

COST-ANALYSIS OF REDUCING MORTALITY RATE FOR LBW BABIES AT FATMAWATI HOSPITAL'S NICU

Analisis Biaya Perbaikan Pelayanan Pada BBLR di NICU RSUP Fatmawati

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Abstract

Background: As a developing country that still struggles with infant mortality, Indonesia needs high-quality and efficient neonatal care. However, due to the complexity of neonatal care, the neonatal intensive care unit (NICU) still has a high cost, approximately USD 950 - 31,000, as the last line of care.

Aims: This study analyzes the cost incurred due to service improvement at Fatmawati General Hospital. The cost analysis may serve as useful evidence for other hospitals with NICUs that seek to improve their service.

Methods: We used cost analysis to examine pre-intervention costs in 2015 and post-intervention costs in 2021. Our data were gathered primarily in the NICU of Fatmawati General Hospital for three months in 2023.

Results: The results showed an increase in total cost of IDR 1,898,040,489 (55%). The largest cost increase was personnel and supplies costs, which accounted for 83.8% of the cost increase. However, this cost increase was also followed by a significant decrease in mortality rates, from 128 deaths per 1,000 births to 17 deaths per 1,000 births.

Conclusion: This study found a correlation between investment in service improvements and decreased infant mortality rates in the NICU of Fatmawati General Hospital. Although the 55% increase in total cost was associated with a significant decrease in infant mortality rates in the NICU of Fatmawati General Hospital, further studies are needed to determine the effectiveness of improvements in the NICU's services.

Keywords: cost, Indonesia, LBW, NICU

Abstrak

Latar Belakang: Sebagai lini akhir penanganan neonatus, Neonatal Intensive Care Unit (NICU) memiliki biaya rawat yang tinggi, sekitar 950 – 31,000 USD. Dengan kompleksitas yang dimiliki ranah neonatus, dibutuhkan tenaga medis dengan fasilitas serta kemampuan berkualitas tinggi. Sebagai salah satu negara berkembang dengan tingkat mortalitas yang masih tinggi, Indonesia membutuhkan perawatan neonatal yang berkualitas dan efisien.

Tujuan: Penelitian ini bertujuan untuk menganalisa biaya yang dibutuhkan untuk memperbaiki pelayanan di NICU RSUP Fatmawati.

Metode: Peneliti menggunakan cost analysis untuk melihat biaya pra-intervensi di 2015, dan biaya paska-intervensi di 2021. Data diambil secara primer di NICU RSUP Fatmawati selama tiga bulan di 2023.

Hasil: Hasil menunjukkan adanya peningkatan dalam biaya total sebesar IDR 1,898,040,489 (55%). Peningkatan terbesar disebabkan oleh biaya personnel dan supplies, mendominasi 83.8% dari peningkatan biaya. Namun, dalam periode yang sama, terlihat pula adanya penurunan angka mortalitas, yang menurun dari 128 kematian per 1000 kelahiran menjadi 17 kematian per 1000 kelahiran.

Kesimpulan: Terdapat korelasi antara investasi untuk perbaikan pelayanan yang dilakukan dan penurunan tingkat mortalitas di NICU RSUP Fatmawati. Peningkatan biaya 55% dari total biaya menunjukkan penurunan signifikan untuk tingkat mortalitas NICU RSUP Fatmawati. Penelitian lanjutan dibutuhkan untuk melihat efektivitas perbaikan pelayanan NICU RSUP Fatmawati.

Kata kunci: Biaya, Indonesia, BBLR, NICU



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Introduction

Infant health and well-being issues are being addressed globally. Goal 3.2 of the United Nations Sustainable Development Goals (SDGs) states that one of its goals is to reduce preventable deaths of newborns to as low as 12 per 1,000 live births by 2030 (UN, 2023). As of 2021, Indonesia's infant mortality rate remained at 19 per 1,000 live births, even after Indonesia regained its status as an upper middle-income country (Indonesian Ministry of Finance, 2023; UNICEF, 2023).

According to data for three consecutive years from the Indonesian Ministry of Health, LBW/ prematurity was the main cause of infant mortality, and the figure was around 27% annually (Table 1). Premature birth occurs when a baby is born before completing 37 weeks of gestation. The more premature a baby is, the greater the risk of mortality and morbidity. Premature babies may experience breathing difficulties, digestive problems, bleeding in the brain, and may have long-term effects such as stunted growth during childhood (CDC, 2022).

Table 1. Three Leading Causes of Death in Indonesian Neonates

Causes of Death	Incidence		
	2019	2020	2021
LBW	27.33%	27.76%	27.60%
Asphyxia	20.42%	21.63%	22.19%
Congenital	9.95%	8.97%	12.36%

Source: Ministry of Health (2022)

As the last line of neonatal care, where premature infants with complications are usually cared for, a neonatal intensive care unit (NICU) is one of the more expensive forms of care. Sharma and Murki (2021) made a summary of NICU costs from a literature study of various studies related to cost analysis in the NICU while Karambelkar *et al.* (2016) examined 126 neonates in India who were treated in the NICU for various diseases. It is estimated that approximately USD 90.7 is spent every day for care in the NICU. Narang *et al.* (2005) showed that the expenditure for each baby admitted to the NICU has several classifications. For extreme low

birth weight (ELBW) babies, it is around 3,800 USD, for babies between 1,000g and 1,250g, it is approximately USD 2,000, and for babies between 1,250g and 1500g, it is around USD 950 (Narang *et al.*, 2005). Meanwhile, Kirkby *et al.* (2007) found that the average cost for each preterm infant admitted to the NICU is USD 31,000.

Although it is difficult to make a balanced comparison for each costing study of the NICU, it can be concluded that managing a neonatal unit has significant costs. The complexity of neonatal unit management can be attributed to the high nurse/patient ratio and high expertise needed to solve neonatal problems (Sharma and Murki, 2021). With all the complexities and difference, and costly NICU treatments in multiple countries, it is important for Indonesia to have publications on NICU costs. To the best of our knowledge, no literature has discussed the empirical cost of NICU in Indonesia.

In addition to infants' early complications, their underdeveloped immune system makes them at greater risk of infection. Unfortunately, infection can sometimes occur during hospitalization, which is called healthcare associated infections (HAIs). The impact of HAIs can be morbidity, mortality, or financial burden to various stakeholders such as patients, their families, and the country's healthcare system (Sikora and Zahra, 2022). The US Center for Disease Control and Prevention states that, every year, nearly 1.7 million treated patients develop HAIs, and more than 98,000 of them die from HAIs. The prevalence of HAIs documented in the data shows that approximately 3.2% of all US patients and 6.5% of all patients in the European Union are affected by HAIs, and even higher rates worldwide (Allegranzi *et al.*, 2011; Magill *et al.*, 2018; Suetens *et al.*, 2018).

The occurrence rate of HAIs in the neonatal intensive care unit is around 30%, and 40% of neonatal deaths in developing countries are due to such infections (Pessoa-Silva *et al.*, 2004; Zaidi *et al.*, 2005). There are several reasons why HAIs are increasingly dangerous, with hospitals hosting more patients with weakened immune systems. In addition, with the

outpatient system, the risk for pathogen spread is higher. Sanitation protocols are lacking, and sterilization of equipment by medical staff is not strict. Widespread use of anti-microbial drugs also has a negative impact due to accumulation of anti-microbial resistance. Increased infections are associated with longer hospital length of stay, long-term disability, socioeconomic disruption, and increased mortality (Khan *et al.*, 2017). In addition, newborns admitted to the NICU are at risk for HAIs due to their physiologic instability, exposure to invasive medical equipment, and broad-spectrum antibiotics (NNIS, 2004; Singh, 2004; Sohn *et al.*, 2001). Infection rates in NICUs are also higher than those in well-baby nurseries, with infection rates in NICUs ranging from 6 to 40 per 100 admissions, while infection rates in well-baby nurseries range from 0.3 to 1.7 per 100 admissions (Scheckler and Peterson, 1986; Welliver and McLaughlin, 1984).

Neonatal care is a difficult and expensive domain to implement. If not managed properly, the effectiveness and efficiency of the NICU can be questioned and can place a significant financial burden on healthcare budgets. The high cost in NICUs also makes many hospitals management reluctant to invest in NICUs, especially in the treatment of LBW babies. Therefore, a cost analysis study is needed to provide evidence of the cost of improving NICU service and the extent to which infant mortality rates have changed. Furthermore, we aim to provide evidence for other hospitals with NICUs that also seek to improve their services.

Method

This study used a cost analysis method. The cost analysis referred to in this study is mainly a description of the direct cost with a health facility perspective, unlike other economic evaluation methods such as cost effectiveness analysis (CEA) that compares the cost to an outcome. This distinction is mentioned in Drummond *et al.* (2015).

Table 2. Measurement of costs and consequences in economic evaluation

Type of Study	Measurement of Cost	Measurement of Consequences
Cost Analysis	Monetary Units	None
Cost Effectiveness Analysis	Monetary Units	Natural units (e.g. life years gained, DALY)
Cost Utility Analysis	Monetary Units	Healthy years (quality adjusted life years)
Cost Benefit Analysis	Monetary Units	Monetary Units

Source: Drummond *et al.* (2015)

To record costs for the two periods, we used primary observation, medical records, and financial records to obtain the required data. The data were gathered in Fatmawati General Hospital from January to March 2023. We also conducted interviews with health personnel to clarify and complete our data. Data about infant mortality rates were obtained from the medical records of the NICU division. The unit of analysis was the NICU division of Fatmawati Hospital, with LBW patients. The population of this study was all patients admitted to the NICU in 2015 and 2021.

The period of 2015 and 2021 is chosen to represent the period of pre-intervention and post-intervention. This is due to the fact that the intervention started in 2016, and, in 2021, the period represents a NICU that already has an established improvement.

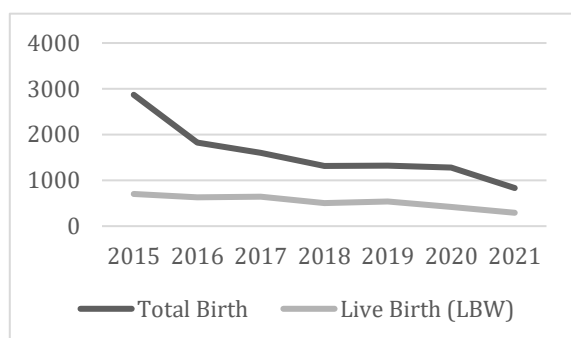
Results and Discussion

In 2015, changes came to Fatmawati General Hospital. The hospital was granted referral hospital status (*rumah sakit rujukan*), which means that it was required to treat patients referred from hospitals within the region. The NICU division of Fatmawati General Hospital was also affected by this policy. This policy also had significant consequences for the services provided.

Since 2015, there has been a continuous decline in births at Fatmawati General Hospital, from a total of 3,109 births in 2015 to 914 in 2021 (Figure 1).

There has been a 70.6% decrease in birth at Fatmawati General Hospital in just six years. However, this decrease in the birth rate does not mean a reduction in the burden on Fatmawati General Hospital, but rather an effort to focus on specializing in the treatment of critically ill patients.

The neonatal intensive care unit (NICU) of Fatmawati General Hospital, one of the healthcare divisions that has a high level of difficulty (Sharma and Murki, 2021), has begun to reduce the number of incoming patients and to treat more patient referrals from other hospitals since 2015, as seen in Figure 1. Patients are usually referred when the referring hospital determines that they are unable to treat the patient. Thus, although the number of patients admitted to the NICU at Fatmawati Hospital has decreased, its difficulty has increased.



Source: Primary Data, 2023

Figure 1. Total and LBW Birth in Fatmawati General Hospital, 2015 - 2021

One of the patient categories that make up the new NICU patient profile is LBW patients. Figure 1 shows that the decrease in total births was much more dramatic than the decrease in LBW patients. Therefore, LBW patients in the NICU also increased, from 24.5% in 2015 to 35.1% in 2021.

The increasing case-by-case difficulty also became one of the foundations for the NICU division of Fatmawati Hospital to implement service improvements. This improvement began in 2016. Some of the service improvements included moving the location of the NICU, the addition of an NICU consultant doctor, a decrease in the patient-per-nurse ratio, purchase of additional medical equipment,

the use of more disposable supplies to reduce infection, the use of total parenteral nutrition (TPN) fluids for infant nutrition, including the added resources needed for its material and labor costs.

In neonatal care, both after and before the improvements, there was no significant difference in the care procedure of LBW or non-BLW. However, the percentage of LBW, the leading cause of death for neonates, continued to increase in the NICU. In addition, LBW patients admitted to the NICU had a longer length of stay than non-BLW patients. This is a consequence of improved LBW care, where mortality rates decreased but patient length of stay increased. Longer lengths of stay also incurred higher costs. Therefore, LBW patients played an important role in determining the quality and efficiency of the NICU division of Fatmawati General Hospital.

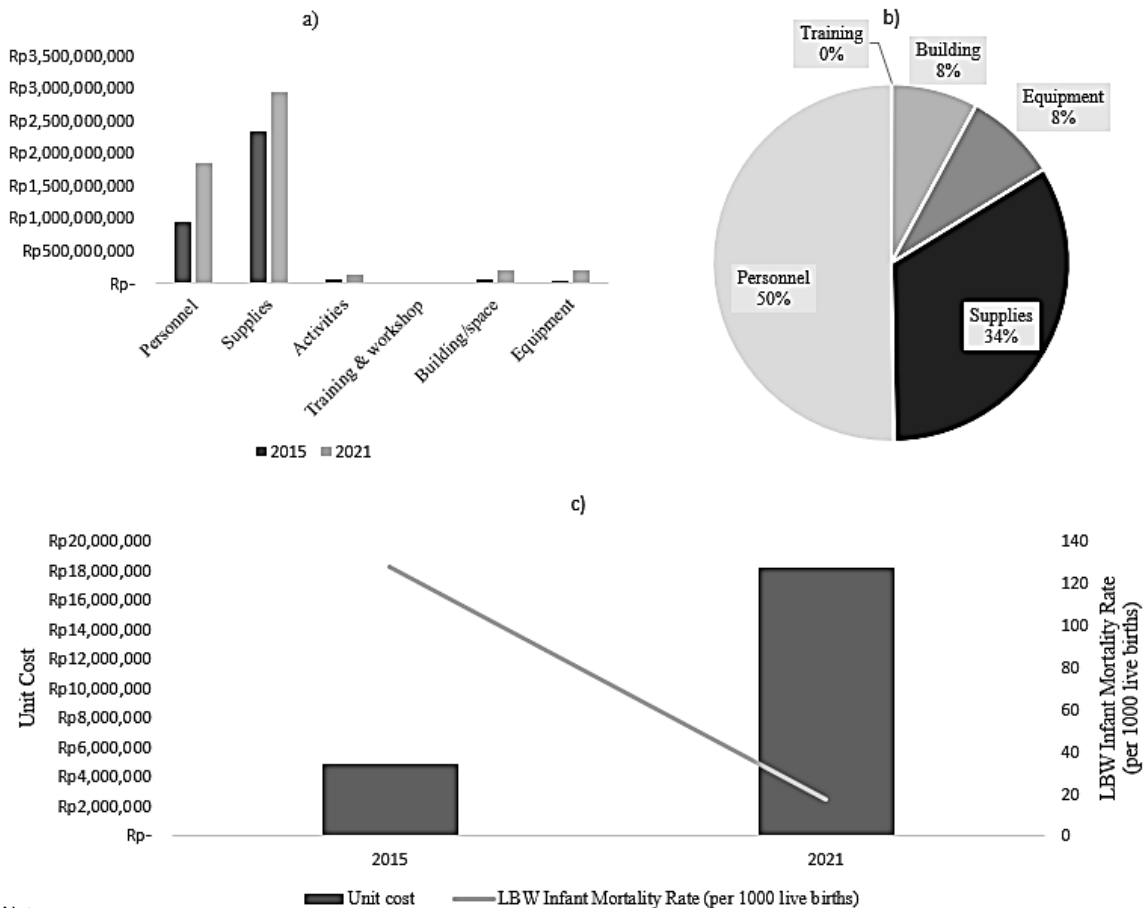
We conducted a cost analysis for the NICU division in two years to record the differences in costs due to improvements in NICU services, notably in 2015 (pre-improvement) and 2021 (post-improvement). It should also be noted that Fatmawati General Hospital is a referral hospital which means that all patient costs are covered by the government (BPJS), except for some costs such as training which is covered individually by the nurses. Table 3 shows the results of our cost analysis for Fatmawati General Hospital's NICU division in 2015 and 2021.

In 2015 and 2021, it was found that supplies, followed by personnel, accounted for the majority of the costs that Fatmawati General Hospital had to bear. The large costs incurred for LBW care supplies may indicate the high-care status of the NICU division. This finding is in accordance with previous literature, which found that neonatal care is a risky endeavor that is expensive to implement and requires high expertise to treat. The cost analysis is presented in Figure 1. In 2015, supplies accounted for 67.8% of total costs, and personnel accounted for 27.2% of total costs. Meanwhile, in 2021, supplies accounted for 55.2% of total costs, and personnel accounted for 34.8% of total costs.

Table 3. Summary of Costs, 2015 and 2021

Cost	2015 Summary		2021 Summary	
	Nominal (IDR)	%	Nominal (IDR)	%
Personnel	933,516,439	27.2	1,855,892,828	34.7
Supplies	2,324,143,238	67.8	2,939,914,476	54.9
Activities	61,601,412	1.8	123,202,824	2.3
Training	2,110,149	0.1	2,989,378	0.1
Building/space	66,733,446	1.9	210,282,402	3.9
Equipment	41,279,227	1.2	219,022,121	4.1
Total Cost	3,429,383,911.65		5,351,304,029	
Unit Cost	4,878,213.25		18,326,384	
Denominator		703		292

Source: Primary Data, 2023



Note:

a) Comparison of costs in 2015 and 2021, b) Percentage of nominal cost increase, c) Unit cost and infant mortality rate in 2015 and 2021

Source: Primary Data, 2023

Figure 1. Data for Cost Analysis

Next, 2% of the total costs was building/space, with the two lowest components being equipment (1.4%) and training (0.2%). Capital costs, especially for building/space and equipment, had very high purchase costs. For example, the purchase cost of an NICU ventilator, which was IDR 180,000,000, and the high land price of Fatmawati Hospital in the metropolitan area. However, the capital cost becomes relatively low due to the long working life of capital goods.

Training and workshop, which was not covered by the health facility or the government, had the lowest cost. Training involved monthly case discussions and practical training in neonatal care. The cost of training was borne by the nurses who also managed the trainings. The nurses collected money every month to carry out these training courses.

Discussion

Comparing 2015 (pre-intervention) and 2021 (post-intervention), equipment had the highest cost increase, approximately 372.7%. This increase was due to the purchase of medical equipment such as echocardiogram, laminar air flow, ultrasound (USG), portable X-ray, additional CPAP, and additional ventilators. The cost of this equipment ranged from IDR 90,000,000 to IDR 788,000,000.

The second largest increase was building/space. The NICU was moved from the Teratai Building, which had a space of approximately 202 m², to the Bougenville Building, with a space of approximately 445 m². In addition, the use of space for LBW was higher in 2021 than in 2015. This percentage difference also affected the amount of cost increase for building/space.

The third largest increase was personnel as two doctors from Fatmawati Hospital's NICU had a specialty training program to become an NICU consultant, which increased the doctor's monthly salary, but quantitatively, it decreased from four doctors in 2015 to three doctors in 2021. In addition, there was also an increase in the number of nurses from 16 nurses in 2015 to 30 nurses in 2021. This supported Fatmawati Hospital's NICU regulation which increased the ratio of

nurses per patient from 1:8 in 2015 to 1:3 in 2021. Four additional pharmacy staff were required to make TPN liquid in 2021, whereas in 2015 there were no pharmacy staff in the NICU.

Training has since expanded. In 2015, only monthly case study discussions were held, while, in 2021, there were two additional trainings: 'Refresh Resuscitation, Stabilization and Transportation of Neonates', which was conducted every three months, and 'Comprehensive Neonates' which was conducted annually.

Finally, the smallest increase was in supplies. Although the percentage was small, there were many changes in this category due to improved services. For example the use of deep venous infusion with a PICC device, which replaced the peripheral infusion method with an IV catheter in 2015. Another example was the use of more disposable perfusor tubing, from the use of one piece per patient in 2015 to six pieces per patient in 2021. Both interventions were carried out to reduce the rate of HAIs. TPN fluids as a main intervention to improve nutrition also led to increased costs in 2015. In addition to TPN, there were also additional fluids such as D40%, magnesium, soluvit, phosphate, 20%, and surfactant.

Due to numerous improvements in supply, the increase in supply cost in nominal terms was very high, reaching IDR 615,771,238, which was the second highest increase in nominal costs. The largest nominal increase came from personnel, which included improved doctor skills, as well as an increase in the number of nurses and additional pharmacy staff. Viewed from a nominal perspective, looking at percentages alone cannot represent the overall cost situation of the NICU. Equipment and building/ space, which had the highest improvement rates, were much cheaper than improvements in supplies and personnel.

Total costs increased by more than half (55.35%). However, in terms of unit costs, costs almost tripled by 274%. This high increase in unit costs was mainly due to a decrease in the number of LBW patients, with each patient receiving far more comprehensive care in 2021 than

before. This highlights the impact of improved services.

The increased use of medical equipment in treating patients, an increase in the use of consumables, especially in the administration of IV fluids to infants, the provision of TPN nutrition, and the addition of healthcare workers, from nurses to pharmacy staff, showed the NICU division of Fatmawati Hospital could provide a better, more focused care for LBW patients. This was also reported by medical personnel at Fatmawati General Hospital's NICU who observed more frequent survival of LBW patients in the NICU. Comparison of unit costs with mortality rates in both periods can also be seen in Figure 2.

With an increase in cost per patient of 274% in 2021, infant mortality rates decreased dramatically from 128 deaths per 1,000 births in 2015 to 17 deaths per 1,000 births in 2021. This may indicate an improvement in services at the NICU of Fatmawati General Hospital although the profile of patients admitted was more challenging due to its status as a referral hospital. This cost increase also indicates that more LBW patients could be saved even at significantly higher costs.

Improved care provided by the NICU division of Fatmawati Hospital increased the costs of caring for LBW patients. One of these costs was an increase in the number of health workers. The ratio of nurses per patient improved from 1:8 to 1:3, allowing nurses to give more attention to each patient. There were 30 nurses on duty in the NICU, with an annual salary ranged from IDR 12,564,704 to IDR 49,994,752. Meanwhile, two doctors in the NICU also obtained a consultant degree (SpAK), increasing their annual salary from IDR 99,473,642 to IDR 206,365,385.

According to a report by medical staff at Fatmawati General Hospital, the NICU

also purchased some medical equipment, but these were expensive, and few NICUs in other hospitals had them. Apart from equipment such as incubators, ventilators, and CPAP which cost approximately IDR 90,000,000 - IDR 180,000,000, the NICU purchased equipment such as portable X-ray (IDR 204,441,200), echocardiogram (IDR 788,493,000), ultrasound (IDR 385,000,000), and blanketrol (IDR 580,400,000). In addition to the medical equipment above, the supplies used were also more expensive but easier to dispose of. Unlike peripheral abocath, which requires multiple IV injections, PICC requires only one injection. Reducing the frequency of injections reduces the likelihood of health-associated infections in LBW patients. In addition, the use of a disposable syringe also reduces that probability. Furthermore, the use of TPN liquid improves the nutritional status of LBW patients who cannot receive oral nutrition.

There is a disclaimer for the comparison in Table 4. Two of the mentioned study were done in advanced countries (the USA and Finland), thus their NICU conditions are quite different from developing countries such as Indonesia, India, and Pakistan. However, it does provide a perspective on how advanced nations spend much more to provide neonatal care. Anwar and Butt (2019) also show that Pakistan as a developing nation spent much more (Rp 25 million) than India (Rp 4,5 million) or Fatmawati General Hospital in 2015 (Rp 4,8 million). In terms of how the study was conducted, it utilized a retrospective study to find the costs, similar to how this study is conducted. Thus, the table could help provide a good comparison.

Table 4. Cost comparison with previous studies

Authors	Year	Country	NICU Unit Cost (adjusted to 2023 in Rupiah)
McLaurin <i>et al.</i>	2009	USA	41,050,319.48
Helle <i>et al.</i>	2016	Finland	64,202,699.67
Narang <i>et al.</i>	2005	India	4,515,535.14
Anwar and Butt	2009	Pakistan	25,122,795.52

Source: Anwar (2009); Helle *et al.* (2016); McLaurin *et al.* (2009); Narang *et al.* (2005).

Our findings suggest that the initial 2015 cost for Fatmawati General Hospital's NICU is similar to the median cost in India (Narang *et al.*, 2005). However, by the end of the 2021 post-service improvement period, the cost has risen to 18,326,384, around Rp 7 million less than the average cost per admission in Pakistan. Even with more than a fourfold increase in cost, which also has shown a significant decrease in neonatal mortality, the cost of Fatmawati General Hospital's NICU care for a preterm baby is still far from the Rp 41,050,319 shown in the USA. This could indicate that there is still a capacity to invest more in Fatmawati General Hospital's NICU to further improve its service

For the improvements made in Fatmawati General Hospital's NICU, many of them were recommended by Sharma and Murki (2021) as proper methods to make NICU more cost-effective. Interventions such as the addition of CPAP and the usage of laminary airflow to ensure the sanitation of the total parenteral nutrition were endorsed in their study, and were also implemented during the period of improvement in Fatmawati General Hospital's NICU

Extra medical personnel, better medical equipment, greater use of supplies, and consulting doctors with more advanced neonatal knowledge at Fatmawati General Hospital, contributed to a significant reduction in mortality rates, from 128 deaths per 1,000 births in 2015 to only 17 deaths per 1,000 births in 2021.

This study has a methodological limitation since it uses cost analysis, instead of other more advanced analysis such as CEA which measures the cost-effectiveness of the intervention. Future studies should measure the cost-effectiveness to further deepen the economic evaluation of the improvements made in Fatmawati General Hospital's NICU.

Conclusion

Considering the high infant mortality rates in Indonesia, especially due to premature birth, Fatmawati General

Hospital has improved its services. A holistic improvement that covered infection control and better nutrition was introduced in 2015. This improvement, increased the total cost from IDR 3,429,383,912 in the pre-intervention period (2015) to IDR 5,351,304,029 in the post-intervention period (2021). The largest increase in nominal costs was also due to supplies and personnel costs, with supplies costs increasing by IDR 615,771,238 and personnel costs increasing by IDR 922,326,388. However, this increase led to a significant decrease in LBW mortality rates as well, with 111 deaths per 1,000 LBW births. Because all patients in NICU were covered by the JKN-KIS healthcare program, the increased costs may place an additional burden on the state's social security system.

The results of the cost analysis can identify the cost elements needed to improve LBW services. However, our results did not allow us to obtain an effectiveness analysis of NICU's service improvements. Further research such as cost-effectiveness analysis could further investigate how effective service improvements have been made in the NICU of Fatmawati General Hospital.

Abbreviations

NICU: neonatal intensive care unit; LBW: low birth weight; TPN: total parenteral nutrition; PICC: peripherally inserted central catheter; CPAP: continuous positive airway pressure

Declarations

Ethics Approval and Consent Participant

There were no direct interactions with patients, but ethics approval was obtained (project no. LB.02.02/VIII.2/2627/2023).

Conflict of Interest

The authors declare no conflict of interest.

Availability of Data and Materials

Data and material research are available upon request.

Authors' Contribution

PRS conceptualized the idea, gathered the data, processed the costing analysis, and prepared the initial draft. NDI conducted in-depth analysis of the NICU, supported the necessary legal and administrative requirements, and conducted a general briefing of the NICU operational ecosystem. EDS supervised the whole process, honed the concept, led the data collection, reviewed the analysis, and revised the draft.

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