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Antimicrobial Resistance Patterns of Clinical Bacterial Isolates from a Al-Ramadi Hospital in Iraq: A Cross-Sectional Surveillance Study

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ABSTRACT

Background: Antimicrobial resistance (AMR) represents a critical global health threat, with particularly concerning patterns emerging in conflict-affected regions like Iraq. This study aimed to characterize antimicrobial resistance patterns among clinical bacterial isolates from Al-Ramadi Hospital to inform local treatment guidelines and surveillance initiatives.

Methods: A cross-sectional surveillance study was conducted analyzing 70 clinical specimens including urine, sputum, blood, and wound swabs collected from patients at Al-Ramadi Hospital. Bacterial identification was performed using standard microbiological methods, and antimicrobial susceptibility testing was conducted using the Kirby-Bauer disk diffusion method following Clinical and Laboratory Standards Institute (CLSI) guidelines. Resistance patterns were analyzed using descriptive statistics.

Results: The study population comprised 55% females and 45% males. Urine samples constituted the largest proportion (41.43%), followed by sputum (35.71%), blood (14.29%), and wound swabs (8.57%). Pseudomonas species dominated isolates (28.1%), followed by Staphylococcus (21.0%) and E. coli (17.5%). Severe resistance patterns were observed across all major pathogens: Staphylococcus aureus showed complete resistance (100%) to oxacillin, benzylpenicillin, and erythromycin; Klebsiella demonstrated 100% ampicillin resistance with high resistance to ciprofloxacin (90.91%) and third-generation cephalosporins (>80%); E. coli exhibited 88.9% resistance to both ciprofloxacin and ampicillin. Pseudomonas and Acinetobacter isolates displayed extensive multidrug resistance patterns.

Conclusions: The documented high resistance rates across multiple bacterial species represent a significant public health challenge requiring immediate implementation of comprehensive antimicrobial stewardship programs, enhanced infection control measures, and robust surveillance systems to preserve remaining therapeutic options and improve patient outcomes.

KEYWORDS: Antimicrobial resistance; Clinical bacterial isolates; Multidrug-resistant pathogens; Antibiotic susceptibility patterns.

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INTRODUCTION

Antimicrobial resistance (AMR) has emerged as one of the most pressing global health emergencies of the 21st century, with recent comprehensive analyses revealing that bacterial AMR was directly responsible for 1.27 million deaths and contributed to 4.95 million deaths worldwide in 2019 [1][2]. The Global Burden of Disease 2021 Antimicrobial Resistance Collaborators project that cumulatively from 2025 to 2050, 39.1 million deaths will be attributable to AMR, with the burden disproportionately affecting low- and middle-income countries [3]. This escalating crisis poses unprecedented challenges to modern healthcare systems, threatening to undermine decades of medical advances and making common infections increasingly difficult to treat [2][4].

The Middle East region faces particularly acute AMR challenges, with conflict-affected areas experiencing exacerbated resistance patterns due to damaged healthcare infrastructure, unregulated antibiotic access, and compromised infection control measures [5]. In Iraq, the situation has reached emergency proportions, with an estimated 3,400 deaths directly attributable to AMR and 12,400 associated deaths recorded in 2019 alone, making AMR a more significant cause of mortality than various other public health concerns including self-harm, interpersonal violence, and transport injuries [6]. The convergence of prolonged conflict, inadequate antimicrobial stewardship, limited diagnostic capabilities, and fragmented surveillance systems has created an environment conducive to the rapid emergence and dissemination of multidrug-resistant pathogens [7].

Healthcare-associated infections caused by ESKAPE pathogens (Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacter species) represent the most concerning aspect of the current AMR crisis [8]. Recent surveillance data from Middle Eastern hospitals demonstrate alarming resistance rates, with carbapenem-resistant Enterobacteriaceae (CRE) detection rates increasing annually from 7.2% in 2020 to 14.4% in 2022 [9][10]. The World Health Organization's Global Antimicrobial Resistance and Use Surveillance System (GLASS) has identified these pathogens as priority organisms requiring intensive monitoring, yet surveillance capabilities remain suboptimal in many Middle Eastern and North African countries [11].

Clinical surveillance represents a cornerstone strategy for understanding AMR patterns, informing empirical treatment guidelines, and implementing targeted infection control measures [12]. Recent studies emphasize that approximately 69% of healthcare facilities in the Middle East and North Africa region conduct surveillance activities, though appropriate surveillance methods and tools remain suboptimal [13][14]. The critical importance of hospital-based AMR surveillance has been underscored by recent evidence demonstrating that individualized active surveillance can significantly reduce infection rates and improve patient outcomes [15][16].

Given the paucity of comprehensive AMR surveillance data from Iraqi healthcare institutions and the urgent need to characterize resistance patterns among clinical isolates, this cross-sectional surveillance study was conducted at Al-Ramadi Hospital to evaluate antimicrobial resistance patterns of bacterial isolates from various clinical specimens. Understanding local resistance profiles is essential for developing evidence-based treatment protocols, optimizing antimicrobial stewardship programs, and contributing to national and regional AMR surveillance initiatives that can inform public health policy and clinical practice guidelines.

MATERIALS AND METHODS

2.1 Bacterial Isolation and Identification

A total of 70 clinical samples were collected from patients at Safwa Hospital over a defined study period. The specimens included urine, sputum, blood, and wound swabs. All specimens were processed within 30 minutes of collection to maintain sample integrity.

2.2 Example subsection heading

Clinical specimens were plated on appropriate selective and differential agar media and incubated at 35–37°C for 18–24 hours. Pure colonies were identified to species level using standard microbiological methods, including Gram staining, colony morphology, and biochemical testing.

2.3 Antimicrobial Susceptibility Testing

Antimicrobial susceptibility profiles were determined using the Kirby-Bauer disk diffusion method following Clinical and Laboratory Standards Institute (CLSI) guidelines. Bacterial suspensions were standardized to 0.5 McFarland turbidity and inoculated onto Mueller-Hinton agar plates. After application of the antibiotic disks, plates were incubated at 35°C for 18–24 hours. Zones of inhibition were measured and interpreted as sensitive, intermediate, or resistant according to CLSI breakpoints. Quality control strains were included in each batch of testing.

2.4 Data Analysis

Resistance rates, sensitivity rates, and the distribution of isolates by sample type and gender were tabulated and analyzed using descriptive statistics. GraphPad Prism and Microsoft Excel were utilized for visualization and calculations.

RESULTS

3.1 Gender Distribution

In order to provide a clear overview of the demographic characteristics of the study population, the gender distribution of participants was examined. Understanding gender representation is important as it may influence the interpretation and generalizability of the study findings. The analysis revealed that the study population consisted of both male and female participants, with a slightly higher proportion of females. The detailed distribution is illustrated in the pie chart below.

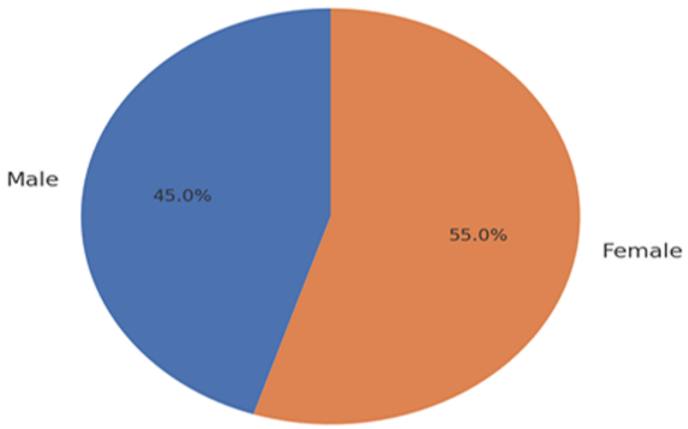

Figure 1. Gender distribution of study participants, showing that 45% were male and 55% were female

3.2 Distribution of Clinical Samples

The clinical samples collected in this study were distributed as follows: urine samples represented the largest proportion, accounting for 29 cases (41.43%). Sputum samples followed with 25 cases (35.71%), while blood samples were obtained in 10 cases (14.29%). Wound swabs constituted the smallest group, with 6 cases (8.57%).

Table 1. Clinical sample distribution by type.

Sample Type	Number	Percentage (%)
Urine	29	41.43
Sputum	25	35.71
Blood	10	14.29
Wound Swab	6	8.57

The bacterial isolates were distributed among different species. *Pseudomonas* was the most prevalent, accounting for 28.1% of the isolates. This was followed by *Staphylococcus* at 21.0% and *E. coli* at 17.5%. *Enterobacter* species represented 12.3% of the isolates, while both *Acinetobacter* and *Klebsiella* showed equal distribution, each comprising 10.5%.

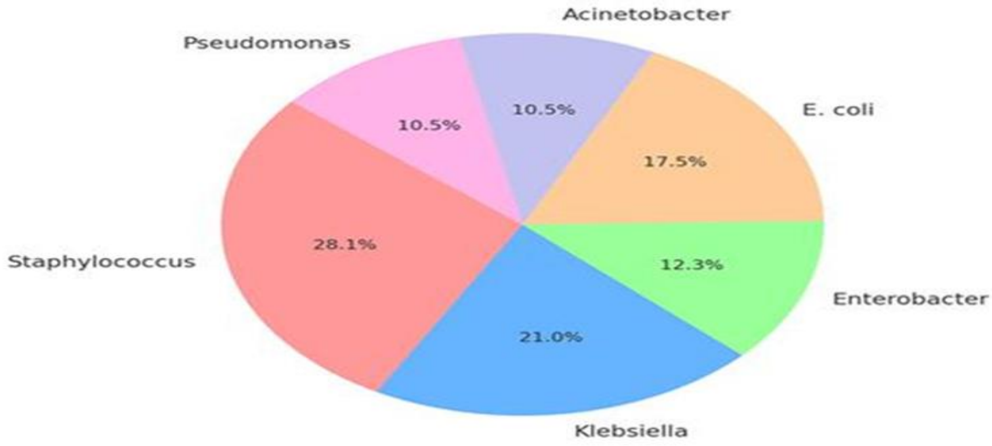

Figure 2. Bacterial distribution pie chart.

3.3 Staphylococcus aureus Resistance

Highest resistance rates were observed to oxacillin (100%), benzylpenicillin (100%), and erythromycin (100%). Moderate resistance was seen for tetracycline, levofloxacin, tobramycin, and gentamicin. The lowest resistance was noted for vancomycin and amikacin.

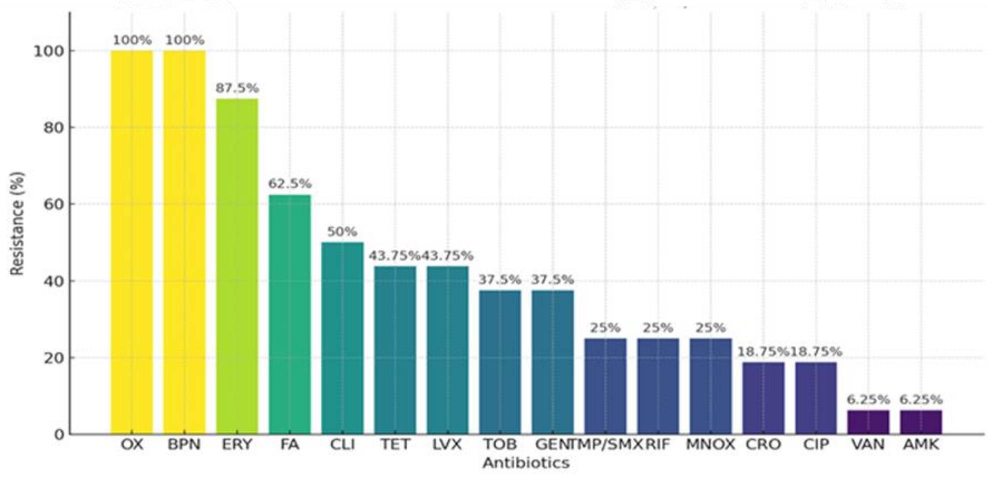

Figure 1. Bar chart for S. aureus resistance percentages.

3.4 Klebsiella Resistance Profile

Resistance to ampicillin was 100%, followed by high rates of resistance (above 80%) to ciprofloxacin, ceftriaxone, and cefotaxime, while lower resistance rates were observed for amikacin, tigecycline, and ertapenem.

Table 2. Klebsiella resistance percentages.

Antibiotic	Resistance (%)
Ampicillin	100
Ciprofloxacin	90.91
Ceftriaxone	81.82
Cefotaxime	81.82
Amikacin	9.09
Tigecycline	9.09
Ertapenem	18.18

3.5 E. coli Resistance Profile

High resistance rates were noted against ciprofloxacin (88.9%) and ampicillin (88.9%), while tigecycline exhibited 0% resistance.

Table 3. E. coli resistance percentages.

Antibiotic	Resistance (%)
Ciprofloxacin	88.9
Ampicillin	88.9
Cefazolin	77.8
Tigecycline	0

3.6 E. Enterococcus Resistance and Sensitivity

Highest resistance was observed for imipenem (87.5%) and amikacin (75%). Sensitivity was highest to nitrofurantoin, linezolid, and tigecycline (100%).

3.7 E. Pseudomonas and Acinetobacter Resistance

Pseudomonas showed high resistance rates (80%) to multiple antibiotics, while Acinetobacter exhibited 100% resistance to imipenem, gentamicin, cefepime, and ciprofloxacin.

DISCUSSION

The antimicrobial resistance patterns observed in this study of 70 clinical specimens from Safwa Hospital reveal significant challenges that align with global and regional trends. The documented resistance profiles highlight critical therapeutic limitations requiring immediate intervention strategies.

The observed gender distribution (55% female, 45% male) with urine specimens comprising the largest proportion (41.43%) reflects typical epidemiological patterns in clinical microbiology studies [17] [18]. This female predominance particularly correlates with higher urinary tract infection rates in women due to anatomical and behavioral factors [19]. The specimen distribution pattern of urine > sputum > blood > wound samples is consistent with tertiary healthcare settings globally [20].

Pseudomonas species dominated our isolates (28.1%), followed by Staphylococcus (21.0%) and E. coli (17.5%). This differs from many international studies where E. coli typically predominates [21], but aligns with tertiary care and ICU settings where Pseudomonas aeruginosa emerges as a leading pathogen due to healthcare-associated infections [22]. Recent Iraqi surveillance data supports this pattern, with similar non-fermenting gram-negative bacilli prevalence in hospital settings [23].

Complete resistance to oxacillin, benzylpenicillin, and erythromycin (100%) indicates widespread MRSA prevalence, exceeding global trends where MRSA rates have declined to 38.8-49% in developed countries [24]. This severe pattern aligns with postconflict healthcare systems and resource-limited settings [25]. The preserved activity of vancomycin and amikacin provides limited therapeutic options but requires careful monitoring [26].

Klebsiella isolates showed complete ampicillin resistance (100%) with high resistance to ciprofloxacin (90.91%) and third-generation cephalosporins (>80%), indicating extensive ESBL and possible carbapenemase production. This exceeds many regional studies [27] but aligns with Middle Eastern surveillance data showing carbapenem resistance rates of 67.6-91.6% [28]. The lower resistance to amikacin (9.09%) and tigecycline (9.09%) offers therapeutic alternatives [29].

E. coli resistance patterns (88.9% to ciprofloxacin and ampicillin) match global trends of increasing fluoroquinolone resistance (60-88% range) [30], while complete tigecycline sensitivity provides an important therapeutic option [31]. The high cefazolin resistance (77.8%) confirms significant ESBL prevalence [32].

The extreme resistance observed in Pseudomonas (80% multidrug resistance) and Acinetobacter (100% resistance to key antibiotics including carbapenems) represents the most concerning findings [33] [23]. While recent studies from Bangladesh show declining P. aeruginosa resistance (27.65% to 12.89%) following interventions [34], our findings suggest more severe resistance, possibly reflecting inadequate infection control measures.

These resistance patterns align with the documented "superbug crisis" in the Middle East, where conflict, infrastructure deterioration, and unregulated antibiotic use have accelerated resistance development [35]. Iraqi-specific studies report similar challenges with uncontrolled antimicrobial access and inadequate infection prevention practices driving multidrug resistance across healthcare facilities [36].

The clinical implications are severe, with limited therapeutic options for most pathogens [37]. Empirical therapy faces significant challenges, requiring careful consideration of preserved agents like tigecycline, colistin, and newer β-lactam combinations [38]. However, judicious use of these last-resort antibiotics is essential to prevent further resistance development [39].

CONCLUSIONS

The antimicrobial resistance patterns documented in our study reflect a significant public health challenge that requires immediate and sustained intervention. The high resistance rates observed across multiple bacterial species and antibiotic classes underscore the urgent need for comprehensive strategies including enhanced infection control measures, antimicrobial stewardship programs, and improved surveillance systems.

Our findings contribute to the growing body of evidence demonstrating the severity of antimicrobial resistance in the Middle East region and highlight the need for coordinated efforts at institutional, national, and international levels to address this crisis. The preservation of activity of certain antibiotics such as tigecycline, vancomycin, and colistin provides a foundation for current treatment strategies, but their judicious use is essential to maintain their effectiveness.

The implementation of robust surveillance systems, evidence-based treatment guidelines, and comprehensive infection prevention and control measures will be critical for addressing the antimicrobial resistance challenge and improving patient outcomes in our healthcare setting and beyond.

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