Research Article
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Quality and Potency of Government-subsidized Antibiotics in Hospitals Across Jakarta, Indonesia

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Abstract: Several pharmaceutical companies have long complained that the price of medicines that win the e-catalogue tender is too low, in some cases even below the cost of production. However, it should not be a concern that only pharmaceutical products with regulation of Indonesian food and drug (BPOM) distribution licenses are eligible for the price tender, as they are of good quality. This study aims to determine the quality and potency of three antibiotic drugs based on their highest utilization (DU 90%) in pneumonia patients at two hospitals, A (ceftriaxone, azithromycin tablet) and B (ceftriaxone, levofloxacin infusion) compared to brand name. The quality of the samples was evaluated following the Indonesian Pharmacopoeia 6th Edition (FI-VI). Antibiotic potency was assessed using the Plate-Cylinder Method with K. pneumonia from human and S. pneumonia ATCC 10015 as the test bacteria evaluated following CLSI. All samples meet the criteria of FI-VI antibiotic content, weight uniformity, dissolution. Antibiotic potency all samples test S.pneumonia and K.pneumonia were sensitive but ceftriaxone test with K.pneumonia was resistance. All antibiotic tablets and injections studied met the requirements of the Indonesian Pharmacopoeia Edition 6 for active medicinal ingredient content, dosage weight uniformity, and dissolution. All drugs from hospitals (INN) have lower antibiotic potency than branded drugs. This highlight the importance of conducting microbiological testing on antibiotic preparations.

Introduction

The National Health Insurance program (JKN) was introduced in Indonesia on January 1st 2014, to enhance healthcare access for citizens, to guarantee Universal Health Coverage (UHC) for everyone and protect them from financial risks while providing necessary healthcare services (1). The JKN system provides public healthcare cost coverage for the whole community, which is funded by the Sosial Health Insurance Administation (BPJS) (2). BPJS ensures sufficient funding for all participants healthcare expenses through strategic health purchasing (2, 3). With the criteria being medication that is needed according to the epidemiology of diseases in Indonesia and proven to be cost-effective (2, 3, 4, 5). Medication is an essential component of the healthcare system as it accounts for a significant portion of healthcare funding, specifically 40%. (6, 7). The government plans to provide top-quality healthcare services by introducing all-encompassing healthcare policies, including pharmaceutical policies (8).

JKN implementation led to a significant reduction of up to 79.6% in drug costs, and three essential drug categories (antineoplastics, antibiotics, and hyperglycaemia drugs) observed a price drop of 3.9%, 3.2%, and 2.6% for both generic and brand-name medications (3). The cost of producing drugs is unpredictable and has been increasing each year due to the expense of materials and production (2). Antibiotics are crucial in treating infectious diseases such as bacterial infections and pneumonia. Pneumonia is a concern in several countries, especially Indonesia where infectious diseases are among the top 10 main causes of death (1, 2), Antibiotics are widely used in Indonesia, where a high number of hospitalized patients (988 out of 100,000) suffer from pneumonia. Additionally, pneumonia has a high mortality rate

among adults in Indonesia, reaching 11.3% and ranking among the highest in Southeast Asia (9). The prevalence rate of pneumonia diagnosed by health workers has increased by 2% from 1.8% in 2013, according to the Indonesian Basic Health Research (Riskesdas) 2018 data (10) and pneumonia was one of the top ten most expensive conditions seen during inpatient hospitalizations. In 2013, pneumonia had an aggregate cost of nearly $9.5 billion for 960,000 hospital stays (11).

The use of low-quality antibiotics has been practiced in some countries but is still underrepresented, particularly in middle-income countries (LMICs) (11). This study aims to determine the quality of two antibiotic drugs based on highest utilization (DU 90%) in pneumonia patients at two hospitals A and B. Hospital A is a public hospital and hospital B is a private hospital. This hospital is a referral hospital for BPJS patients. Branded drugs, typically more expensive, will also be considered as a comparator, whether the price reduction through the JKN program does not result in a reduction in the product's quality. Based on previous research, the brand is more cost-effective and shortens hospital stays (13). The parameters for testing the tablet and injection formulations will be based on the Indonesian Pharmacopoeia VI edition (FI VI). The assessment of microba potency is based on parameters set by the Clinical Laboratory Standard Institute (CLSI) (14).

Material and Methods

Study Setting

This study was conducted in pharmacies located in hospital A and B Jakarta, Indonesia with two Drug Utilization (DU) 90% the two most use. In each hospital These antibiotics were from hospital A ceftriaxone and levofloxacin 500 mg parenteral use, from hospital B ceftriaxone and azithromycin 500 mg peroral use. Azithromycin was in the form of tablet (one stripe contains 3 tablets). Ceftriaxone was in the form of vials. Levofloxacin was in the form of infuse bottle, the three different types of antibiotics, will be compared with branded antibiotics namely were azithromycin, levofloxacin, ceftriaxone. Antibiotics are selected based on the highest use in each hospital for treatment pneumonia patients.

Materials

The materials used were phosphate buffer pH 6.0 (Merck KGaA, Darmstadt, Germany), hydrochloric acid 0.1 N (Merck KGaA, Darmstadt, Germany), Streptococcus pneumonia ATCC gram 10015 as test bacteria Gram-positive, and Klebsiella pneumonia from human as test bacteria Gram-negative (14). Samples were obtained from hospital A for parenteral antibiotics ceftriaxone and azithromycin 500 mg tablets as well as from hospital B for injectable ceftriaxone and levofloxacin 500 mg parenterally. As a comparison, branded antibiotics are used with as reference standard (BPFI) was used for each antibiotic. The tests were conducted at the Faculty of Pharmacy, Pancasila University (FFUP) and the National Research and Innovation Agency (BRIN).

Tools

Analytical balances (AB204, Mettler Toledo, USA), microbalances (Mettler MT5, Mettler Toledo, USA); high-performance liquid chromatography instruments (LC20, Shimadzu Corp., Japan), column C18 (Shimpac VPODS, Marcmoor™ Limited, England), UV-Vis spectrophotometers (Shimadzu 1700 and 1800, Shimadzu Corp., Japan), pH-meters (Hanna HI 2211, Hanna Instruments, Inc, USA); dissolution tester (Erweka DT60, ERWEKA GmbH, Germany), incubator (Memmert IN30, Memmert GmbH, Germany), sterile petri dish (Anumbra,), autoclave (Hi-rayama HL 3e, HIRAYAMA Manufacturing Corp., Japan), filter membrane (Millipore 0.45µm and 0.22µm, Millipore Corp., USA).

Method

Quality Testing for Antibiotic Tablets and Injections

The sample quality involved dissolution testing, determination of content, and examination of dosage uniformity, encompassing examination of weight uniformity employing 20 tablets (15). The content determination method specified in the relevant antibiotic monographs was used for testing content uniformity (15). The results of the weight uniformity test are used to calculate the relative standard deviation (RSD) of the drug content in the preparation. The dissolution test was carried out according to the procedure specified in the relevant monograph of each formulation (15).

Potency-test Antibiotics

The test intended to compare antibacterial activity was performed using the Disc-Cylinder Method. In the testing, for each sterile petri dish, the medium was poured Mueller Hinton Agar (MHA) with sheep blood (5% v/v), inoculum colony suspension 5 mL bacterumi Streptococcus pneumonia and Klabsiella pneumonia, equivalent to 0,5 McFarland standard, prepared using colonies from an overnight (18 to 20 hours) sheep blood agar plate. Incubation 350 200C. the disc diffusion method that uses a standard antibiotic solution and samples with a certain concentration or dilution. This method involves adding 5 µL of these solutions to each petri dish which then undergo incubation at a temperature of 35-37ºC for a duration of 20-24 hours (14).

Antibiotics Disc Preparation

To prepare antibiotic disc we followed the procedure suggested by Clinical Laboratory Standard Institute

(CLSI) (14). Discs with 6 mm diameter were prepared by punching a sheet of Whatman Number 3 filter paper using a perforator. To obtain 30 µg of ceftriaxone, 1000 mg of injectable ceftriaxone was dissolved in 166.7 ml of distilled water and 5 µL of dissolved stock antibiotic was impregnated onto the 6 mm sized disc. To obtain 15 µg of azithromycin, 500 mg of azithromycin tablet was dissolved in a 166.7 ml of 95% ethanol with a broth media and 5 µL of dissolved stock antibiotic was impregnated onto the 6 mm sized disc. To obtain 5 µg of levofloxacin 500 mg of infus ceftriaxone was dissolved in 166.7 ml of ½ volume of water, then 0,1 mol/L NaOH dropwise to dissolve onto the 6 mm sized disc (14).

Antimicrobial Susceptibility Testing

The antimicrobial susceptibility testing was performed following the Kirby-Bauer disc diffusion method as described in the CLSI. Briefly, the reference strains (S.pneumonia and K.pneumonia) were sub-cultured onto blood agar and incubated at 37˚C overnight. Using a sterile wire loop, 3–5 pure colonies were emulsified in 5 mL of normal saline until the turbidity matches 0.5 McFarland standard. Using a sterile dry cotton swab, bacterial suspensions were uniformly inoculated onto the entire surface of Muller Hinton agar (MHA). Antibiotic disks were placed on the surface of MHA and incubated aerobically at 37˚C for 16–18 hours. The diameter of the zone of inhibition was measured using a ruler; isolates were classified as potent (pass) or not potent (fail) based on the CLSI cut-point (14). All experiments were conducted in triplicates and the means were recorded to determine the potency of antibiotics.

Data Analysis

Data analysis was conducted descriptive, including compared with FI-VI requirements for uniformity of tablet weights, tablet dissolution and content of drug. Antibiotic inhibitory zone test using CLSI of inhibition Azithromycin: It is considered as ‘pass’ if the diameter of the zone of inhibition falls within or greater than the susceptibility range of 13-28 mm. Ceftriaxone: It is considered as ‘pass’ if the diameter of the zone of inhibition falls within or greater than the susceptibility range of 19-24 mm. Levofloxacin: It is considered as ‘pass’ if the diameter of the zone of inhibition falls within or greater than the susceptibility range of 16-21 mm (14).

Ethical Clearance Approval

Through letter number Ket-102/UN2. F10. D11/PPM.00.02/2022. the Faculty of Public Health, Universitas Indonesia, Health Research Ethics Committee has granted permission (ethical clearance) for this study.

Result

Quality of Antibiotics

Table 1 presents the results of analyzing three antibiotics, specifically ceftriaxone and levofloxacin in injection form, and azithromycin in tablet form. The research shows that the lowest percentage of active ingredients is present in the generic drug azithromycin 500 mg tablet from hospital B 90.05%, ceftriaxone from hospital A 91.74%, and levofloxacin from hospital B 105.34%. However, all the active ingredient percentages confirm to the minimum standard established by FI-VI which is 90.0%.

Table 1. Quality and potency of some antibiotic preparations.

Antibiotics	Content [RSD]	Dissolution	*S. pneumonia*	*K. pneumonia*
Injection ceftriaxone				
INN DU 90% Hospital A	91.74	NA	90.00%	105.48%
INN DU 90% Hospital B	92.3	NA	90.07%	73.05%
Branded drug	101.55	NA	97.66%	102.01%
Tablet azithromycin				
INN DU 90% Hospital A	90.05 [0.93]	94.41	70.38%	98.62%
Branded drug	91.13[0.92]	98.95	75.31%	109.49%
Infusion levofloxacin				
INN DU 90% Hospital B	105.34	NA	91.77%	105.48%
Branded drug	107.41	NA	100.07%	110.31%

Description: NA: Not available, DU 90%: Drug Utilization 90%, INN: International Nonpropietary Name, RSD: Relative Standard Deviation.

Potency of Antibiotics

Table 2 shows the average zone of antibiotic inhibition. In tests with S. pneumonia the results all antibiotics were included in the sensitive range with azithromycin from hospital A and branded azithromycin inhibition diameter ≥ 18 mm, levofloxacin from hospital B and branded levofloxacin inhibition diameter ≥ 17 mm and ceftriaxone all samples from hospital A, B and branded inhibition diameter ≥ 24 mm. Sensitivity is a condition in which microorganisms are highly susceptible to antibiotics. Intermediate is a condition where there is a change from a sensitive state to a resistant state, but not complete resistance. Resistance is a condition in which microbes have become sensitised or resistant to antibiotics (14).

Table 2. Inhibitory diameter of several antibiotic preparations.

Bacteria	Antibiotics	Mean ZI (mm±SD)	Zone diameter (mm)
S.pneumonia	Azithromycin Hospital Aa	28.97±0.09	S = ≥ 18 I = 14-17 R = ≤ 13
	Azithromycin brandeda	36.26±0.22	
	Levofloxacin Hospital Bb	28.79±0.03	S = ≥ 17 I = 14-16 R = ≤ 13
	Levofloxacin brandedb	31.40±0.16	
	Ceftriaxone Hospital A	39.11±0.09	S = ≥ 24
	Ceftriaxone Hospital B	39.14±0.12	
	Ceftriaxone Branded	42.44±0.06	
K.pneumonia	Azithromycin Hospital Aa	14.27±0.09	S = ≥ 13 R = ≤ 12
	Azithromycin brandeda	15.85±0.05	
	Levofloxacin Hospital Bb	29.50±0.03	S = ≥ 21 I = 17-20 R = ≤ 16
	Levofloxacin brandedb	30.64±0.03	
	Ceftriaxone Hospital A	12.76±0.04	S = ≥ 23 I = 20-22 R = ≤ 19
	Ceftriaxone Hospital B	8.84±0.08	
	Ceftriaxone Branded	12.34±0.02	

Description: S = Sensitive; I = Intermediate; R = Resistance; a = tablet form; b = infuse form.

Discussion

The antibiotic tablets and injections from branded and INN obtained from hospitals A and B met the FI-VI requirements for active drug ingredient content, weight uniformity, and dissolution (Table 1). The azithromycin 500 mg tablets INN, even with the lowest active component level of 90.05%, nevertheless satisfied the standards. Considering the RSD of 0.93, the azithromycin level in the sample remained higher than the minimal requirement set by FI-VI, which is applicable to all types of samples under study. The quality test findings for tablet and parenteral antibiotic formulations met the expected standards. Nevertheless, branded medications exhibited a propensity for containing elevated concentrations of active pharmaceutical components. It is crucial to acknowledge that these branded samples are manufactured by pharmaceutical corporations and are pricier compared to products acquired from hospitals. For example, the content of the branded antibiotic ceftriaxone (101.55) is higher than samples taken from hospitals A (91.74) and B (92.3). However, this is still within FI-VI requirements.

Research conducted in various low- and middle-income countries in Asia and Africa has revealed that counterfeit and substandard medicines are frequently discovered in inexpensive medicines obtained from informal outlets currently there is still lack of research in LMICs (16). These outlets include licensed drug shops that are not legally authorized to sell ethical medicines. The drug studied in this research was an officially licensed medication obtained from a hospital. However, the price was considered to be cheap and well below the regular price, even in the formal pharmaceutical industry, where it was considered to be below the cost of production when it won an e-catalogue auction (2). As an example the most expensive injection was obtained from hospital B with IDR 11,663 per-vial, and from hospital A with IDR 4,141 per-vial. The price difference was IDR 305,000 per-vial when compared to branded drug ceftriaxone. This price difference was influenced by different profit margins between hospitals.

These quality metrics are crucial for the maintenance of a pharmaceutical industry's production license. Nevertheless, the quality of the final pharmaceutical products may not precisely indicate the quality of the active medicinal substances employed. The product's pricing can exert an influence on this. To save costs, cheaper products often use lower quality ingredients, particularly in the active medicinal ingredients and primary packaging (13, 17). In this study, the INN disparity was lower than the generic brands.

The drugs available in e-catalog auctions are typically simple formulations with low technological complexity. The availability of these medications at affordable pricing is a result of fierce market rivalry. These goods consist of active pharmaceutical components that have expired patents and are accessible in the form of tablets, caplets, capsules, or other simple preparations. The rivalry for such drugs is fierce, as all pharmaceutical companies in Indonesia, including lesser-known small-scale organizations, possess the capability to manufacture them. The pharmaceuticals can be manufactured utilizing easily accessible raw ingredients sourced from several locations, including India and China (17).

Chinese insiders in the raw material pharmaceutical industry admit that quality standards in their country, including those for exported products, are not particularly strict. The quality of raw material pharmaceutical products received by clients depends on demand and the bargaining power of the pharmaceutical industry clients in question (13). The

quality of the active pharmaceutical ingredients used can affect both the effectiveness and safety of the formulation. Antibiotic formulations can be evaluated for effectiveness by analyzing their antibacterial activity and for safety by assessing their impurity levels.

The study assessed the effectiveness of broad-spectrum antibiotics in tablet and injection form against both Gram-positive and Gram-negative bacteria. Hospital B's cefriaxone antibiotic showed 73.05% potency against K. pneumoniae, which was 28.96 percentage points lower than the branded sample, but is still accepted. In the antibiotic sample ceftriaxone from Hospital A, however, the potency against K. pneumoniae was 105.48%, a relative difference in potency of 3.28% higher than the branded preparations. Hospital A's azithromycin tablet had a potency of 98.62%, which is 10.87 percentage points lower than the branded preparation. Similarly, hospital B's levofloxacin had a potency of 105.48%, which is 4.83 percentage points lower than the branded preparation.

The efficacy of ceftriaxone injection preparations against S. pneumoniae bacteria was 90% at hospital A and 90.07% at hospital B. The relative difference in potency between the brand name ceftriaxone products was 8.51% (7.66/90 x 100%) for hospital A and 8.42% (7.59/90.07 x 100%) for hospital B. The potency of azithromycin 500 mg tablets from hospital A against S. pneumoniae bacteria was 70.38%, 4.93 percentage points lower than the brand name product, resulting in a relative difference in potency of 7.00%. The hospital B's parenteral levofloxacin was found to have a potency of 91.77% against S. pneumoniae bacteria, which is 8.3 percentage points lower than the branded preparation. The relative difference in potency was calculated to be 9.04% (8.3/91.77 x 100%).

The efficiency of antibiotics can vary significantly between oral and parenteral forms, with variances occasionally reaching up to two decimal places. Administering generic and branded versions of antibiotics to patients can lead to measurable differences in effectiveness, despite statistical analysis indicating no significant variations in inhibitory zones using Chi Square ($p>0.05$). A study conducted on typhoid patients at a private hospital in Depok demonstrated this. Patients who received the award-winning ceftriaxone injection preparation as part of JKN had a longer average length of stay (LoS) of 5.33 days compared to the independent group who were treated with branded ceftriaxone from a well-established manufacturer (LoS: 4.96 days). Similarly, patients who were part of JKN and received the e-catalog winning brand of cefotaxime required an average length of stay (LoS) of 5.32 days, which was longer than the independent group receiving branded cefotaxime from a renowned manufacturer (LoS 5.04 days) (13).

The difference in average LoS, which ranges from 0.28 to 0.37 days, may seem small. However, with only 100 patients, the impact on bed utilization cannot be ignored: 28-37 person-days, or 28-37 times the room fee per patient in rupiah. If the study shows that using e-Catalogue medicine is more effective, it is because the cost of branded injectable antibiotics supplied to independent patients is 30 times higher than the cost of comparable e-catalogue drugs used by JKN patients (13).

Table 2 shows the diameter of antibiotic inhibition against S. pneumonia and K. pneumonia bacteria. All samples were sensitive except for ceftriaxone on K. pneumonia, with an inhibition diameter of ≤ 19 (14). This is consistent with previous research, the prevalence of K. pneumonia infection varies by country: 13% in the United States, 5% in Pakistan, 64.2% in Nigeria, 33.9% in India, 17.4% in Denmark, and 14.1% in Singapore (18). ESBL-producing Klebsiella pneumonia infections accounted for 52% of Enterobacteriaceae infections at Saiful Anwar Hospital Malang in Indonesia (19). The majority of Klebsiella pneumonia isolates were obtained from respiratory specimens. This is because Klebsiella pneumonia is a common bacterium that can cause respiratory tract infections, such as pneumonia, sinusitis, or otitis (20). Klebsiella pneumoniae is one of the nine bacteria of concern for antibiotic resistance, Klebsiella sp. is an important extended spectrum β-lactamase (ESBL) producing pathogen associated with the increasing incidence of antibiotic resistance, in the context of the increase in the incidence of antibiotic resistance in hospitals (21).

Therefore, given that only a limited number of pharmaceutical companies are capable of producing parenteral formulations - about 20 out of 220 pharmaceutical factories in Indonesia - market competition for formulations with a relatively high technological content is likely to be less intense than market competition for capsule/tablet/capsule formulations. Therefore, the price of the e-catalogue for the injectable drugs ceftriaxone or cefotaxime will not be too low and should provide a reasonable profit margin, even though it is far below the regular price of similar drugs. If a drug product is sold at a price lower than the cost of manufacturing, it is possible that the product's efficacy is also lower than that of similar products sold at regular or reasonable prices. This is especially true if there is a difference in efficacy, as indicated by the difference in length of stay (LoS). Therefore, it is important to consider both the price and efficacy when evaluating the quality of a drug product. Moreover, research has found that there is a large discrepancy between the average antibiotic potency of e-catalogue winning products which are generally the

cheapest and similar branded products which are generally much more expensive (22).

Monitoring is necessary due to the possibility of lower antibacterial activity and significant disparities in more affordable antibiotic preparations. Cost-effective preparations are often preferred in primary healthcare facilities (puskesmas and clinics receiving capitation payments) and referral healthcare facilities (hospitals compensated based on Ina-CBGs rates) in anticipation of the upcoming JKN payment system. This has resulted in their widespread use across the nation (13, 23).

Research conducted in various countries has shown that a high level of antimicrobial usage (AMU) is a risk factor for antimicrobial resistance (AMR) (22). Frequently, the medicines that are commonly utilized are closely linked to difficulties of antimicrobial resistance (AMR). Furthermore, the substandard drug formulation, specifically insufficient amounts of active drug components, poses an additional risk for antimicrobial resistance. (22,24–26).

Low quantities of active medication components can reduce the effectiveness of antibiotics, increasing the risk of antimicrobial resistance (AMR), treatment failure, and unpleasant side effects (24). Other factors, such as insufficient bioavailability/bioequivalence (BA/BE) and poor antimicrobial activity, can also contribute to AMR, treatment failure, and unpleasant side effects (25). These health-related costs will result in significant socioeconomic losses, including reduced community productivity (27).

Conclusion

All antibiotic tablets and injections tested met the requirements of the Indonesian Pharmacopoeia 6th Edition active ingredient content, uniformity of dosage weight and dissolution. However, it is important to consider several factors when determining antibacterial activity. Cheaper antibiotic samples generally have weaker antibacterial activity, as indicated by lower antibiotic potency, against both Gram-positive and Gram-negative bacteria. The inhibitory potency of the cheapest antibiotic samples originated from hospitals are the lowest. Branded drug preparations, the most expensive antibiotic samples, have the highest antibiotic potential. The antimicrobial activity showed all government-subsidized ceftriaxone samples resistant to K.pneumonia.

Declarations

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Conflict of Interest

The authors declare no conflicting interest.

Data Availability

The unpublished data is available upon request to the corresponding author.

Ethics Statement

The study design was approved by the ethics committee of Faculty of Public Health, Universitas Indonesia, with approval letter number of Ket-102/UN2.F10.D11/PPM.00.02/2022.

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