SURABAYA MEDICAL JOURNAL
(SMJ IDI SURABAYA)
Volume 2, Issue 2, November 2024, p. 19-26
e-ISSN: 2986-7584
p-ISSN: 2986-2469

ORIGINAL RESEARCH REPORT

The role of the Neonatal Emergency Transportation Service (NETS) ambulance at dr. Ramelan Central Naval Hospital in reducing neonatal mortality rates in Surabaya

Maria Adventia Debi Mustika Martin[1*], Stefani Miranda[1], Aminuddin Harahap[1]

[1]Department of Child Health, dr. Ramelan Central Naval Hospital, Surabaya, Indonesia

Article Info

Article history:
Received: 30-10-2024
Revised: 03-11-2024
Accepted: 12-11-2024
Published: 29-11-2024

Keywords:
NETS;
neonatal transport;
referral system;
neonatal mortality;
survival

ORCID ID

Stefani Miranda
https://orcid.org/0000-0002-2764-6528

Aminuddin Harahap
https://orcid.org/0009-0003-1473-8786

ABSTRACT

Background: Limited access to health services is one of the factors that increases the risk of neonatal death. Previous studies identified inadequate transportation as a problem in the neonatal referral system in Indonesia. The Neonatal Emergency Transportation Service (NETS) was established to address this problem. NETS is equipped with an incubator, transport ventilator, and mobile vital sign monitor. Newborns transported via NETS are accompanied by a doctor and trained nurses. **Objective**: This study aims to compare the survival rates of newborns referred with and without using the NETS ambulance. **Materials and Methods**: This descriptive observational study employed a total sampling technique. Data were collected retrospectively from the electronic medical records at dr. Ramelan Central Naval Hospital, comparing the number of referrals and neonatal deaths between September 2021 and August 2022 (without the NETS ambulance) and between September 2022 and August 2023 (with the NETS ambulance). The data were analyzed using a chi-squared test ($p = 0.004$). **Results**: A total of 81 newborns were referred to the hospital using the NETS ambulance. The survival rate of newborns transported with the NETS ambulance was higher (69.1%) compared to those transported without the NETS ambulance (48.1%) ($p = 0.004$). The risk ratio was calculated at 0.413. **Conclusion**: Neonatal survival rates were higher for referrals using the ambulance compared to those without using the ambulance.

Citation:
Martin, M.A.D.M., Miranda, S., Harahap, A. (2024). 'The role of the Neonatal Emergency Transportation Service (NETS) ambulance at dr. Ramelan Central Naval Hospital in reducing newborn mortality rates in Surabaya'. Surabaya Medical Journal, *2* (2): 19-26. doi: 10.59747/smjidisurabaya.v2i2.90

Corresponding Author:
Maria Adventia Debi Mustika Martin, Department of Child Health, dr. Ramelan Central Naval Hospital, Surabaya, Indonesia
Email: madebimm@gmail.com

Highlights

1. Limited access to health services is one of the factors that increases the risk of neonatal death.
2. Previous studies identified inadequate transportation as a problem in the neonatal referral system in Indonesia. The Neonatal Emergency Transportation Service (NETS) was established to address this problem.

BACKGROUND

Neonatal death is a major global health problem, especially in developing countries (Islam et al., 2022). The first 28 days of life represent a vulnerable period (Mohamed et al., 2022), with neonatal deaths commonly resulting from preterm birth complications, intrapartum-related complications, neonatal sepsis, and other infections (Pathirana et al., 2016). Other factors that contribute to neonatal death include limited access to health services (Harahap et al., 2019; Kiputa et al., 2022). Previous studies identified the absence of ambulances or inadequate transportation as a problem in the neonatal referral system in Indonesia (Brooks et al., 2017; Deviany et al., 2022; Harahap et al., 2019; Rosales et al., 2017). The lack of ideal neonatal transportation, which is used to refer neonates from a healthcare facility to another, remains a problem in many developing countries, including Indonesia (Harahap et al., 2019; Rosales et al., 2017). Maternal and neonatal mortality rates are relatively high in developing countries, especially in Sub-Saharan Africa (Gudayu, 2023) and Southeast Asia (Acuin et al., 2011), ranging from 38% to 39% (UNICEF et al., 2017), due to limited access and inadequate transportation (Tey and Lai, 2013). Thaddeus and Maine (1994) identified three delays that influence maternal and neonatal deaths: delays in seeking healthcare, delays in reaching health facilities, and delays in receiving treatment. These delays are compounded by cultural factors, geographic barriers, and disparitities in the quality of health services (Actis Danna et al., 2020).

Early-life deaths accounted for 47% of the total number of deaths among children under five in 2020 and 2021, with the majority deemed preventable (Mohamed et al., 2022). Of the estimated 5.4 million deaths among children under five in 2018, half were newborns (UN Report, 2018; WHO, 2018). In 2020, an estimated 2.4 million newborns died in their first month of life, translating to approximately 6,700 deaths per day (WHO, 2022). The primary causes of maternal and neonatal death include premature birth complications, labor-related events (e.g., asphyxia and congenital abnormalities), and lower respiratory tract infections that necessitates timely transport to adequately equipped health facilities to receive better treatment (Neil et al., 1999). Transporting sick newborns, preterm and low-birth-weight infants, and women at risk of preterm birth or previously identified pregnancy complications to appropriate health facilities is important to improve neonatal outcomes (Chirla and Panigrahy, 2021; Abdul Wahab et al., 2019). This can prevent up to 80% of newborn deaths (WHO, 2022).

A transportation system for sick, premature, and low-birth-weight newborns to health facilities is a crucial intervention for achieving a good prognosis (Chirla and Panigrahy, 2021), by ensuring the safety of newborns during the transfer to referral hospitals. Awareness of the importance of neonatal transport system can improve the condition of neonates in neonatal care centers. Stabilization before and during the transfer is necessary to reduce neonatal mortality (Marsubrin et al., 2018), including resuscitation within the first minute to one hour after birth to establish breathing, thermal care to maintain body warmth, delayed cord clamping, and breastfeeding (Wainaina et al., 2024).

The implementation of a referral system including pre-referral care, access to emergency transport, and continuity of care between facilities is important for newborns (Kiputa et al., 2022), especially preterm and critically ill newborns (Perry, 2021). Neonatal referrals are often necessitated by factors such as lack of expert staff or lack of life-support equipment. A report from Cipto Mangunkusumo Hospital identified the primary reasons for neonatal referrals as surgery (34.4%), respiratory distress (29.3%), and early-onset sepsis (EOS) (12.6%) (Marsubrin et al., 2018). When critically ill newborns are transported using systems with inadequate equipment, they often arrive at referral hospitals in poor condition, such as hypothermia (33%), hypoxia (21.3%), poor perfusion (8.6%), and hypoglycemia (14.1%). These conditions increase the risk of mortality (Kiputa et al., 2022), particularly hypothermia during the transfer. The risk of mortality is higher in neonates exposed to environmental temperatures below 36-37^{o}C during transport (Wainaina et al., 2024). Supporting evidence indicates that 25% of referred neonates arrive at referred hospitals in a hypothermic state (WHO, 2022). Recent findings reported that 17.5% of neonates arrived with hypothermia, defined as a body temperature below 36.0°C (Wainaina et al., 2024).

An adequate referral system, including trained personnel, is essential for transferring neonates to tertiary health facilities (Kiputa et al., 2022). Trained personnel are a critical component of the Neonatal

Surabaya Medical Journal (SMJ IDI Surabaya)
e-ISSN: 2986-7584; p-ISSN: 2986-2469

Emergency Transportation Service (NETS), especially those who provide specialized care during transport. Their expertise is pivotal in reducing neonatal mortality associated with long transport distances and optimizing outcomes. For this reason, NETS operations must be conducted by teams specifically trained in stabilization techniques and effective management before and during transport (Chirla and Panigrahy, 2021). NETS is a transportation service operated by the Surabaya City Government, which can pick up and refer newborns or infants up to 28 days old in emergency situations within Surabaya and its surrounding areas. NETS features neonatal care equipment, including an incubator, transport ventilator, and mobile vital sign monitor. The system is staffed by skilled nurses and doctors, and includes consultations with neonatologists during transport, as mandated by the Regulation of the Mayor of Surabaya City Number 14 of 2022 (Walikota Surabaya, 2022).

OBJECTIVE

This study aims to compare the survival rates of newborns referred with and without using the NETS ambulance service.

MATERIALS AND METHODS

Study design

This study employed a descriptive observational method using a total sampling technique. Data were collected retrospectively from the electronic medical records at dr. Ramelan Central Naval Hospital, comparing the number of referrals and neonatal deaths between September 2021 and August 2022 (without the NETS ambulance) and between September 2022 and August 2023 (with the NETS ambulance).

Data collection

This study collected data on the characteristics of referred newborns and the differences between the survival rates of referred newborns with and without using the NETS ambulance. The collected data were compiled using Microsoft Excel.

Data analysis

The data were analyzed using a chi-squared test.

RESULTS

During the study period, 81 neonates were referred to dr. Ramelan Central Naval Hospital using the NETS ambulance. Neonates transported using the NETS ambulance presented with complex medical conditions, as summarized in **Table 1**. The most common diagnoses among the patients were respiratory distress syndrome (n = 26, 32.1%), asphyxia (n = 11, 13.6%), and transient tachypnea of the newborn (n = 11, 13.6%) (p = 0.002). Additionally, the gestational age of referred neonates included 51 full-term neonates and 30 premature neonates. In terms of birth weight, 51 neonates were categorized as having normal weight, 22 as low birth weight, two as very low birth weight, and six as extremely low birth weight. According to the 2017 WHO classification, low birth weight is defined as a birth weight of ≤2,500 grams and is further categorized into low birth weight (1,500–2,499 g), very low birth weight (1,000-1,499 g), and extremely low birth weight (<1,000 g) (Novitasari et al., 2020).

Table 1. Characteristics of the study population

Variables	Category	Before NETS Frequency (%)	After NETS Frequency (%)	p
Sex	Male	49 (60.5)	49 (63.6)	0.342
	Female	32 (39.5)	28 (36.4)	
Birth Weight (gram)	≥2,500	52 (64.2)	58 (75.3)	0.279
	1,500–2,499	22 (27.1)	16 (20.8)	
	1,000–1,499	2 (2.5)	2 (2.6)	
	<1,000	5 (6.2)	1 (1.3)	
Gestational Age	Premature	30 (37)	24 (31.2)	0.219
	Full-term	51 (63)	53 (68.8)	
Working Diagnosis	Asphyxia	11 (13.6)	16 (20.8)	**0.002***
	Respiratory distress syndrome	26 (32.1)	19 (24.7)	
	Transient tachypnea of the newborn	11 (13.6)	3 (3.9)	
	Respiratory failure	1 (1.2)	0	
	Pneumonia	7 (8.6)	2 (2.6)	
	Septicemia	8 (9.9)	4 (5.2)	
	Down syndrome	2 (2.5)	6 (7.8)	
	VACTERL	19 (23.5)	37 (48.1)	
	Neonatal jaundice	9 (11.1)	0	
	Imperforate anus	4 (4.9)	8 (10.4)	
	Hirschsprung's disease	2 (2.5)	7 (9.1)	
	Omphalocele	2 (2.5)	9 (11.7)	
	Laryngomalacia	1 (1.2)	0	
Outcome	Survived	56 (69.1)	37 (48.1)	**0.004***
	Died	25 (30.9)	40 (51.9)	

Note: *significant: $p < 0.05$
Abbreviations: VACTERL: vertebral defects, anal atresia, cardiac defects, tracheoesophageal fistula, renal anomalies, and limb abnormalities

The results of this study revealed that without the use of NETS ambulances, the mortality rate of referred neonates was significantly higher (51.9%) compared to with the use of NETS ambulances (30.9%) ($p = 0.004$). Similarly, the survival rate of referred neonates was significantly higher (69.1%) with the use of NETS ambulances compared to without the use of NETS ambulances (48.1%) ($p = 0.004$). The risk ratio (RR) was calculated at 0.413, indicating that the use of NETS ambulances served as a protective factor.

Table 2. Comparison of survival rates between neonates referred with and without the NETS ambulance

	Without NETS	With NETS
Survived Neonates	37	56
Died Neonates	40	25
Total	77	81

Risk ratio of using the NETS ambulance = $\frac{25x37}{40x56}$ = 0,41294

Based on the RR calculation, the use of NETS ambulances increases the survival rate of referred neonates at referral hospitals by 41% compared to referrals without the use of NETS ambulances.

Surabaya Medical Journal (SMJ IDI Surabaya)
e-ISSN: 2986-7584; p-ISSN: 2986-2469

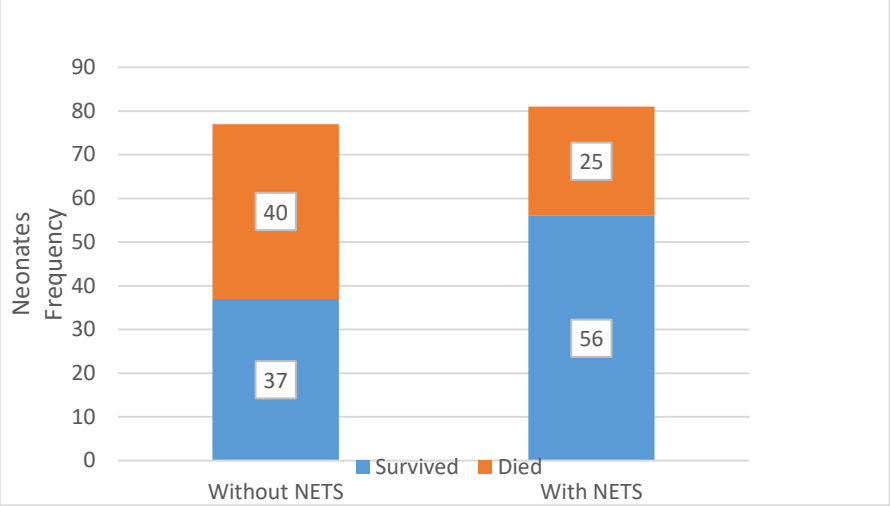

Figure 1. Comparison of survival rates between neonates referred with and without the NETS ambulance

DISCUSSION

The primary reason for neonatal transfer using the NET ambulance in this study was the presence of vertebral defects, anal atresia, cardiac defects, tracheoesophageal fistula, renal anomalies, and limb abnormalities (VACTERL). VACTERL is an anorectal malformation involving different subtypes with anatomical and functional multisystemic involvement (Hakalmaz and Topuzlu Tekant, 2023). This malformation requires specific medical care in the form of multiple surgical procedures shortly after birth due to its impact on various organ systems (Gregg et al., 2024). The prevalence of these anomalies has increased since the introduction of the NETS ambulance. A study conducted in a South African tertiary hospital involving newborns with congenital esophageal atresia and tracheoesophageal fistula revealed transport delays in 63% of patients, half of which (52%) requiring preoperative mechanical ventilation. Additionally, 29% of the patients presented with major cardiac abnormalities. The survival rates of the patients categorized using the Okamoto classification were 90% for class 1 and 45% for class 4 due to airway and ventilation difficulties and hemodynamic instability (Balkisson et al., 2022). Meanwhile, before the introduction of the NETS ambulance, respiratory distress syndrome was the most common reason for neonatal transport. A study in Germany identified the leading causes of neonatal referral as respiratory, infectious, asphyxia, cardiac, and hematological disorders, with a prevalence of more than 80%. Among the cases, respiratory adaptation disorders were the most prevalent, with asphyxia representing the most severe condition (Schumacher et al., 2024).

The first hours of life are critical for the prognosis of critically ill preterm neonates. When optimal care cannot be provided at the current facility, neonates must be safely transferred to another equipped hospital (Jordán Lucas et al., 2021). This study found no significant differences in neonatal birth weight, sex, or gestational age before or after the introduction of the NETS ambulance. Meanwhile, a study in Italy reported that most transported neonates were of low birth weight, with a total of 133 transports over the course of a year. The incidence of preterm birth was 31.6%, which is consistent with the finding of this study (Olivo et al., 2023).

The goal of the NETS is to provide advanced neonatal care during transfers to referral hospitals, especially those located far from tertiary care facilities and to ensure a safe transfer to referral hospitals with more complete resources for definitive care. NETS is an important link in the care continuum for high-risk neonates, including those critically ill, preterm, or having low birth weight. While transport itself poses risks for critically ill neonates, NETS is an essential intervention aimed at improving neonatal outcomes. NETS should function as an “on-wheel moving neonatal intensive care unit (NICU)” equipped with highly specialized personnel and appropriate equipment designed with a standardized system ideal for neonates (Balkisson et al., 2022). For this reason, a good team with trained personnel is important and represents the most valuable element of NETS, especially those who can

provide appropriate care during transport in order to reduce mortality rates associated with long-distance transports, and to improve outcomes. The personnel must possess skills for adequate stabilization and effective management before and during transport. Evidence from three studies indicated that care provided by a specially trained neonatal team was associated with improved physiological stability, regardless of transport distance. As a consequence, a NETS team should include a neonatologist, a NICU nurse, a driver, and a green cross volunteer. During the transport, the team must stabilize the neonates in accordance with the latest neonatal resuscitation program and NETS protocols (Cavicchiolo et al., 2021). Other than transferring critically ill neonates, the NETS team must also coordinate with staff at the referred hospital to ensure the continuity of medical management. This comprehensive and coordinated system guarantees the safety of the neonates (Jordán Lucas et al., 2021).

A study in China involved 243 critically ill neonates transferred with NETS managed by a team comprising trained medical staff and NICU professionals. The team was provided with on-site guidance for transporting high-risk infants, resulting in improved outcomes upon the arrival of neonates at referral hospitals. Medical interventions performed during transport included mask ventilation, endotracheal intubation, pulmonary surfactant administration, and chest compressions. The study reported lower mortality rates in neonates with dyspnea and nervous system abnormalities as well as improved blood gas and sugar levels (Xu et al., 2019). Another study showed a reduction in complications such as hypoglycemia, hypoxia, and apnea among infants transported by NETS with a specialized team, with higher survival rates at 96%. Additionally, fewer adverse events were observed, including airway problems, cardiopulmonary resuscitation, hypotension, loss of vascular access, temperature instability, and abnormal blood glucose levels. Without a specialized NETS team, referred neonates experienced higher rates of complications and less favorable outcomes (Chirla and Panigrahy, 2021).

In terms of mortality, this study found a significant reduction in mortality rates after the implementation of NETS compared to the period before its implementation. A study in Sicily, Italy, reported similar findings with an advanced version of NETS services aimed at reducing infant mortality by transporting vulnerable neonates from primary care birth centers to tertiary facilities equipped with specialized NICU services. The service transported 325 neonates and successfully reduced the mortality rate from 4.41 per 1,000 of live births in 2016 to 4.15 per 1,000 live births after 2015, with respiratory diseases being the most common reason for transport (Toledo et al., 2022). A three-year study conducted in Japan between 2011 and 2014 involving 2,780 neonates examined the outcomes of neonatal transfer and found a higher prevalence of neurodevelopmental impairments among transferred neonates compared to those who were not transferred. Specifically, impairments were more common in communication (6.5% vs 3.5%, OR = 1.42), gross motor (7.6% vs 4.0%, OR = 1.26), fine motor (11.3% vs 7.1%, OR = 1.19), problem solving (10.8% vs 6.8%, OR = 1.29), and personal-social (6.2% vs 2.9%, OR = 1.52) domains (Hirata et al., 2022). Another study categorized transport duration into short (≤1 hour) and long (>1 hour) groups and found an improvement in the Transport Risk Index of Physiologic Stability (TRIPS) scores after arrival at the referral hospital, with a mortality rate of 14.8% and no significant differences in seven-day mortality and total mortality between the two groups. However, complications during transport, such as hyperglycemia, prolonged capillary refill time (CFT), hypothermia, accidental extubation, hypoglycemia, hyperthermia, hypotension, and persistent hypoxia were noted (Mohan and Kumar, 2019). A previous study in 1974 which examined neonates transferred to Montreal Children's Hospital with assistance from health professionals reported hypothermia in 25.2% of cases, with only 3.1% maintaining normothermia after transfer despite receiving warming treatment during transfer. Hypothermia during transfer was associated with mortality (Gunn and Outerbridge, 1978).

Limitations

This study did not consider additional factors other than NETS ambulance that may contribute to the survival rates of referred neonates. Therefore, further research is necessary.

Surabaya Medical Journal (SMJ IDI Surabaya)
e-ISSN: 2986-7584; p-ISSN: 2986-2469

CONCLUSION

The results of this study revealed that the survival rate of referred neonates using NETS ambulances was higher than those referred without using NETS ambulances.

Conflict of Interest

The author declares no conflict of interest.

Funding

None

Ethical Clearance

This study received ethical approval from the Research Ethics Committee of dr. Ramelan Central Naval Hospital with a certificate number 119/EC/KEP/2023.

Author Contribution

MADMM: draft preparation, editing, data curation, translating, data analysis; SM: data analysis; AH: conceptualization

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