Journal of Preventive and Population Health
https://jpphealth.com/

ORIGINAL ARTICLE

Antibiotics prescribing pattern assessment in comparison to World Health Organization/ International Network of Rational Use of Drugs in the Emergency Department of Care Medical Al-Malaz, Riyadh, Saudi Arabia

Abdulmohsen Mahdi Alanazi[1*], Ibrahim Mofarih Assiri[2], Fawaz Thamer Alsalamh[3], Khalid Obeed Alanizy[4], Talal Salem Alanazi[5]

Full list of author information is available at the end of the article.

ABSTRACT

Background: Evaluating antibiotic prescribing patterns is important to enhancing patient safety and healthcare quality. According to the World Health Organization (WHO), antibiotics are the most commonly prescribed medication in emergency departments (EDs), where 20%-50% of prescribed antibiotics are unnecessary and contribute to antimicrobial resistance (AMR). AMR is directly responsible for 1.27 million deaths worldwide annually. Increasing prevalence of AMR in Saudi Arabia underscores the urgent need to assess antibiotic utilization.

Objective: To assess antibiotic prescribing patterns at the ED of Care Medical Al-Malaz (CMM) using the WHO/ International Network of Rational Use of Drugs (INRUD) indicators, compare them with the WHO benchmark data, and support antimicrobial stewardship improvements.

Methods: A retrospective cross-sectional study analyzed adult ED antibiotic prescriptions at CMM (October-December 2024). The WHO/INRUD prescribing indicators were used to evaluate trends in antibiotic patterns. Key metrics included average drugs per encounter, generic prescribing, and rates of antibiotic and injection use.

Results: This retrospective study analyzed 14,893 ED encounters, identifying 2,775 eligible prescriptions with 3,251 antibiotics. Oral antibiotics were prescribed (73.2%), and Watch-antibiotic agents (67.3%) predominated, mainly macrolides (30.4%) and cephalosporins (28.3%). The average number of drugs per encounter (3.9) and antibiotics prescribed in 32.0% exceeded the WHO standards. Generic prescribing (100%) and injection rates (20.9%) met the standard, and essential drug compliance was 99.56%. Culture testing was performed in only 59 cases with over 2,775 patients.

Conclusion: Antibiotic prescribing at the ED of CMM exceeds the WHO guidelines, driven by high polypharmacy, irrational antibiotic use, reliance on Watch-group antibiotics, and higher empirical treatment with limited diagnostic testing. These findings underscore the urgent need to enhance antimicrobial stewardship and prescribing practices.

Keywords: Antibiotic prescribing patterns, antimicrobial resistance (AMR), emergency department (ED), WHO/INRUD indicators, antimicrobial stewardship, Saudi Arabia.

Introduction

Assessing medication prescribing patterns is important in healthcare quality, cost-effectiveness, and improvement in any healthcare system. Appropriate use of medications is an essential element in achieving health quality and medical care for patients and the community as a whole [1]. Emergency departments (EDs) are one of the critical

Correspondence to: Abdulmohsen Mahdi Alanazi
*Department of Pharmacy, Narcotic and Controlled In-Charge, and Medication Safety Officer, Care Medical Hospital, Riyadh, Saudi Arabia.
Email: Ph.3bdulmohsen@gmail.com
Received: 14 February 2025 | **Revised:** 23 March 2025 | **Accepted:** 30 March 2025

areas where timely and effective treatment decisions are important. Among different classes of medications, antibiotics are the most commonly prescribed in EDs [2]. Infections that are caused by antimicrobial-resistant pathogens have been increasing over the last two decades, which has increased morbidity, mortality, and healthcare costs [3]. According to the World Health Organization (WHO), 20%-50% of prescribed antibiotics are inappropriate [4]. Regular reviews of prescribing patterns are necessary for evaluating current practices and for identifying areas where improvements can be made. By implementing robust antimicrobial stewardship programs that focus on improving the quality of prescribing practices, healthcare systems can reduce irrational prescribing of antibiotics, thereby minimizing the development and spread of resistant pathogens. The main causes of antibiotic resistance are self-medication, polypharmacy, and inappropriate use of antibiotics, overuse of injectable medicines, and the prescribing of medicines without following relevant clinical practice guidelines. Annually, 1.27 million mortality cases are directly caused by antimicrobial resistance (AMR), in addition to 4.95 million death cases associated with AMR [5]. The WHO, in collaboration with the International Network of Rational Use of Drugs (INRUD), has developed a set of core drug prescribing indicators to assess and evaluate antimicrobial prescribing patterns [1]. These indicators are generalized to be standardized tools for measuring the rational use of medicines and ensuring adherence to evidence-based prescribing guidelines [1]. According to a statistical health indicator published by the Saudi Ministry of Health, the number of ED visitors in 2021 was 13.6 million in the whole country [6]. To focus on the problem in Saudi Arabia, A Saudi National Surveillance on Gram-positive cocci demonstrated that 32% of *Staphylococcus aureus* are methicillin-resistant (MRSA), 33% of *Streptococcus pneumonia* are resistant to penicillin G, and 26% are resistant to erythromycin [7]. During the 6 years from 2000 to 2006, the resistance of *Enterobacter cloacae* to Ciprofloxacin was raised from 8.3% to 17.4% in Saudi Arabia [8]. A study from Riyadh demonstrated that *S. aureus* was colonizing the nasal cavity of 40% of the 200 tested healthcare workers. Among that *S. aureus*, 45% were MRSA, resulting in a total prevalence of 18% of health workers carrying MRSA [9]. Our aim in this study is to evaluate the antimicrobial prescribing patterns at ED in Care Medical Al-Malaz (CMM) and to compare them with the WHO/INRUD standard to improve quality, the antimicrobial stewardship program, and physician training and to minimize the AMR in our hospital and population. The study aimed to evaluate the antibiotics prescribing patterns at the ED of CMM by using the WHO/INRUD guidelines. This study also aimed to compare our antibiotic prescribing patterns with local and international hospital data, improve quality and patient safety by improving the antimicrobial stewardship program, and reduce antibiotic resistance, side effects, and healthcare costs.

Research Methodology

Study design and setting

This retrospective cross-sectional study analyzed all ED prescriptions containing at least one antibiotic at CMM in Riyadh, Saudi Arabia, from October 1 to December 30, 2024. Prescription data were extracted from the hospital's electronic medical record system (CAREWARE). CMM is a 459-bed private hospital and part of the National Medical Care Company, which also operates Care Medical Al-Rawabi. Located in central Riyadh, CMM was established in 1966 and acquired by the National Medical Care Company in 2003. It serves both Saudi and non-Saudi patients and provides comprehensive healthcare services across multiple departments, including ED, Outpatient Department, inpatient care, radiology, laboratory, pharmacy, surgical and medical specialties, ICU, labor and delivery, and more. The ED comprises 60 beds and manages approximately 52,800 patient visits annually (about 4,400 monthly). CMM is accredited by both the Joint Commission International and the Saudi Central Board for Accreditation of Healthcare Institutions, reflecting its commitment to high-quality healthcare standards.

Study population and sampling technique

It was a retrospective cross-sectional study aiming to evaluate the antibiotic prescribing patterns in the ED of CMM using the WHO/INRUD prescribing indicators [1]. The study aims to assess the extent of antibiotic use, identify prescribing trends, and highlight any deviations from standard prescribing practices that may contribute to AMR. The study population consisted of adult patients aged 18 to 65 years who had visited the ED at CMM, had an assigned medical record number, and received at least one antibiotic prescription during their encounter. These patients represented the primary target group for evaluating prescribing patterns and adherence to recommended guidelines within emergency care settings. To maintain a focused and standardized assessment, the study applied strict inclusion and exclusion criteria. The following prescriptions were excluded from the analysis: pediatric patients (<18 years old) because including pediatric patients may dilute the relevance and accuracy of the findings, geriatric patients (>65 years old) are mainly on several medications, which can affect the polypharmacy indicator, illegible handwritten prescriptions, incomplete or canceled prescriptions, and undispensed prescriptions. A Microsoft Excel-based data extraction tool was developed specifically for this research to ensure consistency and accuracy in collecting data aligned with the WHO/INRUD prescribing indicators. The Excel sheet designed for the research purpose included structured fields containing patient demographics, used brand name, brand cost, generic name, antibiotics classification, AWaRe classification, antibiotic spectrum, presence on the CMM essential medication list or no, dosage form, route of administration, patient diagnosis, culture sensitivity if obtained, type of

culture, culture result, and pathogen result. The data were filed by two certified pharmacists. It also included WHO/INRUD indicator fields such as the number of antibiotics per prescription, percentage of antibiotics prescribed by generic name, and adherence to essential drug lists.

Methods of Measurement

All prescriptions that were generated by the ED through the computerized hospital database (CareWare) during the 3-month study period were reviewed and evaluated. Data collection was conducted by two certified pharmacists with expertise in medication assessment and who were well-trained on research criteria, provided with a secure Excel sheet that accepted only the required data. The data variables examined in this study were patient characteristics - unique patient identifier, age, gender, and nationality - and prescription characteristics - number of antibiotics prescribed per encounter, antibiotic generic name, antibiotic brand name, antibiotic brand cost, route of administration, diagnosis associated with the antibiotic prescription, total number of medications prescribed per encounter, culture sensitivity test if performed (yes/no), type of culture (e.g., blood, urine, sputum, wound swab), and culture test result (e.g., positive, negative, inconclusive).

WHO/INRUD antibiotic prescribing indicators

The study utilized WHO/INRUD core prescribing indicators to assess the rational use of antibiotics in the ED of CMM. These indicators included the average number of drugs per encounter (optimal: 1.6-1.8) to evaluate polypharmacy, with combination drugs counted as a single medicine. The percentage of drugs prescribed by generic name (optimal: 100%) would measure the extent of generic prescribing. The percentage of encounters with an antibiotic prescribed (optimal: 20.0%-26.8%) would assess the frequency of antibiotic use, while the percentage of prescribed antibiotics administered via injection (optimal: 13.4%-24.1%) would reflect reliance on parenteral formulations. Lastly, the percentage of antibiotics prescribed from the essential medicines list (EML) (optimal: 100%) would determine adherence to national formulary standards. These indicators collectively offered a comprehensive evaluation of prescribing patterns and help identify areas for improvement in antibiotic stewardship.

Data management and statistical analysis

After data collection, management and analysis were conducted using the Statistical Package for the Social Sciences (SPSS, Version 25.0, IBM SPSS). Descriptive statistics will be applied to summarize the data, where quantitative ones were presented as mean ± SD, while categorical variables were expressed as frequencies and percentages. Additionally, bar charts were generated to visually represent the most commonly prescribed antibiotic types and classes, categorized by age groups and common diseases treated with antibiotics. Correlations were performed using a *t*-test or chi-square based on the data type, and $p \leq 0.05$ was defined as a significant value.

Results

As shown in Table 1, this retrospective analysis examined 14,893 ED encounters, comprising 9,759 (65.5%) adult and 5,134 (34.5%) pediatric patients. Among adult visits, 1,094 (11.2%) resulted in hospital admission, yielding a final cohort of 8,665 adult ED patients. Pharmacological data extraction identified 7,540 prescriptions containing 33,813 medications, of which 3,200 (42.4%) contained at least one antibiotic. Following the exclusion criteria application, 2,775 prescriptions comprising 3,251 antibiotics met the study inclusion criteria.

Demographic stratification revealed a male predominance (64.72%, *n* = 1,796) over female recipients (35.28%, *n* = 979), with 26.39% Saudi nationals (16.37% male, 10.02% female) and 73.61% non-Saudi patients (48.34% male, 25.27% female). Age distribution demonstrated peak antibiotic utilization in the 30-39 years' cohort (41.12%, *n* = 1,141), followed by 18-29 years (24.72%, *n* = 686), 40-49 years (23.35%, *n* = 648), and 50-65 years (10.81%, *n* = 300) Table 2.

Administration routes were distributed as follows: oral (73.21%, *n* = 2,380), parenteral (20.95%, *n* = 681), topical (4.64%, *n* = 151), and ophthalmic (1.20%, *n* = 39). CMM EML compliance was 100.00% (*n* = 3,237),

Table 1. *ED visits, pharmacy database screening, and final included prescriptions.*

	N
Total ED visits	8,665
Pharmacy database records (CareWare system)	7,540
Antibiotic-containing prescriptions	3,200
Excluded prescriptions (per study criteria)	425
Eligible prescriptions meeting inclusion criteria	2,775
Total antibiotic agents prescribed	3,251
Total medications prescribed	33,813

Table 2. *Demographic characteristics (N = 2,775).*

Category	Group	*N*	%
Age	Range	18-65	
	Mean ± SD	36.7 ± 9.7	
	<20	72	2.59%
	20-29	614	22.13%
	30-39	1,141	41.12%
	40-49	648	23.35%
	50-59	222	8.00%
	60-69	78	2.81%
Gender	Female	979	35.28%
	Male	1,796	64.72%
Nationality	Saudi	732	26.39%
	Non-Saudi	2,042	73.61%

with 0.43% (n = 14) representing non-formulary agents. AWaRe classification demonstrated substantial Watch group utilization (67.3%, n = 2,189) versus Access antibiotics (32.7%, n = 1,062), with no reserve category prescriptions documented. Prescribing pattern analysis revealed monotherapy predominance (72.22%, n = 2,348), with dual and triple antibiotic regimens observed in 23.25% (n = 756) and 4.52% (n = 147) of cases, respectively Table 3.

Clinical indications for antibiotic therapy were predominantly upper respiratory tract infections (50.36%, n = 1,397), followed by post-trauma prophylaxis (10.71%, n = 297), lower respiratory tract infections (9.48%, n = 263), and gastrointestinal infections (9.19%, n = 255). Notably, 3.79% (n = 105) of prescriptions were inappropriately issued for viral upper respiratory tract infections, with additional non-indicated use for fever (0.90%, n = 25) and pain management (0.79%, n = 22) Table 4.

Analysis of 3,251 prescribed antibiotics showed distinct utilization patterns across antibiotic classes (Figure 1), and there was a clear pattern of utilization. Macrolides are the most used class of antibiotics (30.39%, n = 988), followed by cephalosporins (28.33%, n = 921). Penicillin/beta-lactamase inhibitor combinations made up 17.75% (n = 577), while fluoroquinolones were 10.21% (n = 332), and Nitroimidazoles were used in 6.67% of cases (n = 217).

As shown in Figure 2, the results demonstrate a clear predominance of broad-spectrum antimicrobial agents, with marked variability in the frequency of individual antibiotic prescriptions. Azithromycin emerged as the single most frequently prescribed antibiotic, accounting for 28.98% (n = 942) of all prescribed antibiotics. This was closely followed by ceftriaxone at 18.21% (n = 592) and amoxicillin-clavulanic acid at 17.75% (n = 577). Together, these three antibiotics constituted nearly two-thirds (64.94%) of all the prescribed antibiotics in this study. Third-generation cephalosporins as a class showed substantial use, with cefdinir prescribed at 3.78% (n = 123), cefuroxime at 3.57% (n = 116), and cefixime at 2.68% (n = 87). The fluoroquinolones were also commonly prescribed, with ciprofloxacin accounting for about 5.44% (n = 177) and levofloxacin about 3.48% (n = 113) of total antibiotic prescriptions. Metronidazole prescriptions represented 6.67% (n = 217), and fusidic acid was about 3.11% (n = 101).

Table 3. *Characteristics of prescribed antibiotic (N = 3,251).*

		N	%
Route of administration	Oral	2,380	73.21%
	Injection	681	20.95%
	Topical	151	4.64%
	Ophthalmic	39	1.20%
CMM EML	Yes	3,237	99.56%
	No	14	0.43%
WHO AWaRe classification	Access	1,062	32.67%
	Watch	2,189	67.33%
	Reserve	0	0.00%
No. of antibiotics/ prescription	One antibiotic	2,348	84.61%
	Two antibiotics	378	13.62%
	Three antibiotics	49	1.77%

Table 4. *Clinical diagnosis.*

Diagnosis	N	%
Upper respiratory tract infection	1,397	50.34%
Post-trauma prophylaxis	297	10.70%
Lower respiratory tract	264	9.51%
Gastrointestinal infection	255	9.19%
Skin and soft tissue infection	141	5.08%
Urinary tract infection	134	4.83%
Other	287	10.38%

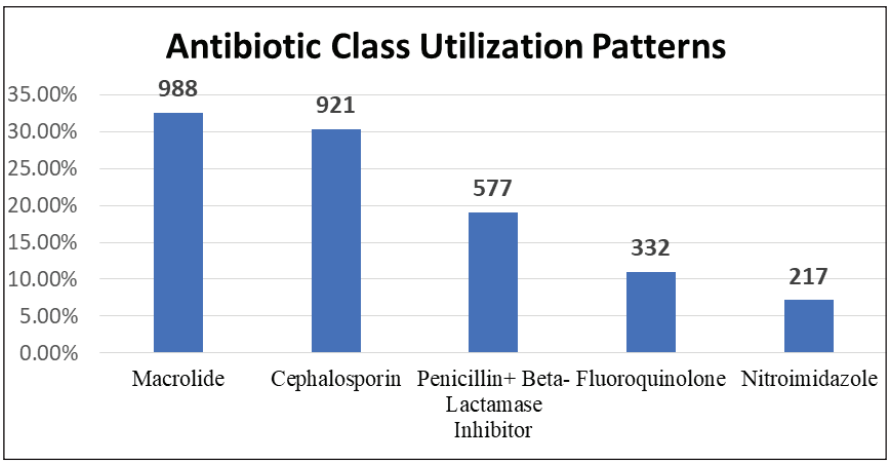

Figure 1. *Antibiotic class utilization patterns (N = 3,251).*

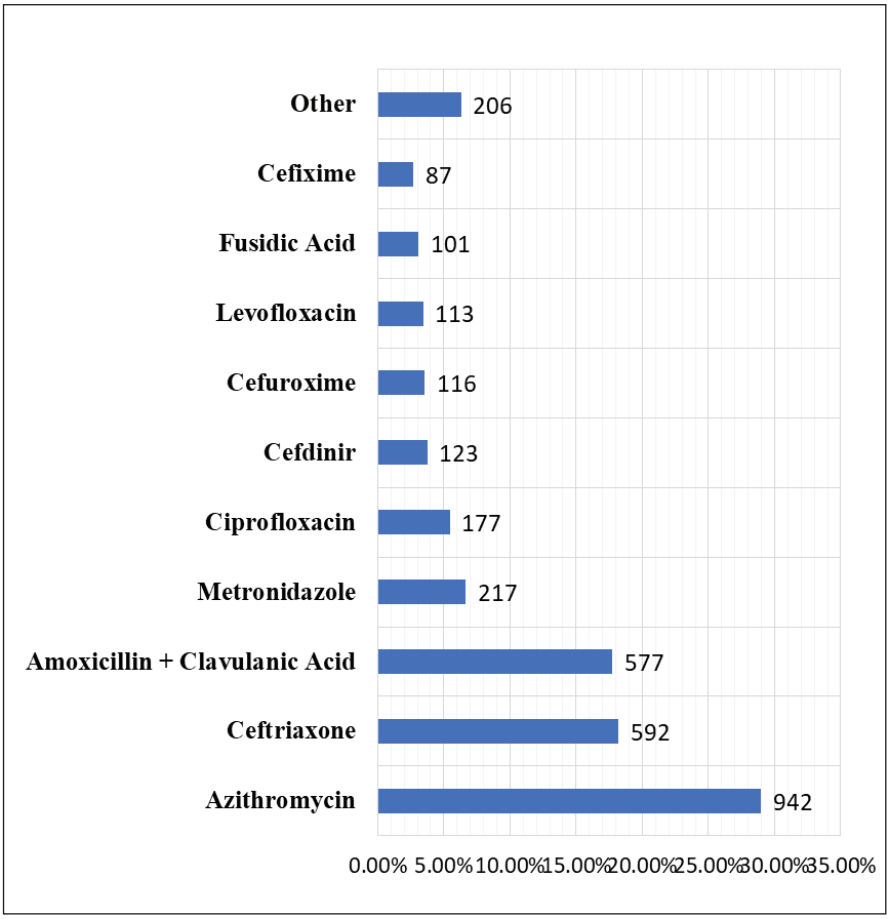

Figure 2. *Antibiotic utilization patterns (N = 3,251).*

The average number of drugs per encounter was 3.9, exceeding the WHO/INRUD standard of 1.6-1.8. The percentage of drugs prescribed by generic name was 100%, meeting the recommended standard. The percentage of encounters with an antibiotic prescribed was 32.02%, which is above the standard range of 20.0%-26.8%. The percentage of encounters with an injected antibiotic was 20.90%, falling within the acceptable range of 13.4%-24.1%. The percentage of antibiotics prescribed from the EML was 99.56%, which is nearest below the recommended 100% Table 5.

Among 2,775 patients, culture tests were performed in only 59 cases, representing 2.13% of the total. Among the 59 tests conducted, the most common specimen type was urine (n = 43, 72.88%), followed by stool (N = 6, 10.17%), blood (N = 5, 8.47%), and swab (N = 5, 8.47%). Of the culture results, 39 were negative. Among the 20 positive cultures, *Escherichia coli* was the most frequently isolated organism (n = 13; 65% of positive cultures), followed by *S. aureus* (n = 3, 15%), specimen contamination (n = 2, 10%), and *Enterococcus faecalis* (n = 1, 5%) Table 6.

Table 5. *WHO/INRUD prescribing indicators.*

Indicator	Result	Standard value
Average number of drugs per encounter	3.9	1.6-1.8
Percentage of drugs prescribed by generic name	100%	100%
Percentage of encounters with an antibiotic prescribed	32.02%	20.0%-26.8%
Percentage of encounters with an injected antibiotic	20.90%	13.4%-24.1%
Percentage of antibiotics prescribed from the CMM EML	99.56%	100%

Discussion

This comprehensive evaluation of prescribing patterns of 8,665 adult patient encounters with 2,775 prescriptions that included 3,251 antibiotics at CMM ED demonstrates an alarming critical deviation from the WHO/INRUD standards benchmarks [1]. The antibiotic prescribing rate (32.02%) exceeds the WHO recommended range (20.0%-26.8%), reflecting an overuse trend similar to findings in Pakistan (52.4%) [10] and Tanzania (51.9%)

Table 6. *Microorganism's lab test.*

		Test results	*N*	% of total (*N* = 2,775)	% of tested sample (*N* = 59)
Test performance (*n* = 2,775)	Not performed	-	2,716	97.87%	-
	Performed	-	59	2.13%	-
Specimen types (*n* = 59)	Urine	-	43	1.55%	72.88%
	Stool	-	6	0.22%	10.17%
	Blood	-	5	0.18%	8.47%
	Swab	-	5	0.18%	8.47%
Culture results (*n* = 59)	Negative (no growth)	-	39	1.41%	66.10%
	Positive (*n* = 20)	*Escherichia coli*	13	0.47%	65%
		Staphylococcus aureus	3	0.11%	15%
		Specimen contamination	2	0.07%	10%
		Enterococcus faecalis	1	0.04%	5%
		Klebsiella pneumoniae	1	0.04%	5%

[11], and it contrasts significantly with Saudi tertiary centers such as King Abdullah Medical City (KAMC) (17.6%) [12] and KSMC (12.41%) [13]. The extensive use of Watch-group antibiotics (67%), especially with the higher consumption of azithromycin (28.98%) and ceftriaxone (18.21%), reflects the high cephalosporin use (30.3%) reported in KAMC [12] and the broad-spectrum antibiotic preference highlighted across the Gulf region [14]. Regardless of that, the hospital achieved near-complete EML compliance (99.56%) and excellent generic prescribing, meeting the WHO standard (100%), surpassing Eastern Province PHCCs (61.2%) [15], and matching KSMC published results [13]. However, diagnostic practices were lacking: culture testing was conducted in only 2.13% of cases, which is lower than the 10% reported at KAMC [16], and 3.79% of prescriptions were given for viral infections, closely mirroring KAMC of 8.5% unnecessary antibiotic use [16]. The average number of drugs per encounter (3.9) reflects a concerning polypharmacy trend, exceeding the WHO's optimal range (1.6-1.8) and surpassing polypharmacy rates in Egyptian PHCs (2.5 drugs/encounter) [17]. Injectable antibiotic results (20.90%) aligned with the WHO standards (13.4%-24.1%) and contradictory results with KSMC (61%) [13] and bilateral vestibular hypofunction (98%) [10]. The demographic findings of male dominance (64.72%) and higher consumption rate of antibiotics among non-Saudis (73.61%) compared to Saudi patients (26.39%) introduce new variables absent in comparable published Saudi studies, where the antibiotic class distribution of macrolides (30.39%) and cephalosporins (28.33%) led, followed by penicillin/beta-lactamase inhibitors (17.75%), mirroring KSMC cephalosporin preference [13]; it differs from KAMC, where Co-Amoxiclav was dominant [16]. These findings collectively highlight the fact that although CMM performs better than some regional peers in terms of generic prescribing and injection practices, Watch-group antibiotic overuse, polypharmacy, and diagnostic deficiencies reflect widespread issues that have been reported from Pakistan to Saudi Arabia. As emphasized by Rania et al. (2020), particularly the gap in antimicrobial stewardship in Gulf regions [14], our study highlights the necessity of targeted interventions on antimicrobial stewardship, clinician education, and electronic decision support, which will narrow the implementation gaps observed across these comparative studies.

Conclusion

This study critically evaluated antibiotic prescribing in the ED of CMM, Riyadh, using the WHO/INRUD indicators. While CMM demonstrated strong performance in generic prescribing (100%) and formulary compliance (99.56%), notable concerns included high antibiotic prescription rates (32.02%), predominant use of Watch-group antibiotics (67.3%), low culture testing (2.13%), and polypharmacy (3.9 drugs/encounter). Despite these issues, CMM showed strengths in avoiding Reserve antibiotics and maintaining appropriate injectable use (20.9%). The findings highlight the urgent need for antimicrobial stewardship to reduce empirical prescribing and align with the WHO standards to combat rising AMR in Saudi emergency care.

List of Abbreviations

AMR	Antimicrobial resistance
CMM	Care Medical Al-Malaz
ED	Emergency department
EML	Essential medicine list
INRUD	International Network for Rational Use of Drugs
SPSS	Statistical package for social science
WHO	World Health Organization

Conflict of interest
No conflict of interest according to the authors.

Funding
None.

Consent to participate
There is no need, as this was retrospective study based on the data from the hospital system. However, security of data and anonymity was guaranteed.

Ethical approval
Ethical approval for this study was obtained from the Institutional Review Board of Riyadh Second Health Cluster, IRB Log Number [25-196E]. All procedures were performed in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Author details
Abdulmohsen Mahdi Alanazi[1], Ibrahim Mofarih Assiri[2], Fawaz Thamer Alsalamh[3], Khalid Obeed Alanizy[4], Talal Salem Alanazi[5]

1. Department of Pharmacy, Narcotic and Controlled In-Charge, and Medication Safety Officer, Care Medical Hospital, Riyadh, Saudi Arabia
2. Department of Pharmacy, Outpatient Pharmacist, Care Medical Hospital, Riyadh, Saudi Arabia
3. Department of Pharmacy, Antimicrobial Stewardship Co-Chairman, Care Medical Hospital - Almalaz, Riyadh, Saudi Arabia
4. Department of Radiology, General Directorate of Medical Services, Ministry of Interior, Dammam, Saudi Arabia
5. Department of Pharmacy, Head of Pharmacy, Care Medical Hospital, Riyadh, Saudi Arabia

References

1. World Health Organization. How to investigate drug use in health facilities: selected drug use indicators. 1993. Available from: https://www.who.int/publications/i/item/who-dap-93.1
2. Harrison RF, Ouyang H. Fever and the rational use of antimicrobials in the emergency department. Emerg Med Clin North Am. 2013;31(4):945–68. https://doi.org/10.1016/j.emc.2013.07.007
3. Laxminarayan R, Duse A, Wattal C, Zaidi AK, Wertheim HFL, Sumpradit N, et al. Antibiotic resistance—the need for global solutions. Lancet Infect Dis. 2013;13(12):1057–98. https://doi.org/10.1016/S1473-3099(13)70318-9
4. World Health Organization. The world health report 2007: a safer future: global public health security in the 21st century: overview. Geneva, Switzerland: World Health Organization; 2007.
5. Vollset SE, Altay U, Bhattacharjee NV, Chalek J, Giannakis K, Gray A, et al. Forecasting the fallout from AMR: human health impacts of antimicrobial resistance. Rep EcoAMR Ser. 2024.
6. Ministry of Health, Kingdom of Saudi Arabia. Health indicators 2021. Riyadh, Saudi Arabia: Ministry of Health; 2021. Available from: https://www.moh.gov.sa/en/Ministry/Statistics/book/Documents/Health-Indicators-2021-en.pdf
7. Zowawi HM. Antimicrobial resistance in Saudi Arabia: an urgent call for immediate action. Saudi Med J. 2016;37(9):935.
8. van Belkum A, Goessens W, van der Schee C, Lemmens-den Toom N, Vos MC, Cornelissen J, et al. Rapid emergence of ciprofloxacin-resistant Enterobacteriaceae containing multiple gentamicin resistance-associated integrons in a Dutch hospital. Emerg Infect Dis. 2001;7(5):862.
9. Zakai SA. Prevalence of methicillin-resistant *Staphylococcus aureus* nasal colonization among medical students in Jeddah, Saudi Arabia. Saudi Med J. 2015;36(7):807.
10. Atif M, Azeem M, Sarwar MR, Shahid S, Javaid S, Ikram H, et al. WHO/INRUD prescribing indicators and prescribing trends of antibiotics in the Accident and Emergency Department of Bahawal Victoria Hospital, Pakistan. Springerplus 2016;5:1928.
11. Kilipamwambu A, Bwire GM, Myemba DT, Njiro BJ, Majigo MV. WHO/INRUD core prescribing indicators and antibiotic utilization patterns among primary health care facilities in Ilala district, Tanzania. JAC Antimicrob Resist. 2021;3(2):dlab049.
12. Alanazi MQ, Salam M, Alqahtani FY, Ahmed AE, Alenaze AQ, Al-Jeraisy M, et al. An evaluation of antibiotics prescribing patterns in the emergency department of a tertiary care hospital in Saudi Arabia. Infect Drug Resist. 2019;12:3241–7.
13. Alharafsheh A, Alsheikh M, Ali S, Baraiki AA, Alharbi G, Alhabshi T, et al. A retrospective cross-sectional study of antibiotics prescribing patterns in admitted patients at a tertiary care setting in the KSA. Int J Health Sci (Qassim). 2018;12(4):67.
14. Mahmood RK, Gillani SW, Saeed MW, Hafeez MU, Gulam SM. Systematic review: study of the prescribing pattern of antibiotics in outpatients and emergency departments in the Gulf Region. Front Pharmacol. 2020;11:585051.
15. El Mahalli AA. WHO/INRUD drug prescribing indicators at primary health care centres in Eastern province, Saudi Arabia. East Mediterr Health J. 2012;18(11):1091.
16. Oqal MK, Elmorsy SA, Alfhmy AK, Alhadhrami RM, Ekram RA, Althobaiti IA, et al. Patterns of antibiotic prescriptions in the outpatient department and emergency room at a tertiary care center in Saudi Arabia. Saudi J Med Med Sci. 2015;3(2):124–9.
17. Akl OA, El Mahalli AA, Elkahky AA, Salem AM. WHO/INRUD drug use indicators at primary healthcare centers in Alexandria, Egypt. J Taibah Univ Med Sci. 2014;9(1):54–64.