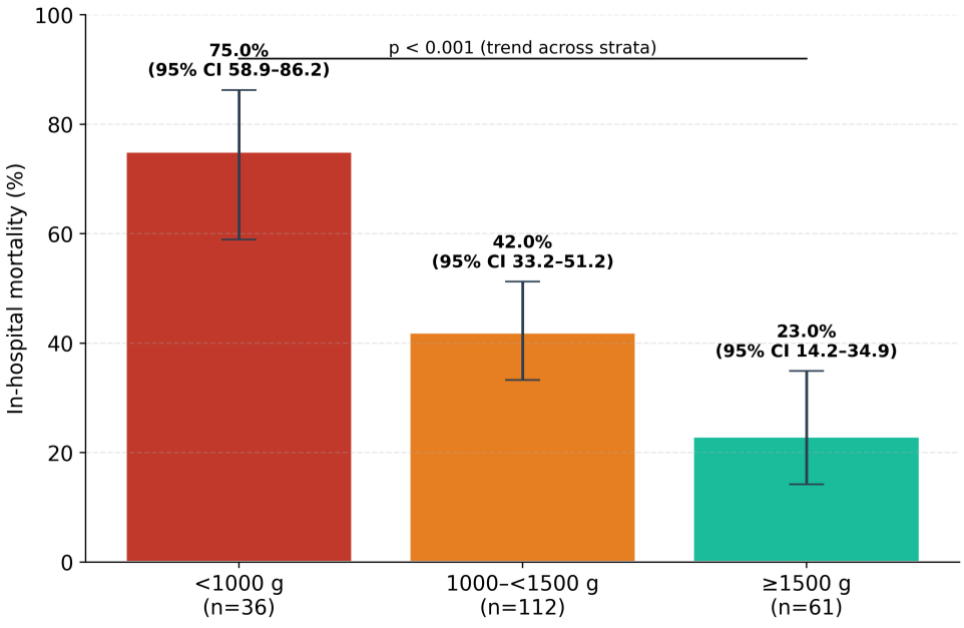

Figure 2. In-hospital mortality of preterm neonates by birth-weight stratum (N = 209). Error bars represent 95% Wilson confidence intervals. The Cochran–Armitage trend test yielded p < 0.001.

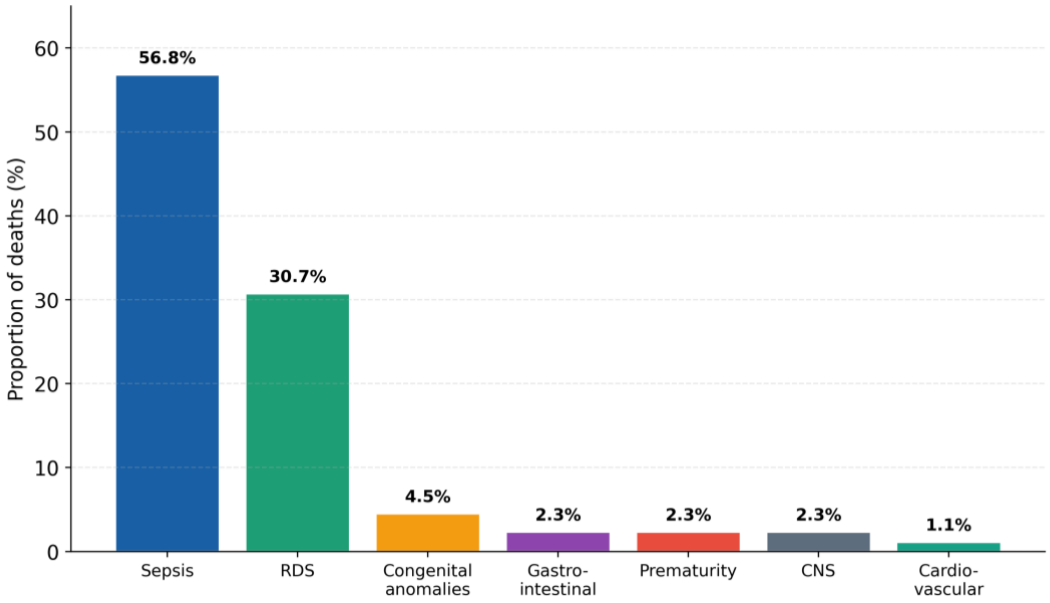

Figure 3. Distribution of immediate causes of death among 88 in-hospital deaths. Sepsis (56.8%) and respiratory distress syndrome (30.7%) together account for 87.5% of deaths. CNS = central nervous system; RDS = respiratory distress syndrome.

Bivariate associations with mortality

In bivariate logistic regression (Table 3), birth-weight stratum, 5-minute Apgar score, maternal urinary tract infection and mode of delivery were significantly associated with mortality. Compared with infants <1000 g, infants 1000–1499 g had a crude OR of 0.24 (95% CI 0.10–0.56; p<0.001) and infants ≥1500 g had a crude OR of 0.10 (95% CI 0.04–0.26; p<0.001). Each 1-point increment in 5-minute Apgar score was associated with a crude OR of 0.72 (95% CI 0.61–0.85; p<0.001). Maternal UTI was associated with higher mortality (crude OR 2.82, 95% CI 1.08–7.40; p=0.035), and caesarean section with lower mortality (crude OR 0.41, 95% CI 0.23–0.75; p=0.003). Hypertensive disorders of pregnancy, maternal age and antenatal corticosteroids met the p<0.25 inclusion threshold and were carried forward as candidate adjusters.

Table 3. Bivariate logistic regression — crude associations with in-hospital mortality (N = 209)

Variable	Category	Crude OR (95% CI)	p-value
Birth weight	<1000 g	1.00 (reference)	—
	1000–1499 g	0.24 (0.10–0.56)	**<0.001**
	≥1500 g	0.10 (0.04–0.26)	**<0.001**
5-min Apgar score	Per 1-point increase	0.72 (0.61–0.85)	**<0.001**
Hypertensive disorder of pregnancy	Yes vs no	1.73 (0.80–3.76)	0.164
Maternal urinary tract infection	Yes vs no	2.82 (1.08–7.40)	**0.035**
Mode of delivery	Caesarean vs spontaneous	0.41 (0.23–0.75)	**0.003**
Antenatal corticosteroids	Yes vs no	0.70 (0.41–1.22)	0.214
Maternal age	Per year	0.97 (0.92–1.01)	0.157

OR = odds ratio; CI = confidence interval. Statistically significant values (p < 0.05) are shown in red.

Multivariable analysis

In the final multivariable binary logistic regression model (Table 4; Figure 4), birth-weight stratum and 5-minute Apgar score remained independently associated with mortality. Compared with infants <1000 g, those weighing 1000–1499 g had an adjusted OR of 0.36 (95% CI 0.15–0.90; p=0.029), and those weighing ≥1500 g had an adjusted OR of 0.17 (95% CI 0.06–0.51; p=0.001). Each 1-point increment in 5-minute Apgar score was associated with an adjusted OR of 0.81 (95% CI 0.67–0.98; p=0.031). Maternal urinary tract infection demonstrated a strong trend

toward higher mortality (aOR 2.85, 95% CI 0.97–8.35; p=0.057). The Hosmer–Lemeshow test indicated adequate calibration (x^2=6.31, df=8, p=0.612), Nagelkerke R^2 was 0.286, and the AUC was 0.787 (95% CI 0.72–0.84) (Figure 5). VIFs ranged from 1.07 to 1.63, indicating no problematic multicollinearity.

Table 4. Multivariable binary logistic regression for in-hospital mortality (N = 209; 88 events)

Variable	Category	aOR (95% CI)	p-value
Birth weight	<1000 g	1.00 (reference)	—
	1000–1499 g	0.36 (0.15–0.90)	**0.029**
	≥1500 g	0.17 (0.06–0.51)	**0.001**
5-min Apgar score	Per 1-point increase	0.81 (0.67–0.98)	**0.031**
Hypertensive disorder of pregnancy	Yes vs no	1.23 (0.51–2.97)	0.647
Maternal urinary tract infection	Yes vs no	2.85 (0.97–8.35)	0.057
Mode of delivery	Caesarean vs spontaneous	0.59 (0.30–1.17)	0.130
Antenatal corticosteroids	Yes vs no	0.60 (0.32–1.13)	0.113
Maternal age	Per year	0.98 (0.93–1.03)	0.440

Model fit: Hosmer–Lemeshow x^2=6.31 (df 8), p=0.612; Nagelkerke R^2=0.286; AUC 0.787 (95% CI 0.72–0.84). VIF range 1.07–1.63. Intermediate-outcome variables (RDS, surfactant therapy) were excluded a priori. aOR = adjusted odds ratio; CI = confidence interval. Statistically significant values (p < 0.05) are shown in red.

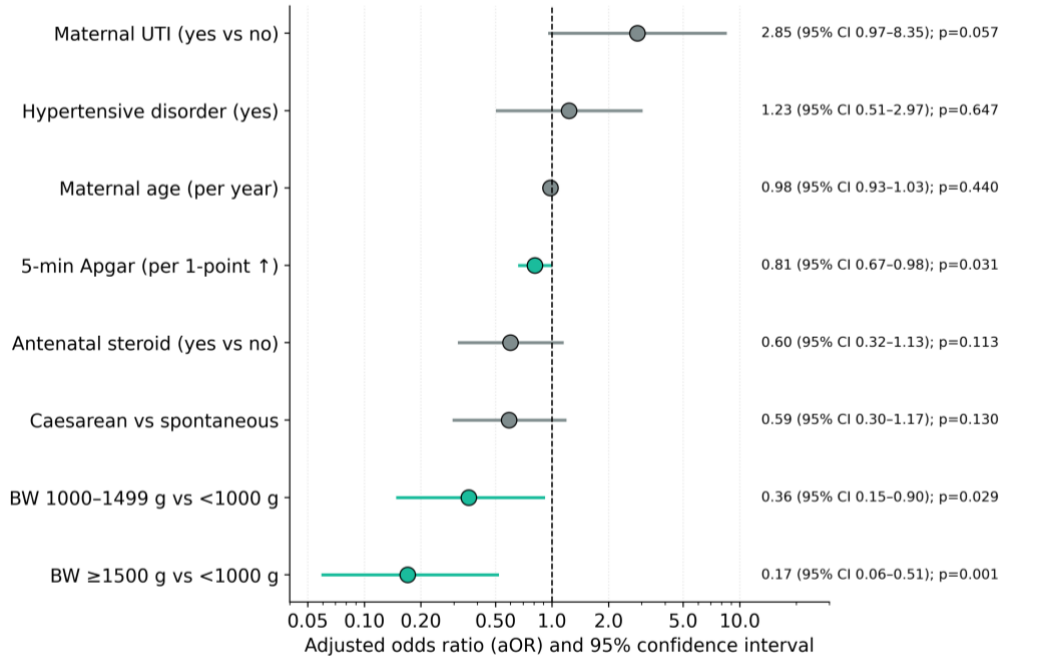

Figure 4. Forest plot of adjusted odds ratios from the final multivariable model (N = 209). Markers represent point estimates; horizontal lines represent 95% confidence intervals. Green markers denote statistically significant predictors (p < 0.05). The vertical dashed line indicates the null OR of 1.0. aOR = adjusted odds ratio; UTI = urinary tract infection.

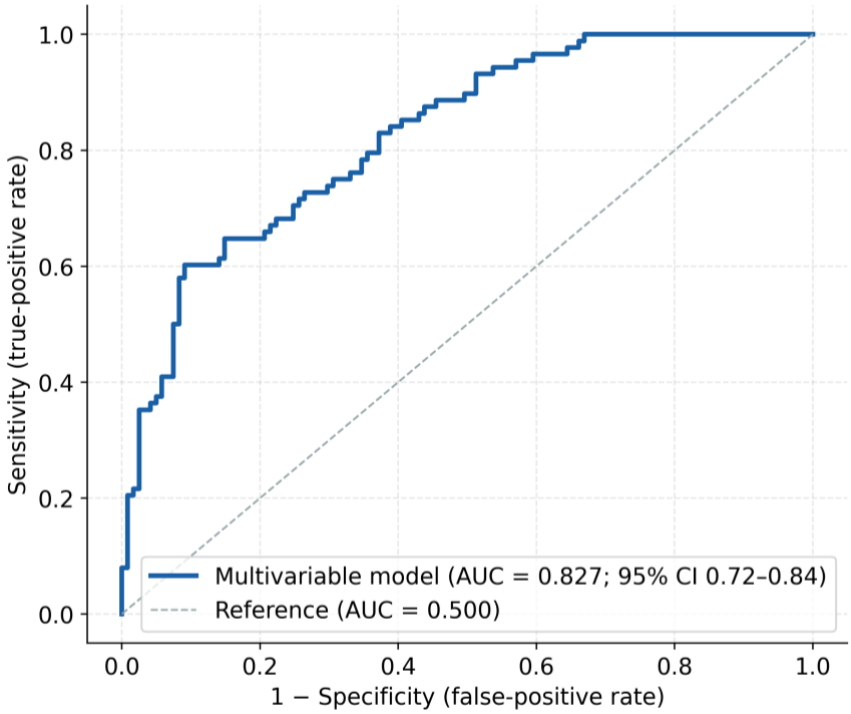

Figure 5. Receiver-operating-characteristic curve for the final multivariable model predicting in-hospital mortality (N = 209; 88 events). The model yielded an AUC of 0.787 (95% CI 0.72–0.84) by DeLong's method. The diagonal reference line corresponds to chance prediction (AUC = 0.500).

4. Discussion

In this single-centre retrospective cohort of 209 preterm neonates admitted to an Indonesian tertiary referral NICU between September 2024 and September 2025, in-hospital mortality was 42.1% and was driven primarily by sepsis (56.8% of deaths) and RDS (30.7%). In multivariable analysis with causal-pathway-aware adjustment, birth-weight stratum and 5-minute Apgar score remained independent predictors of mortality: infants weighing 1000–1499 g and ≥1500 g had 64% and 83% lower odds of death, respectively, than infants <1000 g, and each 1-point increase in 5-minute Apgar score reduced the odds of death by 19%. Maternal urinary tract infection showed a strong trend toward higher mortality. The model exhibited acceptable discrimination (AUC 0.787) and adequate calibration (Hosmer–Lemeshow p=0.612).

The 42.1% in-hospital mortality observed here is broadly consistent with contemporary Southeast Asian tertiary-NICU literature and is markedly higher than the 8–15% reported by the U.S. NICHD Neonatal Research Network at comparable gestational ages.[14-16] The gap is not explained primarily by infant biology but reflects system-level differences in antenatal corticosteroid coverage, antenatal surveillance, surfactant access, and sepsis-prevention infrastructure. Our cohort's antenatal corticosteroid coverage of 55%, well below the ≥85% recommended by the European RDS guideline and WHO, and surfactant administration rate of 17.7%, well below high-income-country benchmarks of 60–70%, identify two specific modifiable drivers.[17-19]

The strong inverse association between birth weight and mortality is consistent with the Vermont Oxford Network and NICHD Neonatal Research Network datasets that have documented near-monotonic declines in mortality across the same 1000-g and 1500-g cut-offs.[20,21] The aOR of 0.17 for infants ≥1500 g corresponds to a relative-risk reduction of approximately 70%. Mechanistically, the steep birth-weight gradient is biologically anchored in convergent multi-organ immaturity: quantitative SP-B and SP-C deficiency together with ABCA3 immaturity drives RDS;[23] fragility of germinal-matrix vasculature predisposes to IVH;[10,11] and innate-immune ontogeny predisposes to overwhelming sepsis. The combination of these vulnerabilities in <1000-g infants produced the 75% mortality observed in our cohort and is

consistent with 60–80% mortality reported in comparable LMIC cohorts.[21,22]

The protective effect of higher 5-minute Apgar scores is fully consistent with the contemporary Swedish national cohorts reported by Cnattingius et al. and Razaz et al., which documented a roughly log-linear gradient between 5-minute Apgar and mortality, with a 12–22% relative mortality reduction per point.[23-25] Our per-point aOR of 0.81 (19% reduction per point) falls squarely within this range. The 5-minute Apgar integrates the four major physiological transitions of birth; a low score signals a failed transition that activates the systemic inflammatory response and hypoxic–ischaemic cytokine cascades, with downstream multi-organ dysfunction. Its independent effect after adjustment for birth weight indicates that resuscitation quality and golden-hour care are independently modifiable determinants of mortality.[24]

The trend-level signal for maternal urinary tract infection (aOR 2.85; 95% CI 0.97–8.35; p=0.057) is biologically and epidemiologically plausible. The bivariate association was robust (crude OR 2.82; p=0.035) and the multivariable estimate remained large, with the lower bound of the 95% CI approaching unity; the non-significance likely reflects the limited number of UTI cases (n=20) rather than the absence of a true effect. The biological pathway involves bacterial-mediated activation of the chorioamniotic NF-κB pathway and chorioamnionitis-driven cytokine response that predisposes the fetus to sepsis after birth.[26] Maternal UTI is universally screenable and treatable, and universal antenatal urine culture in the third trimester with first-line antibiotic treatment for asymptomatic bacteriuria is a low-cost intervention that could plausibly reduce a substantial fraction of subsequent neonatal sepsis.

The dominance of sepsis (56.8% of deaths) and RDS (30.7%) reflects two tightly coupled biological pathways. Surfactant deficiency in the immature lung increases alveolar collapse and tidal-volume requirements, predisposing to ventilator-induced lung injury, which upregulates NF-κB-mediated proinflammatory signaling and amplifies systemic cytokine activity.[21] The immature innate immune system — hyporesponsive toll-like-receptor signaling, reduced antigen-presenting-cell function, deficient antimicrobial-peptide expression, and slow neutrophil recruitment — leaves preterm infants vulnerable to nosocomial pathogens. A single sepsis event can precipitate hemodynamic instability and impair cerebrovascular autoregulation, increasing the risk of IVH. This coupling explains why interventions targeting either pathway — for example, antenatal corticosteroids that simultaneously accelerate alveolar maturation and enhance early innate immunity — produce outsized mortality benefits.[26]

The translational implications are concrete. The combination of birth weight and 5-minute Apgar score forms a parsimonious bedside risk-stratification framework available within minutes of admission, requiring no laboratory tests; infants with birth weight <1000 g and 5-minute Apgar ≤5 represent the highest-risk subgroup in whom immediate surfactant administration, early targeted echocardiography, and aggressive sepsis-prevention bundling are justified. The 55% antenatal corticosteroid coverage represents the single highest-yield quality-improvement target, since the WHO ACTION-1 trial demonstrated a 16% relative mortality reduction with dexamethasone in LMIC settings and the McGoldrick et al. Cochrane meta-analysis estimates a 22% relative reduction overall.[25] The maternal-UTI signal supports universal third-trimester urine culture as a primary-prevention strategy, and the centre-level mortality gap identifies room for improvement through golden-hour bundles and structured NICU quality-improvement collaboratives modelled on the Vermont Oxford Network.[24]

Strengths of this study include total sampling over a 13-month period, prospective ascertainment of morbidities using standardized criteria, separation of intermediate-outcome variables from causal-pathway adjusters in the multivariable model, reporting of effect sizes with 95% CIs and exact p-values to three decimal places, and a complete cause-of-death decomposition that is rare in Indonesian NICU literature. Limitations should be considered: the single-centre tertiary-referral nature limits generalisability; outborn infants (27.3%) may carry

residual confounding from pre-transport instability; retrospective record review is vulnerable to misclassification, particularly for clinical sepsis (culture-confirmed in only 21.4% of early-onset sepsis episodes); the limited number of UTI (n=20) and chorioamnionitis (n=7) cases constrains power for these predictors; socio-economic confounders were not measured; and longer-term neurodevelopmental outcomes could not be assessed within the hospital-stay window.

5. Conclusion

In this contemporary Indonesian tertiary-referral NICU cohort, in-hospital mortality among preterm neonates remained high at 42.1% and was driven primarily by neonatal sepsis (56.8%) and respiratory distress syndrome (30.7%). Birth-weight stratum and the 5-minute Apgar score were independent, immediately measurable predictors of mortality: infants ≥1500 g had 83% lower odds of death than infants <1000 g (aOR 0.17; 95% CI 0.06–0.51), and each 1-point increment in 5-minute Apgar score reduced the odds of death by 19% (aOR 0.81; 95% CI 0.67–0.98). Maternal urinary tract infection emerged as a strong, clinically actionable upstream signal (aOR 2.85; p=0.057). Translation of these findings should prioritise deployment of a parsimonious birth-weight-plus-Apgar bedside risk score at NICU admission, systematic audit and escalation of antenatal corticosteroid coverage from the current 55% toward the ≥85% WHO standard, and universal antenatal urine-culture screening with prompt treatment of asymptomatic bacteriuria, implemented through a structured neonatal quality-improvement collaborative.

6. References

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