ANTIBIOTIC RESISTANCE IN HOSPITALS IN INDONESIA: ANTIBIOTIC USE AND ASSOCIATED COSTS

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Abstract. Antimicrobial resistance (AMR) reveals a serious, worldwide threat to public health. One of the causes is inappropriate antibiotic (AB) therapy in health services. It leads to patients' difficulty healing, needs longer times, and other higher lines of antibiotics lead to higher treatment costs. This study aimed to describe the situation of antibiotic resistance (ABR) in hospitals related to antibiotic use and its costs. Research was conducted in 2018. Sample locations were in 10 public hospitals in 10 provinces. Hospitals selected must fulfill the following criteria: having a microbiology laboratory; running AMR Control Program; clinical pharmacy services running well; financial hospital being computerized. Medical and cost data from patients who suffered from pneumonia and septicemia in 2017 were collected retrospectively. Data calculated were the costs of administration, patient's room, professional visit, diagnostic test, medicines, and other treatments and were analyzed descriptively. Total samples were 3164 cases: 1686 pneumonia and 1478 septicemia. The most used AB in pneumonia and septicemia was cephalosporin, followed by fluoroquinolone. The results of sensitivity tests for pneumonia and septicemia cases were 14.9% and 9.6%, respectively. There were >90% of patients hospitalized for more than 30 days compared to <10% without ABR. Result also shows that costs of pneumonia and septicemia hospitalization were 149.0% and 262.3% higher if the patients were resistant to antibiotics. The sensitivity test results for pneumonia and septicemia showed more resistance than in sensitive cases. This study has demonstrated that antibiotic resistance leads to longer hospital stays and greatly increased hospital costs.

Keywords: antibiotic resistance in hospital, AMR, hospitals in Indonesia, hospital cost

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INTRODUCTION

The Global Antimicrobial Resistance and Use Surveillance System report has indicated high levels of antibiotic resistance in Indonesia (Siahaan *et al*, 2022; WHO, 2020). Antibiotic resistance arises because the use of antibiotics in health services is often inappropriate and, therefore, ineffective (Hadi *et al*, 2008); it may also be caused by sufferers of chronic infectious diseases such as tuberculosis and HIV, who often do not comply with the requirement to take drugs for relatively long periods (Sukoco, 2012). The irrational use of antibiotics facilitates the acquisition of resistance by microorganisms through genetic mutations and can lead to increased morbidity and mortality. In addition, the healing of infectious diseases may be prolonged, requiring the use of newer classes of antibiotics, which may be costlier. Furthermore, economic impacts such as reduced community productivity can result from antibiotic resistance. Thus, the state may also lose productivity, while the burden of health costs borne by the government will increase due to high levels of disease (Taylor *et al*, 2019).

Antimicrobial resistance (AMR) results in reduced antibacterial, antiparasitic, antiviral, and antifungal properties, making the treatment of patients difficult, expensive, or even impossible. In highly susceptible patients, AMR results in prolonged illness and increased mortality. During the coronavirus disease 2019 (COVID-19) pandemic, using antimicrobials for infection prevention and treatment affects the AMR burden (Knight *et al*, 2021). The global magnitude of the problem and impact of AMR on human health, as well as the costs to the healthcare sector and wider social impact, remain largely unknown (WHO, 2014). In Europe, hospital costs for treating resistant organisms are estimated to be USD10,000-40,000 higher than for treating susceptible organisms. Overall, to date, there has been little research on the cost of AMR in low- and middle-income countries. High costs are not only a consequence for health care providers but also for individual patients, who often have to bear the increased costs. Although the drivers of AMR are multifactorial, antibiotic use

is the biggest factor, with overuse and mis-prescribing also playing significant roles (Founou *et al*, 2017; Roberts *et al*, 2021).

This article aims to describe the situation of antibiotic resistance in Indonesian hospitals with regard to the use and costs of antibiotics. This can be used as scientific evidence by healthcare services and the government to improve the control of AMR.

MATERIALS AND METHODS

The study was an operational research study of health services, conducted in 2018. A retrospective study of medical and cost data was collected from hospitals spread across large cities in 10 provinces in Indonesia ranging from the capital area to central, western, and eastern regions. The selected hospitals fulfilled the following criteria: presence of an on-site microbiology laboratory, initiation of an AMR Control Program (PPRA), well-run clinical pharmacy services, and financial records that were computerized and integrated among units within the hospital.

Samples included medical and cost data from hospitalized patients suffering from pneumonia and septicemia in 2017. The Tenth Revision of the International Classification of Diseases (ICD-10) codes of patients suffering from pneumonia were J13, J14, J15, and J18, while the codes for septicemia were A40 and A41 (WHO, 2019). Pneumonia is the most infectious and septicemia is the leading infectious cause of death in Indonesia, particularly in newborns and neonates (MOH RI, 2021). Data were collected from medical records, hospital information systems, and the financial departments of hospitals.

Medical and cost data for 2017 were obtained from the medical records of study subjects who fulfilled the inclusion and exclusion criteria. The inclusion criteria were: patient age ≥18 years, hospitalization for a minimum of five days and a maximum of two months, being diagnosed with pneumonia or septicemia, and patients who were discharged or died. The exclusion criteria were: forced discharge, patients coinfected with tuberculosis or human immunodeficiency virus/ acquired immunodeficiency syndrome (HIV/AIDS), patients with malignancies or autoimmune diseases, patients who were re-admitted with the same diagnosis within the same year, sample data for cases of pneumonia

not suffering from septicemia, and postoperative recovery patients admitted to intensive care/high care units (ICU/HCU).

The study followed the hospital perspective that the costs calculated were direct costs based on patient data, that is, the costs of administration, rooms, consultations or professional visits, diagnostic tests, antibiotics and other medicines, disposable health devices, and other medical treatments.

Study sites were located in 10 hospitals in 10 provinces, namely, Jakarta, Central Java, Yogyakarta, East Java, Bali, West Nusa Tenggara, Riau, North Sumatra, South Sulawesi, and North Sulawesi.

Medical records of patients who fulfilled the inclusion criteria were collected from selected hospitals. The inclusion criteria were age >18 years, admitted to the hospital with septicemia and pneumonia in 2017 (pneumonia cases as the primary diagnosis referring to the ICD-10 codes J13, J14, J15, and J18, and septicemia cases as the primary diagnosis referring to the ICD-10 codes A40 and A41). A sample set consisting of 3,164 medical records covering clinical data and billing information. This sample set comprised 1,686 pneumonia cases and 1,478 septicemia cases.

Sensitivity tests were based on sputum and blood specimen results for pneumonia samples. For septicemia samples, data was sourced from sensitivity tests using blood specimens. Sensitivity tests were carried out on antibiotics in accordance with the guidelines for treating pneumonia and septicemia at individual hospitals.

The results of treatment using proxies were considered successful if patients were allowed to go home by the doctor and unsuccessful if patients died. These operational definitions were formulated jointly by researchers, pulmonologists, internists, and clinical microbiologists.

The results of the study as a whole were analyzed descriptively. The samples in this study are the total samples from all hospitals. This study is not analyzing each hospital sample separately.

The Ethics Committee of the National Institution of Health Research and Development issued ethical clearance for this study with the number LB.02.01/2/KE.131/2018.

RESULTS

There were 1,686 pneumonia cases and 1,478 septicemia cases (Fig 1). Only 323 of the 1,686 pneumonia cases were tested for antibiotic sensitivity, with 48 showing sensitivity to antibiotics according to treatment guidelines. For septicemia cases, only 574 of 1478 cases had an antibiotic sensitivity test performed, with 55 demonstrating sensitivity to antibiotics according to treatment guidelines.

Data on the background characteristics of pneumonia and septicemia patients, namely age, sex, length of stay (LOS), and hospital rooms are shown in Table 1.

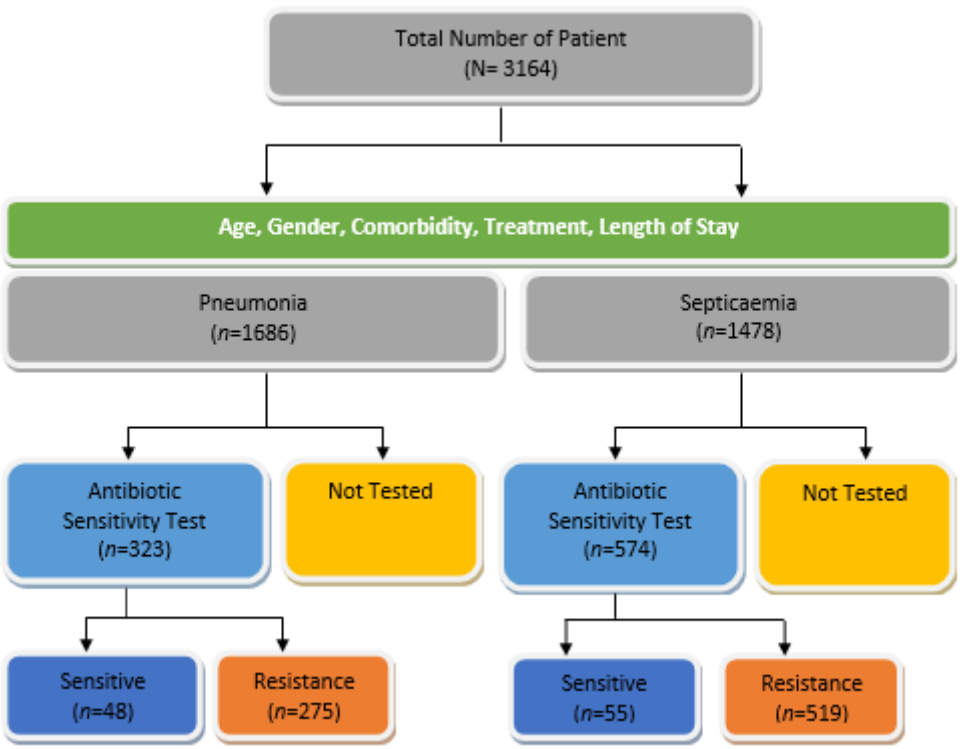

Fig 1 - Sample screening flow and number of samples

Table 1
Distribution characteristics of samples

Characteristics	Frequency, *n* (%)	
	Pneumonia (N = 1,686)	Septicemia (N = 1,478)
Age (years)		
18-65	1119 (66.4)	1053 (71.2)
>65	567 (33.6)	425 (28.8)
Sex		
Male	927 (55.0)	780 (52.8)
Female	759 (45.0)	698 (47.2)
Length of stay (days)		
5-14	1375 (81.6)	1035 (70.0)
15-30	277 (16.4)	358 (24.2)
>30	34 (2.0)	85 (5.8)
Patient room		
ICU/HCU	357 (21.2)	473 (32.0)
Non-ICU/HCU	1329 (78.8)	1005 (68.0)

HCU: High Care Unit; ICU: Intensive Care Unit

The subjects were mainly aged 18 to 65 years, and the number of male patients (53.9%) was slightly higher than the number of female patients (46.0%). Most patients were treated for between 5 and 14 days, with the majority treated in non-ICU/HCU rooms.

The sensitivity tests for pneumonia and septicemia cases showed that 14.9% and 9.6% of samples, respectively, were sensitive, while the percentages of resistant samples were considerably higher (Table 2).

Rates of antibiotic use for cases of pneumonia and septicemia in 2017 in the 10 sampled hospitals are illustrated in Fig 2.

The most commonly used antibiotic for the treatment of pneumonia and septicemia was cephalosporin, followed by fluoroquinolone. In addition,

nitro-imidazole and carbapenem were used more frequently for the treatment of septicemia than for pneumonia. Conversely, macrolides and cephalosporin were used more frequently for pneumonia than for septicemia treatment (Fig 2).

Furthermore, for cases of pneumonia, the use of first- and second-line antibiotics was slightly higher than the use of third-line antibiotics and

Table 2
Distribution of cases based on antibiotic sensitivity test results

Percentage of cases based on antibiotic sensitivity test results	Pneumonia (n = 323)	Septicemia (n = 574)
Percentage of sensitive cases	14.9	9.6
Percentage of resistant cases	85.1	90.4

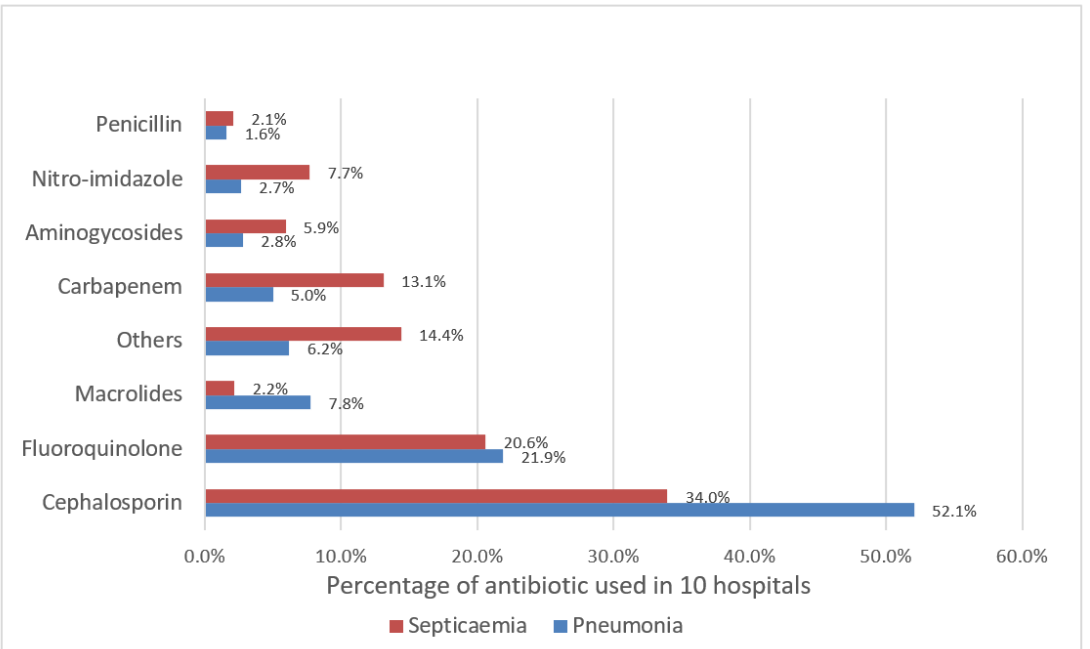

Fig 2 - Distribution of antibiotics used in 10 hospitals in Indonesia

non-national formulary antibiotics (Table 3). However, for septicemia cases, the use of third-line antibiotics was higher than the use of first and second-line antibiotics. Combining the data for both diseases showed that the overall use of third-line antibiotics and non-national formulary antibiotics was greater than the use of first and second-line antibiotics.

In addition, the cost components for the treatment of pneumonia and septicemia were assessed (Fig 3). Pneumonia and septicemia treatment showed similar patterns of cost components. The largest component was the cost of the hospital rooms (>40%), followed by the cost of the medical treatment (11-12%) and medicines other than antibiotics (8-9%), while the cost of the antibiotics ranged from 2-3%.

Results of a comparison between length of stay (LOS) and hospitalization costs for pneumonia and septicemia based on the results of the antibiotic sensitivity tests (sensitive *vs* resistant cases are presented in Table 4. The results showed that there were increased numbers of LOS >30 days for resistant pneumonia and septicemia cases, compared with sensitive cases. Furthermore, resistant cases incurred much higher hospital costs for both diseases.

DISCUSSION

The results of this study show that although some sensitivity tests were carried out, the treatment of pneumonia and septicemia using antibiotics was not

Table 3
Use of antibiotics for pneumonia and septicemia cases in 10 hospitals in 2017, based on antibiotic lines

Antibiotic classification	Number of antibiotics doses used, *n* (%)		
	Pneumonia	Septicemia	Total
First/second line	3394 (48.2)	3645 (51.8)	7039 (100.0)
Third line	649 (33.9)	1263 (66.1)	1912 (100.0)
Non-FORNAS	107 (43.1)	141 (56.9)	248 (100.0)
Total	4150 (45.1)	5049 (54.9)	9199 (100.0)

Non-FORNAS: non-national formula

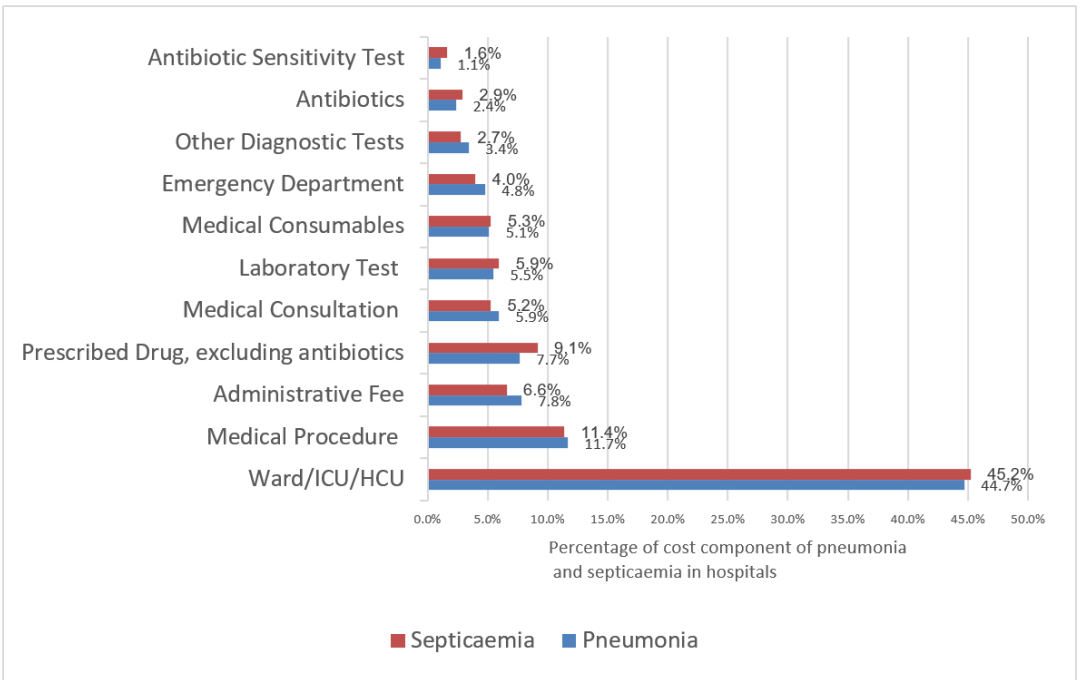

Fig 3 - Cost component of pneumonia and septicemia treatment in hospitals

Table 4

Use of antibiotics for pneumonia and septicemia cases in 10 hospitals in 2017, based on antibiotic lines

Cases with sensitive or resistant	Pneumonia		Septicemia	
	LOS >30 days	Median costs	LOS >30 days	Median costs
Sensitive	7.7%	IDR 10,476,200	5.3%	IDR 13,028,274
Resistant	92.3%	IDR 15,589,192	94.7%	IDR 34,175,316

Note: Sensitive cases are the standard/typical cases when the patients suffer from pneumonia and septicemia treated with the standard treatment.

IDR: Indonesia Rupiah; LOS: length of stay

always preceded or accompanied by a sensitivity test. This is in line with the results of studies reported in low and middle-income countries showing that regular microbiologic cultures and sensitivity testing may not be carried out in health facilities (including hospitals) due to a lack of personnel, resources, and/or money (Sartelli *et al*, 2020; Wardhani *et al*, 2020). The few available antibiotics may be overused and abused as a result of empirical antibiotic therapy. Although this strategy has the benefit of being affordable, it can lead to less-than-ideal clinical outcomes by accelerating the establishment and spread of AMR (Sartelli *et al*, 2020). The lack of adequate diagnostic tests to quickly identify organisms and their antibiotic susceptibility profiles, guide antibiotic prescription at the point of therapy, and minimize the need for broad-spectrum antibiotics are major issues contributing to improper antibiotic prescription and use. Since conventional culturing and susceptibility testing takes time, empirical prescription almost invariably comes before culture results (Machowska and Stålsby Lundborg, 2018).

In clinical settings, identifying and detecting bacteria in patient samples before administering antibiotics is critical for selecting the appropriate antibiotic. In this regard, there are numerous research initiatives for the development of sensors that can assist physicians, particularly those whose outcomes can be rapidly recognized. Even though none of the presented technologies is perfect in every way, the integration of rapid diagnostic and susceptibility techniques with antimicrobial stewardship significantly improved clinical and financial outcomes for patients with bloodstream infections caused by antibiotic-resistant. The intervention reduced 30-day mortality from all causes, total hospital costs, and duration length of stay in hospitals and intensive care units (Leonard *et al*, 2018; Vasala *et al*, 2020; Perez *et al*, 2014; Wardhani *et al*, 2020).

The most commonly used antibiotic in pneumonia and septicemia cases was cephalosporin, followed by fluoroquinolone, while nitro-imidazol and carbapenem were used more often in cases of septicemia than of pneumonia. Conversely, macrolides and cephalosporin were used more frequently to treat pneumonia than to treat septicemia. Cephalosporins were one of the drugs of choice for both pneumonia and septicemia. It is recommended to use a third-generation cephalosporin in conjunction with a macrolide for community-acquired pneumonia (CAP) that could develop into septicemia (Ceccato and

Torres, 2018). In addition, the other types of antibiotics used varied, ranging from first-line one to third line of antibiotics, while there was also a substantial level of usage of antibiotics that were not in the national formulary (namely, the formulary used nationally for patients who are participants in national health insurance). All the hospitals in this study were public hospitals with the majority of their patients participating in the national health insurance scheme. In Botswana, cefotaxime and metronidazole were reportedly the most prescribed antibiotics in public hospitals, whereas ceftriaxone was most frequently prescribed in private hospitals (Anand Paramadhas *et al*, 2019). In addition, a study evaluating the total consumption of antimicrobials in a Romanian hospital in 2017 showed that cephalosporins and fluoroquinolones were the most frequently administered antibiotics (Zaha *et al*, 2019). Meanwhile, another study showed that ceftriaxone was the first-choice prophylactic antibiotic in an Indonesian hospital; significant noncompliance with local and international norms was also observed in the same study (Muliani *et al*, 2021).

Numerous studies have demonstrated the financial impact of AMR, including excessively high health care expenditure brought on by a rise in hospital admissions and medicine use (Dadgostar 2019). Infection with antibiotic-resistant microbes may lead to serious illnesses, prolonged hospital stays, increased health care expenses, higher costs resulting from the use of second- or third-line antibiotics, and treatment failures. In addition, the treatment of resistant infections is linked to greater expenditure on drugs and research, as well as longer hospital stays (Shrestha *et al*, 2018). The results of this study (Figs 3 and 4) show that the biggest cost component for pneumonia and septicemia was the patients' rooms (>40%). Prolonged hospital admissions certainly lead to increased hospital costs (or costs that have to be paid by the patients or through insurance). This was confirmed by the increased costs in cases of resistant pneumonia and septicemia in our study (Table 4). One of the explanations for the irrational use of antibiotics is that it may be caused by a lack of facilities for sensitivity and culture testing. Meanwhile, the longer the length of hospital stay, the higher the risk of nosocomial infection, potentially adding to the cost of treatment (Prestes-Carneiro *et al*, 2015; Manosuthi *et al*, 2017). In all, AMR has severe effects on health care expenses. The direct financial implications of AMR on health care include increased resource use and the high costs associated with expensive and intensive treatments (Dadgostar,

2019). Therefore, the implementation of policies regarding guidelines for the use of antimicrobials in hospitals and monitoring of their use is necessary to reduce antimicrobial resistance (Wathne *et al*, 2018; Bouchet *et al*, 2020; Gitaka *et al*, 2020).

In summary, this study showed that cephalosporin was the antibiotic most commonly used overall for the treatment of pneumonia and septicemia, followed by fluoroquinolone. In addition, macrolides were more commonly administered for pneumonia than for septicemia, while the use of carbapenem and nitro-imidazole was more common in septicemia than in pneumonia. There was also substantial use of third-line antibiotics as well as antibiotics that were not based on the national formulary.

The largest component of costs for both pneumonia and septicemia was the hospital room (>40%), followed by treatment costs (11-12%), medicines other than antibiotics (8-9%), while the antibiotics themselves range from 2-3%.

Importantly, the implementation of sensitivity tests for pneumonia and septicemia in hospitals is still low. This study has demonstrated that antibiotic resistance leads to longer hospital stays and greatly increased hospital costs. Therefore, the government should support hospitals in their attempts to implement the rational use of antibiotics on a broad scale through an antibiotic stewardship program. In addition, it is necessary to develop a rapid diagnostic tool for antibiotic resistance testing in hospitals.

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CONFLICT OF INTEREST DISCLOSURE

The authors declare that there are no conflicts of interest.

REFERENCES

Anand Paramadhas BD, Tiroyakgosi C, Mpinda-Joseph P, *et al*. Point prevalence study of antimicrobial use among hospitals across Botswana; findings and implications. *Expert Rev Anti Infect Ther* 2019; 17: 535-46.

Bouchet F, Le Moing V, Dirand D, *et al*. Effectiveness and acceptance of multimodal antibiotic stewardship program: considering progressive implementation and complementary strategies. *Antibiotics* 2020; 9: 848.

Ceccato A, Torres A. Sepsis and community-acquired pneumonia. *Ann Res Hosp* 2018; 2: 7.

Dadgostar P. Antimicrobial resistance: implications and costs. *Infect Drug Resist* 2019; 12: 3903-10.

Founou RC, Founou LL, Essack SY. Clinical and economic impact of antibiotic resistance in developing countries: a systematic review and meta-analysis. *PLoS One* 2017; 12: e0189621.

Gitaka J, Kamita M, Mureithi D, *et al*. Combating antibiotic resistance using guidelines and enhanced stewardship in Kenya: a protocol for an implementation science approach. *BMJ Open* 2020; 10: e030823.

Hadi U, Duerink DO, Lestari ES, *et al*. Survey of antibiotic use of individuals visiting public healthcare facilities in Indonesia. *Int J Infect Dis* 2008; 12: 622-9.

Knight GM, Glover RE, McQuaid CF, *et al*. Antimicrobial resistance and COVID-19: intersections and implications. *ELife* 2021; 10: e64139.

Leonard H, Colodner R, Halachmi S, Segal E. Recent advances in the race to design a rapid diagnostic test for antimicrobial resistance. *ACS Sens* 2018; 3: 2202-17.

Machowska A, Stålsby Lundborg C. Drivers of irrational use of antibiotics in Europe. *Int J Environ Res Public Health* 2018; 16: 27.

Manosuthi W, Thientong V, Moolasart V, Rongrungrueng Y, Sangsajja C, Danchaivijitr S. Healthcare-associated infections at selected hospitals in Thailand. *Southeast Asian J Trop Med Public Health* 2017; 48: 204-12.

Muliani N, Herawati F, Yulia R, Wijono H. Quantity and quality profiles of antibiotics pre, on, and post surgery in a hospital setting. *Int J Clin Pharm* 2021; 43: 1302-10.

Perez KK, Olsen RJ, Musick WL, *et al*. Integrating rapid diagnostics and antimicrobial stewardship improves outcomes in patients with antibiotic-resistant Gram-negative bacteremia. *J Infect* 2014; 69: 216-25.

Prestes-Carneiro LE, Azevedo AM, Nakashima MA, Xavier JM, Cabral C. Frequency and antimicrobial susceptibility of pathogens at tertiary public hospital, Sao Paulo, Brazil. *Southeast Asian J Trop Med Public Health* 2015; 46: 276-84.

Roberts T, Luangasanatip N, Ling CL, *et al*. Antimicrobial resistance detection in Southeast Asian hospitals is critically important from both patient and societal perspectives, but what is its cost? *PLOS Glob Public Health* 2021; 1: e0000018.

Sartelli M, Hardcastle TC, Catena F, *et al*. Antibiotic use in low and middle-income countries and the challenges of antimicrobial resistance in surgery. *Antibiotics* 2020; 9: 497.

Shrestha P, Cooper BS, Coast J, *et al*. Enumerating the economic cost of antimicrobial resistance per antibiotic consumed to inform the evaluation of interventions affecting their use. *Antimicrob Resist Infect Control* 2018; 7: 98.

Siahaan S, Herman MJ, Fitri N. Antimicrobial resistance situation in Indonesia: a challenge of multisector and global coordination. *J Trop Med* 2022; 2022: 2783300.

Sukoco NEW. A qualitative study on interaction between pulmonary tuberculosis patients and the roles of treatment observers (PMO) in Majalengka District, 2012 [cited 2000 Aug 12]. Available from: URL: https://media.neliti.com/media/publications-test/21359-studi-kualitatif-deskripsi-interaksi-ant-d22013d6.pdf

Taylor J, Hafner M, Yerushalmi E, *et al*, editors. Estimating the economic costs of antimicrobial resistance: model and results, 2019 [cited 2022 Aug 20]. Available from: URL: https://www.rand.org/content/dam/rand/pubs/research_reports/RR900/RR911/RAND_RR911.pdf

Vasala A, Hytönen VP, Laitinen OH. Modern tools for rapid diagnostics of antimicrobial resistance. *Front Cell Infect Microbiol* 2020; 10: 308.

Wardhani DK, Wibowo YI, Setiawan E. Physicians' perceptions towards antibiotic stewardship program strategies at a public hospital in Surabaya, 2020 [cited 2022 Aug 18]. Available from: URL: http://jsfk.ffarmasi.unand.ac.id/index.php/jsfk/article/view/536/205 [in Indonesian]

Wathne JS, Kleppe LKS, Harthug S, *et al*. The effect of antibiotic stewardship interventions with stakeholder involvement in hospital settings: a multicentre, cluster randomized controlled intervention study. *Antimicrob Resist Infect Control* 2018; 7: 109.

World Health Organization (WHO). Antimicrobial resistance: global report on surveillance, 2014 [cited 2022 Aug 07]. Available from: URL: https://apps.who.int/iris/bitstream/handle/10665/112642/9789241564748_eng.pdf?sequence=1&isAllowed=y

World Health Organization (WHO). ICD-10: international classification of diseases, 10th revision, 2019 [cited 2022 Jul 30]. Available from: URL: https://icd.who.int/browse10/2019/en#/

World Health Organization (WHO). Global Antimicrobial Resistance and Use Surveillance System (GLASS) Report: Early implementation, 2020 [cited 2022 Aug 07]. Available from: URL: https://apps.who.int/iris/rest/bitstreams/1277847/retrieve

Zaha DC, Bungau S, Aleya S, *et al*. What antibiotics for what pathogens? The sensitivity spectrum of isolated strains in an intensive care unit. *Sci Total Environ* 2019; 687: 118-27.