Mediterranean Journal of
Pharmacy & Pharmaceutical Sciences
www.medjpps.com

ISSN: 2789-1895 online
ISSN: 2958-3101 print

ORIGINAL RESEARCH article

Antibiotic stewardship in a Vietnamese public security hospital: Addressing antimicrobial resistance challenges through the AWaRe framework

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Article number: 215, **Received:** 03-06-2025, **Accepted:** 11-07-2025, **Published online:** 13-07-2025

HOW TO CITE THIS

Nguyen et al. (2025) Antibiotic stewardship in a Vietnamese public security hospital: Addressing antimicrobial resistance challenges through the AWaRe framework. Mediterr J Pharm Pharm Sci. 5(3): 19-27. [Article number: 215].
https://doi.org/10.5281/zenodo.15870874

Keywords: Antibiotic consumption, antibiotic resistance, AwaRe, defined daily dose, Hospital

Abstract: Antimicrobial resistance poses a critical threat to global health, exacerbated by inappropriate antibiotic usage. This study evaluates antibiotic consumption at Hospital 199, a public security hospital in Vietnam, using the defined daily dose per 100 bed-days and the World Health Organization AWaRe classification framework. Data were collected retrospectively from inpatient departments over 2022, analyzing prescribing trends to assess stewardship effectiveness and identify areas for improvement. The findings reveal a total antibiotic usage rate of 60.8 defined daily dose per 100 bed-days, predominantly driven by watch antibiotics (63.8%), followed by access antibiotics (36.2%), and minimal use of reserve antibiotics (0.0003%). Critical care departments, such as anesthesiology and intensive care, reported the highest consumption (190.54 DDD/100 bed-days), which may reflect the complexity of care provided and potential empirical prescribing practices, or an elevated infectious burden. β-lactam antibiotics accounted for 59.4% of total use, with third-generation cephalosporins representing the largest subgroup at 40.2% of defined daily doses. While adherence to stewardship principles was evident in the limited use of reserve antibiotics, the reliance on broad-spectrum agents highlighted systemic challenges, including empirical prescribing practices and limited diagnostic capacity. This study highlights the need for targeted interventions to promote access to antibiotics, reduce over-reliance on watch agents, and enhance diagnostic support. By aligning local practices with World Health Organization guidelines, Hospital 199 demonstrates its potential to combat antimicrobial resistance effectively. These findings offer insights for similar low- and middle-income settings, contributing to global efforts to mitigate resistance and optimize antibiotic stewardship.

Introduction

Drug resistance-the evolution of genetic or physiological adaptations that nullify a drug's activity in pathogenic microorganisms or cancer cells-now imperils the success of modern therapeutics [1, 2]. Nowhere is this more evident than in antimicrobial resistance (AMR), which the World Health Organization (WHO) ranks among the

ISSN: 2789-1895 online
ISSN: 2958-3101 print

most pressing global health threats [1, 3]. International surveillance relies on the WHO-defined daily dose (DDD) per 100 bed-days and the AWaRe classification, which stratifies antibiotics into access (first-line, narrow-spectrum), watch (broad-spectrum, higher resistance risk), and reserve (last-resort) groups to guide stewardship [4, 5]. Yet low- and middle-income countries (LMICs) often struggle to translate these frameworks into practice, hindered by weak regulation, over-the-counter sales, and limited professional training [1, 4, 6-10]. Vietnam typifies these challenges: antibiotic consumption remains high, and AMR rates are rising [5-7, 11, 12]. Hospital 199 - a tertiary facility serving police personnel and civilians- routinely performs culture and susceptibility testing and compiles an annual antibiogram, but lacks comprehensive usage audits. This study quantifies antibiotic use at Hospital 199 via DDD/100 bed-days and AWaRe categories, compares patterns across departments, and offers evidence-based recommendations to strengthen local stewardship, thereby informing national and regional AMR control efforts [1, 5, 11].

Materials and methods

Study design: This study used a cross-sectional descriptive design, employing a retrospective analysis of antibiotic consumption data collected across inpatient departments at Hospital 199 from January 1st, 2022 to December 31st, 2022. The study focused on the DDD per 100 bed-days as a metric to assess antibiotic usage patterns. DDD/100 bed-day=number of units administered in a given period (g)x100 per DDD (g)∗number of days in the period.

Study population and sample criteria: The sample included antibiotic usage records from inpatients, and adult, with a specific focus on patients prescribed at least one third-generation cephalosporins (C3G)-class antibiotic and treated with these antibiotics for a minimum of three days.

Inclusion criteria: Antibiotic consumption records for which a DDD value was calculated, patients aged 18 years and older, were admitted to an inpatient unit within the hospital.

Exclusion criteria: Antibiotic consumption records without a defined DDD value by the WHO.

Ethical approval: This study was submitted to the Ethical Approval Committee of Duy Tan University, but, no ethical approval was not required by the committee as the study did not involve human participants, animal subjects, or sensitive data.

Data analysis: Data was collected through the hospital's management software and included the quantity of antibiotics consumed and a number of inpatient bed days. Data were analyzed using SPSS 20 software to quantify the DDD per 100 bed-days for each department and antibiotic classification group.

Results

Antibiotic use by AWaRe classification across the entire hospital: According to the 2021 WHO AWaRe classification, 257 antibiotics are grouped into three categories: Access, watch, and reserve [4]. Hospital 199 utilized 12 out of 87 access antibiotics, 27 out of 141 watch antibiotics, and two out of 29 reserve antibiotics. The total antibiotic utilization rates across Hospital 199 in 2022 were recorded as shown in **Table 1**.

As a result, the overall antibiotic usage rate at Hospital 199 in 2022 was 60.78 DDD per 100 bed days. The hospital predominantly utilized antibiotics in the watch category (63.8%), followed by access antibiotics (36.2%), while reserve antibiotics were minimally used at 0.0003%.

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ISSN: 2958-3101 print

Table 1: Antibiotic consumption by AWaRe classification at Hospital 199

AWaRe group	DDD/100 bed-days	Percentage
Access	22.03	36.24
Watch	38.75	63.76
Reserve	0.0002	0.0003
Total	**60.78**	**100.00**

Antibiotic utilization by AWaRe classification in each clinical department: The data in **Table 2** reveals substantial variability in antibiotic consumption across clinical departments. The anesthesiology and intensive care department reported the highest antibiotic usage at 190.54 DDD per 100 bed-days, followed by the respiratory and dermatology departments (162.09 DDD/100 bed-days) and the otolaryngology department (161.28 DDD/100 bed-days). Conversely, the traditional medicine department had the lowest usage at just 0.48 DDD per 100 bed-days. As shown in **Figure 1**, antibiotic consumption patterns among clinical departments at Hospital 199 indicate that certain departments have a relatively high proportion of access to antibiotics. Notably, the physical therapy-rehabilitation department reported access antibiotic usage at 51.0%, the obstetrics department at 56.3%, and the dental-maxillofacial-ophthalmology department at 60.4%, which aligns closely with the WHO's target of 60.0% for access antibiotics. The study also identified two departments with minimal use of reserve antibiotics: the otolaryngology department (0.0007%) and the emergency resuscitation department (0.004%). This restricted use of reserve antibiotics is in line with stewardship principles to limit their application to cases of severe, multidrug-resistant infections, reflecting the hospital's adherence to antibiotic management guidelines.

Table 2: Antibiotic consumption by clinical department at Hospital 199 in 2022

Department	DDD/100 Bed-Days			
	Access	Watch	Reserve	Total
Anesthesiology and intensive care	90.84	99.70	0	**190.54**
Respiratory and dermatology	28.31	133.78	0	**162.09**
Otolaryngology	56.24	105.04	0.001	**161.28**
Emergency resuscitation	7.49	132.87	0.006	**140.36**
Abdominal surgery	29.10	91.39	0	**120.49**
Gastroenterology	36.31	41.56	0	**77.88**
Dental - maxillofacial - ophthalmology	46.55	30.58	0	**77.12**
Obstetrics	38.39	29.79	0	**68.18**
Trauma surgery - burns	12.76	52.12	0	**64.88**
Endocrinology - hematology - clinical	8.49	21.88	0	**30.37**
Infectious diseases	8.30	20.03	0	**28.32**
Neurology - psychiatry	3.34	20.44	0	**23.78**
Cardiology - geriatrics - renal - rheumatology	3.35	15.15	0	**18.50**
Physical Therapy-Rehabilitation	1.29	1.24	0	**2.52**
Traditional medicine	0.17	0.32	0	**0.48**

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ISSN: 2958-3101 print

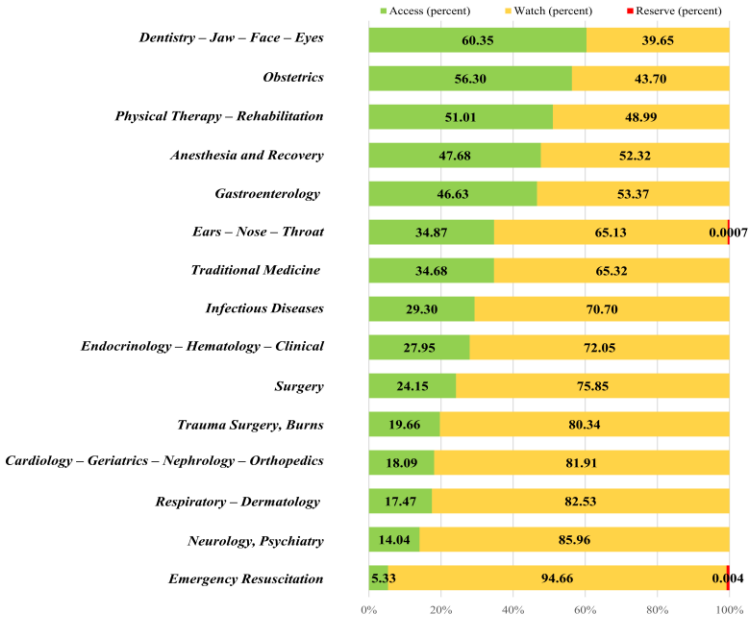

Figure 1: Proportion of antibiotic usage by AWaRe classification across clinical departments at Hospital 199

Antibiotic utilization by pharmacological effects and chemical structure across the entire hospital: As displayed in **Table 3**, β-lactam antibiotics accounted for the largest proportion of overall antibiotic consumption at Hospital 199, comprising 59.4% of total usage. This was followed by quinolones (17.3%) and macrolides (11.5%). Lincosamides, specifically clindamycin, showed minimal use at 0.2%, and the lowest consumption was observed for other miscellaneous antibiotics, making up 0.1%.

Table 3: Antibiotic consumption by pharmacological effects and chemical structure at Hospital 199

Antibiotic class	DDD/100 bed-days	Percentage
β-lactam	36.1	59.39
Quinolones	10.50	17.28
Macrolides	7.00	11.52
Cyclines	3.17	5.21
Nitroimidazoles	2.41	3.96
Aminoglycosides	1.15	1.89
Glycopeptides	0.30	0.49
Lincosamides	0.12	0.20
Other antibiotics	0.03	0.06
Total	**60.78**	**100.00**

DDD per 100 bed-days for β-lactam antibiotics across the hospital: The β-lactam class at Hospital 199 includes several subclasses based on pharmacological effects and chemical structure: broad-spectrum penicillins, cephalosporins, β-lactamase inhibitors, and carbapenems. **Table 4** illustrates detailed consumption for each subclass. Thus, the findings demonstrate that third-generation cephalosporins (C3G) represented the highest DDD/100 bed-days usage among β-lactam antibiotics at 40.2%, followed by penicillins combined with β-lactamase inhibitors (29.0%). Among the four cephalosporin generations, C3G and C2G were the most utilized, while C1G saw minimal use at 4.5%, and C4G represented 0.1% of total consumption.

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ISSN: 2958-3101 print

Table 4: Consumption of β-lactam antibiotics at Hospital 199

No.	β-lactam subclass	DDD/100 bed-days	Percentage
1	Third-generation cephalosporins (C3G)	14.49	40.15
2	Penicillin + β-lactamase inhibitors	10.46	28.98
3	Second-generation cephalosporins (C2G)	5.46	15.12
4	Penicillins	3.24	8.98
5	First-generation cephalosporins (C1G)	1.62	4.50
6	Carbapenems	0.78	2.16
7	Fourth-generation cephalosporins (C4G)	0.04	0.11
Total		**36.10**	**100.00**

DDD per 100 bed-days for third-generation cephalosporins by clinical department: **Table 5** highlights the variability in C3G antibiotic utilization across departments. The highest usage was observed in the abdominal surgery department (41.71 DDD/100 bed-days), anesthesiology and intensive care (41.54 DDD/100 bed-days), trauma surgery (38.25 DDD/100 bed-days), emergency resuscitation (28.42 DDD/100 bed-days), and respiratory and dermatology (20.07 DDD/100 bed-days). Cefixime emerged as the most frequently used C3G antibiotic at Hospital 199, accounting for 65.7% of C3G usage and was particularly predominant in departments like cardiology - geriatrics - renal - rheumatology (73.3%), endocrinology - hematology - clinical (67.1%), neurology - psychiatry (73.8%), and infectious diseases (96.8%). Notably, physical therapy - rehabilitation and traditional medicine exclusively utilized cefixime, with 100.0% of C3G consumption in these departments attributed to this antibiotic. These findings indicate that C3G antibiotics, especially cefixime, ceftriaxone, ceftazidime, and cefoperazone/sulbactam, are extensively used across clinical departments, reflecting their effectiveness against a wide range of infections treated within Hospital 199.

Table 5: Consumption of third-generation cephalosporins antibiotics by clinical department at Hospital 199

Department	DDD/100 bed-days (C3G)	Most common C3G	
		INN name	Percentage
Abdominal surgery	41.71	Cefoperazone/sulbactam	44.76
Anesthesiology and intensive care	41.54	Cefoperazone/sulbactam	77.09
Trauma surgery - burns	38.25	Cefoperazone/sulbactam	32.95
Emergency resuscitation	28.42	Ceftriaxone	46.62
Respiratory and dermatology	20.07	Ceftazidime	45.34
Obstetrics	19.28	Ceftriaxone	75.14
Endocrinology - hematology - clinical	8.91	Cefixime	67.08
Neurology - psychiatry	7.90	Cefixime	73.76
Infectious diseases	7.83	Cefixime	96.77
Otolaryngology	7.35	Cefoperazone/sulbactam	36.48
Cardiology - geriatrics - renal - rheumatology	6.70	Cefixime	73.27
Dental - maxillofacial - ophthalmology	5.91	Ceftriaxone	50.43
Gastroenterology	4.25	Ceftriaxone	48.58
Physical therapy - rehabilitation	0.11	Cefixime	100.00
Traditional medicine	0.02	Cefixime	100.00
Overall hospital	**14.49**	**Cefixim**	**65.70**

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ISSN: 2958-3101 print

Discussion

Hospital 199 recorded 60.78 DDD/100 bed-days in 2022, lower than published rates from Vietnamese provincial (129.55 DDD/1000 patient-days, 2021) and district hospitals (64.6 DDD/100 bed-days, 2020) and below the 89.3-96.2 DDD/100 bed-days reported by several general hospitals during 2017-2019 [13-16]. Such variability reflects the institutional scale, case mix, and stewardship maturity [6]. Internationally, this level approximates German benchmarks (55.40 DDD/100 bed-days, 2015-2016), yet LMICs often endure higher resistance despite lower absolute use, driven by inappropriate prescribing e.g., heavy reliance on broad-spectrum penicillins [17, 18]. Audit-and-feedback programs and context-adapted guidelines can curb misuse, but implementation is hampered by limited diagnostics and personnel [19]. AWaRe stratification revealed a predominance of watch agents (63.8%) and a shortfall of access drugs (36.2%), well below the WHO target of ≥60% access; reserve antibiotics were scarcely used (0.0003%) [20, 21]. This broad-spectrum bias likely stems from the empirical treatment of severe infections amid constrained culture capacity [11]. In this study, the departmental analysis showed wide divergence: anesthesiology/intensive care unit consumed 190.54 DDD/100 bed-days, whereas traditional medicine used 0.48. These data call for department-tailored stewardship that ensures evidence-based selection, dosing, duration, and administration route to optimize therapy while mitigating resistance. In 2022, β-lactams represented 59.4% of antibiotic use at Hospital 199, with C3G alone accounting for 40.2% (DDD/100 bed-days). However, their overuse raises concern about the emergence of extended-spectrum β-lactamase-producing organisms, necessitating interventions to curb excessive reliance while preserving their utility in critical care settings [22]. Quinolones ranked second at 17.3%, predominantly levofloxacin for respiratory or urinary infections, but their high resistance-selection potential and toxicity warrant caution. Despite their clinical utility, quinolones require cautious use due to their association with resistance selection pressures and adverse effects [23]. Macrolides (11.5%) and tetracyclines (5.2%) were used more sparingly, reflecting infection-specific prescribing. Consumption varied markedly by department: anesthesiology/intensive care unit reached 190.54 DDD/100 bed-days, whereas traditional medicine recorded 0.48, highlighting the need for unit-tailored stewardship. AWaRe analysis showed disproportionate watch use (63.8%), inadequate access use (36.2%), and negligible reserve use (0.0003%), falling short of the WHO goal of ≥60.0% access to antibiotics. Recommendations to optimize antibiotic usage at Hospital 199, aligned with the WHO AWaRe framework and addressing local and global antimicrobial stewardship challenges [**Table 6**, 14, 20, 21, 24]. These interventions can lower inappropriate use, mitigate emerging ESBL and multidrug-resistant threats, and position Hospital 199 as a stewardship exemplar for comparable low- and middle-income settings.

Hospital 199 typifies the stewardship dilemma faced by many LMICs: high antibiotic consumption, escalating AMR, over-the-counter drug access, and resource constraints. Although the WHO AWaRe framework offers a universal blueprint, its real-world application demands local adaptation [6, 25-27]. The hospital's disproportionate Watch use and underuse of access agents signal the need for department-specific guidelines, decision-support tools, and stronger diagnostic capacity, while its negligible reserve consumption shows appropriate conservation. Aligning hospital policy with global targets therefore hinges on tailored interventions that address these contextual barriers. This study's use of DDD/100 bed-days and AWaRe categorisation provides a standardised lens to benchmark utilisation patterns nationally and internationally. The granular, department-level analysis further pinpoints where stewardship efforts should concentrate, and a full-year dataset mitigates seasonal bias. Nonetheless, the retrospective design limits patient-level insight excludes outpatient prescribing, and cannot directly correlate use with resistance because real-time microbiology data are lacking. Variations in data collection and clinician training may also confound results.

ISSN: 2789-1895 online
ISSN: 2958-3101 print

Table 6: Optimizing antibiotic usage at Hospital 199 with strategies aligned to the WHO AWaRe framework

Recommendation	Details	Rationale	Expected outcomes
Increasing 'Access' antibiotic use	Promote 'Access' antibiotics through evidence-based guidelines and ensure availability in formularies.	Aligns with WHO recommendations to reduce resistance risks [16, 17].	Increase usage to meet the 60.0% target.
Limiting broad-spectrum agents	Develop decision-support tools and audit-feedback systems to limit 'Watch' antibiotic usage.	Reduces reliance on agents with high resistance potential [18].	Decrease 'Watch' antibiotic use by 15.0%.
Targeted education programs	Organize training for prescribers on AMR risks and optimal prescribing practices.	Improves prescriber adherence to guidelines [20].	Increase awareness among 90.0% of prescribers.
Strengthening monitoring mechanisms	Conduct regular departmental audits to identify and address prescribing discrepancies.	Ensures accountability and promotes consistent prescribing [21].	Identify and rectify discrepancies within three months.

Conclusion: This study highlights the critical need for enhanced antibiotic stewardship at Hospital 199 to address the growing challenge of antimicrobial resistance. The over-reliance on watch antibiotics and underutilization of access antibiotics deviates from WHO recommendations, indicating areas for improvement. Targeted interventions, such as promoting access to antibiotics, restricting broad-spectrum agents, and strengthening diagnostic support, are essential to optimize prescribing practices. The variability in departmental antibiotic usage reveals the importance of tailored stewardship strategies. By aligning its practices with global guidelines, Hospital 199 can not only improve local antibiotic use but also contribute to broader efforts to combat antimicrobial resistance, setting a benchmark for similar low-resource settings.

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Author contribution: All authors conceived and designed the study. H-PN & T-V-AT collected data. H-PN, V-TH & T-V-AT performed the analysis and interpreted data. All authors drafted and revised the manuscript and approved the final version of the manuscript and agreed to be accountable for its contents.
Conflict of interest: The authors declare the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
Ethical issues: The authors completely observed ethical issues including plagiarism, informed consent, data fabrication or falsification, and double publication or submission.
Data availability statement: The raw data that support the findings of this article are available from the corresponding author upon reasonable request.
Author declarations: The authors confirm that they have followed all relevant ethical guidelines and obtained any necessary IRB and/or ethics committee approvals.