Antibiotic Evaluation Of Hospitalized Pneumonia Patients Using Gyssen or DDD 100 Bed Days or DDD 1000 Patient Days: Review

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Abstract

Pneumonia remains one of the significant infectious diseases in society, especially in developing countries such as Indonesia, with its prevalence continuing to increase year after year. Pneumonia caused by bacteria requires antibiotic treatment, increasing antibiotic use and presenting a risk of antibiotic resistance. Therefore, this study evaluated the use of antibiotics in hospitalized pneumonia patients, with qualitative and quantitative approaches using the Gyssen and ATC / DDD methods. The articles taken as research samples involve a publication period from 2013 to 2023. The data included include the Gyssen parameter, DDD/100, and DDD/1000 patient days. The synthesis showed that ceftriaxone and meropenem antibiotics were the top choices, with values of 1547.735 DDD/100 bed days and 3011.2 DDD/1000 patient days, respectively. Ceftriaxone was documented in 21 journals, while in 8 of 37 journals, meropenem considered antibiotic use in hospitalized pneumonia patients. Evaluation of the quality of antibiotic use showed the highest level in category (0) at 93.7%, followed by (IVa) at 67.6%. Meanwhile, analysis of bacterial resistance to antibiotics showed that Klebsiella pneumonia was the most resistant bacteria, especially to antibiotics carbapenems, ertapenem, doripenem, cephalosporin generation 3, extended-spectrum cephalosporin, and piperacillin/tazobactam, with significant values < 0.05%. These findings provide deep insight into patterns of antibiotic use in hospitalized pneumonia patients while identifying potential areas for improving the quality of antibiotic use and treating bacterial resistance. Thus, this study contributes to efforts to optimize pneumonia management and reduce the impact of antibiotic resistance in the community.
***Keywords**: Antibiotics, Defined Daily Dose, Gyssen, Pneumonia.*

INTRODUCTION

Pneumonia is an infectious disease still common in society, especially in developing countries. It can affect both children and older people (WHO, 2013; Arifin and Roriq, 2023). In 2014, an institute in Indonesia conducted a survey reporting that pneumonia caused 944,000 deaths out of a population of 5.9 million. The prevalence of pneumonia in Indonesia has shown an increasing trend, from 2.1% in 2007 to 4.0% in 2013 and 4.5% in 2018. Doctors mainly treat pneumonia caused by bacteria with antibiotics. Due to the high pneumonia infection rate, many antibiotics are needed to treat the infection. Antibiotic use has increased consistently over time, as demonstrated by the increase in global antibiotic use, which increased 65% between 2000 and 2015, from 21.1 billion to 34.8 billion DDD/100 hospital days (Kresnawati, et al., 2021; Kristiani et al., 2019). This increase also increases the risk of antibiotic resistance. By 2050, at least 10 million people each year will be at risk of antibiotic resistance (Pratama *et al.*, 2022). Increased antibiotic resistance leads to more extended hospital stays, an increased prevalence of resistant bacteria, and an increased risk of death (Isnaasar *et al.*, 2022). Evaluation of antibiotic use serves as one of the quality indicators for antibiotic resistance control strategies in hospitals. Evaluation of the use of antibiotics can be carried out using qualitative and quantitative methods (Permenkes, 2015). The Gyssen method evaluated the quality of antibiotic use (Luciana *et al.*, 2015). Based on the accuracy and selection of indications in terms of effectiveness, toxicity, price, spectrum, duration of administration, dosage, interval, route, and time of administration, The rationality of antibiotic prescribing is categorized into categories 0-IV (Sitompul *et al.*, 2016). Quantitative evaluation can be done using the ATC/DDD (Anatomical Therapeutic Classification/Defined Daily Dose) and DU/90% methods (Ahmad *et al.*, 2023). PDD (prescribed daily dose) is used to evaluate the type and amount of antibiotics used (Sitepu *et al.*, 2020). This study aimed to evaluate the use of antibiotics qualitatively and quantitatively in hospitalized pneumonia patients.

RESEARCH METHODOLOGY

Search Strategy

This review is presented by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page *et al.*, 2021). A research report on the use of antibiotics in hospitals was used as the database. We selected two international sources (PubMed and Google Scholar) from a database of original articles published between 2013 and 2023. The keywords used in Google Scholar are pneumonia* AND antibiotic* AND Gyssen* AND ATC/DDD OR PDD, and in PubMed, antibiotic* AND pneumonia* AND ATC OR DDD OR PDD OR Gyssen*. We use reference filtering to identify other relevant scientific articles. This review is limited to antibacterials for systematic human use.

Criteria And Selection

The journal found in the database is further filtered based on inclusion and exclusion criteria. The inclusion criteria encompass articles or journals employing qualitative and quantitative methods with predetermined keywords, articles from PubMed and Google Scholar, and articles published during the last decade. This study consists of Gyssen data and DDD/100 bed/day or DDD/1000 patient days. The exclusion criteria include articles not in full-text format, articles with unclear information on the number of research samples and pediatric patients, and articles written in languages other than English or Indonesian.

Data Analysis

Data on the use of antibiotics in studies are presented in the table. These data, which relate to antibiotic use in hospitalized pneumonia patients, come from research articles published in high-quality journals. In addition to antibiotics, information about research methodology, research subjects, research results, and antibiotic extraction comes from selected research articles. The study subjects were confirmed as pneumonia patients in the hospital who were given antibiotics. The data collected consisted of the quality of antibiotic use and the quantity of antibiotic use. The data collected on the quality of antibiotic use included seven indicators proposed by Gyssen. These indicators include incomplete data (VI), improper use of antibiotics (V), availability of alternative antibiotics that are more effective (IV-A), less toxic (IV-B), cheaper (IV-C), and have a narrower spectrum (IV-D), incorrect duration of treatment (III), too long (III-A) or too short (III - B); incorrect dose, interval (II-B) or route (II - C); wrong time of treatment (I); and proper use. (0). The data obtained represent the use of antibiotics as DDD/100 or DDD/1000 days patients. Data analysis was performed using descriptive statistics. Antibiotic use, such as the quality and quantity of antibiotics, will be compared to other types of antibiotics in individual research articles and throughout the findings of research reports.

RESULT AND DISCUSSION

Results

The article was obtained based on 159 searches from Google Scholar and 60 from PubMed. After that, screening is carried out based on the title of the paper and abstract based on the established inclusion criteria. The process of selecting this literature review is shown in (**Fig. 1**). During the identification stage, there were four duplication articles, resulting in 215 duplication-free articles. In the first screening stage, there were 136 articles. With titles and abstracts not entering the desired category, the articles obtained 79, and 13 articles did not meet the inclusion criteria, so 66 were obtained and re-screened. There were 18 articles whose full text was not available. A total of 48 pieces that met the inclusion criteria were selected.

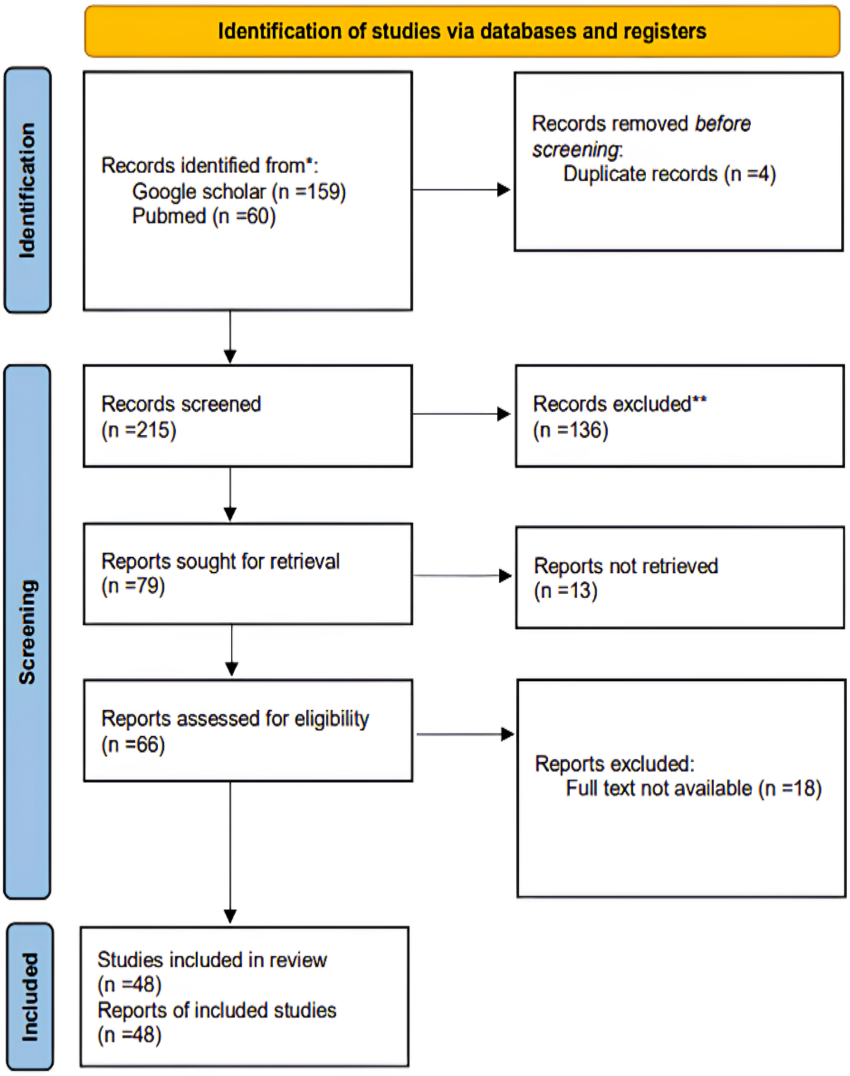

Figure 1. Article search flow

Table 1. Characteristics and research results of selected articles

Author & year	Country /Sample /DDD	Antibiotic most widely used	Gyssens research results
(Sedláková et al., 2014)	Czech Republic N=113207 DDD= 366.67	Fluoroquinolone (169.34; Aminoglycosides (106.32; and Cephalosporins (generations 3 and 4) 31.25 DDD/100 BD).	-
(Joseph et al., 2015)	India N=1000 DDD=8.43	3rd Generation cephalosporins (3.68); Aminoglycosides (1.62); and Fluoroquinolones (1.3 DDD/1000 patient days).	-

Table 1. Continued

Author & year	**Country /Sample /DDD**	**Antibiotic most widely used**	**Gyssens research results**
(Tedeschi et al., 2017)	Italy N=150 DDD=19.59	Beta-lactamase 11 enzyme inhibitors; Glycopeptide 3.9; and Other antibiotics 2.8 DDD/100 BD.	-
(Yulia et al., 2017)	Indonesian N=45 DDD=242.5	Ceftriaxone (79.2); Cefixime (38.1); and Levofloxacin IV (34.5 DDD/100 BD).	
(Barberi et al., 2017)	Italy N=420 DDD=1143.75	Meropenem (373.54); Amoxicillin/clavulanate IV (131.1); and Colistin (103.4 DDD/1000 patient days).	-
(Ziółkowski et al., 2018)	United States N=187 DDD=177.56	Penicillin (54.7); Carbapenems (23.6); and Macrolides (19.3 DDD/100 BD).	-
(Gutema et al., 2018)	Ethiopia N=97 DDD=67.6	Ceftriaxone (36.0), Metronidazol (IV) (16.3), and Vancomycin (5.2 DDD/100 BD).	-
(Rumende et al., 2019)	Indonesian N=151	-	(IIIb) at 21.53%. (IVa) 17.21%. (I) 10.9%.
(Vu *et al.*, 2019)	Vietnamese N=3290 DDD=798	Cephalosporin group 3 generation 223; Cephalosporin generation 2 generation 112; and Penicillin 164 DDD/1000 patient days.	-
(Rachmawati *et al.*, 2020)	Indonesian N=973 DDD=77.64	Ceftriaxone (27.79); Metronidazol (IV) (9.71); and Ciprofloxacin (PO) (5.81 DDD/100 BD).	-
(Mijović *et al.*, 2020)	Montenegro N=1000 DDD=8.43	3rd Generation cephalosporins (3.68); Aminoglycosides (1.62); and Fluoroquinolones (1.3 DDD/1000 patient days).	-
(Kim *et al.*, 2020)	South Korea N=97711 DDD=62.99	3rd Generation cephalosporin group 29.24; Beta-lactamase enzyme inhibitors 12.68; and Fluoroquinolones 8.51 DDD/1000 patient days.	
(Sukmawati et al., 2020)	Indonesian N=100 DDD=53.57	Ceftriaxone 36.15; Cefotaxime 2.83; and Ceftazidime 2.73 DDD/100 BD.	(IVa) amounted to 62.96%. (V) 13.38%. (IVb) and (V) 8.89%.
(Miranda-Novales *et al.*, 2020)	Mexico N=20 DDD=29.42	3rd generation cephalosporin group (17.82); carbapenem (7.08); and vancomycin (4.52 DDD/100 BD).	-
(Popović *et al.*, 2020)	Serbia N=921 DDD=828.4	Cephalosporins Generation 2 and 1 109.1; and Carbapenems 99 DDD/100 BD.	-
(Kresnawati et al., 2021)	Indonesian N=130 DDD=77.25	Ceftriaxone (38.79); Cefotaxime (28.88); and Levofloxacin IV (3.29 DDD/100 BD).	-
(Ermawati *et al.*, 2021)	Indonesian N=212 DDD=151.51	Ceftriaxone (96.08); Cefixime (37.78); and Metronidazol IV (7.67 DDD/100 BD).	(V) at 45%. (VI) (43%). (0) 7%.
(Putra et al., 2021)	Indonesian N= 86 DDD= 135.08	Azithromycin 48.12, Levofloxacin IV 44.01, and Ceftriaxone 21.13 DDD/100 BD.	(0) by 35.4%. (IVa) 19.1%. (V) 13.5%).

Table 1. Continued

Author & year	**Country /Sample /DDD**	**Antibiotic most widely used**	**Gyssens research results**
(Karuniawati *et al.*, 2021)	Indonesian N=96 DDD=148.62	Levofloxacin (IV) 45.62; Ampicillin sulbactam 36.72; Ceftriaxone 35.62 DDD/100 BD.	(0) Pre-ASP (31.25%) and Post-ASP (62.5%) (IVa) Pre-ASP (33.33%) and Post-ASP (16.67%) (IIIb) Pre-ASP (20.83%) and Post-ASP (12.50%).
(Mariana et al., 2021)	Indonesian N=50 DDD=171.12	Antibiotics being Procaine (97.22); Ceftriaxone (25.26); and Netilmicin (10.5 DDD/100 BD).	-
(Puspita and Dhirisma, 2021)	Indonesian N=97 DDD=149.97	Azithromycin (IV) 68.4; Ceftriaxone 32.1; and Levofloxacin (PO) 12.6 DDD/100 BD.	-
(Anggraini, 2021)	Indonesian N=35	-	(IVa) of 38.24%. (IIb) 20.59%. (0) 13,34%.
(Mugada *et al.*, 2021)	India N=1128 DDD=43.89	Azithromycin 14.97; Cefixime 9.17; and Amoxicillin/clavulanate (IV) 8.64 DDD/1000 patient days.	-
(Wojkowska-Mach *et al.*, 2021)	Polish N=2281 DDD=81.75	Penicillin group 23.58; Other antibacterial 14.88; and Beta-lactamase 13.26 DDD / 1000 patient days.	-
(Stelzhammer *et al.*, 2022)	Austria N=4800 DDD=62.96	Amoxicillin (11.6, Cephalexin (10.75, and Clindamycin (IV) (9.01 DDD/100 BD).	-
(Kusuma et al., 2022)	Sweden and Hungary N=3 805 083 DDD=1060.8	Ciprofloxacin (IV) 136.7; Levofloxacin (IV) 95.8; and Phenoxymethylpenicillin (81.5 DDD/1000 patient days).	-
(Pangeran et al., 2022)	Indonesian N=74 DDD=70.8	Ciprofloxacin (IV) at 44.9; Levofloxacin (IV) at 18.5; and Azithromycin at 1.7 DDD/100 BD.	(IVa) amounted to 67.6%. (0) 18,9%. (IVb) 12.2%.
(Andarsari et al., 2022)	Indonesian N=68 DDD=73.64	Levofloxacin (IV) at 21.92; Ceftriaxone at 20.45; and Meropenem at 14.29 DDD/100 BD.	-
(Isnaasar *et al.*, 2022)	Indonesian N=72 DDD=73.52	Meropenem 66.53; Doripenem 4.74; and Imipenem/cilastatin 2.25 DDD/100 BD.	(0) by 56.81%. (IVa) 21.78%. (IVb) 8.63%.
(Izzati and Goni, 2022)	Indonesian N=144 DDD=104.11	Ceftriaxone (46.08); Levofloxacin (IV) (22.76); and Azithromycin (20.07 DDD/100 BD).	-
(Manurung and Andriani, 2022)	Indonesian N=763 DDD=1157.53	Ceftriaxone (797.63); Levofloxacin (IV) (248.77); and Meropenem (86.73 DDD/100 BD).	-
(Chrysou *et al.*, 2022)	Greece N=2506 DDD=424.27	Ampicillin/sulbactam 108.45; Fluoroquinolone group 54.23; and 2nd Generation cephalosporins 41.47 DDD/100 BD.	-

Table 1. Continued

Author & year	**Country /Sample /DDD**	**Antibiotic most widely used**	**Gyssens research results**
(Van Laethem et al., 2022)	Belgium N=115 DDD=31.48	Beta-lactamase enzyme inhibitors 22.506; Other beta-lactams 4.482; and Fluoroquinolone 1.298 DDD/100 BD.	-
(Alawi *et al.*, 2022)	Saudi Arabia N=550 DDD=1241.9	Meropenem 432.8, Tazobactam 267.2, and Tigecyline 150.7.	-
(Sadli *et al.*, 2023)	Indonesian	-	(0) by 41.22%. (IIa) 11.98%. (IIIa) 6.32%.
(Rachmawati *et al.*, 2023)	Indonesian N=40 DDD=167.54	Cefazolin 70; Ceftriaxone 35.79; and Gentamicin 22.68 DDD / 100 BD.	(0) by 89%. (IIb, IIIb, VI) 3%. (IVa) 2%.
(Dewi *et al.*, 2023)	Indonesian N=271 DDD=100.803	Levofloxacin (IV) 53.416; Ceftriaxone 21.551; and Azithromycin 11.851 DDD/100 BD.	(0) 63,97%. (IIIa) 30.57%. (V) 5.02%.
(Widiyastuti *et al.*, 2023)	Indonesian N=144 DDD=103.89	Ceftriaxone (46.8); Levofloxacin (IV) (22.76); and Azithromycin (20.7 DDD/100 BD).	(0) amounted to 85.95%. (IVa) 15.49%. (IIIa) 4.7%.
(Desideria et al., 2023a)	Indonesian N=121 DDD=165.8	Ceftriaxone (42.75); Cefixime (34.16); and Levofloxacin IV (20.93 DDD/100 BD).	-
(Hurtado *et al.*, 2023)	Colombia N=23 DDD=184.1	Meropenem 57.4; Ceftriaxone 38; and Tazobactam 35.1 DDD/100 BD.	-
(Qonita et al., 2023)	Indonesian N=64 DDD=131.33	Ceftriaxone (60.71); Levofloxacin IV (29.15); and Meropenem (16.10 DDD/100 BD).	-
(Önal *et al.*, 2023)	Turkey N=8157 DDD=4491	Meropenem 2114; Ceftriaxone 514; and Teicoplanin 692 DDD/1000 patient days.	
(Allel *et al.*, 2023)	Chile N=530 DDD=265.86	Carbapenem group 110.07; Beta-lactamase broad spectrum 142.45; and Colistin 13.34 DDD/1000 patient days.	

ATC: Anatomical therapeutic Classification, DDD: Defined Daily Dose, BD: Bed/Day, PO: Per Oral: IV: Intravenous.

Based on the data that has been obtained on the quality of antibiotic use, it was found that there are differences in the rationality of antibiotic use among the 13 articles discussing the rationality of antibiotic use (Table 2). Number of antibiotic uses by type The data obtained revealed that ceftriaxone was the most frequently used antibiotic, with levels of (21.13 DDD/100 BD), (60.10 DDD (100 BD), (36.15 DDD / 100 BD), (20.45 DDD 100 BD) (38.79 DDD 100, BD), (96.08 DDD100 BD), (42.75 DDD-100 BD), (797.63 DDD BD), (27.79 DDD/100 BD) (25.62 DDD 100,000 BD), (15.76 DDD), (21,551 DDD,100 BD) (46.8 DDD,100BD), (36.0 DDD/100 BD, (621.25 DDD/1000 Patient Days), (38DDD/100BD), (ceftriaxone 32.1 DDD/100 BD), (79.2 DDD, 100 BD, (514 DDD and 1000 DDD). Twenty-one journals review ceftriaxone as the most commonly used antibiotic, and 37 discuss using antibiotics based on DDD/100 Bed Day (BD) or DDD/1000 Patient Days(Table 1). Several articles have revealed antibiotic resistance in bacteria, especially in *Klebsiella pneumoniae*. These bacteria have shown resistance to five antibiotics: carbapenems, colistins, third-generation cephalosporins, extended-spectrum cephalosporins, and piperacillin/tazobactam. Statistical measurements showed that colistin showed P values above 0.05, which showed no correlation between colistin antibiotic resistance and *Klebsiella pneumoniae* bacteria (Table 3). The top antibiotic uses for pneumonia patients in hospitals are meropenem, ceftriaxone, teicoplanin, tanzobactam, and vancomycin.

Table 2. Distribution by category Gyssen

Author & year	**Quality of antibiotic use (%)**												
	Rational	**Irrational**											
	0	**I**	**II**			**III**		**IV**				**V**	**VI**
			a	**b**	**c**	**A**	**b**	**a**	**b**	**c**	**d**		
(Putra *et al.*, 2021)	35.4	3.5	8.5		0.7	2.8	15.6	19	0.7			13.5	
(Pangeran *et al.*, 2022)	18.9		1.4					67.6	12.2				
(Sukmawati *et al.*, 2020)			0.74	2.96		1.48	0.74	62.96	8.89			13.33	8.89
(Makaba *et al.*, 2019)	92.8					2.4	2.4				2.4		
(Ermawati *et al.*, 2021)	7							5				45	43
(Sadli *et al.*, 2023)	41.22	0.24	11.98	3.94	0.10	6.32	3.23	16.32	5.91	6.07	4.23	9.2	
(Karuniawati *et al.*, 2021)	93.7	6.25	6.24	8.33	2.08	2.08	33.33	50	14.58				27.08
(Rachmawati *et al.*, 2023)	89			3			3	2					3
(Isnaasar *et al.*, 2022)	56.81		5.45			4.02	2.5	21.78	8.63			0.81	
(Rumende *et al.*, 2019)	6.65	10.9	1.32	4.63		5.63	21.53	17.21					

Description: Category 0: Exact, Category I: Improper administration time, Category IIa: Inappropriate dose, Category IIb: Inappropriate interval, Category IIc: Mismatched route, Category IIIa: Taking too long antibiotics, Category IIIb: Antibiotics too short, Category IVa: There are more effective alternatives, Category IVb: There are less toxic alternatives, Category IVc: There are cheaper alternatives, Category IVd: There are other narrower spectrum alternatives, Category V: No indication of antibiotic use, Category VI: Incomplete data.

Table 3. Overview of antibiotic resistance to bacteria

Author & year	**Antibiotic**	**Bacteria**	**%**	**p-value**
(Barberi *et al.*, 2017)	Piperacillin/tazobactam	*Klebsiella pneumoniae*	19.3%	P=0.04
(Barnsteiner *et al.*, 2021)	Methicillin	*Staphylococcus aureus*	6%	P=0.005
	Glycopeptide	*Enterococcus faecalis/faecium*	3%	P=0.011
	extended-spectrum cephalosporin	*Escherichia coli*	15%	P=0.001
	extended-spectrum cephalosporin	*Klebsiella pneumoniae*	11%	P=0.002
	Carbapenems	*Enterobacteriales*	5%	P=0.008
(Vu *et al.*, 2019)	Cephalosporin	*Escherichia coli*	50%	P<0.0001
	Fluoroquinolones	*Escherichia coli*	50%	P<0.0001
	trimethoprim/sulfamethoxazole	*Escherichia coli*	50%	P = 0.03
	Third generation cephalosporins	*Klebsiella*	68%	P<0.0001
	Carbapenems	*Klebsiella*	16%	P<0.0001
	Amikacin	*Acinetobacter*	68%	P<0.0001

Table 2. Continued

Author & year	Antibiotic	Bacteria	%	p-value
	Imipenem	*Acinetobacter*	21%	P<0.0001
	Third generation cephalosporins	*P. aeruginosa*	33%	P<0.0001
	aminoglycosides.	*P. aeruginosa*	39%	P=0.04
(Čižman *et al.*, 2021)	broad-spectrum penicillin	*S. pneumoniae*	23%	p <.001
	penicillin with β-lactamase inhibitors	*S. pneumoniae*	22.2%	P <0.05
(Popović *et al.*, 2020)	Doripenem	*Acinetobacter*	90%	P=0.012
		K. pneumoniae	56.3%	P<0.001
	Ertapenem	*K. pneumoniae*	67.3%	P=0.007
	Colistin	*K. pneumoniae*	16.7%	P=0.021
	Piperacillin-tazobactam	*P. Aeruginosa*	60%	P=0.006
(Hurtado *et al.*, 2023)	Extended spectrum beta lactamase	*Klebsiella pneumoniae*	24%	<0.001
	Extended spectrum beta lactamase	*E. coli*	9%	0.054
	Carbapenems	*Klebsiella pneumoniae*	2%	<0.001
	Carbapenems	*Pseudomonas aeruginosa*	8%	<0.001
	Carbapenems	*Acinetobacter baumannii*	9%	<0.001
	Carbapenems	*E. coli*	(<1%)	0.926
	Vancomycin	*Enterococcus faecium*	57%	0.034
	methicillin	*S. aureus,*	39%	0.082

*% Percentage, *p-values < 0.05 are considered statistically significant.

Discussion

This review is the first attempt to synthesize evidence on antibiotic use in pneumonia patients, spanning the past ten years. We gathered the evidence for this review from health services, particularly hospitals. Based on our study, the top 5 antibiotics most often consumed in hospital care were ceftriaxone at a rate of 1547,735 DDD/100 days of sleep, levofloxacin at a rate of 594.31 DDD/100 days of rest, metronidazole at a rate of 91,013 DDD/100 days of sleep, azithromycin at a rate of 189,561 DDD/100 days of sleep, and Ciprofloxacin at a rate of 59,319 DDD/100 days of sleep. In addition, meropenem was consumed at a rate of 3011.2 DDD/1000 patient days, ceftriaxone at a rate of 1174.85 DDD/1000 patient days, teicoplanin at a rate of 692 DDD/1000 patient days, Tazobactam at a rate of 607.93 DDD/1000 patient days, and vancomycin at a rate of 340 DDD/1000 days of patient care in the hospital. The articles discuss antibiotic resistance to bacteria, including resistance to antibiotics such as carbapenems, aminoglycosides, third-generation cephalosporins, colistin, piperacillin-tazobactam, penicillin inhibitors beta-lactamase, Methicillin, and extended-spectrum beta-lactamase and cephalosporins.

In several articles that discuss antibiotic resistance to bacteria, eight bacteria were found to be resistant to antibiotics such as carbapenems, aminoglycosides, third-generation cephalosporins, colistin, piperacillin, tazobactam, penicillin-inhibitors beta-lactamase, methicillin, extended-spectrum beta-lactamase, and cephalosporins. Evaluation of the quality and quantity of antibiotic use there are 13 journals that discuss the quality of antibiotic use, which are categorized into gyssen found the rationality of antibiotic use is above 50% as shown in the research of Karuniawati et al., 2021 where category 0 of 93.7% is considered rational use of antibiotics, while in research conducted by Pangeran et al., 2022 the highest irrational use of antibiotics is shown in category IVa, i.e. there is a more effective alternative by 67.6%. The Journal of Antibiotic Quantity Evaluation conducted in Indonesia and abroad in the 2013–2023 period found that the total number of antibiotics used in both hospitalizations was 5497.99 DDD per 100 BD and 10385.42 DDD per 1000 patient days. Compared to research conducted by (Limato *et al.*, 2022). Among adult hospitalized patients, overall antibiotic consumption was 134.8 DDD/100 bed days. Ceftriaxone, levofloxacin, and ampicillin are commonly used antibiotics, as stated in a study by (Kim *et al.*, 2023) 920.69 DDD/1000 patient days with cephalosporins generation 3 and 4, beta-lactam, beta-lactamase inhibitors, carbapenems, tigecycline, glycopeptides, oxazolidinone, polymyxin, and fluoroquinolones were the most widely consumed. According to national pharmaceutical sales data for 2000–2015, antibiotic consumption increased primarily, driven by the broad-spectrum main classes of penicillins (2.6-fold), fluoroquinolones (7.1-fold), and cephalosporins (5.1-fold). In 2015, the per capita antibiotic consumption rate in Indonesia (3022 DDD per 1000 population per year) was in the same range as, for example, China (3060) and the Philippines (2600), but still lower than, for instance, Vietnam (11,480) and Thailand (6682). Around 69% of antibiotic consumption in Indonesia is access antibiotics, above the WHO target of >60% of access antibiotics in total consumption (Klein *et al.*, 2018). In the European Union, the average consumption of antibiotics during 2010–2019 was 18.0 DDD per 1,000 inhabitants per day in the primary care sector, ranging from 8.7 in the Netherlands to 32.4 in Greece and 1.8 DDD per 1,000 population per day in the hospital sector, ranging from 0.8 in the Netherlands to 2.5 in Greece and 2.5 in the UK (WHO, 2018). In the research report by Nelita Manurung *et al.*, 2022 regarding the evaluation of antibiotic use in pneumonia patients at the Abdul Manap Regional General Hospital for the 2018 period using the Gyssen method, the use of antibiotics was rational (74.2%) of the 31 pneumonia cases at the Abdul Manap Regional General Hospital for the 2018 period (Desideria *et al.*, 2023b). Based on the data that has been described in the manual, *Klebsiella pneumoniae* is the most common bacteria that experience resistance to carbapenem antibiotics (2% and 16%), ertapenem (67.3%), Doripenem (90%, cephalosporin generation (3.68%), extended-spectrum cephalosporin (11%), piperacillin/Tazobactam 19.3% and shows significant values ≤ 0.05. The total DDD/100 BD or DDD/1000 patient days range is 19.59–1157.53 DDD/100 BD and 8.43–4491 DDD/1000 patient days. This shows that DDD/100 BD or DDD/1000 patient days of total antibiotic use still vary. The rationality of antibiotic use based on the data that has been described shows the highest value is the use of appropriate antibiotics or category (0) of 46.51%. This is based on research conducted by Nelita Manurung et al., 2022 showing the rational use of antibiotics. However, there is still a need for further supervision of the use of antibiotics in hospitalized pneumonia patients to prevent the irrational use of antibiotics.

CONCLUSIONS

Based on the study findings, it was concluded that the commonly used antibiotic for pneumonia patients in hospitals was ceftriaxone at a rate of 1547.735 DDD/100 days of sleep, followed by meropenem at a rate of 3011.2 DDD/1000 days of patients. Levofloxacin is also typically used at 594.31 DDD/100 days of sleep for inpatient cases, while ceftriaxone is used at a rate of 1174.85 DDD/1000 days for hospital cases. Assessment of antibiotic use using the Gyssen method resulted in the following qualitative categories: category (0) had the highest percentage of 93.7%, followed by category (IVa) at 67.6%. The description of antibiotic resistance showed that *Klebsiella pneumoniae* bacteria were the most resistant to antibiotics and showed significant values of <0.05%.

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