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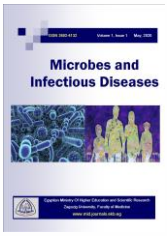

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Review article

Comprehensive review of antibiotic prescription practices, overuse, misuse, and resistance trends in Al Muthanna, Iraq

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ABSTRACT

Background: Antibiotic resistance is a global health concern exacerbated by the overuse and misuse of antibiotics. This retrospective study aims to investigate the clinical trends of antibiotic use and its overuse and misuse rates in two hospitals and community pharmacies in Al Muthanna, Iraq, with a focus on adherence to WHO guidelines. **Methods**: Medical records from two main hospitals in Al Muthanna, Iraq, were obtained from the Health Information System in 2023-2024. Additionally, data on antibiotic sales without prescriptions were collected from community pharmacies. Classification of antibiotic use was performed based on WHO guidelines. **Results**: A total of 5700 antibiotic prescriptions were retrieved from hospitals, and an additional 2,000 antibiotic sales without prescriptions were recorded from pharmacies. Uncomplicated respiratory infections were the most prevalent condition, representing 60% of all hospital prescriptions. The primary group of antibiotics used was Penicillins penicillin (50%), followed by cephalosporins (20%) and macrolides (15%). Of 4,000 patient visits in hospitals, appropriate use accounted for 20% of all antibiotic prescriptions. While combined use, escalated use of extended-spectrum antibiotics, incorrect spectrum, and unnecessary antibiotic use were prevalent. In community pharmacies, 90% of antibiotics were sold without a prescription, with penicillins and cephalosporins being the most commonly dispensed. Antibiotic misuse was much more common among newly employed physicians with lower levels of professional education. Adult patients had a higher risk of being prescribed unnecessary antibiotics. **Conclusion**: Adherence to WHO guidelines for antibiotic prescribing and dispensing needs urgent attention to mitigate the growing threat of antibiotic resistance.

Introduction

Antibiotics have been utilized to treat and prevent infections caused by bacteria. The second part of the nineteenth century showed a notable increase in life expectancy, which was mostly attributed to antibiotics [1]. Antibiotics either cytotoxically or cytostatically destroy microorganisms, enabling the body's defense mechanisms, including the body's defenses, to eradicate them. Low molecular weight compounds, the majority of which are produced by microbes or derived from natural goods, exhibit small amounts of activity against other microorganisms. However, certain antibiotics, such as sulfa medicines and oxazolidinones, are not derived from natural products [2]. They serve by preventing the formation of proteins, deoxyribonucleic acids (DNA), ribonucleic acid (RNA), bacterial cells wall, and other particular processes [3]. However, improper access to antibiotics can reduce their effectiveness and cause bacterial resistance to antibiotics, which has become one of the greatest risks to human survival and is projected to have

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killed up to 7.7 million people globally in 2019 [4,5]. Antibiotic resistance has become a serious threat to global health. The World Health Organization (WHO) has placed antibiotic resistance as one of the top ten threats to human health, and by 2050, deaths could exceed ten million annually if the world does not take precautionary measures against antibiotic resistance [6]. One of the biggest issues facing global health today is antibiotic resistance. Antibiotic resistance mechanisms frequently arise as a result of misuse of antibiotics in agriculture and medicine. Overuse of broad-spectrum antibiotics, inappropriate prescription of antibiotics, and self-medication are among the reasons that have led to the rise of antibiotic resistance, endangering contemporary medicine by reducing the effectiveness of clinically relevant medications. Antimicrobial resistance (AMR) has led to higher healthcare expenses, treatment failure-related morbidity, and mortality [7, 8, 9]. Resistance to antibiotics and adverse effects can rise with inappropriate antibiotic use. A prior study found that about one-third of the antibiotic prescriptions in an outpatient setting are unnecessary and that the choice of antibiotics and length of therapy are frequently unsuitable. Research indicates that a number of psychosocial factors, including habit, perceived patient expectations, lack of accountability, and clinician busyness, have an impact on the prescription of antibiotics [10]. Decades of advancements in medical outcomes are under risk due to the rising threat of antimicrobial resistance (AMR) across the world. It threatens the practice of veterinary and human medicine today and compromises food safety [11]. Bacteria can resist antibiotics by several mechanisms, including mutation, biofilm formation, alteration of antibiotic target sites, and inactivation of antibiotics by enzymes and efflux pumps [12]. Infections of the urinary and respiratory systems accounted for most of the antibiotic prescriptions written in primary care. Unfortunately, there was no documented therapeutic reason for nearly one-third of all prescriptions. Significant differences were seen in the rates of antibiotic prescriptions between practices, indicating a possibility for minimum practices to reduce prescribing [13]. Previous research in Al-Muthanaa, Iraq, confirmed an alarming increase in antibiotic resistance [14, 15, 16]. Molecular analysis is one method used to investigate the existence of an antibiotic resistance gene [12]. The exceptional genetic flexibility of bacteria enables them to adapt to a variety of environmental stresses, including the presence of antibiotics [17]. Humans use antimicrobial substances extensively and often without thought, which leads to the emergence of resistance. However, there are still several confusing aspects of this situation [18]. Antibiotic resistance can be significantly reduced by the appropriate use of antibiotics, immunization, education, research, creation of novel antibiotics, policy, legislation, monitoring of antimicrobial resistance, and antibiotic use [19]. An international health emergency brought on by improper antibiotic usage is the growth of antimicrobial resistance (AMR). The purpose of this study is to assess prescribing procedures in Al Muthanna, Iraqi hospitals and pharmacies, with an emphasis on following WHO recommendations and determining the causes of abuse and overuse.

Methods

Study design and data sources

We conducted a retrospective observational study of antibiotic prescriptions from two government hospitals and sales records from community pharmacies in Al-Muthanna, Iraq. Hospital data were obtained from the regional Health Information System for the period January 2023 through December 2024. Pharmacy sales data (prescription status, antibiotic class) were collected concurrently from local community pharmacies.

Population

All patient encounters in the hospitals that resulted in an antibiotic prescription were included, encompassing all ages and both sexes. In total, 5,700 prescriptions (from 4,000 patient visits) were analyzed. Pharmacy data included 600 sales of systemic antibiotics during the same period.

Classification of appropriateness of antibiotic use

The present study focused on antibiotic prescriptions provided by government hospitals and sales from local pharmacies for various infectious diseases. Antibiotic prescriptions were classified into appropriate antibiotic use, inappropriate use, escalating use of extended-range antibiotics, and unnecessary use and incorrect spectrum of antibiotic uses following the WHO guidelines, Aantibiotics are divided into three categories under the categorization system: Access (critical first-line antibiotics with limited resistance potential), Watch (greater resistance risk needing demanding monitoring), and Reserve (last-resort medicines for

multidrug-resistant illnesses) [6]. These prescriptions included all patients of different age groups and both sexes.

Data analysis

Data were summarized as frequencies and percentages (nNo., %). Comparisons of antibiotic use patterns across categories were descriptive. The identification of factors that associated with inappropriate antibiotic prescribing, we performed multivariate logistic regression. Physician related factors (sex, age group, level of education, years of practice, and title) were entered as independent variables and inappropriate prescribing as the outcome. Odds ratios (ORs) and 95% CIs were calculated. $p<0.05$ was considered statistically significant. The analyses were performed with common (general) statistical software (e.g., SPSS or R).

Physician characteristics (sex, age group, education level, years of experience, and professional title) were entered as independent variables, with inappropriate prescribing (yes/no) as the outcome. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were estimated. Statistical significance was defined as $p<0.05$. Analyses were conducted using standard statistical software (e.g., GraphPad Prism v. 8.0.2 SPSS or R).

Results

A total of 5700 antibiotic prescriptions belonging to 4000 patients who visited the hospitals in Al-Muthnna were obtained from the computerized database during the study period. Table 1 compare the amount of antibiotics administered for different prevalent conditions, categorized as appropriate use, inappropriate use, escalated use of extended spectrum, incorrect spectrum, and unnecessary use of antibiotics. 52.6% of all prescriptions for antibiotics were for respiratory system infections Of all prescriptions 52.6% of antibiotics were for respiratory system infections, digestive tract infections were 14%, and genitourinary system infections were 10.5%, and 22% for the rest of the infections during the study period. Infections pertaining to the musculoskeletal system were the highest account (25%) of all appropriate hospital prescriptions, followed by skin and subcutaneous tissue infections (23.3%) and eye and adnexa (20%), while they were less in other conditions recorded in this study. Inappropriate use of antibiotics was found in 7.9% of total prescriptions. The highest percentage of inappropriate usage was found in urethritis and urethral syndrome (40%), then in acute appendicitis, and less in eye and adnexa diseases (0%). Escalated usage of extended-spectrum antibiotics was widespread in patients with urethritis and urethral syndrome (40%), followed by acute appendicitis and acute sinusitis (30% and 20%, respectively). An The incorrect spectrum was common in patients with injury, poisoning, and other external causes (80%) and respiratory system diseases (65%). While unnecessary use of antibiotics was 14.5% of all antibiotic prescriptions.

On the other hand, Table table 2 show that the most commonly sold antibiotics in Al-Muthanna pharmacies were broad-spectrum antibiotics such as fluoroquinolones (95%), macrolides (90%), cephalosporins (85%), and penicillins (80%).

Table 3 illustrates factors related to inappropriate antibiotic use based on multivariate analysis. Among physicians, being male, aged 32-38, having a lower level of education, working for 21-30 years, and holding the position of associate chief physician were linked to a higher likelihood of inappropriate antibiotic use.

According to the WHO AWaRe classification, 80.8% of hospital antibiotic prescriptions were in the Watch or Reserve category, indicating a serious pattern of overuse and inappropriate escalation. Furthermore, a significant percentage of community antibiotic sales contained Watch-category medicines without a prescription, showing weak regulatory compliance.

Table 1. Antibiotic Prescription Patterns in Hospitals.

Diagnosis	**Total**	**Appropriate use, n (%)**	**Inappropriate use, n (%)**	**Escalated use of extended spectrum**	**Incorrect spectrum**	**Unnecessary use**
1.Respiratory System Diseases	3,000	600 (20%)	50 (1.7%)	400 (13.3%)	1950 (65%)	300 (10%)
Upper respiratory tract infection	1,200	200 (16.7%)	0 (0%)	100 (8.3%)	900 (75%)	
Acute tonsillitis	500	200 (40%)	0 (0%)	100 (20%)	200 (40%)	
Acute pharyngitis	300	150 (50%)	0 (0%)	0 (0%)	150 (50%)	
Acute sinusitis	200	50 (25%)	50 (25%)	50 (25%)	50 (25%)	
Others	800	0 (0%)	0 (0%)	150 (18.8%)	650 (81.2%)	
2.Digestive System Diseases	800	120 (15%)	160 (20%)	160 (20%)	360(45%)	100 (12.5%)
Gastritis and duodenitis	300	30 (10%)	60 (20%)	60 (20%)	150 (50%)	
Cholecystitis	200	60 (30%)	40 (20%)	40 (20%)	60 (30%)	
Acute appendicitis	100	20 (20%)	30 (30%)	30 (30%)	20 (20%)	
Other non-infective gastroenteritis and colitis	200	10 (5%)	30 (15%)	30 (15%)	130 (65%)	
3. Genitourinary System Diseases	600	110 (18.3%)	180 (30%)	120 (20%)	190 (31.6%)	180 (30%)
Cystitis	200	100 (50%)	50 (25%)	20 (10%)	30 (15%)	
Urethritis and urethral syndrome	200	0 (0%)	80 (40%)	80 (40%)	40 (20%)	
Others	200	10 (5%)	50 (25%)	20 (10%)	120 (60%)	
4. Musculoskeletal System Diseases	400	100 (25%)	40 (10%)	60 (15%)	200 (50%)	100 (25%)
Other arthritis	200	80 (40%)	20 (10%)	40 (20%)	60 (30%)	
Others	200	20 (10%)	20 (10%)	20 (10%)	140 (70%)	
5. Injury, poisoning and other external causes	300	40 (13.3%)	0 (0%)	20 (6.7%)	240 (80%)	40 (13.3%)
6. Eye and adnexa Diseases	300	60 (20%)	0 (0%)	60 (20%)	180 (60%)	60 (20%)
7. Skin and subcutaneous tissue Diseases	300	70 (23.3%)	20 (6.7%)	30 (10%)	180 (60%)	50 (16.7%)
Total	5,700	1100(19.2%)	450 (7.9%)	850 (15%)	3300 (57.9%)	830 (14.5%)

Table 2. Antibiotic Sales in Community Pharmacies.

Antibiotic Class	Prescription Required	Number of Sales	Percentage of Sales without Prescription
Penicillins	Yes	200	80%
Cephalosporins	Yes	150	85%
Macrolides	Yes	100	90%
Fluoroquinolones	Yes	50	95%
Others	Yes	100	70%
Total		600	90%

Table 3. Factors Predicting Inappropriate Use of Antibiotics on Multivariate Analysis

Characteristic	Adjusted OR (95% CI)	P value
Physicians		
Sex: ref = Female		
Male	1.65 (1.54, 1.78)	< 0.001
Age: ref = 25–31 years (years)		
32–38	0.58 (0.53, 0.64)	< 0.001
39–75	0.30 (0.27, 0.35)	< 0.001
Education: ref = College		
Junior college	1.30 (1.21, 1.39)	< 0.001
Technical secondary school		
Work duration: ref = ≤ 5 (years)		
6–10	1.36 (1.25, 1.48)	< 0.001
11–20	3.14 (2.78, 3.54)	< 0.001
21–30	3.80 (3.20, 4.53)	< 0.001
> 31	1.54 (1.29, 1.83)	< 0.001
Professional title: ref = Resident physician		
Attending physician	0.97 (0.87, 1.08)	0.60
Associate chief physician	1.99 (1.62, 2.43)	< 0.001

Discussion

Despite Iraqi laws requiring that anyone working in a pharmacy must have an academic degree in pharmacy and that their assistants should hold a degree from a medical college, in practice, pharmacists are often absent. In many cases, antibiotics are sold directly by assistants without the supervision of a qualified pharmacist, therefore, this is one of the reasons that increases antibiotic resistance. Globally, the issue of bacterial resistance became more serious, and every year, more people die due to antibiotic resistance [20]. Overuse of antibiotics causes antibiotic resistance, which raises the risk of prolonged hospital stays, severe infections, complications, and mortality [21, 22]. This study identified five categories of antibiotic usage: the appropriate use of antibiotics, the inappropriate use, and escalated use of extended spectrum antibiotics, incorrect spectrum, and the unnecessary use of antibiotics. Approximately fifty percent of all prescriptions for antibiotics were for respiratory system infections, digestive tract infections were 14% and genitourinary system infections were 10.5%. In primary care, infections of the respiratory tract are the most frequent cause for prescribing antibiotics; however, antibiotics are not always necessary for treating these illnesses, because viruses are the major cause of respiratory tract infections, and the use of antibiotics in this case is not effective in fighting viruses [23, 24], therefore, the excess use of antibiotics increases antibiotic resistance [25].

This study reveals a modest rate of appropriate usage of antibiotics (19.2%). A study by [26] conducted on inpatients found that 56.5% of antibiotics were used appropriately, and ceftriaxone, one of the cephalosporin antibiotics, was the most effective. In this study, inappropriate use of antibiotics was noticed in 7.9% of full prescriptions; musculoskeletal system infections were the highest, accounting for 25% of all hospital prescriptions. Inappropriate antibiotic access procedures can also have unfavorable outcomes, such as side effects, toxicities, and increased risks of antibiotic resistance [27]. Unnecessary consumption of antibiotics may be attributed to fears of unknown or high-risk infections [28, 29, and 30]. Also, it was estimated that 44% of antibiotic prescriptions in Al-Muthanna were given incorrectly. Table 3 emphasized that junior clinicians (e.g., those with lower education levels, OR 1.30) and long-tenured staff (21–30 years of experience, OR 3.80) are significantly associated with inappropriate antibiotic use. These finding indicates that inappropriate prescribing is not limited to inexperience but may also stem from outdated practices or clinical inertia among more experienced clinicians.

Antibiotics are essential medications in clinical practice; nevertheless, evidence indicates that these medications are not always prescribed correctly. In our data, incorrect Spectrum accounted for 57.9% of all antibiotic prescriptions, making it the most prevalent category of misuse identified in the study. This pattern is particularly concerning due to incorrect prescribing of antibiotics means that the

selected antibiotic does not effectively target the causative pathogen which could leads to significant clinical consequences. This includes treatment failures, prolonged illness, higher risk of complications, and the need for secondary treatments, all of which may contribute to higher healthcare costs and negative results. Moreover, incorrect empiric therapy, particularly in high-prevalence cases such as respiratory infections (65% of incorrect spectrum), affects the efficacy of early treatment protocols and promotes the emergence and selection of resistant bacterial strains. This emphasizes the urgent need for improved adherence to clinical guidelines and local antibiograms when selecting empiric antibiotics The expense of treatment and the health of the patient are negatively impacted by the improper use of antibiotics [31]. Through these wrong strategies, bacteria resist antibiotics using mechanisms that contribute to resistance. In previous molecular studies during the years 2020-2025, a significant increase in the antibiotic resistance was observed in Al-Muthanna Governorate. Alabdali et al., 2024 [14] detected a mutation in the gyrA gene that causes resistance to ciprofloxacin, prompting them to offer ciprofloxacin derivatives as therapeutic alternatives. ZnO nanoparticles have also been tested as therapeutic alternatives to antibiotics for combating resistant bacteria [14, 32]. Another study reported mutations in the toxA gene of P. aeruginosa, although toxA is a virulence gene, it was found that these mutations have been associated with antibiotic resistance of P. aeruginosa that was detected in Al-Muthanna Governorate [33]. Also, recent studies suggested that the presence of mobile genetic elements such as integrons in P. aeruginosa and A. baumannii played a very important role in the spread of antibiotic resistance in Al-Muthanna Governorate [34, 35]. Moreover, high rates of antibiotic resistance have recently been detected in Gram-positive bacteria Enterococcus spp., isolated from hospitals in Al-Muthanna Governorate, and their resistance has been linked to mutations in resistance genes such as blaTEM, vanA, and vanB. Besides mutant genes, biofilm formation has been reported to play a major role in increasing the antibiotic resistance of Enterococcus spp. [36]. However, despite the presence of these resistance mechanisms developed by bacteria, the presence of the bacterial immune system CRISPR has been found to reduce the rate of resistance [15]. Finally, we believed that inappropriate and incorrect usage of antibiotics has contributed to the prevalence of resistant bacterial strains via various mechanisms, including the emergence of mutations in resistance genes.

Penicillins were the most widely prescribed antibiotics, while cephalosporins and macrolides were more widely sold antibiotics without prescription. This could be due to penicillin allergies, which led individuals to sell alternative antibiotics. Several community members in developing countries admit antibiotics without prescriptions [37, 38]. Antibiotics are medications that can only be obtained with a prescription from an appropriately trained physician. Without a prescription, antibiotics should not be sold; similarly, unlicensed personnel and locations should not sell antibiotics [39]. Personal behaviors as well as healthcare-related gaps, including the lack of health insurance, inconvenience, and medication unavailability, in addition to the difficulty of rapid diagnosis of the infections, have led community members to look for antimicrobial agents from unlicensed and non-prescribed sources. Antibiotic excess was also more prevalent among those concerned about distance, medication availability, and healthcare convenience at public medical centers [40]. Our data showed that 90% of antibiotics dispensed in community pharmacies were sold without a prescription, highlighting a widespread violations of pharmaceutical regulations. This uncontrolled access to antibiotics significantly contributes to misuse, self-medication, and the acceleration of antimicrobial resistance. Therefore, we now explicitly advocate for pharmacy crackdowns, including regular inspections, licensing enforcement, penalties for non-compliance, and mandatory presence of qualified pharmacists during dispensing. These measures are critical to curbing the unauthorized sale of antibiotics and ensuring that these potent medications are used only under appropriate clinical supervision, in alignment with national laws and WHO stewardship guidelines.

The high rate of mistaken antibiotic usage, particularly among those in the Watch and Reserve categories, highlights the critical need for better adherence to the WHO AWaRe classification system in Iraq. Future efforts ought to focus on physician education, prescription rules, and public awareness in order to promote safe antibiotic usage [6].

Limitations

The study might not accurately represent national trends because it was restricted to Al Muthanna, Iraq The study was conducted in Al Muthanna, a region that, while limited geographically, presents a relevant case study due to it combines both urban and rural healthcare settings, high antibiotic dispensing rates, and previously documented resistance issues. While these findings may not fully reflect national trends, we believe Al Muthanna offers valuable insights into the broader challenges of antibiotic misuse in Iraq, particularly in under-resourced regions. Nonetheless, we agree that multi-regional studies would provide a more comprehensive picture and have highlighted this as a direction for future work. Although our study discusses resistance trends, direct antibiotic resistance data were not analyzed quantitatively. We acknowledge this as a limitation, incorporating such data will be useful for future research aimed at linking prescription patterns directly to resistance outcomes. The data collection based on readily available Pprescription records that were readily available were used for data collection, which might lead to reporting bias.

Recommendations

sStricter adherence to WHO recommendations about antibiotic prescriptions and. stricter laws governing the selling of antibiotics in pharmacies are needed. focused training initiatives to enhance antibiotic stewardship for prescribers.For junior clinicians, focused training on updated WHO prescribing guidelines, diagnostic stewardship, and antimicrobial resistance awareness is essential early in their careers. For long-tenured staff, continuing medical education (CME) programs that address emerging resistance patterns, guideline updates, and reflection on prescribing behaviors may be more effective.

Conclusion

The study revealed three primary themes behind the inappropriate and incorrect usage of antibiotics, namely personal, psychological, and organizational aspects. These themes encompassed seven determinants, which include job experience, expertise, adherence to guidelines, management of ambiguity, felt pressure, time constraints, and availability of diagnostic resources. Managing uncertainty is essential, and knowledge and experience at work may help in reducing inappropriate use of antibiotics. Furthermore, herein we reviewed some of the previous molecular studies in Al-Muthanna Governorate that conducted genomic surveillance. It was concluded that the misuse and overuse of antibiotics contributed to significant stress on bacterial populations, leading to the emergence of mutations in vital genes, the acquisition of mobile genetic elements such as introns, and the formation of biofilm. These bacterial strategies played a crucial role in the emergence and prevalence of antibiotic-resistant bacterial strains.

Based on these findings, strict control measures and regulatory interventions are indispensable to mitigate the growing threat of antibiotic resistance. Regional policies must be reinforced to ensure that antibiotics are prescribed and dispensed only under stringent professional supervision. Moreover, public awareness and guidance campaigns should be intensified to educate communities about the risks of antibiotic overuse. Finally, without urgent and coordinated actions, antibiotic resistance will continue to rise, posing severe public health challenges in Iraq and globally.

Declarations

Funding

Not applicable.

Conflict Interest

The authors declare that they have no conflict of interest.

Ethics and approval

Not applicable.

Data availability

All the data are represented in the manuscript. The data were collected to ensure reliability and validity of the hospital body medical records and community pharmacy sales in Al Muthanna, Iraq.

Author contributions

Yasir Adil Jabbar Alabdali: Conceptualization, Supervision, Methodology, writing – review & editing, Murad G. Munahi: Data analysis, Validation, and Writing–original draft, editing original draft.

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