Review Article

Cost-minimization analysis of pneumonia treatment in Indonesia

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Abstract

Pneumonia is one of the significant causes of death in developing countries, including Indonesia. As the capital of West Java, Bandung is one of the cities with the highest pneumonia cases in this province. The objective of this study was to conduct cost-minimization analysis of pneumonia treatment in Indonesia by using one of the private hospitals in Bandung as a reference case. The use of cefuroxime and ceftizoxime was considered in adult hospitalized patients. In addition, ampicillin-sulbactam and ceftriaxone usage was compared in pediatric hospitalized patients. A cross-sectional descriptive study was applied by collecting data retrospectively from medical records of adult and pediatric patients who met the inclusion criteria at one of the private hospitals in Bandung from January 2017 to December 2018. We applied the following inclusion criteria: (i) adult (> 20 years old) and pediatric (0–5 years old) patients who were diagnosed with pneumonia; and (ii) adult patients who received cefuroxime or ceftizoxime antibiotic therapy and pediatric patients who received ampicillin-sulbactam or ceftriaxone antibiotic therapy. We excluded patients who were diagnosed with any other co-morbidities and who did not complete the treatment. The result showed that drug cost was the primary contributor to total treatment cost in adult and pediatric patients. We calculated the average total treatment cost with ceftizoxime and cefuroxime in adult patients at $149.39 and $193.05, respectively, and the average total treatment cost with ampicillin-sulbactam and ceftriaxone in pediatric patients at $202.83 and $192.77, respectively. We also estimated the LoS in a group of ceftizoxime and cefuroxime in adult patients at 3.8 and 4.1 days, respectively, and the LoS in a group of ampicillin-sulbactam and ceftriaxone in pediatric patients at 3.9 and 5.3 days, respectively. In conclusion, using ceftizoxime to treat hospitalized pneumonia in adult patients would require less cost and yield shorter LoS than cefuroxime. Using ampicillin-sulbactam to treat hospitalized pneumonia in pediatric patients would require higher costs and yield shorter LoS than ceftriaxone.

Keywords

cefuroxime, ceftizoxime, ampicillin-sulbactam, ceftriaxone

PENSOFT.

Introduction

Pneumonia is an acute lower respiratory tract infection in the lung parenchyma caused by microorganisms (e.g., bacteria, viruses, fungi, and parasites). Pneumonia remains a significant problem globally, occurring throughout the year in pediatric and adult age groups with different clinical manifestations (Lakhanpaul et al. 2004). In addition, pneumonia is one of the significant causes of death in developing countries, including Indonesia. A primary health survey in Indonesia confirmed a prevalence of pneumonia of 4.5%, associated with 15% of deaths in children under five (Ministry of Health 2017). West Java is considered one province with high pneumonia cases, specifically in children under five years old. As the capital of West Java, Bandung is one of the cities with the highest pneumonia cases, with a coverage of 81.84% in children under five years old (District of Health, Province of West Java 2017).

Up to now, the primary pneumonia treatment in Indonesia is through administering antibiotics. Broad-spectrum antibiotics are given as empiric therapy for pneumonia. Nevertheless, uncontrolled use of these broad-spectrum antibiotics can increase the risk of bacterial resistance, increasing the morbidity and mortality rates associated with pneumonia. In addition, the irrational use of antibiotics can cause more extended treatment periods and more expensive costs. Therefore, using selected antibiotics as an alternative therapy for pneumonia needs to be evaluated continuously.

According to the guideline for pneumonia launched by the National Institute for Health and Care Excellence (NICE) and the Infectious Diseases Society of America (IDSA), the first choices of empirical pneumonia treatment for hospitalized patients are fluoroquinolone (e.g., levofloxacin and moxifloxacin), cephalosporin (e.g., cefuroxime and ceftizoxime) or in combination with macrolides (National Clinical Guideline Centre 2015). Furthermore, several previous studies in Indonesia highlighted the most widely used antibiotics to treat hospitalized pneumonia: cefuroxime and ceftizoxime in adult patients and ampicillin-sulbactam and ceftriaxone in pediatric patients (Wahyuni et al. 2015; Kurniasih et al. 2020). The objective of this study was to conduct cost-minimization analysis of pneumonia treatment at one of the private hospitals in Bandung, Indonesia, by focusing on the use of cefuroxime and ceftizoxime in adult hospitalized patients and the use of ampicillin-sulbactam and ceftriaxone in pediatric hospitalized patients.

Methods

We applied a cross-sectional descriptive study by collecting data retrospectively from medical records of adult and pediatric patients who met the inclusion criteria at one of the private hospitals in Bandung. We applied a 2-year time horizon analysis (2017–2018) and considered the following inclusion criteria: (i) adult (> 20 years old) and pediatric (0–5 years old) patients who were diagnosed with pneumonia; and (ii) adult patients who received cefuroxime or ceftizoxime antibiotic therapy and pediatric patients who received ampicillin-sulbactam or ceftriaxone antibiotic therapy. We excluded patients diagnosed with any other comorbidities and those who did not complete the treatment. Ethical approval for the study was obtained from the Ethics Committee of Universitas Padjadjaran, Indonesia (Registration number: 89/UN6.KEP/EC/2019).

We applied the healthcare perspective to estimate the treatment cost by considering the hospital's point of view. We derived data related to direct medical costs from the hospital's billing database by following cost classifications in the system, such as the cost of drugs, physician fees, treatment room, laboratory tests, and nursing services. To estimate the cost of drugs, we applied the hospital's price in 2017–2018. We considered the following dosage regimens: ceftizoxime 2×500 mg and cefuroxime 2×250–500 mg for adult patients, and ampicillin-sulbactam 4×500 mg and ceftriaxone 2×350–1000 mg for pediatric patients. We conducted a cost-minimization analysis by assuming that all alternatives compared in this study would yield the same effectiveness at a 100% cure rate. We calculated physician fees, treatment rooms, laboratory tests, and nursing services by considering the hospital tariff in 2017–2018. We also collected data related to the length of stay (LoS) due to its association with other doctor's assessments, such as laboratory tests (e.g., the number of leukocytes), the level of coughing and tightness, and other clinical assessments. We converted all costs to 2018 US\$ (1\$ = IDR14,500).

Results

Applying the inclusion and exclusion criteria, we included 100 pediatric and 110 adult patients in this study. These numbers were distributed as 42% of females and 58% of males in pediatric patients and 37% of females and 63% of males in adult patients (see Table 1). Most patients were 1–12 months old and 60–69 years old for pediatric and adult patients, respectively (see Table 1). Of the 100 pediatric patients, 59% and 41% received ampicillin-sul-

Table 1. Distribution of pneumonia patients by gender and distribution of patients by age.

	Pediatric		Adult	
Sex	Amount	Percentage (%)	Number	Percentage (%)
Female	42	42	41	37
Male	58	58	69	63
Total	100	100	110	100
	Age	Amount	Age	Amount
	<1 month	9	20–29 years	22
	1–12 months	52	30–39 years	12
	2–3 years	29	40–49 years	9
	4–5 years	10	50–59 years	23
	Total	100	60–69 years	26
			70–79 years	15
			>79 years	3
			Total	110

bactam and ceftriaxone antibiotics therapy. Of the 110 adult patients, 54% and 46% received ceftizoxime and cefuroxime antibiotics therapy, respectively (see Table 2). Additionally, we observed that the unit price of ampicillin-sulbactam is higher than ceftriaxone in pediatric patients, and the unit price of ceftizoxime is higher than cefuroxime in adult patients (see Table 2).

Table 2. Antibiotic profile of pneumonia patients and unit price of antibiotics.

Pediatric			Adult		
Antibiotics	Number	%	Antibiotics	Number	%
Ampicillin-sulbactam	59	59	Ceftizoxime	59	54
Ceftriaxone	41	41	Cefuroxime	51	46
Total	100	100	Total	110	100
	Dosage form	Unit price		Dosage form	Unit price
Ampicillin-sulbactam	Injection	$6.14	Ceftizoxime	Injection	$8.45
Ceftriaxone	Injection	$1.72	Cefuroxime	Injection	$8.06

Regarding total treatment cost, drug cost was the primary contributor to total treatment cost in adult and pediatric patients. The average total treatment cost with cefuroxime is higher than ceftizoxime in adult patients, and the average total treatment cost with ampicillin-sulbactam is higher than ceftriaxone in pediatric patients. In addition, the LoS in a group of cefuroxime is longer than ceftizoxime in adult patients, and the LoS in a group of ampicillin-sulbactam is shorter than ceftriaxone in pediatric patients (see Table 3).

Discussion

The World Health Organization (WHO) developed the Access-Watch-Reserve (AWaRe) system to classify antibiotics by considering their spectrum of activity and potential for favoring the development of antibiotic resistance. Each category in the system is associated with narrow spectrum/low potential for resistance, broader spectrum/higher potential for resistance, and last resort antibiotics to use very selectively (Sharland et al. 2023). In the context of pneumonia, the treatment should use narrow-spectrum antibiotics whenever possible, which are selected based on the underlying pathogen (Williams et al. 2013). Since optimal outcomes in this treatment are associated with rapid initiation of antibiotics, initial pneumonia treatment must

be empirical. To select initial empirical treatment, physicians should consider several factors, such as the setting in which pneumonia arose, the illness's severity, the patient's age, the presence of comorbidities, recent treatment, and specific clinical manifestations. Geographic and other specific factors (e.g., the local prevalence of specific microorganisms) may also affect the initial treatment choice (Torres et al. 2016). A delay in starting therapy may increase the length of hospitalization and has been associated with increased mortality.

Several guidelines recommend cefuroxime and ceftizoxime as the first-line antibiotics for adults' community-acquired pneumonia (CAP), while ceftriaxone and ampicillin-sulbactam are for pediatric hospitalized patients. However, which of these antibiotics is more effective for treating non-aspiration CAP remains to be determined. This study aimed to analyze the cost-minimization of pneumonia treatment at one of the private hospitals in Bandung, Indonesia, by focusing on the use of cefuroxime and ceftizoxime in adult hospitalized patients and the use of ampicillin-sulbactam and ceftriaxone in pediatric hospitalized patients. This study's result confirmed that ceftizoxime use in adult patients would require less cost and yield shorter LoS compared to cefuroxime. This finding strengthens the result of a previous study by Weinstein et al. on the cost-effective choice of antimicrobial therapy for severe infections. They found that ceftizoxime was less expensive than other regimens for pneumonia when costs of dose preparation and administration, monitoring, and toxicity were added to drug acquisition costs (Rittenhouse et al. 2000). Additionally, this study confirmed that using ampicillin-sulbactam in pediatric patients would require higher costs and yield shorter LoS compared with ceftriaxone. This finding is linear with the result of a previous study (Hamao et al. 2020). They concluded that even though ampicillin-sulbactam is more costly than ceftriaxone, it is considered more effective, specifically in the early phase of treatment (Weinstein et al. 1986).

Our study has a major notable strength. To our knowledge, this initial study is the first in Indonesia to conduct economic evaluations of cefuroxime and ceftizoxime in adult hospitalized patients and economic evaluations of ampicillin-sulbactam and ceftriaxone in pediatric hospitalized patients. Nevertheless, this study also has several limitations. Firstly, we applied an observational study, where several critical covariates (e.g., socioeconomic factors)

Table 3. Average total treatment cost and length of stay.

Antibiotics	Treatment Cost (%)						Length of Stay
	Drug	Physician	Room	Laboratory	Nurse	Total	
Adult							
Ceftizoxime	$64.44 (43.13%)	$27.62 (18.49%)	$26.30 (17.61%)	$11.31 (7.57%)	$19.73 (13.20%)	$149.39 (100%)	3.8 days
Cefuroxime	$100.45 (52.03%)	$30.10 (15.59%)	$28.67 (14.85%)	$12.33 (6.39%)	$21.50 (11.14%)	$193.05 (100%)	4.1 days
Pediatric							
Ampicillin-sulbactam	$72.41 (35.70%)	$59.66 (29.41%)	$46.10 (22.73%)	$2.97 (1.46%)	$21.69 (10.70%)	$202.83 (100%)	3.9 days
Ceftriaxone	$18.25 (9.47%)	$80.30 (41.66%)	$62.05 (32.19%)	$2.97 (1.54%)	$29.20 (15.15%)	$192.77 (100%)	5.3 days

were not measured or included as pre-treatment covariates or associated outcomes. Secondly, we needed help to precisely identify the bacteriological origins of the disease. The variation in our results may be associated with differences in bacterial etiology. Further studies with larger sample sizes are needed, as a lack of power may have contributed to our findings. Regardless, this study provides meaningful insights into the treatment of CAP in Indonesia.

Conclusion

The result of this study confirmed that ceftizoxime to treat hospitalized pneumonia in adult patients would require less cost and yield shorter LoS compared with cefuroxime. It also confirmed that using ampicillin-sulbactam to treat hospitalized pneumonia in pediatric patients would require higher costs and yield shorter LoS than ceftriaxone.

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