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Research Article

Impact of Clinical Decision Support System on Antibiotic Dosing in Patients with Renal Impairment: An Implementation Study at a Vietnamese Tertiary Hospital

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ABSTRACT

Background: Preventing adverse drug reactions is the primary goal in pharmaceutical care, especially antibiotics as it can contribute to the deterioration of renal function. At 108 Central Military Hospital, Vietnam, managing renally cleared antibiotics (RCA) poses a considerable challenge due to its large facility with 2000 beds. Implementing a clinical decision support system (CDSS) holds promise in improving RCA dosing in patients with renal impairment. Methods: A retrospective study was conducted to assess antibiotic prescriptions in adults > 18 years old with an estimated glomerular filtration rate (eGFR) calculated by both Cockcroft-Gault and MDRD-4 formula under 90 mL/min/1.73 m^2 during two distinct periods: pre- and post-implementation of a CDSS, which included a drug compendium of 48 antibiotics requiring renal dose adjustment that was established through consensus among multiple summaries of product characteristics and specialized literature. Alerts were triggered when an antibiotic was prescribed within the threshold of the patient's eGFR. The impact of this CDSS was determined by comparing the percentage of inappropriate dosing between these periods. Results: Among 1012 total patients, 65.2% were over 65 years old, and 71.3% were male. The eGFR ranging from 60-90 mL/min was observed in 54.8% of patients during both periods. Of 1545 and 1730 antibiotic prescriptions in the pre- and post-period, 28.2% and 19.4% respectively, had inappropriate dosing (OR 0.61; 95% CI: 0.52-0.72; p<0.001). Inappropriate RCA dosing significantly decreased in the internal medicine department (OR 0.45; 95% CI: 0.36-0.57; p<0.001) and intensive care unit (OR: 0.57; 95% CI: 0.39-0.83; p=0.003), with marked reductions observed for cefoperazone/sulbactam, levofloxacin, and meropenem during the post-period (p<0.001). Conclusions: This study demonstrates the initial success of implementing a CDSS for antibiotic dosage prescriptions. Future research endeavors should focus on pharmacist interventions and integrate antibiotic indications into these recommendations to achieve optimal, personalized care.

Keywords:
Antibiotics; Renal Disease; Prescription Alerts; Clinical Decision Support Systems; Medication Safety

1. INTRODUCTION

Patients with renal impairment are prone to adverse drug events due to the inappropriateness of drug dosage adjustment[1]. This medication error can lead to adverse drug reactions, increasing the risk of hospitalization

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and mortality[2-5]. A literature review of clinical outcomes in patients who have kidney disease receiving inappropriate medications showed that medication errors are associated with a higher risk of hospitalization, bleeding rate, and all-cause mortality[1, 4]. In a study of 375 patients with chronic kidney disease (CKD), 30% were prescribed medications without the appropriate adjustment for their kidney function[1]. Antibiotics are the most common unadjusted medication in patients with renal impairment, especially among the elderly[6,7]. The rate of inappropriate antibiotic dosing among renally vulnerable populations varies from 51.6% to 100% in different studies[8-12].

Vietnam is a low- and middle-income country with the lion's share of antibiotic consumption[13,14]. A study found that among 76 countries in the world, Vietnam ranked 11th in antibacterial consumption with 32.0 DDD per 1000 inhabitants per day, much higher than that seen in most European nations over 15 years from 2000[13]. Meanwhile, more than the number of healthcare professionals in Vietnam is needed to provide personalized pharmaceutical care. According to the World Health Organization (WHO) statistics report, the average number of physicians and pharmacists per 10,000 population from 2013 to 2021 was 8.3 and 3.4 respectively[15]. In comparison, European regions had significantly higher figures, with 36.6 physicians and 6.5 pharmacists per 10,000 population during the same period[15]. Furthermore, as the Vietnamese aging population continues to increase rapidly[16,17], the shortage of healthcare professionals may exacerbate, particularly with the heightened demand among elderly patients who typically have more health conditions and more inappropriate prescriptions[18].

To address this challenge, digital health technologies (DHTs) can be a solution to support patient-centered outcomes by increasing efficiency, reducing strain on healthcare resources, and supporting patient-centered clinical practice[19]. One type of DHT is a clinical decision support system (CDSS), which is often integrated into the computerized order entry (CPOE) and provides personalized recommendations to medical practitioners[20]. In 2011, Tawadrous et al. conducted a systematic review of 32 prospective studies employing CDSS to support medication prescribing for renal failure patients[21]. Results revealed that in 11 studies employing CDSS in real-time within the CPOE software, the frequency of appropriate drug dosage significantly improved across all studies.

Given the advantages of using information technology in healthcare, the Vietnamese government has issued the decision on a digital health transformation program since 2017. Although many healthcare facilities have implemented DHTs into their systems, the impact of this approach is unknown due to the many challenges, especially in large settings. Moreover, there is a scarcity of studies evaluating the efficiency of DHTs in Vietnam. Therefore, we aimed to evaluate the performance of the CDSS in prescribing antibiotics that require dosage adjustment for patients with renal impairment.

2. MATERIALS AND METHODS

2.1. Research setting.

This study was conducted at 108 Central Military Hospital, which is a 2000-bed tertiary hospital in Hanoi, Vietnam. At this hospital, a CPOE system was implemented in 2016. This system facilitates personalized medication dispensing from the pharmacy, reducing errors caused by illegible handwriting or transcription mistakes in drug orders. Initially, the CPOE was paired with a CDSS to manage drug interactions. In 2021, a CDSS was integrated to calculate the estimated glomerular filtration rate (GFR) using both the Cockcroft-Gault (CG eGFR) and Modification of Diet in Renal Disease (MDRD eGFR) formulas. With access to eGFR values, a CDSS featuring alerts for contraindicated medications in patients with renal impairment was implemented in 2022, enhancing medication safety. Subsequently, in 2024, another CDSS was introduced to provide alerts for adjusting antibiotic dosages in this patient population.

2.2. Study design and patient population.

A retrospective study was carried out over two distinct periods: From the 1st to the 28th of February 2023 for the pre-implementation group and from the 1st to the 29th of February 2024 for the post-implementation group. The inclusion criteria of this study were adults over 18 years old, who experienced eGFR below 90 mL/min/1.73 m^2 by CG eGFR and MDRD eGFR methods, and who received at least one systemic antibiotic during the study period. Dialysis patients requiring specific recommendations were excluded.

The data collection process was identical for both periods. We extracted patient demographics (age, gender, weight), antibiotic usage (type of antibiotic, dosage, duration), and medical conditions (diseases on admission and location of care) from the CPOE system. The eGFR values including the date of the test, creatinine concentration, CG eGFR, and MDRD eGFR, were obtained from another file. Then we matched the date of the creatinine test with the date of antibiotic use for analysis through the patient codes. Renal clearance calculated based on CG eGFR was used to assess the appropriateness of antibiotic dosing.

During both periods, ward-based clinical pharmacists were actively involved. They routinely reviewed prescriptions and provided insights to physicians upon consultation. In the post-implementation phase, clinical pharmacists could also track physicians' prescribing practices when recommendations were not followed. However, only antibiotic prescriptions prior to pharmacist intervention were collected.

2.3. Development of a clinical decision support system.

Clinical pharmacists specializing in nephrology developed dosage adjustment recommendations for antibiotics by synthesizing information from the "Summary of Product Characteristics" (SmPC) of the medicines, along with the drug information in the Compendium about Drugs Licensed for Use in the United Kingdom (the Electronic Medicines Compendium) and the Compendium about Drugs Licensed for Use in the United States (the DailyMed). In cases where precise renal impairment dosage guidance was lacking in the SmPC, the pharmacists referred to established pharmacotherapy reference books[22,23]. Discrepancies between these references prompted the convening of a multidisciplinary team consisting of clinical pharmacists, pharmacy lecturers, infectious disease specialists, critical care doctors, and nephrologists to establish a drug compendium. Medications not reaching an agreement within this team were excluded. The final consensus was integrated into the CDSS within the CPOE system.

The CDSS operated by: (1) automatically comparing prescriptions with dosage adjustment recommendations, considering the patient's most recent available CG eGFR value, and (2) displaying a pop-up window if the patient's CG eGFR was below the threshold necessitating antibiotic dosage adjustment when the physician first prescribed antibiotics or when the patient's CG eGFR changed (Figure 1). This pop-up window reminded healthcare providers of the patient's kidney function and the appropriate drug dosage for that level of clearance. The physician can accept or disregard this reminder and provide justification if disregard (optional).

2.4. Outcome measures.

Each prescription was independently analyzed by clinical pharmacists and categorized as appropriate, inappropriate, or undefined. A prescription was considered appropriate if the dose and interval adhered to the recommendations. It was considered inappropriate if it involved an overdose or an incorrect interval. If additional information, such as the indication for multidrug-resistant organisms (MDROs),was needed for assessment the prescription

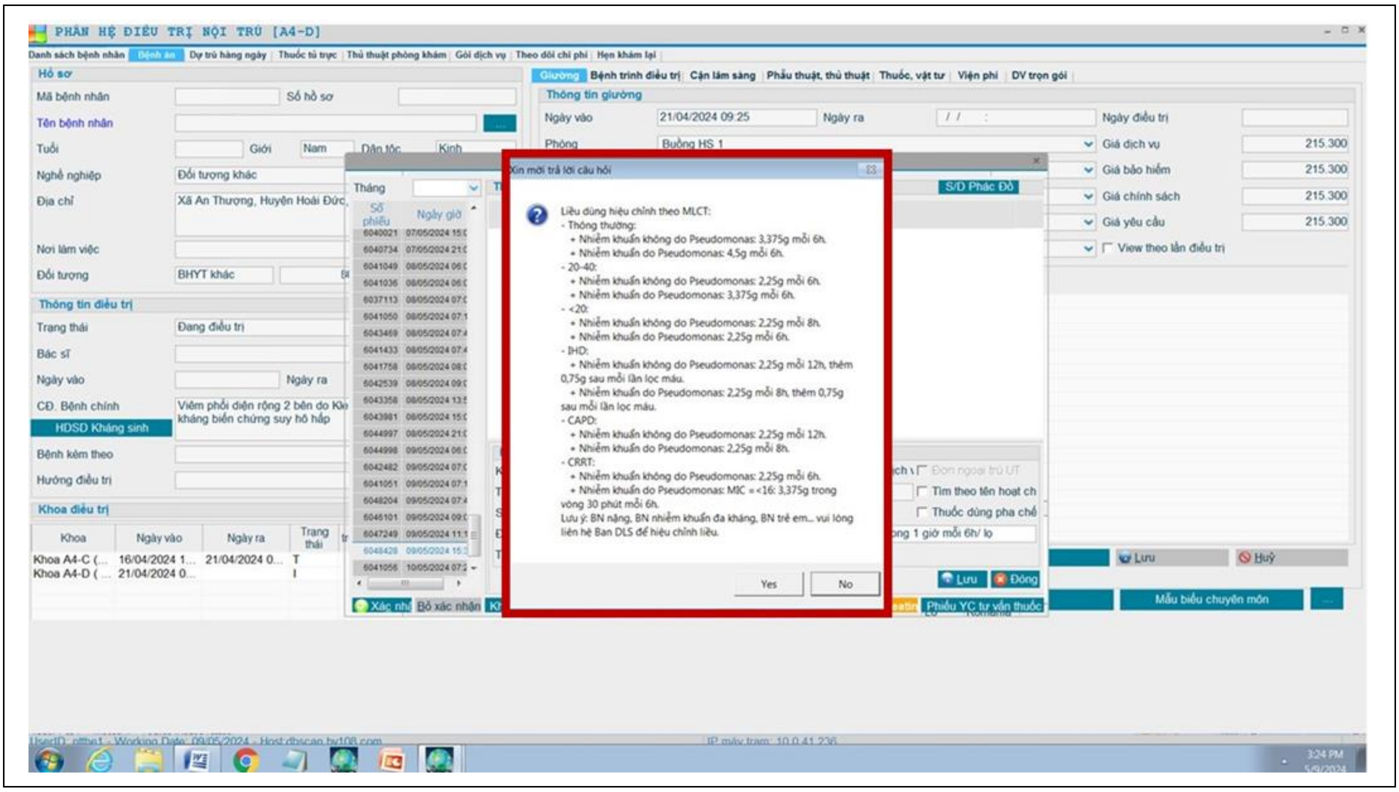

Figure 1. Pop-up window on the doctor's screen showing a dosage adjustment recommendation for an antibiotic from the CDSS. This pop-up window displays recommendations when a physician prescribes piperacillin/tazobactam, indicating a need for dosage adjustment for an actual patient. The box outlined in red shows the dosage recommendation provided by the CDSS. Physicians can either select "Yes" or "No" to indicate their agreement with this recommendation. All patient information has been anonymized to ensure privacy.

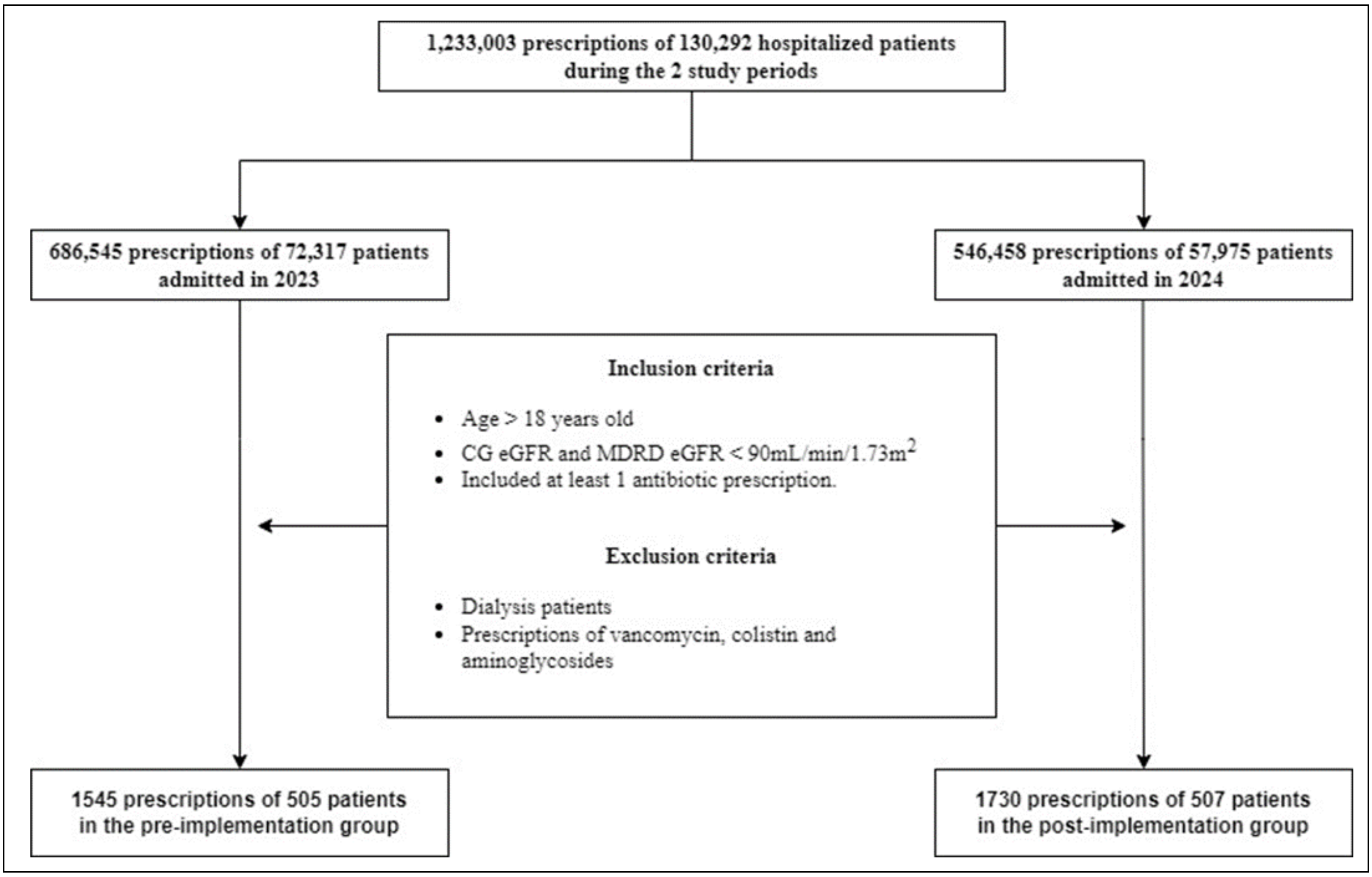

Figure 2. Selection of study participants.

was categorized as undefined. Furthermore, antibiotics with unique hospital usage guidelines, including vancomycin, colistin, and aminoglycosides, were excluded from this evaluation. The primary endpoint was the proportion of inappropriate antibiotic prescriptions before and after the implementation of the CDSS. Additionally, inappropriate prescriptions were analyzed in various subgroups such as departments, ranges of eGFR values, and individual antibiotics.

2.5. Statistics analysis.

Categorical data was presented as median numbers with interval quartile range (IQR) while continuous variables were revealed as mean numbers with standard deviation (SD). The student's t-test was employed to compare normally distributed continuous variables between two groups, while the Mann–Whitney Wilcoxon test was used for non-normally distributed continuous variables. The Pearson's Chi-squared test was utilized for categorical comparisons. The odds ratio (OR) of inappropriate prescriptions before and after the CDSS implementation and 95% confidence intervals (95% CI) were computed. A p-value of less than 0.05 was considered statistically significant. All analyses were performed using R for Windows® version 2.6.2.

3. RESULTS.

3.1. Selection of study participants.

In 2023, there were 686,545 prescriptions for 72,317 patients, while in 2024, there were 546,458 prescriptions for 57,975 patients. Following this, 71,812 patients were excluded in 2023, while 57,468 patients were excluded in 2024, as illustrated in Figure 1. Prescription data underwent analysis, encompassing 1545 prescriptions from 505 patients in the pre-implementation group and 1730 prescriptions from 507 patients in the post-implementation group (Figure 2).

3.2. Patient's characteristics.

Table 1 demonstrates the characteristics of patients in two study periods. Within the total population, 71.3% were male, with a mean (SD) age of 69.1 (15.5) years, and 65.2% were over 65. Among patients requiring dosage-adjusted antibiotics, 54.8% had eGFR ranging from 60 to 90 mL/min/m^2 during the study period. These demographic characteristics did not exhibit significant differences between the two groups. The median antibiotic usage per patient was 1 (1-2), while the median (IQR) of morbidities was 2 (1-4). There were no statistically significant disparities observed in the use of cephalosporins (p=0.9), which remained the most prevalent antibiotic class between the two time periods, followed by fluoroquinolones and carbapenems. However, there were notable differences in the distribution of nitroimidazoles and sulfonamides between two years (p<0.0001). 24.5% of the total population in 2023 and 13% in 2024 were diagnosed with rheumatic heart diseases, while non-insulin-dependent diabetes mellitus accounted for 13% and 24.5% in 2023 and 2024, respectively. The only disparity in disease patterns was observed among transplant recipients, with a prevalence of 6.9% in 2023, which decreased to 0.2% in 2024 (<0.0001). Location of care of patients requiring dosage-adjusted antibiotics was largely in the internal medicine department, followed by the surgical and intensive care units.

Table 1. Demographic Data of Patients Prescribed Antibiotics Requiring Dosage Adjustment.

Characteristics	Total population (N = 1012)	Pre-implementation group (N = 505)	Post-implementation group (N = 507)	p-value
Male, n (%)	722 (71.3%)	368 (72.9%)	354 (69.8%)	0.3159
Age, mean (SD), in years	69.06 (15.48)	68.64 (15.79)	69.48 (15.50)	0.4581**
< 65	352 (34.8%)	192 (38.0%)	160 (31.6%)	0.0881
≥ 65	660 (65.2%)	313 (62.0%)	347 (68.4%)	0.1857
Weight, mean (SD), in kg	57.13 (11.12)	56.96 (10.13)	57.29 (11.14)	0.8256
CG eGFR, n (%), in mL/min/1.73 m^2				
60–90	555 (54.8%)	278 (55.0%)	277 (54.6%)	0.9661
30–60	314 (31.0%)	156 (30.9%)	158 (31.2%)	0.9101
15–30	97 (9.6%)	51 (10.1%)	46 (9.1%)	0.6117
<15	46 (4.5%)	20 (4.0%)	26 (5.1%)	0.3763
Number of antibiotics per patient, median (IQR)	1 (1-2)	1 (1-2)	1 (1-2)	0.0505**
One antibiotic	655 (64.7%)	342 (67.7%)	313 (61.7%)	0.3831
Two antibiotics	289 (28.6%)	132 (26.1%)	157 (31.0%)	0.2298
More than two antibiotics	68 (6.7%)	31 (6.1%)	37 (7.3%)	0.5732
Antibiotic Class*, n (%)				
Carbapenems	248 (24.5%)	115 (22.8%)	133 (26.2%)	0.2530
Cephalosporins	532 (52.6%)	267 (52.9%)	265 (52.3%)	0.9309
Fluoroquinolones	418 (41.3%)	203 (40.2%)	215 (42.4%)	0.5572
Nitroimidazoles	74 (7.3%)	13 (2.6%)	61 (12.0%)	<0.0001
Penicillins	77 (7.6%)	41 (8.1%)	36 (7.1%)	0.5688
Fosfomycin	7 (0.7%)	0 (0.0%)	7 (1.4%)	0.0082
Tetracyclines	2 (0.2%)	0 (0.0%)	2 (0.4%)	0.1573
Sulfonamides	54 (5.3%)	53 (10.5%)	1 (0.2%)	<0.0001
Number of diseases per patient, median (IQR)	2 (1-4)	2 (1-4)	2 (1-4)	0.0593**
Disease on admission*, n (%)				
Rheumatic heart diseases	248 (24.5%)	126 (25.0%)	122 (23.9%)	0.7995
Non-insulin-dependent diabetes mellitus	132 (13.0%)	70 (13.9%)	62 (12.1%)	0.4862
Gastritis and duodenitis	55 (5.4%)	38 (7.5%)	17 (3.3%)	0.0046
Heart failure	80 (7.9%)	37 (7.3%)	43 (8.4%)	0.5023
Kidney transplant status	37 (3.7%)	35 (6.9%)	2 (0.4%)	<0.0001
Secondary hypertension	55 (5.4%)	33 (6.5%)	22 (4.3%)	0.1380
Bacterial pneumonia	54 (5.3%)	33 (6.5%)	21 (4.1%)	0.1025
Chronic renal failure	44 (4.3%)	27 (5.3%)	17 (3.3%)	0.1317
Acute renal failure	50 (4.9%)	26 (5.1%)	24 (4.7%)	0.7773
Septic shock	57 (5.6%)	26 (5.1%)	31 (6.1%)	0.5078
Location of Care				
Internal medicine	606 (59.9%)	309 (61.2%)	297 (58.6%)	0.6259
Surgical unit	241 (23.8%)	130 (25.7%)	111 (21.9%)	0.2210
Outpatient department	40 (4.0%)	9 (1.8%)	31 (6.1%)	0.0005
Intensive care unit	125 (12.4%)	57 (11.3%)	68 (13.4%)	0.3252

Abbreviation: CG eGFR: estimated glomerular filtration rate calculated by Cockcroft-Gault equation.
* Patients may receive multiple antibiotics or have multiple diseases.
** Statistical analysis performed using Wilcoxon’s test.

3.3. Performance of the CDSS on antibiotic dosage prescriptions.

Table 2 displays the prevalence of inappropriate antibiotic prescriptions between two periods. In the pre- and post-implementation groups, there were 1545 and 1730 prescriptions respectively. Following the implementation of the CDSS, the proportion of inappropriate antibiotic dosage adjustments decreased by around 40% (OR: 0.61; 95%CI: 0.52-0.72). The reduction rate of inappropriate prescriptions in patients who had CG eGFR below 60mL/min/1.73 m^2 was statistically significant. While the percentage of inappropriate dosage declined after the CDSS implementation at the internal medicine wards ($p<0.001$) and intensive care unit ($p=0.003$), the opposite was true for the surgical unit and outpatient department. Regarding individual antibiotics, the number of inappropriate dosage prescriptions significantly decreased by at least 3-fold for amoxicillin + acid clavulanic, cefoperazone + sulbactam, levofloxacin, and meropenem after the CDSS implementation. Meanwhile, there were no statistical differences observed for cefpirome, ciprofloxacin, doripenem, ertapenem, metronidazole, and piperacillin + tazobactam. In contrast, there was a rise in the inappropriateness of antibiotic dosage for cefamandole, cefoxitin, cefprozil, and imipenem/cilastatin, with the latter exhibiting a statistical increase in the post-implementation period

Table 2. Prevalence of Inappropriate Antibiotic Dosage Before and After CDSS Implementation

	Pre-implementation group			Post-implementation group			Odds Ratio (95% Confidence Interval)	P-value
	N*	IP	Rate(%)	N*	IP	Rate(%)		
Total population	1545	436	28.2	1730	336	19.4	0.61 (0.52-0.72)	<0.001
CG eGFR, n (%), in mL/min/1.73 m^2								
60–90	614	74	12.1	727	85	11.7	0.97 (0.69-1.35)	0.839
30–60	590	216	36.6	523	124	23.7	0.54 (0.41-0.70)	<0.001
15–30	223	83	37.2	301	77	25.6	0.58 (0.40-0.84)	0.004
<15	118	63	53.4	179	49	27.4	0.33 (0.20-0.54)	<0.001
Location of Care								
Internal medicine	1001	288	28.8	976	151	15.5	0.45 (0.36-0.57)	<0.001
Surgical unit	294	72	24.5	316	96	30.4	1.35 (0.94-1.92)	0.104
Intensive care unit	236	71	30.1	389	77	19.8	0.57 (0.39-0.83)	0.003
Outpatient department	14	5	35.7	49	11	22.4	0.52 (0.14-1.88)	0.511
Antibiotic								
Amoxicillin/ Acid clavulanic	50	21	42.0	34	6	17.6	0.30 (0.10-0.84)	0.019
Cefamandole	6	0	0.0	10	6	60.0	-	-
Cefditoren	0	0	-	2	1	50.0	-	-
Cefoperazone/ Sulbactam	299	42	14.0	259	1	0.4	0.02 (0.00-0.17)	< 0.001
Cefotiam	51	0	0.0	60	0	0.0	-	-
Cefoxitin	119	5	4.2	97	9	9.3	2.33 (0.75-7.20)	0.132
Cefpirome	33	25	75.8	74	45	60.8	0.50 (0.20-1.25)	0.133
Cefprozil	2	0	0.0	7	1	14.3	-	-
Ciprofloxacin	20	8	40.0	25	6	24.0	0.47 (0.13-1.71)	0.249
Ciprofloxacin (IV)	53	8	15.1	93	13	14.0	0.91 (0.35-2.37)	0.853
Doripenem	71	39	54.9	61	32	52.5	0.91 (0.46-1.80)	0.777
Ertapenem	41	10	24.4	73	12	16.4	0.61 (0.24-1.57)	0.302
Fosfomycin	0	0	-	7	0	0.0	-	-
Imipenem/cilastatin	42	1	2.4	4	2	50.0	41.00 (2.52-666.63)	0.009
Levofloxacin	333	158	47.4	309	52	16.8	0.22 (0.16-0.32)	<0.001
Meropenem	264	78	29.5	410	43	10.5	0.28 (0.19-0.42)	<0.001
Metronidazole	25	15	60.0	106	50	47.2	0.60 (0.25-1.44)	0.248
Ofloxacin	0	0	-	42	21	50.0	-	-
Piperacillin/ Tazobactam	37	26	70.3	54	34	63.0	0.72 (0.29-1.76)	0.470
Sulfamethoxazole/ Trimethoprim	99	0	0.0	1	0	0.0	-	-
Tetracycline hydrochloride	0	0	-	2	1	50.0	-	-

* Number of antibiotic prescriptions
Abbreviation: IP, inappropriate prescriptions; IV, intravenous administration; CG eGFR: estimated glomerular filtration rate calculated by Cockcroft-Gault equation

4. DISCUSSION

The prevalence of inappropriate prescriptions decreased after the implementation of CDSS (OR: 0.61; 95%CI: 0.52-0.72). This result was similar to previous studies, in which a CDSS shows the effectiveness in preventing inappropriate prescriptions in these vulnerable populations[24-27]. However, Desmedt et al. showed that their CDSSs do not reduce inappropriate prescriptions in clinical settings[26]. This can be due to the differences between the development process of recommendations. In Desmedt's study, two clinical pharmacists established and decided the included information, even if there were conflicts among the reference sources. Our study, however, employed a multidisciplinary group including clinical pharmacists, physicians, and experts to reach a consensus on the developed drug compendium. This approach could present multifaceted perspectives on the appropriateness of recommendations, which can lead to a higher acceptance rate of alerts.

In our study, departments were categorized into four blocks, including internal medicine, surgical unit, intensive care unit, and outpatient department. Surprisingly, the inappropriateness of antibiotic prescribing increased in the surgical units (OR: 1.35; 95% CI: 0.94-1.92), while the opposite was true for the internal medicine department (OR: 0.45; 95% CI: 0.36-0.57) and the intensive care unit (OR: 0.57; 95% CI: 0.39-0.83). Although there was an increase in the rate of inappropriate antibiotic use in the surgical unit, this trend was not statistically significant and could be due to random variation. Having said that, there are several factors can explain the absence of appropriate prescriptions in the surgical units. Firstly, the number of bedside clinical pharmacists in these units was modest, whereas there was a higher number in other blocks in our hospital. A previous study showed that the intervention of clinical pharmacists with CDSS has more benefits compared to CDSS alone[27]. Secondly, patients in the surgical unit might experience significant variations in creatinine concentration. This phenomenon is also observed in another study[28], where it is noted that high or low eGFR values do not solely indicate the deterioration of kidney function. However, no studies have been conducted in our research setting to investigate this variation in the surgical unit. Therefore, we hypothesize that this trend is present in our research setting, and future studies should focus on this issue. Moreover, patients admitted to these units in our setting were not frequently tested for creatinine levels, usually once at hospital admission. Hence, this sole result, which is automatically utilized by the CDSS to provide information on antibiotics' dosage, may not reflect the actual renal function at the time of prescription.

Throughout both study periods, piperacillin/tazobactam emerged as the most commonly prescribed antibiotic without appropriate dosage adjustments. This observation corroborates findings from previous research[10, 12]. A recent study conducted in Lebanon highlighted similar trends, indicating that piperacillin/tazobactam is frequently administered at doses of 3.375 g every 6 hours or 4.5 g every 6-8 hours, rather than the recommended 2.25 g every 6 or 8 hours based on patients' CG eGFR and infection type, which mirrors our findings[12]. However, some population pharmacokinetic studies of piperacillin/tazobactam suggest other dosage regimens based on minimum inhibitory concentration (MIC) values, such as infusions of 4 g every 8 hours for patients with creatinine clearance ≥120 mL/min for organisms with higher MICs [29]. In our study, antibiotics with unique hospital guidelines, such as vancomycin, colistin, and aminoglycosides, were excluded. However, piperacillin/tazobactam has been used following the traditional dosage regimen from the SmPCs. Therefore, this research represents the current use of this antibiotic and provides insight for administrators to develop guidelines based on population pharmacokinetics studies rather than SmPCs. Surprisingly, the use of imipenem/cilastin significantly increased after the implementation of the CDSS, rising from 2.4% (1/42) to 50% (2/4). However, this increase can be attributed to a shortage in the supply of this antibiotic in 2024, resulting in limited usage during that period.

The strength of our study lies in the successful implementation of a CDSS in a large tertiary setting. Handling over 500,000 prescriptions per month, this CDSS can automatically compare prescriptions with the current eGFR values of patients. Consequently, it provides eGFR values calculated using different methods to improve the convenience of physicians' workloads. This system can be further refined to enable more personalized interventions. Another advantage of this study is the development of a drug compendium, formulated through consensus among a multidisciplinary team comprising clinical pharmacists, nephrologists, infectious disease specialists, and clinical pharmacy experts. This collaborative approach enhances the clinical significance of our recommendations and fosters wider acceptance among medical practitioners

However, our research also presents certain limitations. Firstly, our recommendations solely assess the appropriateness of antibiotic dosage by the eGFR value, overlooking the importance of considering therapeutic indications, particularly in critically ill patients or in MDROs infections. Future research should aim to incorporate these therapeutic indications into our recommendations to optimize personalized care. Secondly, inadequate monitoring of creatinine levels in some patients may result in errors in antibiotic prescribing. This issue arises because our CDSS relies on the latest creatinine test results to assess prescriptions, and our study only evaluates medication appropriateness based on available creatinine values. Consequently, there may be instances of under-identification of inappropriate dosages during our study periods. Lastly, we did not assess doctors' perspectives on our recommendations. Therefore, future research should incorporate a co-design study approach to solicit feedback from healthcare providers and enhance the efficacy of the CDSS.

5. CONCLUSION

This study demonstrates the initial success of implementing a CDSS for antibiotic dosage prescriptions. Future research endeavors should focus on pharmacist interventions and integrate antibiotic indications into these recommendations to achieve optimal and personalized care indications into these recommendations to achieve optimal and personalized care.

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Conflict of interest
The authors declare that they have no conflict of interest

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Ethics approval
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