



Unveiling the Problems of Critically Ill Children in Indonesia: A Narrative Review

Endonezya'da Kritik Durumdaki Çocukların Sorunlarının Ortaya Çıkarılması: Anlatımsal Bir Derleme

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Abstract

The mortality rate of children in Indonesia is still high when compared to that in developed countries. The mortality rate of children in Indonesia remains high due to various factors. Efforts to reduce child mortality should focus on improving family understanding of health risks, enhancing access to quality healthcare services, and addressing social and environmental determinants of child health. The aim of this study was to describe the problems from upstream to downstream of critically ill children in Indonesia, thus Indonesia can work towards lowering the children's mortality rate of children. The PubMed, Cochrane, and Embase databases were meticulously examined utilizing specific search terminologies. Original articles, meta-analyses and systematic reviews in the English and Indonesian languages describing the problems of critically ill children in Indonesia were selected. Relevant references in some of these articles were included as well. The problem of high mortality of children treated in intensive care units in Indonesia is not only due to limited pediatric intensive care unit (PICU) capacity, limited equipment, and unqualified resources. However, it is necessary to identify various underlying factors including family factors, socio-economic status, community culture, referral systems, knowledge of health workers, and health facilities at both primary and secondary levels. A critical concern is that external factors influencing the hospital environment are infrequently or never evaluated for their effects on the referral system, which is essential for ensuring that critically ill pediatric patients are not presented for care too late. The high mortality rate of critically ill children in Indonesia is influenced by many factors, including parents' awareness of pediatric emergencies, the socio-cultural and family economy, community, the ability of primary care providers to identify emergencies and provide initial care, referral system communication and the availability of beds and facilities in the PICU.

Keywords: Critically ill, children, Indonesia

Öz

Endonezya'da çocuk ölüm oranı, gelişmiş ülkelerdeki çocuk ölüm oranına kıyasla hala yüksektir. Çocuk ölüm oranını düşürmeye yönelik çalışmalar ailelerin sağlık riskleri konusundaki farkındalığını artırmaya, kaliteli sağlık hizmetlerine erişimi geliştirmeye ve çocuk sağlığının sosyal ve çevresel belirleyicilerini ele almaya odaklanmalıdır. Bu çalışmanın amacı, Endonezya'da kritik durumda olan çocukların sorunlarını tanımlamak ve böylece Endonezya'nın çocuk ölüm oranını düşürmeye yönelik çalışmalar yapabilmesini sağlamaktır. PubMed, Cochrane ve Embase veritabanları, belirli arama terminolojileri kullanılarak titizlikle incelendi. Çalışmaya Endonezya'daki kritik durumdaki çocukların sorunlarını anlatan İngilizce ve Endonezce dillerinde yazılmış orijinal makaleler, meta analizler ve sistematik incelemeler seçildi. Bu makalelerin bazılarının ilgili referansları da dahil edildi. Endonezya'da yoğun bakım ünitelerinde tedavi gören çocukların yüksek ölüm oranı sorunu, sadece çocuk yoğun bakım ünitesi (ÇYBÜ) kapasitesinin sınırlı olması, ekipman yetersizliği ve nitelsiz kaynaklardan kaynaklanmamaktadır. Bununla birlikte, ailesel faktörler, sosyo-ekonomik faktörler, toplum kültürü, sevk sistemleri, sağlık çalışanlarının bilgisi ve hem birincil hem de ikincil düzeydeki sağlık tesisleri gibi çeşitli altta yatan faktörlerin belirlenmesi gerekmektedir. Hastane ortamını etkileyen dış faktörlerin sevk sistemi üzerindeki etkilerinin nadiren değerlendirilmesi veya hiç değerlendirilmemesi önemli bir sorundur. Çünkü bu durum kritik durumdaki çocuk hastaların tedaviye geç kalmamalarını sağlamak için çok önemlidir. Endonezya'da kritik durumda olan çocukların yüksek ölüm oranı ebeveynlerin pedyatrik acil durumlar konusundaki farkındalığı, sosyo-kültürel ve aile ekonomisi, toplum, birinci basamak sağlık hizmetleri sağlayıcılarının acil durumları tespit etme ve ilk yardım sağlama becerisi, sevk sistemi iletişimi ve ÇYBÜ'de yatak ve tesislerin mevcudiyeti gibi birçok faktörden etkilenmektedir.

Anahtar Kelimeler: Kritik durum, çocuklar, Endonezya

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Introduction

The mortality rate of children in Indonesia is still high when compared to the mortality rate of children in developed countries. Data from UNICEF shows that in Indonesia, the average mortality rate of children aged 1-11 months old, 1-4 years old, 5-14 years old is 7.64 per 1000 children, 3.35 per 1000 children, and 4.73 per 1000 children, respectively. From 2002 to 2022, there was a decrease in the mortality rate of children under 5 years old, from 71 per 1000 live births in 2002 to 37 per 1000 live births.¹ This is in contrast to the mortality rate of children in developed countries, such as the United Kingdom (UK). In the UK, the average mortality rate for children aged 1-11 months old, aged 1-4 years old, and aged 5-14 years old is 0.86 per 1000 children, 0.54 per 1000 children, and 0.71 per 1000 children, respectively.² This is in accordance with the condition of pediatric patients who are treated in a pediatric intensive care unit (PICU) in Indonesia. In a retrospective analysis conducted on pediatric patients who experienced septic shock at the PICU of Dr. Sardjito Hospital in Yogyakarta, the average patient mortality was 88.2%.³ Meanwhile, in a prospective study in 2020, septic shock pediatric patients at the PICU of Dr. Sardjito Hospital, had an average mortality of 55.7%.⁴ The mortality rate of septic shock patients decreased compared to the previous study in the same place in 2013, which was 60%.⁵ In addition to septic shock, the mortality rate of critically ill pediatric patients affected by conditions such as dengue shock syndrome (DSS) is also still high. The average mortality rate of DSS at the PICU of a certain hospital, Surabaya, Indonesia is 52.2%.⁶ The high mortality rate of critically ill children in Indonesia is likely due to complex problems from upstream to downstream, such as low knowledge of parents in recognizing emergencies in children, inadequate ability of doctors in primary care to stabilize patients before they obtain care at referral hospitals, inefficient referral systems, uneven distribution of skilled doctors, and incomplete equipment in referral hospitals.^{7,8} This work provides an overview of the problems behind the high mortality rate in critically ill pediatric patients in Indonesia.

Rationale and Knowledge Gap

The high mortality rate of critically ill children in Indonesia is likely attributable to various complex issues from upstream to downstream, such as parents' limited knowledge in recognizing emergencies in children, the capability of doctors in primary care to stabilize patients before they receive care at referral hospitals, and referral systems that have not been optimally implemented. Additionally, the ability of doctors and the availability of complete equipment in referral hospitals are not evenly distributed. The issue is that few clinicians or policymakers have investigated the gap between the realities on the ground and existing theories. Based on

human development index (HDI) data from the United Nation, Indonesia is ranked 112 out of 192 countries. Indonesia belongs to the high HDI category. Following after the recommendation on the use of artificial intelligence (AI), there was a significant impact on the HDI ranking.⁹ The technology recommendation is likely to be implemented. Therefore, there is a need to identify problems at the levels of family, socio-cultural context, society, primary health facilities, and referral facilities. One approach to identifying these issues is to develop this narrative review, which can be followed by research in locations that have not been extensively studied.

Objective

We aim to create a narrative review discussing all the problems that can contribute to the high mortality rate of critically ill children in Indonesia from upstream to downstream, so that we can provide recommendations to the Indonesian government to carry out comprehensive interventions. We hope that this narrative review will prompt the Indonesian government to take definitive actions to reduce the mortality of critically ill pediatric patients, starting from the family, community, primary health facility, to referral health facility levels. We present this article in accordance with the narrative review reporting checklist (Table 1).

Materials and Methods

A literature review using the databases PubMed and Google Scholar was performed utilizing search terms "critically ill children, upstream to downstream children health problem, critically ill patients in Indonesia, mortality critically ill children in Indonesia, pediatric critically ill referral cases, pediatric patients in primary health care, pediatric patients in referral hospital, referral systems in Indonesia, emergencies in children, transport system, healthcare facilities" (Table 1). This search was performed from September 2023 to January 2024.

Discussion

The Problem of Parental Knowledge in Recognizing Emergencies in Children

Delays in emergency treatment are still common in children. The management is essential both at the pre-hospital stage and when it has been treated at a health facility. In the pre-hospital phase, if parents are unable to carry out early treatment of emergencies in children, it can increase mortality and morbidity. Therefore, it is essential to provide parents with knowledge about emergencies in children.¹⁰⁻¹³ Emergency recognition and knowledge are the keys to reducing child mortality and morbidity, which should start at the level of parents, doctors in primary care, and doctors in referral

hospitals. Recognizing emergencies in critically ill patients is crucial for determining the right management and should be done as soon as possible (Table 2). A study on pediatric patients who experienced septic shock found that when fluid resuscitation was administered in under 30 minutes, the mortality was 40%. If fluid resuscitation was given between 30 and 60 minutes, mortality increased to 58%. If fluid resuscitation was given after more than 60 minutes, mortality increased to 73%. Early recognition of emergencies followed by treatment as soon as possible can reduce mortality in pediatric patients who experience septic shock.¹⁴

Parents' knowledge about emergencies involving children in Indonesia has not been widely studied, but a study in Malaysia found that older parents and female parents have knowledge about emergencies involving children and respond positively to children with emergencies.¹⁵ Knowledge about child emergencies in Indonesia may differ from that in Malaysia. This is due to Indonesia's large population, varied levels of education, and very diverse socio-cultural background, which require further research. Studies on efforts to improve parents' knowledge about emergencies in children were conducted in Indonesia through training and education. Aspects taught

Table 1. Search strategy summary

Item	Specification
Date of search	September 1, 2023 to January 15 2024
Databases and other sources searched	PubMed, Google Scholar
Search terms used	Critically ill children, upstream to downstream children health problem, critically ill patients in Indonesia, mortality critically ill children in Indonesia, pediatric critically ill referral cases, pediatric patients in primary health care, pediatric patients in referral hospital, referral systems in Indonesia, emergencies in children, transport system, healthcare facilities.
Timeframe	Literature published until search date.
Inclusion and exclusion criteria	Inclusion: English language, Bahasa Indonesia language, focused on the above search term in problem critically ill in children starting from the family, community, primary health facility to referral health facility levels. Exclusion: Non critically ill children's health problems.
Selection process	Selection of references was agreed upon all authors.

Table 2. Recognition of emergencies in children can reduce child mortality

Study	Method	Subject	Result	Conclusion
Simbila et al. ¹¹	Prospective cohort study	Four hundred and forty critically ill children were enrolled in the study (aged 28 days-14 years)	• 26.5% children died within 30 days of presentation. • 64.6% presented late (after 48-h). • 35.4% presented early (before 48-h).	Risk of the hospital mortality is 1.3 times higher for children who present late to the ED.
Tsegaye et al. ¹²	Unmatched case-control study conducted at specialized hospital in Ethiopia	All children who died within 24-h of admission to the emergency department for the case groups. All children who survived 24-h emergency unit admission in all comprehensive specialized hospitals of the south region for the control group.	• Delayed diagnosis and treatment [AOR=2.088, 95% of CI (1.128, 3.864)] were significantly associated with pediatric emergency mortality. • Acute respiratory distress syndrome [AOR=2.804, 95% of CI (1.487, 5.250)] were significantly associated with pediatric emergency mortality. • Dehydration [AOR=3.323, 95% of CI (1.260, 8.761)] were significantly associated with pediatric emergency mortality. • Meningitis [AOR=5.282, 95% of CI (2.707, 10.310)] were significantly associated with pediatric emergency mortality. • Sepsis [AOR=4.224, 95% of CI (2.220, 8.040)] were significantly associated with pediatric emergency mortality. • Accidental injury [AOR=3.603, 95% of CI (1.877, 6.916)] were significantly associated with pediatric emergency mortality. • Duration of sign/symptoms [AOR=5.481, 95% of CI (2.457, 12.230)] were significantly associated with pediatric emergency mortality.	Delayed diagnosis and treatment, acute respiratory distress syndrome, dehydration, meningitis, sepsis, accidental injury, and duration of signs/symptoms were significantly associated with pediatric emergency mortality.

Table 2. Continued

Study	Method	Subject	Result	Conclusion
Wise ¹³	Electronic survey conducted by British Paediatric Surveillance Unit	The British Paediatric Surveillance Unit carried out an electronic survey of 4.075 paediatric consultants, representing over 90% of all of those working in the UK and Ireland.	- Delays in emergency department visits may have contributed to deaths of 9 children. - Causes included sepsis, malignancy, and metabolic disease.	Delays in attending emergency departments may have contributed to deaths.
Devaraj ¹⁵	The study utilized a cross-sectional design	Parents attending health talks at the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia between June 2019 to November 2019.	Parents have good knowledge, attitudes and practices towards childhood emergencies. Older age and female parents showed higher knowledge and positive attitudes.	Older parents have more knowledge on childhood emergencies. Female parents exhibit positive attitudes towards managing children's emergencies.
Sulissia et al. ¹⁶	One group pretest and posttest design	Fifty five respondents (parents of students at TK Aisyiyah 11 Palembang).	There is an increase in knowledge about the knowledge of early treatment of seizures in children.	There is an effect of educational videos on parents' knowledge in early handling of children at Aisyiyah 11 Palembang Kindergarten, so parents should always update their knowledge about the handling through online and offline video media.
Siregar and Damanik ¹⁷	Observational analytic with cross sectional design	Forty parents who have children under five years in Tanjung Pasir Village, Simalungun Regency.	- Majority of respondents had less knowledge as many as 17 people (42.5%). - Negative attitudes as many as 24 people (60%). - There was a relationship between parental knowledge and attitude in the first treatment of febrile seizures in children (p-value 0.000).	Knowledge was related to parents' attitudes about the first treatment of febrile seizures in children. Good knowledge will lead to a good attitude in the first treatment of febrile seizures in children at home. It is expected that health workers, especially nurses, provide increased health education to increase knowledge and attitudes of parents about the first treatment of children with febrile seizures.
Wibawati et al. ¹⁸	One group pretest posttest design	A sample of Forty respondents using an accidental sampling technique.	The distribution of the frequency of knowledge before counseling was carried out as many as 25 (62.5%) had poor knowledge, while after counseling there were 36 respondents (90%) had good knowledge.	There is an effect of health education about first aid on the level of knowledge of parents in handling injuries to toddler.
Feri and Juartika ¹⁹	One group pretest and posttest design	Thirty mothers in Marga Rahayu Village.	- An increase in mother's knowledge and skills about diarrhea. - Before the training it was 38.2 and after attending the training it increased to 83.67. - An increase knowledge and skills about diarrhea of 45%.	Training on managing children with diarrhea at home is effective in increasing mothers' knowledge in managing diarrhea at home.
Anestia et al. ²⁰	Cross sectional design	Sixty five respondents.	86.2% of parents had good knowledge about DHF disease and 84.6% made efforts to prevent the disease. - There is a relationship between parental knowledge and efforts to prevent DHF in children.	Good knowledge will form the best prevention efforts from parents to prevent their children from declining health, especially DHF disease.

AOR: Aortic regurgitation, CI: Confidence interval, ED: Emergency department, DHF: Dengue hemorrhagic fever

include febrile seizures, choking and cardiopulmonary resuscitation. The results of this study showed significant differences in knowledge about emergencies in children, which included aspects of febrile seizures, choking, and cardiopulmonary resuscitation before and after education.⁷ This is in accordance with a previous study which conducted research on parents' knowledge of handling children with febrile seizures. Parents are given educational videos about the early treatment of children with seizures. In this study, we prove that providing education through learning videos can increase parents' knowledge about how to handle the emergency of children who have febrile seizures.¹⁶

Low levels of parental knowledge have a significant relationship with the occurrence of negative attitudes when dealing with children who have febrile seizures.¹⁷ Several other studies also prove that training and counseling methods for parents can increase parents' knowledge about emergencies in children, such as handling injuries in toddlers, recognizing dangers, and managing diarrhea in children at home.^{18,19} In both of these studies, there was a significant increase in knowledge level after training or counseling. Increasing parents' knowledge about emergency prevention is equally important for an effort to reduce child mortality and morbidity due to emergencies among children. In an Indonesian study, it was found that good knowledge of dengue hemorrhagic fever (DHF) has a significant relationship with DHF prevention.²⁰ The problem is that efforts to comprehensively and systematically equalize knowledge about emergency situations in children do not yet exist. Training and education for parents about emergencies in children should be carried out by the government so that the initiative can cover all parents throughout Indonesia.

A study in Indonesia demonstrated that educating parents about the recognition of emergencies effectively increases their ability to handle children's emergencies, thereby potentially reducing the death rate. Future research should explore the correlation between education level and emergency response effectiveness to tailor interventions.²¹ A limitation of this study is that the population sample only covers one area. Thus, this can be developed for multicenter studies to enable wider research.

One recommendation that can be made, apart from providing education about emergencies to children and parents, is developing emergency response technologies. Through AI, technology that can be easily used by parents to recognize emergencies in children can be developed. One idea for developing AI in recognizing emergencies in children, is to apply the pediatric assessment triangle (PAT) method in the form of AI videos. Parents can record videos of their children who are sick and enter them into the PAT application, so they can conclude whether their children are in a serious condition.

This method certainly requires measurable validation. However, it could become a target for scientific studies.

Social and Cultural Aspects of the Family and the Surrounding Environment in Responding to Emergencies in Children

The high mortality and morbidity rates in children are, one of which is related to parents delaying bringing their children to the doctor or emergency room. The problem of delay is not only because parents do not recognize a child's emergencies, but is also related to socio-cultural aspects, such as the extended family asking that the child be taken to receive alternative medicine. Financial constraints can also cause parents to be late in bringing children to the hospital. Transportation costs and expensive living costs in hospitals often make parents delay bringing their children to the hospital.^{22,23} According to research conducted in Vietnam and Africa, poor patients tend to take children in emergency conditions to under-resourced facilities. This causes delays in taking children to referral hospitals.^{24,25} The problem of late referrals is influenced not only by socio-cultural aspects, such as families preferring to take sick children to a traditional healer rather than to a doctor, but also by financial issues, which are a consideration for parents who are reluctant to take sick children to the doctor. One of the recommendations is that the government should provide treatment and transport services for patients at a low cost or even for free. This will make the burden lighter for parents when taking their children to the doctor for treatment or to the hospital.

Knowledge of Health Workers in Primary Health Facilities in Recognizing and Managing Pediatric Patients who Experience Emergencies

Another problem that plays a role in increasing child mortality and morbidity is the lack of knowledge of health workers in recognizing emergencies in children in the emergency department (Table 3). A previous study in Indonesia found that only 18.1% of health workers had high knowledge about acute diarrhea with dehydration, with the remaining 45.5% having moderate knowledge and 36.4% having low knowledge about it in children. However, most health workers are able to properly manage acute diarrhea with dehydration (72.7%).²⁶ A strategy to overcome the lack of equal knowledge of health workers about pediatric emergencies is to conduct training for doctors or nurses. A study proves that nurses who are given emergency training experience a significant increase in their knowledge.²⁷ In Indonesia, primary care provided by Puskesmas or primary care clinics covers 86% of the total health care facilities. Doctors in primary care play an important role as gatekeepers and coordinators of health services. Therefore, doctors working in primary care health facilities need to receive training to improve their knowledge. However, special

training for doctors working in primary care in Indonesia is still not well programmed (Table 3).^{28,29} In addition to providing continuous training on pediatric emergencies to doctors, primary health care facilities must also be equipped with infrastructure that supports the management of pediatric emergencies. The problem that occurs is that pediatric patients often have to delay referral to health facilities with a PICU, because the PICU at the referral hospital is still full. One of the recommendations is that the government can provide oxygen therapy facilities for children experiencing respiratory distress at community health centers (CHCs), such as with continuous positive airway pressure (CPAP) or high flow nasal cannula (HFNC), so that respiratory failure can be prevented. The success rate of therapy at referral hospitals will increase because delays in therapy can be minimized. Another recommendation is that the government can provide hemodynamic monitoring tools that are simple yet possess high sensitivity and specificity in monitoring hemodynamic disorders in shocked children at CHCs. Patients can still be treated for shock early and adequately at the CHC before they are referred. This will certainly help reduce the mortality of pediatric patients in referral hospitals.

Limited Pediatric Intensive Care

Limited space in the intensive room of referral hospitals in Indonesia is often a problem that can increase the risk of death of children in referral hospitals. In 2020, the number of PICU beds in Indonesia was 1653, for 270.2 million Indonesians. Based on data from the Indonesian Central Bureau of Statistics, the number of children in Indonesia in 2020 was 88.673.000.³⁰ Therefore, 1 PICU bed serves 53.644 Indonesian children. When compared to the situation in the

United States (US) and the UK, the availability of PICU beds in Indonesia remains significantly limited. In the US, one PICU bed is for 10.000 children, while in the UK, one PICU bed is for one thousand children. Even so, the situation in Indonesia is slightly better than in Pakistan, where there is 1 PICU bed for 500.000 children under the age of 14 years.³¹

The limited number of beds in the PICU results in patients not being able to be referred from the referring hospital, thus requiring treatment at their facilities with makeshift arrangements. It is not only the problem of bed availability that causes child patients to be delayed in being referred. Even when a child has received a place of care, many other factors cause children to not be referred to hospitals that have PICU facilities. Based on research conducted in Yogyakarta, out of 494 critically ill patients, only 398 were admitted, and 98 were refused admission to the PICU. Some reasons for being rejected at referral hospitals include a lack of available PICU beds (84%), patients not being transportable (9%), patients not meeting the priority criteria (5%), patients being terminal or palliative (1%), and the referring hospital being too far (1%).³²

Factors Affecting the Outcomes of Critically Ill Children Treated in the Referral Hospital

The problem of high child mortality in the PICU in Indonesia occurs because patients who enter the PICU were late and did not get adequate treatment before being referred. Critically ill patients treated at the PICU of the referral hospital often face several challenges. These include patients with hemodynamic disorders who did not receive adequate treatment at the previous hospital and respiratory distress patients who did not receive adequate treatment due to incomplete equipment at

Table 3. Knowledge of health workers in primary health facilities in recognizing and managing pediatric patients who experience emergencies

Study	Method	Subject	Result	Conclusion
Yosi ²⁶	Analytic study with cross-sectional design	Forty four health workers in 2 hospitals, 1 clinic and 4 health centers in Pontianak city.	- Physicians's knowledge level about acute watery diarrhea is 36.4% low, 45.5% moderate, 18.1% high and the treatment is 27.3% bad and 72.7% good. - Corelation score between physicians's knowledge and treatment (r) 0.615 and p=0.000	There is a meaningful relation between physicians's knowledge level towards the treatment of 1-5 years old dehydrated children with acute watery diarrhea in Pontianak's emergency units.
Ekawati et al. ²⁸	Semi-structured interviews with a topic guide	The participants were GPs practicing in Yogyakarta primary care clinics who were recruited using purposive-maximum variation sample design.	- Almost all the GP participants were unfamiliar with the primary care training program. - GP partisipants were also pessimistic if the training could change the health service in the country while it lacked resources and infrastructures. - Exposure to the training brought positive insights that it could improve the doctors' knowledge and skills in primary care practice.	The government intention to establish PCP training is currently on the right tract.

the referring hospital, such as the absence of HFNC, CPAP, or ventilators. Additionally, infection remains a significant problem for children in Indonesia, as the detection of sepsis faces many obstacles (Table 4). Hemodynamic disorders in critically ill children in Indonesia are caused by several factors, including DSS, sepsis shock, hypovolemic shock, and other causes. An Indonesian study obtained results from a total of 239 shock patients: 55 experiencing DSS, 136 with sepsis shock, 1 with obstructive shock, and the remaining could not be classified as the type of shock.³

DSS cases are prevalent in Indonesia. For example, in Yogyakarta, from January to December 2016, of the 271 patients admitted to the PICU, 97 (35.7%) were DSS patients.³³ Meanwhile, DSS cases in Malang, Indonesia (January-December 2016, out of 100 patients): 92% are classified as DHF grade III and 8% of patients are classified as DHF grade IV.³⁴ A study in Indonesia stated that the mortality rate of DSS patients was 5.5%. The predictive factors of mortality in DSS patients are fluid overload, disseminated intravascular coagulation (DIC), acute kidney injury (AKI), and unresolved shock upon admission to the PICU.³⁵ Those predictors are associated with monitoring, and determining inadequate fluid resuscitation. Efforts are made to minimize this condition by finding effective hemodynamic monitoring methods to determine patients with shock who do and do not respond to fluid. Studies in Indonesia aim to find hemodynamic monitoring methods in pediatric patients experiencing shock by determining the response to fluid administration using ultrasound cardiac output monitoring (USCOM) compared to the electrical cardiometry monitor (ICON) hemodynamic monitoring tool.³⁶ The determination of shock patients who respond to fluid resuscitation is by using the stroke volume variation parameter which has a sensitivity of 72.7% and specificity of 70%.³⁷ Hypovolemic shock is dominant in DSS. However, some studies have found that DSS patients also experience myocardial dysfunction or cardiomyopathy, so USCOM can help DSS patients unresponsive to fluid resuscitation and requiring inotropic vasopressor drugs. The USCOM parameter used to determine the need for inotropic support is the Smith-Madigan inotropic index, while the parameter used to determine the afterload condition of patients who experience DSS is the systemic vascular resistance index (SVRI).^{33,34}

The problem in Indonesia is the use of non-invasive hemodynamic monitoring devices such as USCOM and ICON is only available in referral hospitals. This causes patients in referring hospitals to be resuscitated with fluids based on clinical parameters only. This situation sometimes causes children with DSS to fluid overload, because it is difficult to determine whether pediatric patients have reached a normovolemic state, are still hypovolemic, or have experienced

overload due to fluid resuscitation. Shock that is not resolved promptly can also cause complications such as AKI and DIC.³⁵

Another problem faced by pediatric patients in Indonesia who experience hemodynamic disorders is septic shock. A prospective study in Indonesia conducted for 6 months found that 52 pediatric patients experienced sepsis shock, of whom only 23 patients survived (44.2%).⁴ The high mortality of septic shock patients in developing countries such as Indonesia is related to several factors, including fluid overload, the need for mechanical ventilation support, the use of vasoactive drugs, and congenital anomalies.³⁸

The strategy to reduce the mortality rate of shock patients in children is to use several monitoring tools, namely clinical, macrocirculation, and microcirculation parameters. Clinical parameters that can be used as a monitoring tool for pediatric patients experiencing septic shock are heart rate, systolic blood pressure, body temperature, mean arterial pressure (MAP), capillary refill time, Glasgow Coma scale, and diuresis. Macrocirculation hemodynamic parameters include cardiac index (CI), stroke volume index, SVRI measured using USCOM, while microcirculation hemodynamic parameters include lactate, bicarbonate, and base excess. Research in Indonesia found that a strong pulse after fluid resuscitation at 6 hours, MAP more than 50th percentile at 12 hours, and SVRI at 24 hours are strong predictors of survival in septic shock patients. If we resuscitate pediatric patients who have septic shock, then within 6 hours the pulse must be strong, and within 12 hours, the MAP must be more than the 50th percentile; then the child has a greater chance of survival. This can be applied at the Referrer Hospital or at the first health facility if you get a pediatric patient who has septic shock but has not been admitted to the PICU.⁴ Based on non-invasive hemodynamic monitoring using USCOM, pediatric patients in Indonesia who experience sepsis shock are mostly hypodynamic, where CI is normal, preload, inotropy and afterload are still abnormal.³⁹ Resuscitation can be carried out at the first referral hospital or health facility, targeting the study results, and monitored using clinical parameters, macro-circulation parameters with non-invasive hemodynamic monitoring tools such as USCOM, and micro-circulation parameters using arterial blood gas (AGB) tests. The government should facilitate the availability of hemodynamic monitoring in hospitals in Indonesia, as well as provide laboratory equipment to conduct AGB tests. This will help monitor the hemodynamics of pediatric patients and reduce pediatric mortality. A study in Indonesia has proven that fluid resuscitation of pediatric patients who experience sepsis shock using the ultrasound-guided fluid resuscitation protocol can prevent fluid overload and reduce child mortality at 72 hours. This is compared to pediatric patients who experience sepsis shock and resuscitation using the American College of Critical Care Medicine protocol (Table 4).⁴⁰ The problem of

Table 4. The problem of high children mortality with hemodynamic problem in PICU in Indonesia

Study	Method	Subject	Result	Conclusion
Rusmawatiningtyas and Nurnaningsih ³	A retrospective study	Two hundred thirty nine shock cases from all types, from all PICU admissions between November 1, 2011 to June 30, 2014.	- From 239 cases, there were 55 cases related to dengue shock syndrome; 136 case of septic shock, 38 cases who failed to meet the criteria for septic shock, and 1 case of obstructive shock. - The median length of PICU stay was 4 days. A total of 48.5% of the subjects were in need of crystalloid and colloid fluid in a median amount of 40 mL/kg. - The median time required to complete the initial resuscitation was 60 minutes. - Mechanical ventilator support in the first 24-h was required in 79.4% of the cases. - Fluid overload of >10% (FO >10%) was found in 58.8% of the subjects.	The mortality rate in pediatric septic shock in our unit is very high. There is a higher incidence of fluid overload in non-survival group.
Yulianto et al. ³⁴	A retrospective observational study	Pediatric patients who were between one month to 18 years old, presented with clinical criteria for DHF grade III and IV based on WHO classification of dengue fever in 2011, and admitted to the Saiful Anwar General Hospital, Malang-Indonesia, from January 2016 to December 2016.	- Among 100 patients, 92 patients were classified as DHF grade III and 8 patients were DHF grade IV. 74 patients were in the restrictive group and 24 patients were in the liberal group. - No significant differences were observed between length of stay in PICU ($p=0.09$), and duration of ventilator use between liberal and restrictive group. - The restrictive group had 53% lower mortality compared to the liberal group ($p=0.18$). - There were no significant differences in hemodynamic parameters between two groups based on measurement with USCOM which were preload component (SVV) ($p=0.89$), inotropy components (SMII) ($p=0.07$), SVRI ($p=0.85$) as well as the CI ($p=0.66$).	This study showed that there is no difference in clinical outcomes (length of mechanical ventilation and length of PICU stay), and hemodynamic parameters (preload, inotropy, afterload, and CI) in dengue shock syndrome patients who receive restrictive or liberal fluid resuscitation.
Armenda et al. ³⁵	A prospective observational study	Consecutive sampling method from 97 children admitted to the PICU with DSS from 1 January 2016 to 31 July 2016.	Ninety-seven (35.7%) among them had a primary diagnosis of DSS on PICU arrival. Slightly more than three-quarter (76.7%) of DSS patients arrived in PICU with clinically shock condition (group 1) while the rest (23.3%) showed no clinical sign of shock (group 2). This study found that in group 1, patients had received less intravenous fluid prior to their admissions to the PICU compared to group 2 patients (6.90 vs. 7.52 mL/kg BW/h). Three patients in group 1 had not received any fluids before they were admitted to this hospital because of difficulties in obtaining intravenous access.	Only a small percentage of DSS patients with clinically shock admitted to the PICU were fluid responsive.
Yulianto et al. ³⁴	A prospective study	Fifty two subjects were aged 1 month to 18 years who were diagnosed with septic shock based on clinical and laboratory findings according to the Surviving Sepsis Campaign Guidelines from August to December 2020 at the PICU in Dr. Saiful Anwar Hospital, Malang, East Java, Indonesia.	- There was a significant correlation between the outcomes of the pediatric septic shock patients 72-h after fluid resuscitation and clinical, macrocirculatory hemodynamic, and microcirculatory laboratory parameters. - After the 6th hour of observation, strong pulse was predictive of survival, with 88.2% AUC. At the 12th hour of observation, MAP >50th percentile for age was predictive of survival, with 94% AUC. - Macrocirculatory hemodynamic parameters include blood pressure, CI, MAP, and SVRI. Microcirculatory laboratory parameters include serum lactate, central venous pressure, central venous oxygen saturation (ScvO₂), mixed venous oxygen saturation (ScvO₂), HCO₃, and base excess.	Pediatric patients with septic shock, the treatment target in the first 6-h is to improve strength of pulse, and that in the first 12-h is to improve MAP >50 th percentile for age to limit mortality .

Table 4. Continued

Study	Method	Subject	Result	Conclusion
Rusmawatiningtyas et al. ³⁸	A retrospective observational study	Patients' data from 1 st January 2014 to 31 st December 2019 who had been diagnosed with sepsis and admitted to the PICU in our tertiary hospital (Dr. Sardjito Hospital, Yogyakarta, Indonesia). The definition sepsis using the Goldstein 2005 criteria.	- Higher risk of mortality in PICU was associated fluid overload percentage of >10% (HR: 9.6, 95% CI: 7.4-12.6), the need of mechanical ventilation support (HR: 2.7, 95% CI: 1.6-4.6), vasoactive drugs (HR: 1.5, 95% CI: 1.2-2.0) and the presence of congenital anomaly (HR: 1.4, 95% CI: 1.0-1.9). - On the contrary, cerebral palsy (HR: 0.3, 95% CI: 0.1-0.5) and post-operative patients (HR: 0.4, 95% CI: 0.3-0.6) had lower mortality.	PICU mortality in pediatric patients with sepsis is associated with fluid overload percentage of >10%, the need for mechanical ventilation support, the need of vasoactive drugs, and the presence of congenital anomaly. In septic patients in PICU, those with cerebral palsy and admitted for post-operative care had better survival.
Yuliarto et al. ⁴³	A prospective observational study	Fifty shock patients from January to September 2014 in an emergency department and PICU, at Dr. Cipto Mangunkusumo General Hospital, Jakarta City, Indonesia.	- Fifty patients were included with 25 of them are male. The median age was 35 months (1 month-18 years old). - Septic shock was the most (60%) clinical type of shock, due to pneumonia, meningitis, malignancy, and post-surgery condition. - The survival rate at PICU discharge was 74%. - Based on normal hemodynamic values for age, at 1st hour, all of low CI patients had low SMII, while 6/7 were in fluid-refractory shock and high afterload. In the normal CI group, the majority (19/33) were in fluid-refractory shock; more than half (10/19) had low SMII. In the high CI group, the majority (6/10) were in fluid-responsive shock, and most of them (4/6) had normal SMII. At the 6th hour, 5/7 and 18/33 subjects in groups 1 and 2, respectively, still revealed low SMII (with various afterload levels). Conversely, most subjects in group 3 (6/10) revealed normal SMII along with various afterload levels.	Most pediatric shock patients were hypodynamic. Even when the CI was normal, the preload, inotropy, and afterload may still be abnormal. It represented the inotropy as a key to hemodynamic.

FO: Fluid overload, PICU: Pediatric intensive care unit, DHF: Dengue hemorrhagic fever, WHO: World Health Organization, USCOM: Ultrasonic cardiac output monitor, SVV: Stroke volume variation, SMII: Smith-madigan inotropy index, SVRI: Systemic vascular resistance index, DSS: Dengue shock syndrome, HR: Heart rate, CI: Cardiac index, CI: Confidence interval, AUC: Area under the curve, MAP: Mean arterial pressure

septic shock lies not only in establishing the diagnosis but also in hemodynamic monitoring, as well as in adequately managing and treating the patients. Hemodynamic monitoring is crucial to anticipate fluid overload during fluid resuscitation in patients with septic shock. One of the consequences of fluid overload during resuscitation is prolonged use of mechanical ventilation.^{41,42}

High PICU mortality rates are also associated with pediatric patients with respiratory distress, but inadequate oxygen therapy treatment. A study conducted in Indonesia over 5 months of observation found that 35 pediatric patients who entered the PICU had respiratory failure: 37.1% had respiratory failure type 1, 37.1% had respiratory failure type 2, and 25.7% had mixed type respiratory failure. Of the patients who developed respiratory failure, 28.6% died.⁴⁴ High mortality rates can be prevented by providing patients referred by hospitals with non-invasive oxygen therapy, such

as CPAP or HFNC. However, this situation has not materialized in Indonesia. Oxygen therapy is expected to improve the outcomes so that patients who are transferred to referral hospitals do not experience prolonged hypoxia. Another study obtained results for 4 years of observation. Of the 366 patients who entered the PICU: 100 patients (27.3%) experienced pediatric acute respiratory distress syndrome.

Patients who use invasive mechanical ventilation are more than patients who use non-invasive mechanical ventilation, which is 80% and 20%, respectively.⁴⁵ A non-invasive therapeutic modality, HFNC, is proven to provide excellent outcomes. HFNC can reduce excessive breathing effort by several mechanisms, including reducing work of breathing, reducing energy expenditure, improving lung component and muco-ciliary function, and providing positive pressure on the airway.⁴⁶ Currently, research is needed to determine the effectiveness of HFNC in critically ill children in Indonesia.

Infection is also a problem for critically ill children that can affect the outcomes and can increase child mortality. A study conducted in Surabaya, observed over a 5-year period (2011-2016) in the PICU presented results showing that, among 1138 patients with positive microbial cultures; 44.6% came from blood, 19.15% from urine, 11.59% from sputum, 8.96% from feces, 7.5% from cerebrospinal fluid, 4.04% from endotracheal tube (ETT), 2.89% from pus swab, and 1.41% from pleural fluid. Most microorganism communities are dominated by Gram-negative bacteria. The most abundant bacteria are *Burkholderia cepacia* in blood, *Escherichia coli* (*E. coli*), in urine, *Pseudomonas aeruginosa* in sputum, *E. coli* in feces, *Staphylococcus cohnii* in cerebrospinal fluid, *Klebsiella pneumoniae* extended-spectrum beta-lactamase in ETT, *Staphylococcus aureus* in pus swab, and *Stenotrophomonas maltophilia* in pleural fluid. Some antibiotics that are still sensitive to these bacteria include amikacin, cefoperazone-sulbactam, linezolid, vancomycin, and carbapenem groups. Pneumonia is the most common disease that causes positive microorganism cultures.⁴⁷ In another study in Jakarta, Indonesia, observations conducted over one year resulted in a total of 486 blood cultures, 410 of which were sterile. Culture results were positive; 64 microorganisms were Gram-positive, and 12 microorganisms were Gram-negative. Gram-positive bacteria consist of *Staphylococcus hominis*, *Staphylococcus epidermidis*, *Staphylococcus haemolyticus*, and *Staphylococcus aureus*. Gram-negative bacteria consist of *Salmonella typhi* and *Acinetobacter baumannii*. The appropriate antibiotics for Gram-positive bacteria were vancomycin (95.2%), gentamycin (68.3%), cotrimoxazole (44.4%), cefotaxime (31.7%), and ceftriaxone (31.7%). Antibiotics for Gram-negative bacteria consist of meropenem (84.6%), cotrimoxazole (84.6%), amikacin (61.5%), gentamycin (53.8%), and cefepime (46.2%).⁴⁸

The study conducted in Yogyakarta, aimed to predict infections caused by *Candida*. Patients in PICU are divided into two groups, namely those infected with *Candida* and those who are not infected with *Candida*. From the results obtained in this study, from 43 patients infected with *Candida*, 7 had candidemia.⁴⁹ The problem faced by doctors working in PICU is the lack of specific antibiotic guidelines for PICU; not all hospitals have these guidelines. Therefore, easy-to-understand guidelines are needed in managing infection in the PICU, so that people have no difficulty determining which antibiotics or antifungals will be used for pediatric patients with infections.

Another problem for critically ill children is the outcomes of patients post-treatment in the PICU. A study conducted in Malang, Indonesia that examined neurocognitive predictor factors and psychological disorders in children after treatment in PICU obtained results from 53 critically ill patients aged 4-18 years, treated in PICU for more than 24 hours and alive,

neurocognitive problems, pro-social behavior improved after 3 months of treatment in the PICU, but in children aged 4-5 years neurocognitive abnormalities continued to occur, especially in boys, coming from families of low socio-economic level, incomplete family members, having previously had neurological problems or disorders and and in postoperative patients.⁵⁰ Post-PICU treatment causes detriments to the quality of life, both in patients and their families. The patient's family was shown to experience significant depression, anxiety, and stress after their child received treatment in the PICU compared to before the treatment. In the meantime, children's quality of life and functional level decline despite post-PICU treatment. The severity of neurological disease is significantly associated with decreased functional status.⁴³ Until now, efforts to improve PICU services have focused on increasing the capacity of human resources, both pediatricians and nurses. Trainings between pediatric intensive care doctors, general pediatricians, and nurses are carried out every year in the PICU-NICU update program held by the Indonesian Pediatric Society's Emergency and Pediatric Intensive Therapy coordination work unit. This training aims to improve the skills of pediatric intensivists, general pediatricians, and PICU nurses. Apart from that, the Indonesian Pediatric Society's Emergency and Pediatric Intensive Therapy coordination work unit also collaborates with pediatric intensivist doctors in Southeast Asia, Asia and the world to carry out scientific development.

In the end, it can reduce mortality in infants and children. Another problem is that blood, urine, and fecal cultures are only available in the laboratory of referral hospitals, but few referring hospitals and primary health facilities are equipped to culture microorganisms. This prevents primary health facility or referring hospital doctors from finding out what microorganisms cause infections in patients, thus hindering them from providing adequate treatment. The government must have a policy that facilitates primary health facilities and referring hospitals to carry out blood culture examinations, urine, feces, swabs, and other cultures. This ensures that if the patient cannot be referred to a referral hospital with intensive care facilities, antibiotics that are culturally appropriate can be given immediately.

Conclusion

To enhance the quality of PICU services and decrease child mortality and morbidity rates, efficacy does not solely rely on proficient medical practitioners and resources available at tertiary care hospitals; it also depends on the ability to execute emergency interventions in children effectively. It also necessitates consideration of factors such as parental aptitude in identifying pediatric emergencies, socio-economic and

cultural influences, competence of healthcare professionals in primary care settings in recognizing and managing pediatric emergencies, availability of hospital beds at referral facilities, and the implementation of optimal protocols at referral hospitals. This ensures that the patient being transferred has attained stabilization at the referring institution or primary healthcare center through appropriate interventions.

Footnotes

Authorship Contributions

Concept: K.T.K., Design: S.Y., Data Collection or Processing: C.M., Analysis or Interpretation: K.T.K., Literature Search: S.Y., T.K., Writing: K.T.K., T.K.

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