

Appropriateness of antimicrobial selection for treatment of pneumonia in selected public hospitals of Eastern Ethiopia: A cross-sectional study

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Abstract

Objective: Inappropriate antimicrobial use leads to drug resistance and poor clinical outcomes. Considering the lack of data regarding the drug use patterns in the treatment of pneumonia in selected study areas, the authors felt compelled to assess the appropriateness of antimicrobial usage in the treatment of pneumonia at Hiwot Fana Specialized Comprehensive University Hospital and Jugal Hospital from May 1 to 31, 2021.

Methods: A cross-sectional retrospective study was conducted using the medical cards of 693 admitted patients with pneumonia. The collected data were analyzed using SPSS version 26. Bivariable and multivariable logistic regression analyses were used to identify the factors associated with an initial inappropriate antibiotic use. A *p* value of 0.05 was used to determine the statistical significance of the association using an adjusted odds ratio with 95% confidence interval.

Results: Of the total participants, 116 (16.74%, 95% confidence interval: 14.1–19.6) of them received an initial inappropriate antimicrobial regimen. Ceftriaxone plus azithromycin was the most prescribed antimicrobial agent. Patients who were younger than 5 years (adjusted odds ratio = 1.71; 95% confidence interval: 1.00–2.94), between 6 and 14 years (adjusted odds ratio = 3.14; 95% confidence interval: 1.64–6.00), and older than 65 years (adjusted odds ratio = 2.97; 95% confidence interval: 1.07–2.66), with comorbid conditions (adjusted odds ratio = 1.74; 95% confidence interval: 1.10–2.72) and prescribed by medical interns (adjusted odds ratio = 1.80; 95% confidence interval: 1.14–2.84) were associated with an initial inappropriate antimicrobial use.

Conclusion: Around one out of every six patients had received initial inappropriate treatments. Adherence to the recommendation of guidelines and attention to extreme-aged groups and comorbidity may improve antimicrobial use.

Keywords

Antimicrobial, appropriateness, pneumonia, Eastern Ethiopia

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Introduction

Pneumonia causes 6.8 million hospital admissions with 1.1 million in-hospital deaths among older adults.¹ The annual incidence rate among adults aged ≥ 18 years is 24.8 cases per 10,000, and this rate increases for individuals above 65 years.^{2–5} Moreover, it is the primary contributor to morbidity and mortality, accounting for 15% of all fatalities in children under the age of 5 years.⁶ Similarly, in sub-Saharan countries like Ethiopia, pneumonia affects children under the age of 5 years at a cumulative frequency of 20.68%.⁷

The use of antimicrobials is still considered the gold standard for treating pneumonia,^{8,9} and decisions on which

agents to employ are based on a number of factors, including pharmacokinetic and pharmacodynamic principles. Prompt

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antimicrobial delivery, antimicrobial therapy choice, and the use of a crucial pneumonia route are all associated with a positive clinical result in patients with pneumonia.¹⁰ Since pneumonia is a heterogeneous serious illness¹¹ both in terms of the pathogens involved and the host response, it demands critical diagnostic evaluation.¹² Antibiotic therapy for pneumonia includes β -lactams, macrolides, and fluoroquinolones alone or in combination. Combination therapy yields better results than monotherapy does. A better prognosis is linked to combination therapy with a macrolide for a wide range of atypical pneumonia, polymicrobial pneumonia, or resistant *Streptococcus pneumoniae*.¹¹

But the emergence to antimicrobial agents' resistance^{13,14} has raised concerns about empirical therapy.^{11,15} A number of drugs currently available are lacking antibacterial activity, while others do have antibacterial action but at the cost of collateral damage and patient safety.^{16–18} In addition, the widespread abuse of anti-infectives may contribute significantly to the development of antimicrobial resistance and have a significant influence on healthcare expenditures and the quality of drug therapy.^{19–23} According to,^{18,24} the prevalence of antimicrobial misuse ranges from 16% to 54%. In addition to its practicality, the empirical treatment approach may further exacerbate inappropriateness; a problem particularly relevant to pneumonia treatment.^{18,25} As a result, pharmaco-epidemiological investigations evaluating individual antimicrobial agent exposure are crucial.^{26–28} It evaluates the actual process of prescribing, distributing, or delivering a prescription that might be drug/disease specific.²⁹ Henceforth, owing to the absence of data describing drug use patterns of pneumonia in selected study areas, this study sought to evaluate the appropriateness of antimicrobials used to treat pneumonia at Hiwot Fana Comprehensive Specialized University Hospital (HFCSUH) and Jugal Hospital (JH) from May 1 to 31, 2021.

Methods

Study Design, area, and period

An institutional-based cross-sectional study was conducted at HFCSUH and JH, Harar town which is found 526 km to the East of Addis Ababa, the capital city of Ethiopia. Harari regional state is one of the 10 states in Ethiopia and it has a total population of 232,000; of those, 117,000 are males and the remaining are females.³⁰ This region is bounded by East, West, North, and South by Oromia regional state.³¹ There are 1 Federal Police Hospital, 2 public and 2 private hospitals, 8 health centers (4 urban and 4 rural), 24 health posts, and 10 nonprofit clinics in this region. One of the public hospitals is HFCSUH which is a teaching hospital of Haramaya University and serves as a referral hospital for the entire Eastern part of Ethiopia. This study was conducted at the medical and pediatric wards of HFCSUH and JH between May 1 and 31, 2021.

Study population

The study included all patients diagnosed with pneumonia and admitted to the medical and pediatric wards of HFCSUH and JH and treated with antimicrobial medications between April 2020 and April 2021. Those with incomplete medical record cards were excluded from the study.

Sample size determination

To determine the sample size, factors significantly associated with unfavorable treatment outcomes were considered along with the outcome variable. The sample size for objectives was calculated separately by adding 10% contingency and the one with the largest number was considered by revising works of literature and the formula $n = ((Z_{\alpha/2})^2 P(1-P)) / (d^2)$ ^{12,32–34} Finally, 693 patients with complete medical record cards and pneumonia were included in our analysis.

Sampling procedure

A total of 1060 patients with pneumonia admitted in the medical and pediatric wards of HFCSUH and JH between April 2020 and April 2021 were reviewed and identified from the inpatient patient registration book. The sample size was determined proportionally based on the number of hospital cases (HFCSUH=405, JH=288). The medical record cards of the patients were then registered, coded, and entered into a computer program (Microsoft Excel). Finally, a random sample of 693 medical record cards was generated and considered for data collection using simple random sampling. The sampling procedure is summarized in Figure 1.

Data collection tools, collectors, and procedures

A structured data collection format was used to collect data from the patient's medical record cards. Keeping the study's objective in mind, we reviewed previous studies to develop the data collection format. The data collection tool was divided into two sections: the first contained the patients' sociodemographic information (age, gender, and place of residence) and the prescriber's qualifications, while the second contained clinical characteristics, laboratory findings, and medications given to the patients (drug name, dose, frequency, and duration of therapy). Six pharmacists collected the data. Three pharmacists were assigned to each hospital. All the necessary information was obtained from the patients' medical record cards. Then the collected data were compared to both Ethiopian standard treatment guidelines for general hospitals³⁵ and American Thoracic Society and the Infectious Diseases Society of America (ATS/IDSA).¹² Finally, any divergence from the guidelines' recommendations was considered as inappropriate treatments.

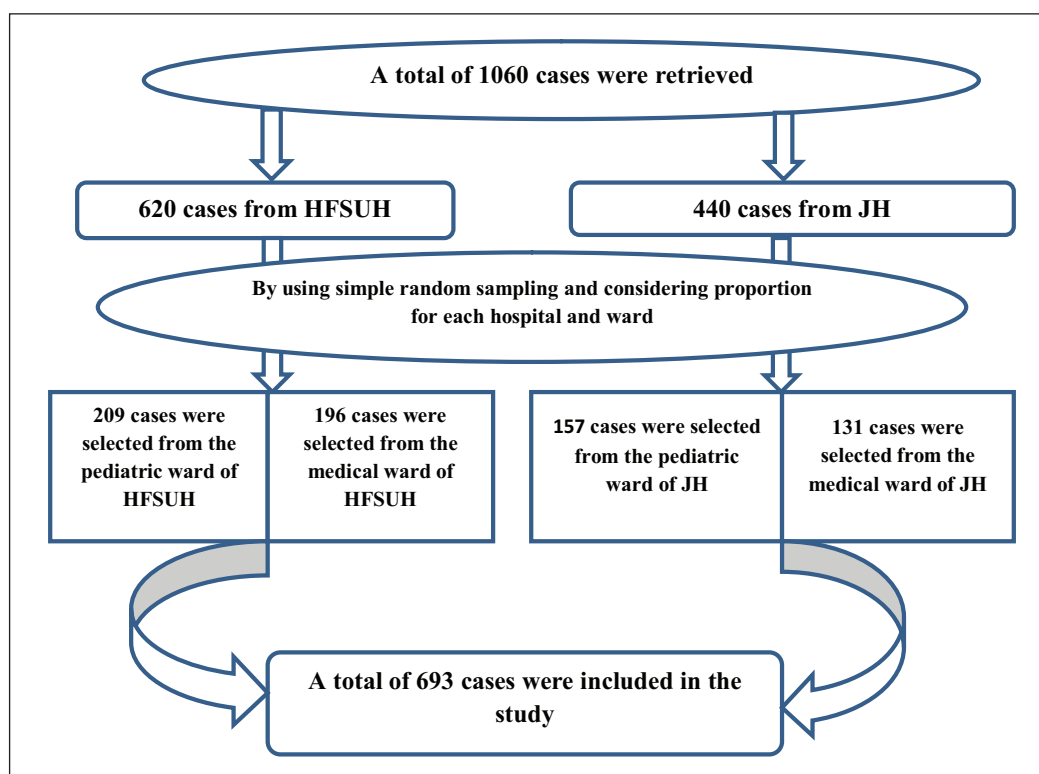


Figure 1. Sampling procedure of patients with pneumonia in the medical and pediatric wards of HFCSUH and JH, Harar, Eastern Ethiopia from May 1 to 31, 2021 ($n=693$).

HFCSUH: Hiwot Fana Comprehensive Specialized University Hospital; JH: Jugal Hospital.

Study variables

Dependent variable

- Appropriateness of the antimicrobial (medication administered; the name of the drug, dose, route, frequency of administration, and duration)

Independent variables

- Sociodemographic characteristics of the patients (age, sex, and place of residency)
- Qualification of the prescriber
- Clinical characteristics (types of pneumonia, comorbidity)
- Laboratory findings (complete blood count, liver function test, renal function test, blood glucose, and electrolytes)

Operational definitions

Appropriateness of the regimen: In this study, appropriateness of the regimen indicates the drug, dose, frequency, and duration of therapy, and is compared with Ethiopian standard treatment guidelines for general hospitals³⁵ and clinical practice guidelines of the ATS/IDSA,¹² and any deviation from these guidelines was considered as inappropriate (Supplemental Materials).

Data quality control

Before data collection, a pretest was conducted on 5% of the calculated sample size outside of the study facility (Federal Police Hospital) to assess the validity and reliability of the data collection format, and changes were made as needed. The principal investigator oversaw the data collection process and ensured that the data were complete. Data were cleaned and checked for missing data using frequency before analysis, and missing data were rechecked and entered before proceeding to the next step.

Statistical analysis

The data were coded and entered into EpiData version 3.1 before being exported to SPSS version 26. The data were then cleaned and cross-tabulated for completeness using simple frequencies and cross-tabulation. SPSS version 26 was used to analyze the completed data. Concerning antimicrobial appropriateness, the given regimen (drug name, dose, frequency, and duration of therapy) was recorded from the medication administration chart and compared to Ethiopian standard treatment guidelines for general hospitals and clinical practice guidelines of the ATS/IDSA.^{12,35}

To identify the association between independent variables and inappropriate initial treatment, bivariate and multivariable

Table 1. Sociodemographic characteristics of patients with pneumonia in the medical and pediatric wards of HFCSUH and JH, Harar, Eastern Ethiopia from May 1 to 31, 2021 ($n=693$).

Variables	Category	Frequency (%)
Age categories (years)	<5	273 (39.4)
	6–14	89 (12.8)
	15–24	37 (5.3)
	25–64	246 (35.5)
	>65	48 (6.9)
Sex	Male	384 (55.4)
	Female	309 (44.6)
Place of residence	Harar	159 (22.9)
	Outside of Harar	534 (77.1)
Prescriber qualification	General practitioner	150 (21.6)
	Medical intern	195 (28.1)
	Resident	384 (50.2)

HFCSUH: Hiwot Fana Comprehensive Specialized University Hospital; JH: Jugal Hospital.

logistic regression analyses were performed, and variables with $p \leq 0.25$ were included in the final model of multivariable analysis to control all the confounding variables. The Hosmer–Lemeshow statistical test was used to assess the model's goodness of fit. The crude odds ratio and adjusted odds ratio (AOR) were calculated using the 95% confidence interval (CI) to assess the strength of the association between the outcome and the independent variables. The variable with a p value less than 0.05 in the multivariable analysis was considered significantly associated with inappropriate initial treatment.

Results

Sociodemographic characteristics of the patients

Of the total 693 patients included, 384 (55.4%) of them were male, and 273 (39.42%) were <5 years. The median age was 13 years with an interquartile range of 39 years. The majority, 534 (77.1%), of the patients were residents of Harar town. A total of 348 patients (50.2%) were prescribed by the residents (Table 1).

Clinical characteristics and laboratory findings

Concerning the types of pneumonia, community-acquired pneumonia (CAP) was found to be the most common, 671 (96.8%), followed by hospital-acquired pneumonia in 15 (2.2%) patients. Among a total of 693 patients, 414 (59.7%) had comorbidity. Chest X-ray screening was also undertaken for 619 (89.3%) patients of whom 519 (83.8%) results suggested pneumonia and 82 (13.2%) were normal (Table 2).

Prescribed antimicrobials

Regarding the treatment approach, the empirical treatment approach was considered among all (100%) patients. The

study revealed that various antimicrobial agents were used to treat pneumonia. Ceftriaxone plus azithromycin in 322 (46.5%) patients followed by ceftriaxone alone in 159 (22.9%) patients were the most frequently used antimicrobials. The majority of the patients, 534 (77.1%), had taken antibiotics for 7–10 days, and 27 (3.9%) had taken antibiotics for more than 15 days. Furthermore, out of the four parameters (drug selection, dose, frequency, and duration of therapy) used to assess the appropriateness of the given regimen, only two (prolonged duration of therapy and wrong drug selection) of them were identified as the cause of inappropriateness of the treatments. From a total of 116 patients who received initial inappropriate regimen, prolonged therapy duration was found to account for 62 (53.4%) patients of inappropriateness, while incorrect drug selection was found to account for 54 (46.6%) patients. In all, 550 (79.4%) of the patients stayed in the hospital for 7–10 days with a mean duration of 9.4 days (Table 3).

Factors associated with inappropriate antimicrobial use

Inappropriate antimicrobial use was reported in the indication and prolonged duration of ceftriaxone, vancomycin, azithromycin, and ceftazidime (Table 4). Bivariable logistic regression was run to identify the factors to be considered in multivariable analysis. Accordingly, initial inappropriate antimicrobial use was associated with ages of ≤ 5 years (AOR=1.71; 95% CI: 1.00–2.94), 6–14 years (AOR=3.14, 95% CI: 1.64–6.00), and ≥ 65 years (AOR=2.94; 95% CI: 1.07–2.66); comorbidity (AOR=1.73; 95%, CI: 1.10–2.72); and medical intern's prescription (AOR=1.80; 95% CI: 1.14–2.84) (Table 5).

Discussion

This study revealed that all patients were treated empirically. Over 90% of patients were treated with ceftriaxone, either alone or in combination with other classes. Around one out of every six patients admitted to hospitals with pneumonia had received an initial inappropriate antimicrobial regimen. Age (≤ 5 years, 6–14 years, and ≥ 65 years), comorbidity, and medical intern's prescription were associated with an initial inappropriate antimicrobial use.

The pharmacological approaches to pneumonia treatment vary depending on the clinical presentation and the underlying etiologies, which are strongly influenced by the patient's age, the infecting organism, the infected site(s), the patient's immunological condition, and the environment in which the infection was first acquired.³⁶ In this study, the empirical treatment approach was the main way of management in all patients (100%). This result was comparable to a study done at the Tikur Anbessa Specialized Hospital in Addis Ababa, where 99.5% of the study subjects were treated empirically.¹⁸

The most frequently utilized antimicrobials in this study were ceftriaxone plus azithromycin (46.5%) followed by

Table 2. Laboratory findings of patients with pneumonia in the medical and pediatric wards of HFCSUH and JH, Harar, Eastern Ethiopia from May 1 to 31, 2021 (n=693).

Variables	Category	Frequency (%)
Result of CXR (n=619)	Normal CXR	82 (13.2)
	Pneumonia	519 (83.8)
	Cardiomegaly	6 (1)
	PTB	3 (0.5)
	Not concluded	3 (0.5)
	*Other	6 (1)
Type of pneumonia	CAP	671 (96.8)
	HAP	15 (2.2)
	AP	7 (1)
RFT (n=524)		
	SCr	
	Normal	488 (93.1)
	≥1.4 (mg/dl)	36 (6.9)
	BUN	
	Normal	432 (82.4)
LFT		
AST	Normal	485 (97.6)
	Elevated	12 (2.4)
ALT	Normal	482 (97)
	Elevated	15 (3)
ALP	Normal	455 (91.5)
	Elevated	42 (8.5)
Electrolyte (n=377)		
	Sodium	
	Normal	353 (93.6)
	Hypernatremia	7 (1.9)
	Hyponatremia	17 (4.5)
Potassium	Normal	369 (97.9)
	Hyperkalemia	3 (0.8)
	Hypokalemia	5 (1.3)
Chloride	Normal	362 (96)
	Hyperchloremia	6 (1.6)
	Hypochloremia	9 (2.4)
Blood glucose (n=198)		
	Normal	184 (93)
	Hyperglycemia	13 (6.6)
	Hypoglycemia	1 (0.5)

*ALT: alanine aminotransferase; ALP: alkaline phosphatase; AP: aspiration pneumonia; AST: aspartate aminotransferase; BUN: blood urea nitrogen; CAP: community-acquired pneumonia; CXR: chest X-ray; HAP: hospital-acquired pneumonia; HFCSUH: Hiwot Fana Comprehensive Specialized University Hospital; JH: Jugal Hospital; LFT: liver function test; PTB: pulmonary tuberculosis; RFT: renal function test; SCr: serum creatinine.

ceftriaxone alone (22.9 %). This was consistent with a study conducted at Nekemte Referral Hospital where ceftriaxone (50.5%) was the most commonly used antimicrobial.³⁷ Guidelines also recommend the use of ceftriaxone plus azithromycin or ceftriaxone alone in the treatment of pneumonia.^{12,35,38} Contrary to this data, the most popular antimicrobials used elsewhere were vancomycin (25%) followed by ceftriaxone (18.3%)¹⁸ and crystalline penicillin (67.3%) followed by ceftriaxone (24%).³⁴ This can be as a result of the various drug selection criteria and the accessibility of the particular antimicrobials in each study setting. In addition, the

Table 3. Prescribed antimicrobials and appropriateness of the regimen among patients with pneumonia in the medical and pediatric wards of HFCSUH and JH, Harar, Eastern Ethiopia from May 1 to 31, 2021 (n=693).

Name of antibiotics	Frequency (%)
Ceftriaxone + azithromycin	322 (46.5)
Ceftriaxone	159 (22.9)
Ceftriaxone + vancomycin	73 (10.5)
Ceftriaxone + ampicillin	54 (7.8)
Ampicillin + gentamycin	24 (3.5)
Vancomycin + ceftazidime	17 (2.5)
Ceftriaxone + metronidazole	15 (2.2)
Ceftriaxone + cloxacillin	8 (1.2)
Crystalline penicillin	8 (1.2)
Vancomycin + cefepime	5 (0.7)
Others*	8 (1.2)
Duration of antimicrobial treatment	
<7 days	35 (5.1)
7–10 days	534 (77.1)
>10 days	124 (17.9)
Appropriateness of the regimen	
Appropriate	577 (83.3)
Inappropriate	116 (16.7)
Cause of inappropriateness (n=116)	
Prolonged duration of therapy	62 (53.4)
Wrong drug selection**	54 (46.6)

*Amoxicillin, cefepime + azithromycin, cefepime + metronidazole, ceftriaxone + cefepime, and vancomycin + ciprofloxacin.

**Ceftriaxone + vancomycin, ceftriaxone + ceftazidime, ceftriaxone + cloxacillin, vancomycin + cefepime, cefepime + azithromycin, vancomycin + ciprofloxacin, and cefepime + metronidazole were given for 40, 7, 2, 2, 1, 1, and 1 patients as initial antimicrobial therapy in patients diagnosed with CAP, respectively. HFCSUH: Hiwot Fana Comprehensive Specialized University Hospital; JH: Jugal Hospital.

most common type of pneumonia in the area may also have an impact on the medication used.¹⁸

The selection of azithromycin has demonstrated a number of benefits in the macrolide category. It is effective against gram-positive bacteria and atypical pathogens.³⁹ It has been found that patients who receive a macrolide-β-lactam combination have shorter hospital stays.⁴⁰ The pharmacokinetic profiles of azithromycin are less complex, which may influence the therapeutic decision when combining a macrolide with a β-lactam antibiotic and other drugs.^{41–45} Furthermore, the longer half-life of azithromycin allowed for a single-dose daily regimen aids in improving adherence and higher rates of clinical cure at the end of treatment.⁴⁰

The study found reservations regarding fluoroquinolones (FQs) and doxycycline. A Clinical perspective would suggest that this was a reasonable strategy. With the risk of delayed tuberculosis diagnosis and treatment, as well as the emergence of FQ resistance in *Mycobacterium tuberculosis*,^{46–54} the role of fluoroquinolones as empirical therapy for

Table 4. Cross-tabulations of the appropriateness of antimicrobial use among patients admitted with pneumonia in the pediatric and medical wards of HFCSUH and JH, Harar, Eastern Ethiopia from May 1 to 30, 2021 ($n = 693$).

Variables	Category	Appropriateness		Total
		Appropriate	Inappropriate	
Age of the patients (years)	≤14	287	75	362
	15–24	33	4	37
	25–64	221	25	246
	>65	36	12	48
Prescriber qualification	Resident	295	53	348
	General practitioner	131	19	150
	Medical intern	151	44	195
Types of pneumonia	CAP	561	110	671
	HAP	12	3	15
	AP	4	3	7
Presence of comorbidity	Yes	330	84	414
	No	247	32	279
Specific antimicrobial	Ceftriaxone + azithromycin	299	23	322
	Ceftriaxone	137	22	159
	Ceftriaxone + vancomycin	31	42	73
	Ceftriaxone + ampicillin	48	6	54
	Ampicillin + gentamycin	23	1	24
	Vancomycin + ceftazidime	6	11	17
	Ceftriaxone + metronidazole	15	0	15
	Others	19	10	29

AP: aspiration pneumonia; CAP: community-acquired pneumonia; HAP: hospital-acquired pneumonia; HFCSUH: Hiwot Fana Comprehensive Specialized University Hospital; JH: Jugal Hospital.

Table 5. Factors associated with an initial inappropriate antimicrobial use among patients admitted with pneumonia in the pediatric and medical wards of HFCSUH and JH, Harar, Eastern Ethiopia from May 1 to 30, 2021 ($n = 693$).

Variables	Category	Appropriateness of an initial antimicrobial regimen		COR	AOR
		Appropriate	Inappropriate		
Age of patient (years)	25–65	221	25	1	1
	<5	223	50	1.98 (1.18–3.32)	1.71 (1.00–2.94)*
	6–14	64	25	3.45 (1.86–6.42)	3.14 (1.64–6.00)*
	15–24	33	04	1.07 (0.35–3.27)	1.09 (0.36–3.38)
	>65	36	12	2.94 (1.36–6.39)	2.97 (1.07–2.66)*
Comorbidity	Yes	330	84	1.97 (1.27–3.05)	1.74 (1.10–2.72)*
	No	247	32	1	1
Prescriber qualification	Resident	295	53	1	1
	GP	131	19	0.81 (0.46–1.42)	1.02 (0.57–1.84)
	MI	151	44	1.62 (1.04–2.52)	1.80 (1.14–2.84)*

Hosmer–Lemeshow goodness of fit test was fitted.

AOR: adjusted odds ratio; COR: crude odds ratio; GP: general practitioner; HFCSUH: Hiwot Fana Comprehensive Specialized University Hospital; JH: Jugal Hospital; MI: medical intern.

Significant at $p < 0.05$.

CAP remains questionable in countries with high tuberculosis burden. Furthermore, even though doxycycline in combination with a β -lactam is associated with similar or better outcomes in terms of mortality in patients hospitalized with pneumonia,^{55–57} it should be reserved as an alternative to macrolides in patients with mild to moderate CAP,

particularly in settings where it is difficult to assess the previous history of antimicrobial use.^{58–60}

The appropriateness of the given regimen was also assessed using Ethiopian standard treatment guidelines for general hospitals,³⁵ and clinical practice guidelines of ATS/IDSA as references.¹² Accordingly, 16.74% of the patients

received an initial inappropriate antimicrobial regimen as initially prescribed, which was comparable to the data from a study conducted in Portugal (16%).⁶¹ However, it is lower than the result in Japan (22.49%)⁶² and Taiwan (54%).²⁴

In terms of indication and duration, there was a higher rate of improper use of ceftriaxone, vancomycin, azithromycin, and ceftazidime in this study. This is possibly due to the limited availability of etiological diagnoses and the infrequent use of existing microbiological test. Consequently, reserved cephalosporins in the treatment of pneumonia caused by gram-negative bacteria (such as *Serratia marcescens* and *Proteus mirabilis*) that are resistant to several commonly used antimicrobial agents could be challenging and expensive.^{63–68}

This investigation also found that vancomycin was being misused for an extended period of time. However, the therapeutic benefits of this medicine, such as possible survival improvements and a lower incidence of nephrotoxicity, were linked to early therapeutic levels and the administration of a loading dosage in critically ill patients with proven gram-positive infection.^{69–71} When used for long periods, it has been associated with a variety of side effects including the “red man” syndrome, allergic reactions, various bone marrow effects, and nephrotoxicity.⁷² Vancomycin is one of the older antibiotics that is effective against most gram-positive cocci and bacilli, especially infections caused by methicillin-resistant *Staphylococcus aureus*, methicillin-resistant *Staphylococcus epidermidis*, and amoxicillin-resistant *enterococci*.^{73–75} Hence, misuse and development of resistance^{76,77} could lead to the use of unaffordable and spare drug indications like linezolid.^{78–80}

Appropriate treatment was also challenged and limited by the ability to rapidly and promptly identify the etiologic agent to initiate or de-escalate the appropriate antimicrobial therapy,⁸¹ which was a major verdict in the current study, since no microbiological test was executed. As a result, prescribers typically rely on clinical judgment and, in some cases, specific patient expectations when prescribing empirical antimicrobial treatment. These difficulties may play a role in the prolongation of ineffective therapy,^{15,17,18} while a shorter antibiotic treatment period based on clinical stability criteria can be safely employed in hospitalized patients with CAP.⁸²

Several factors were found to be associated with an initial inappropriate antimicrobial use in this study. The odds of receiving an initial inappropriate antimicrobial regimen were higher in patients aged ≤ 5 years, 6–14 years, and ≥ 65 years, with comorbidity and prescribed by medical interns.

Patients are endangered when drugs are prescribed for feeble elderly adults and children without adequate care. Patients at the extremes of age are vulnerable groups with much to lose and gain from medical treatment. Extrapolating data from clinical studies that primarily cover middle-aged individuals with a single condition is a common practice in prescribing for geriatric and pediatric patients.⁸³ The lack of medication standards in pediatrics is a critical concern, owing to age-related changes in organ growth and physiological

functions, resulting in significant pharmacodynamic and pharmacokinetic diversity.^{84–86} As a result, the measurement of dosage becomes imprecise, necessitating the development of educational programs aimed at raising rational use.⁸⁷

The prevalence of medical comorbidity^{88,89} in the elderly can also be ascribed to pharmacokinetic and pharmacodynamic alterations, which can directly interfere with the side effects and raise the risk of intoxication.⁹⁰ This is exacerbated by polypharmacy,⁹¹ incorrect indications,⁹² and the clinical experience of prescribers.^{93,94} All of which can increase hospital stays, costs, mortality, and morbidity.^{95,96} This calls for an integrated multidisciplinary strategy to improve the appropriate use of antibiotics, with particular attention to extreme-aged patients with pneumonia. Drug-related problems may be reduced by strengthening pharmaceutical care services at healthcare facilities.^{95,96} Supporting the development of local clinical practice guidelines based on national antimicrobial stewardship programs must be considered to improve antibiotic use and reduce their inappropriate use.⁹⁷

Strengths and limitations

The study seeks to determine whether antimicrobials are utilized appropriately in patients of all ages suffering from pneumonia. The sample size was large and representative. It offered a great chance to contrast antimicrobial therapy with established treatment protocols, and gain insight into actual drug use patterns. However, due to the nature of the study, only a few aspects of the regimen were evaluated.

Recommendation

Thus, our findings encourage the efforts to ensure that early-career physicians receive enough training and supervision. In addition, performing microbiological tests and active surveillance of drug safety monitoring, and use of immunizations against pneumonia in vulnerable populations, should be advocated. Additional researches considering the epidemiological context and interdisciplinary roles in reducing antimicrobial misuse should be carried out.

Conclusion

One out of six patients received an initial inappropriate antimicrobial regimen. The most commonly used drugs were ceftriaxone plus azithromycin, followed by ceftriaxone alone. Patients with early and advanced age, comorbidity, and medical intern prescriptions were associated with inappropriate initial antibiotic regimen. Incorrect durations and indications were the prime reasons for inappropriateness.

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Author contributions

All authors made a significant contribution to the work reported, starting from its conception, study design, execution, and acquisition of data, analysis, and interpretation. Besides, all took part in drafting, critically reviewing the article, finalizing the work of the article, and selecting an appropriate journal.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethical consideration

The Institutional Health Research Ethics Review Committee (IHRERC) of Haramaya University's College of Health and Medical Sciences (CHMS) provided ethical clearance with the reference number IHRERC/055/2021. The goal of this study was elaborated, and a letter of approval was handed to the concerned body of HFCSUH and JH. The administration of each hospital provided voluntary, informed, written, and signed consent. Because the study was based on secondary data, informed consent from patients or healthcare providers was not required (medication records). The information gathered from patient medical record cards was kept strictly confidential, and the patient's name and other personally identifiable information were not recorded. All necessary precautions were taken to avert COVID-19 during data collection.

Ethical approval

Ethical approval for this study was obtained from the Institutional Health Research Ethics Review Committee (IHRERC) of Haramaya University's College of Health and Medical Sciences (CHMS) ethical clearance with the reference number IHRERC/055/2021.

Informed consent

The administration of each hospital provided voluntary, informed, written, and signed consent. Because the study was based on secondary data, informed consent from patients or healthcare providers was not required (medication records). The information gathered from patient medical record cards was kept strictly confidential, and the patient's name and other personally identifiable information were not recorded.

Trial registration

Not applicable

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Data availability statement

The data used to support the findings of this study are included in the article.

Supplemental material

Supplemental material for this article is available online.

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