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Assessing Cost Drivers and a Preliminary Costing Model for Low Birth Weight Neonates in The Neonatal Intensive Care Unit at Rumah Sakit Universitas Airlangga

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ABSTRACT

Low birth weight neonates receiving neonatal intensive care require substantial resources, but the relationship between hospital costs and reimbursement remains important to clarify. This retrospective cohort study identified cost drivers and compared actual costs with BPJS claims among 19 low birth weight neonates with medical complications admitted to the neonatal intensive care unit of Universitas Airlangga General Academic Hospital in 2025. Medical records and financial data were analyzed using descriptive statistics, Spearman correlation, Mann–Whitney U tests, multiple linear regression, and a Wilcoxon signed-rank test. Mean actual cost was IDR19,378,544.74 ± 13,137,212.47, with pharmacy, room, and medical devices representing the largest recorded components. Length of stay showed the strongest correlation with actual cost ($\rho = 0.869$, $p < 0.001$) and remained independently associated with log-transformed cost ($B = 0.069$, $\beta = 0.809$, $p < 0.001$). Each additional hospitalization day was associated with an estimated 7.1% higher cost after adjustment for diagnosis count. The model explained 68.5% of variation in ln (actual cost). Transfusion was associated with higher costs (exact $p = 0.033$), although only three neonates received transfusion. Mean BPJS reimbursement was IDR15,695,789.47, yielding a mean claim-minus-cost gap of –IDR3,682,755.26; the paired difference was not statistically significant ($p = 0.334$). Length of stay was the strongest independent cost correlate in this sample. These findings support further development of a costing model, but do not establish predictive validity or an effect of reimbursement discrepancies on clinical decisions.

Keywords: low birth weight; neonatal intensive care unit; cost drivers; hospital costs; BPJS reimbursement; length of stay; costing model

INTRODUCTION

Low birth weight (LBW), defined as birth weight below 2,500 g, identifies neonates at increased risk of adverse health outcomes [1]. Infants with medical complications may require neonatal intensive care, including respiratory support, medication, nutritional support, diagnostic investigations, and prolonged monitoring. The financial demands of this care vary with clinical condition and the resources used during hospitalization.

Neonatal costing studies have linked expenditure to hospitalization duration and intensity of care. A Malaysian study identified length of stay, birth weight, and sex as cost predictors, while laboratory investigations contributed prominently to consumable costs [2]. Research evaluating a neonatal costing algorithm also demonstrates the importance of assessing resource use when estimating NICU expenditure [3]. These findings support investigation of locally relevant cost drivers rather than assuming that cost estimates transfer directly between institutions.

Actual hospital cost, hospital billing, and insurance reimbursement represent different financial measures. Resource consumption is not necessarily equivalent to the amount charged under hospital tariffs or reimbursed by an insurer. Distinguishing these measures is necessary when examining whether payments correspond to recorded care costs. Transparent reporting of resource measurement and valuation is also central to interpreting health economic evidence [4].

This study examined LBW neonates treated at Universitas Airlangga General Academic Hospital in 2025. Its objectives were to describe recorded cost components, identify clinical and resource-use variables associated with actual cost, and compare actual costs with BPJS claims. An exploratory regression model was evaluated as a preliminary

basis for subsequent costing-model development.

MATERIALS AND METHODS

Study design and participants

A retrospective cohort study was conducted using medical records and financial data from the NICU of Universitas Airlangga General Academic Hospital, Surabaya, Indonesia. Total sampling was used to identify eligible LBW neonates with medical complications admitted during 2025. The stated inclusion criteria were birth weight approximately 1,500–2,500 g, NICU admission, and complete medical records. Infants with incomplete records and those who died during NICU hospitalization were excluded. The final analytic sample comprised 19 neonates, with observed birth weights of 1,500–2,430 g.

Variables and financial measures

Extracted variables included birth weight, length of stay, diagnosis count, core complication count, diagnostic test count, medical supply count, and NICU interventions. Financial measures were the hospital dataset's actual cost, hospital billing, and BPJS claim for each admission. Recorded cost components comprised pharmacy, room, medical devices, blood tests, laboratory services, radiology, and oxygen. All monetary values are reported in Indonesian rupiah (IDR). The claim gap was defined as BPJS claim minus actual cost; negative values indicate claims below recorded actual costs. The coverage ratio was defined as claim divided by actual cost, and cost per day as actual cost divided by length of stay.

Statistical analysis

Continuous variables were summarized using means, standard deviations (SD), and ranges, and categorical variables using frequencies and percentages. Because cost data were reported as non-normally distributed, Spearman correlation was used to examine associations between actual cost and candidate drivers. Mann–Whitney U tests compared costs by transfusion, invasive ventilation, and parenteral nutrition status. Actual costs and BPJS claims were compared using the paired Wilcoxon signed-rank test.

Multiple linear regression used ln(actual cost) as the dependent variable and length of stay and diagnosis count as predictors. Model fit was summarized using R^2, adjusted R^2, and the F statistic. Unstandardized coefficients (B), standardized coefficients (β), p-values, tolerance, and variance inflation factors (VIF) were reported. The proportional change associated with an additional day was calculated as $[\exp(B) - 1] \times 100\%$. Associations were interpreted at $p < 0.05$. Analyses were exploratory; the reported regression does not constitute independent validation of a prediction algorithm.

Ethical considerations

The study was undertaken following permission and approval from Universitas Airlangga General Academic Hospital. Patient identities were kept confidential and were not included in the report. [Ethics committee name, approval number and date, and informed-consent or waiver details to be supplied by the authors.]

RESULTS

Clinical characteristics and resource use

Nineteen neonates were included. Length of stay ranged from 1 to 34 days. Mean diagnosis count was 6.47 ± 2.39 (range 2–13), mean core complication count was 1.00 ± 0.67, mean medical supply count was 8.00 ± 18.03, and mean diagnostic test count was 8.68 ± 6.46. Life-support devices and injectable antibiotics were each recorded for 17 neonates (89.5%). Selected interventions are summarized in Table 1.

TABLE 1: Selected Nicu Interventions (N = 19).

Intervention	N	%
Invasive ventilation	14	73.7
Oxygen support	14	73.7
NIV/CPAP	13	68.4
Enteral nutrition	13	68.4
Parenteral nutrition	12	63.2
Cardiopulmonary resuscitation	9	47.4
Umbilical catheterization	8	42.1
Phototherapy	6	31.6
Intubation	4	21.1
Blood transfusion	3	15.8

NIV, non-invasive ventilation; CPAP, continuous positive airway pressure. Interventions were not mutually exclusive.

Costs and reimbursement

Mean actual cost was IDR19,378,544.74 ± 13,137, 212.47, ranging from IDR5,142,880 to IDR57, 037,254. Mean hospital billing exceeded mean actual cost, while mean BPJS claims were lower (Table 2). The mean claim-minus-cost gap was −IDR3,682,755.26 ± 10,585,653.90. Mean patient-level coverage ratio was 0.996 ± 0.461, and mean cost per day was IDR1,760,346.00 ± 1,636,782.86. The mean of individual coverage ratios should be distinguished from the ratio of mean claim to mean cost.

TABLE 2: Financial Measures (IDR Million).

MEASURE	MEAN ± SD	RANGE
Actual cost	19.38 ± 13.14	5.14–57.04
BPJS claim	15.70 ± 8.17	8.74–40.91
Hospital billing	34.84 ± 22.07	10.58–94.96
Claim − actual cost	−3.68 ± 10.59	−34.65–8.16
Cost per day	1.76 ± 1.64	0.57–8.31

Values are rounded to two decimals in this table. SD, standard deviation; IDR, Indonesian rupiah.

Pharmacy was the largest recorded cost component, followed by room and medical devices (Table 3). These categories accounted for most of the recorded expenditure. Blood tests, laboratory services, radiology, and oxygen contributed smaller mean amounts.

TABLE 3: Mean Recorded Cost Components.

Component	Mean Cost (IDR)
Pharmacy	7,074,876.32
Room	5,265,789.47
Medical devices	5,086,842.11
Blood tests	742,736.84
Laboratory services	582,526.32
Radiology	430,089.47
Oxygen	195,684.21

The paired comparison of actual cost and BPJS claim was not statistically significant (Wilcoxon W = 71.000, p = 0.334). Thus, the descriptive difference between average cost and average reimbursement was not accompanied by a statistically significant paired difference in this sample.

Bivariate associations

Length of stay showed the strongest positive correlation with actual cost (ρ = 0.869, p < 0.001). Diagnostic test count, diagnosis count, and medical supply count were also positively correlated with cost. Birth weight, intervention count, and core complication count were not significantly associated with actual cost (Table 4).

TABLE 4: Correlations with Actual Cost.

Variable	ρ	p
Length of stay	0.869	<0.001
Diagnostic test count	0.714	<0.001
Diagnosis count	0.484	0.036
Medical supply count	0.468	0.043
Intervention count	0.352	0.139
Core complication count	0.252	0.298
Birth weight	0.103	0.675

ρ, Spearman rank correlation coefficient.

Transfusion status was associated with a difference in actual cost (U = 43.000, exact p = 0.033). The mean cost rank was 16.33 among transfused neonates and 8.81 among those not transfused. Differences were not statistically significant for invasive ventilation (U = 46.000, exact p = 0.343; mean ranks 10.79 versus 7.80) or parenteral nutrition (U = 50.000, exact p = 0.536; mean ranks 10.67 versus 8.86).

Exploratory regression model

The regression model containing length of stay and diagnosis count was statistically significant (F [2,16] = 17.417, p < 0.001), with R^2 = 0.685 and adjusted R^2 = 0.646. Length of stay remained independently associated with ln (actual cost), while diagnosis count did not (Table 5). The coefficient for length of stay corresponds to an estimated 7.1% higher cost per additional day after adjustment for diagnosis count. Tolerance was 0.638 and VIF was 1.567, indicating no substantial collinearity between the two predictors.

TABLE 5: Regression for LN (Actual Cost).

Predictor	B	β	p
Length of stay	0.069	0.809	<0.001
Diagnosis count	0.008	0.031	0.864

B, unstandardized coefficient; β, standardized coefficient. Model n = 19; R^2 = 0.685; adjusted R^2 = 0.646.

DISCUSSION

Hospitalization duration and resource intensity

Length of stay was the strongest independent cost correlate among the variables included in the regression. This finding is compatible with accumulation of resource use during hospitalization, including accommodation, medications, monitoring, and supportive care. The association persisted after adjustment for diagnosis count, whereas the bivariate association between diagnosis count and cost did not. Greater diagnostic complexity may coincide with longer hospitalization, but the present analysis cannot establish the direction or causal structure of these relationships.

The association between hospitalization duration and cost is consistent with Zainal et al., who included length of stay in a neonatal cost-prediction model [2]. However, the present sample was restricted to 19 LBW neonates from one hospital, and the magnitude of its association should not be generalized to other populations without validation. Length of stay is also determined by clinical recovery; a cost association alone does not justify earlier discharge or limiting necessary care.

Diagnostic testing and medical supply counts were positively associated with actual cost. These findings suggest that hospitalization duration and intensity of care both warrant attention in resource planning. Laboratory investigations were also relevant to consumable costs in the Malaysian study [2]. In the present study, diagnostic and supply counts were assessed as bivariate correlates, rather than independent predictors in the final regression, and may reflect underlying severity or longer hospitalization.

Interpretation of intervention-related costs

Transfused neonates had higher cost ranks, but only three received transfusions. This association may reflect a more complicated clinical course rather than a distinct causal effect of transfusion on total costs. The small subgroup and multiple exploratory comparisons make the finding provisional. Likewise, non-significant differences for ventilation and parenteral nutrition do not establish that these treatments have no cost implications. Limited power,

overlapping interventions, and differences in treatment duration may obscure their associations.

Cost composition and BPJS reimbursement

Pharmacy, room, and medical devices dominated the recorded cost components. These results describe the categories available in the local dataset and should not be interpreted as a complete comparison of economic cost structures across hospitals. Costing methods differ in how they allocate personnel, equipment, and overhead. For example, Zainal et al. reported a large contribution from overhead and personnel expenditure using a mixed costing approach [2]. Comparisons therefore require consistent definitions and transparent valuation methods [4].

Average BPJS reimbursement was below average actual cost, with a mean gap of approximately IDR3.68 million per admission. However, the paired test was not significant. The data support a descriptive reimbursement gap within the observed sample, but do not establish systematic under-reimbursement across all comparable admissions. Conversely, the non-significant test does not demonstrate equivalence between costs and reimbursement. The small sample and wide variation in patient-level gaps limit the precision of either conclusion.

Hospital billing was higher than both actual cost and BPJS reimbursement. This pattern reinforces the need to keep charges, recorded costs, and payments separate when interpreting financial performance. The available records did not assess whether reimbursement considerations altered treatment, discharge, referral, or continuity of care. Consequently, a direct effect of reimbursement discrepancies on clinical decisions cannot be inferred.

Implications for a costing model

The two-predictor model explained 68.5% of variation in log-transformed cost within the development sample. This provides preliminary information about candidate predictors, but in-sample explanatory fit is not evidence of predictive accuracy in new patients. Published neonatal algorithm research provides a relevant methodological comparison [3]; the present study does not report a corresponding validation exercise. Larger datasets should evaluate calibration, prediction error, and performance outside the development sample before clinical or financial use.

Strengths and limitations

The study combined clinical, resource-use, and financial information and distinguished actual cost from hospital billing and reimbursement. Bivariate and multivariable analyses also allowed observed correlates to be separated from predictors retained after adjustment. Nevertheless, its retrospective, single-center design and sample of 19 neonates limit statistical power and generalizability. Exclusion of deaths and incomplete records may additionally restrict applicability to more severe cases.

The narrow-observed birth-weight range may limit detection of a birth-weight association. Co-occurring interventions and unmeasured severity may confound cost comparisons, while counts do not capture the duration or intensity of every treatment. Detailed cost-allocation methods, coefficient confidence intervals, and comprehensive regression diagnostics were not available in the reported analysis. No external validation or direct assessment of clinical consequences of reimbursement discrepancies was performed. These limitations require the findings to be treated as exploratory.

CONCLUSIONS

Length of stay was the strongest independent correlate of recorded actual NICU cost among 19 LBW neonates at Universitas Airlangga General Academic Hospital. Diagnostic testing, diagnosis count, medical supply use, and transfusion were associated with costs in bivariate analyses. Mean BPJS reimbursement was descriptively lower than mean actual cost, but the paired difference was not statistically significant. The findings support further investigation of cost drivers and development of a costing model using larger, multicenter datasets; they do not establish a validated algorithm or an effect on clinical decision-making.

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