http://doi.org/10.25130/tjphs.2026.20.1.1.1.8

IRAQI Academic Scientific Journals

Tikrit Journal of Pharmaceutical Sciences

ISSN: 1815-2716 (print) -- ISSN: 2664-231X (online)

Journal Home Page: https://tjphs.tu.edu.iq -- Email: tjops@tu.edu.iq

TJPHS

Antimicrobial Resistance in Healthcare Institutions of Nineveh Province

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Keywords:
Prevalence,
Resistance to antimicrobial,
Nineveh province, Health care

Article history:
-Received: 21/05/2026
-Received in revised: 16/06/2026
-Accepted: 16/06/2026
-Available online: 30/06/2026

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Citation:
Ibrahim M. Faisal. Antimicrobial Resistance in Healthcare Institutions of Nineveh Province. Tikrit J. Pharm. Sci. 2026; 20(1): 1-8. ***http://doi.org/10.25130/tjphs.2026.20.1.1.1.8***

Abstract

Background: Resistance to antimicrobials (AMR) represents a global threat, attenuating the efficacy of modern medicines. In war regions such as Nineveh province, Iraq, AMR is increased by damaged healthcare infrastructure, population displacement, and undermined infection control and surveillance systems.

Objectives: This study aims to assess the prevalence and patterns of antimicrobial resistance among essential bacterial pathogens isolated from different biological samples within healthcare facilities in Nineveh province.

Materials and Methods: A retrospective descriptive analysis was done on antimicrobial susceptibility tests that were collected from four major hospitals in Nineveh province. The dataset included information from 8200 clinical bacterial isolates tested routinely for antimicrobial susceptibility by using the disk diffusion method conducted between August 2024 and July 2025. Data were analyzed to determine the susceptibility pictures of common microorganisms. Resistance patterns were categorized by antibiotic class with a specific focus on resistance to last-line antibiotics.

Results: The study showed high rates of resistance to many classes of antibiotics among bacterial isolates. Resistance to commonly prescribed agents was high: resistance to ceftriaxone and to ciprofloxacin was identified in 4300 of 5900 isolates (72.9%) and in 4900 of 8200 isolates (59.8%) respectively. Resistance to carbapenems, which are mainly used for combating Gram-negative infections was noticed at significant levels with 1700 of 5100 isolates (17.6%) resistant to meropenem. Isolates resistant to methicillin were 1899 of 2300 (82.6%) indicating a high prevalence methicillin-resistant bacteria. Finally, resistance to the last-line antibiotic such as polymyxins was also evident, with colistin resistance seen in 500 of 2100 isolates (23.8%).

Conclusion: The increased level of resistance to antibiotics in Nineveh's healthcare facilities shows a critical clinical and public health crisis. The patterns that are found may be due to misuse of first- and last-line antibiotics, inadequate prescribing procedures, and challenges in maintaining Infection Prevention and Control (IPC) requirements in post war areas. This necessitates the application of specific measures including strong AMR surveillance, focused programs for antibiotic stewardship, and restarted the important steps of infection prevention measures to preserve the effectiveness of remaining antibiotics and safeguard patient health across the province.

مقاومة مضادات الميكروبات في مؤسسات الرعاية الصحية بمحافظة نينوى

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الخلاصة

تُمثل مقاومة مضادات الميكروبات تهديدًا عالميًا، مما يُضعف فعالية الطب الحديث. في مناطق النزاعات، مثل محافظة نينوى في العراق، تتفاقم مقاومة مضادات الميكروبات نتيجة لتضرر البنية التحتية للرعاية الصحية، ونزوح السكان، وضعف أنظمة مكافحة العدوى ومراقبتها .تهدف هذه الدراسة إلى تحديد مدى انتشار أنماط مقاومة مضادات الميكروبات بين مسببات الأمراض البكتيرية الأساسية المعزولة من عينات بيولوجية مختلفة داخل مرافق الرعاية الصحية في محافظة نينوى .ُجري تحليل وصفي استرجاعي لاختبارات حساسية مضادات الميكروبات التي جُمعت من أربعة مستشفيات رئيسية في محافظة نينوى. شملت مجموعة البيانات معلومات من ٨٢٠٠ عزلة بكتيرية سريرية خضعت لاختبارات حساسية مضادات الميكروبات بشكل روتيني باستخدام طريقة الانتشار المكتبي، وذلك خلال الفترة من اب ٢٠٢٤ إلى تموز ٢٠٢٥. حُللت البيانات لتحديد أنماط حساسية الكائنات الدقيقة الشائعة. صُنفت أنماط المقاومة حسب فئة المضاد الحيوي، مع التركيز بشكل خاص على مقاومة المضادات الحيوية من الخط الأخير .تم تحليل البيانات لتحديد أنماط حساسية الكائنات الدقيقة الشائعة. النتائج: أظهرت الدراسة معدلات مقاومة عالية للعديد من فئات المضادات الحيوية بين العزلات البكتيرية. تم رصد مقاومة للمضادات الحيوية الشائعة الاستخدام، سيفاترياكسون، في ٤٣٠٠ من أصل ٥٩٠٠ عزلة (٧٢,٩%)، وسيبروفلوكساسين في ٤٩٠٠ من أصل ٨٢٠٠ عزلة (٥٩,٨%). ولوحظت مقاومة ملحوظة للكاربابينيمات، المستخدمة بشكل أساسي لمكافحة العدوى بالبكتيريا سالبة الغرام، حيث كانت ١٧٠٠ من أصل ٥١٠٠ عزلة (١٧,٦%) مقاومة للميروبينيم. وبلغت نسبة العزلات المقاومة للميثيسيلين ١٨٩٩ من أصل ٢٣٠٠ عزلة (٨٢,٦%)، مما يشير إلى انتشار واسع لبكتيريا المكورات المقاومة للميثيسيلين. وأخيرًا، ظهرت أيضًا مقاومة للمضادات الحيوية المستخدمة كخط علاج أخير، مثل البوليميكسينات، حيث لوحظت مقاومة للكوليستين في ٥٠٠ من أصل ٢١٠٠ عزلة (٢٣,٨%). يُشير ارتفاع مستوى مقاومة المضادات الحيوية في مرافق الرعاية الصحية في نينوى إلى أزمة صحية عامة وسريرية حرجة. وقد تُعزى الأنماط الملحوظة إلى سوء استخدام المضادات الحيوية من الخط الأول والأخير، وعدم كفاية إجراءات وصف الأدوية، والتحديات التي تواجه تطبيق متطلبات مكافحة العدوى والوقاية منها في مناطق ما بعد الحرب. وهذا يستدعي تطبيق تدابير محددة، تشمل ترصدًا دقيقًا لمقاومة مضادات الميكروبات، وبرامج مُركزة لإدارة استخدام المضادات الحيوية، واستئناف الخطوات المهمة لتدابير الوقاية من العدوى، وذلك للحفاظ على فعالية المضادات الحيوية المتبقية وحماية صحة المرضى في جميع أنحاء المحافظة.

الكلمات المفتاحية: انتشار، مقاومة المضادات الحيوية، محافظة نينوى، المؤسسات الطبية.

INTRODUCTION

AMR has become one of the most serious threats to global public health[1,2]. It is defined as the ability of microorganisms, particularly bacteria, to withstand exposure to an antimicrobial that would generally kill them or inhibit their growth. AMR instantaneously erodes the efficacy of traditional treatments. The end result of this dilemma is thought to be longer disease durations, increased mortality rates, higher health care costs and more complications[3]. According to the estimates, the AMR caused 1.27 million deaths worldwide in 2019 alone and played a role in the deaths of millions more. The World Health Organization (WHO) considers AMR a quiet epidemic and emphasizes the potential to reverse decades of medical development gain. Recent studies predict 10 million deaths from AMR each year by 2050, which exceeds deaths from cancer and diabetes combined. The primary underlying causes of AMR are the abuse and overuse of antibiotics in human and veterinary and agricultural practices[1,4]. Excessive use of antibiotics aggravates the natural evolutionary processes by which bacteria obtain resistant genes[5]. Of significant concern are multidrug-resistant organisms (MDR) like Escherichia coli, Klebsiella pneumoniae, and Staphylococcus aureus that have developed resistance to various antibiotic classes, including last-line antibiotics like carbapenems and colistin[6,7].

AMR in the medical field is very obvious in Low- and Middle-Income Countries (LMICS) where health care services are usually stretched and under-resourced[1,3]. Reasons for observed increases in resistant pathogens include inadequate infection prevention and unrestricted antibiotic use, decreased diagnostic capacity, and barriers to implementing effective antimicrobial stewardship programs. This is even compounded by some providers having a lack of understanding, and similarly for patients, of rational antimicrobial usage[3].

Years of war in areas like Nineveh have left hospitals in bad condition. Because doctors don't

have the right equipment to test exactly what's making a patient sick, they just have to guess which antibiotics to use. This causes bacteria to adapt and turn into resistant. Because the standard drugs no longer work, even a normal, everyday infection can quickly become hazardous. According to the experience as a part of medical staff in clinical setting in Nineveh's health systems, the authors have observed the increasing proportion of patients who do not respond to first-line antibiotic therapies. It is becoming more common for providers move to broader-spectrum or last resort agents that not only incur greater costs of treatment but expose patients to increased risk for toxicity and essentially increases the risks for treatment failures in many patients[8]. Often, these are practical difficulties that related to an underlying systemic issue-based in inadequate stewardship[9], lack of surveillance system, and unrestricted access to antibiotics, including over-the-counter consumption without prescriptions[10,11]. Additionally, there is an absence of locally gleaned data that may support evidence-based prescribing related to our own antimicrobial-resistant patterns. The vast majority of national surveillance systems remain incomplete, and often times, hospitals do not have microbiology labs capable of identifying cultures and determining sensitivities. Without this baseline data, physicians and policymakers cannot create targeted interventions and systems to monitor susceptibilities in the entire population[12] thus leading to generalized and less effective interventions. Given the set of challenges, there is a determined need for investigating the locally reported antimicrobial resistant patterns, causation, and outcomes[13,14].

This study aims to explore the prevalence and characterize resistance patterns of bacterial isolates to antimicrobials in healthcare facilities in Nineveh province. It also aims to provide evidence-based recommendations to support local policy appropriate to a national and international approach to addressing AMR. Ultimately, antibiotic resistance is not a distant or hypothetical situation, it is a real clinical and public health crisis that requires immediate, coordinated, and context-relevant action. Solutions to this problem require a multi-faceted response and include accurate diagnostic tools, tighter regulation, improved infection control, continuing medical education, and raising awareness of the public.

METHODS

This study was done to investigate the prevalence and patterns of antimicrobial resistance (AMR) within healthcare institutions in Nineveh province, Iraq.

Study design

A retrospective, descriptive, cross-sectional research design was used for this study. This approach is very suitable for analyzing the data (antimicrobial susceptibility tests determined by using disk diffusion method) of patients attending different health services in Nineveh Province, Iraq. By checking the laboratory records, the purpose of this study is to determine the resistance to a wide range of antibiotics, identify the most important resistance pattern and establish the basic understanding of the AMR landscape in the area after a conflict.

Data sources and collections

Data were obtained from an overall and anonymous electronic database of microbiology laboratories of four tertiary health institutions in the Nineveh province: Al-Slam Teaching Hospital, Ibn-Sena Teaching Hospital, Ibn-Alather Teaching Hospital and Al-Khansa Teaching Hospital. The data consisted of entries for a wide range of antibiotics such as penicillins, cephalosporins, carbapenems, fluoroquinolones, aminoglycosides, macrolides and polymyxins.

The dataset in the present work contained only the antimicrobial susceptibility tests for isolates from different body sample (blood, urine, sputum, wound swab) and a total of 8200 bacterial isolates were obtained for analysis. Records with obvious data entry errors were excluded. Information about patient age and sex, patient ward location, and community versus hospital acquisition were not available so that not included in analysis. For each drug tested, the data classified the bacterial isolates based on their susceptibility profile and according to the Clinical and Laboratory Standards Institute (CLSI) criteria as sensitive (S), medium sensitive or intermediate (I) and resistant (R).

Statistical analysis

Data analysis was done using descriptive statistical processes. The evaluation focused on quantifying the isolates showing resistance to each

antimicrobial agent. The number of resistant (R), intermediate (I), and sensitive (S) isolates for each antibiotic was tabulated immediately from the information source and percentages were calculated for susceptible, intermediate and resistant isolates for each drug. This allowed for an immediate check of the resistance levels for each agent. SPSS Statistics for Windows was used for data analysis.

Ethical Considerations

This study was done in agreement with Medical Research Ethics Committee under the Reference Number 2024175. The main priority was given to the patient safety, privacy, and confidentiality. This was done by using a fully nameless, grouped set of data. It contained no personal details, like patient names, medical record numbers, addresses, or exact dates of admission. Given the retrospective and anonymized nature of the data, the study posed no direct risk to patients.

RESULTS

The results were performed to provide a comprehensive observation of the resistance patterns, which begin with overall sensitivity profile and focus on the specific antibiotic classes and most important agents.

Patterns of Resistance by Antibiotic Class

A detailed analysis of resistance from the antibiotic class shows deep insight into the extent of the AMR problem. The data shows a varying degree of resistance across large medical groups.

Beta lactam antibiotics

This important class of antibiotics showed widespread resistance. Within penicillins subgroup, resistance reaches higher rates recording 88.9% for ampicillin and 100% for ticarcillin. More significantly, cephalosporins exhibited higher rates of resistance particularly cefazolin was 92.6%, ceftriaxone was 72.9% and ceftazidime was 71.2%. (Table 1 and 2).

Table (1): The percentage of sensitivity test of the collected samples against the commonly used penicillin antibiotics

Drug/No. of Isolates	Sensitivity patterns (%)		
	Sensitive	Moderately sensitive	Resistant
Benzylpenicillin, n=4700	8.5	21.3	**70.2**
Ampicillin, n=2700	7.4	3.7	**88.9**
Amoxicillin, n=600	16.6	16.7	**66.7**
AmoxiClav, n=3000	10	23.3	**66.7**
Piperacillin, n=4100	26.8	22	**51.2**
Piperacillin/Tazobactam, n=5200	40.4	17.3	**42.3**
Ticarcillin, n=700	0	0	**100**
Ticarcillin/Clavulanic acid, n=1400	7.1	7.2	**85.7**
Methicillin, n=2300	13	4.4	**82.6**
Oxacillin, n=1800	22.2	11.1	**66.7**

Table (2): The percentage of sensitivity test of the collected samples against the commonly used cephalosporin antibiotics.

Drug/No. of Isolates	Sensitivity patterns (%)		
	Sensitive	Moderately sensitive	Resistant
Cefalothin, n=2500	8	0	**92**
Cefazolin, n=2700	7.4	0	**92.6**
Cefalexin, n=2200	27.3	4.5	**68.2**
Cefoxitin, n=2200	27.3	4.5	**68.2**
Cefotaxime, n=2400	8.3	16.7	**75**
Ceftriaxone, n=5900	8.5	18.6	**72.9**
Cefixime, n=2400	4.2	4.2	**91.6**
Ceftazidime, n=5900	25.4	3.4	**71.2**
Cefepime, n=5700	31.6	19.3	**49.1**

Table (3): The percentage of sensitivity test of the collected samples against the commonly used quinolone antibiotics.

Drug/No. of Isolates	Sensitivity patterns (%)		
	Sensitive	Moderately sensitive	Resistant
Ciprofloxacin, n=8200	31.7	8.58	**59.8**
Norfloxacin, n=1500	33.3	20	**46.7**
Levofloxacin, n=8100	28.4	21	**50.6**
Moxifloxacin, n=2900	37.9	10.3	**51.8**

Fluoroquinolones: According to the study results, resistance to this class was significant. Ciprofloxacin exhibited the highest rate of resistance (59.8%) followed by moxifloxacin (51.8%) and finally levofloxacin (50.6%) suggesting reduced usefulness of this group of agents . (Table 3).

Tetracyclines and macrolides

Resistance was also widespread among older antibiotic classes that are still used for specific indications. Higher rates of resistance had been shown for tetracycline (69.8%) and erythromycin (88.2%). In contrast, good levels of sensitivity patterns had been recorded for tigecycline (83.8%) (Table 4).

Table (4): The percentage of sensitivity test of the collected samples against the commonly used tetracyclines and macrolides.

Drug/No. of Isolates	Sensitivity patterns (%)		
	Sensitive	Moderately sensitive	Resistant
Tetracycline, n=4300	30.2	0	**69.8**
Doxycycline, n=2300	**65.2**	8.7	26.1
Tigecycline, n=3700	**83.8**	8.1	8.1
Minocycline, n=800	**62.5**	25	12.5
Azithromycin, n=1500	33.3	13.3	**53.4**
Erythromycin, n=3400	11.8	0	**88.2**

Critical and Last-Line Antibiotics Resistance Rates

Although the results shown lower resistance to carbapenems in comparison to first-line drugs, resistance to imipenem (24.45%) and meropenem (17.6%) still significant. In addition, resistance to colistin (23.8%) may limit therapy options. Teicoplanin resistance was observed in 51.4% of the tested isolates while 59.3% of isolates were resistant to aztreonam (Table 5 and 6).

Table (5): The percentage of sensitivity test of the collected samples against the commonly used carbapenems, teicoplanin and aztreonam.

Drug/No. of Isolates	Sensitivity patterns (%)		
	Sensitive	Moderately sensitive	Resistant
Imipenem, n=7000	**67**	8.6	24.4
Meropenem, n=5100	**66.7**	15.7	17.6
Teicoplanin, n=3500	45.7	2.9	**51.4**
Aztreonam, n=2700	33.3	7.4	**59.3**

Table (6): The percentage of sensitivity test of the collected samples against the commonly used polymyxins.

Drug/No. of Isolates	Sensitivity patterns (%)		
	Sensitive	Moderately sensitive	Resistant
Colistin, n=2100	**47.6**	28.6	23.8
Polymyxin b, n=900	**44.5**	33.3	22.2

DISCUSSION

The outcomes of this study showed a serious antimicrobial resistance (AMR) in healthcare institutions of Nineveh province. A large proportion of the isolated bacteria were resistant to several commonly used antibiotics. There was an increment in the rate of resistance particularly among Gram-negative bacteria such as E. coli and Klebsiella pneumoniae. These organisms are the main cause of hospital and community infections. The resistance makes the treatment of many cases very difficult[15].This condition which was caused by a sudden rush of severe injuries, crowded hospitals, and a weak ability to stop infections, has created a good place for the growth and spread of very strong and resistant germs[16].

The high resistance to β-lactam antibiotics including penicillins and third-generation cephalosporins, indicates overuse and misuse of these drugs for a long time. This may be due to the availability of antibiotics in pharmacies without prescription, and the habit of self-medication among the population[10]. In many hospitals, because of the lack of proper diagnostic facilities antibiotics are still given empirically without culture and sensitivity testing. These practices increase the chance of developing resistant strains and spreading them inside healthcare settings[9].

The high rate of resistance to ticarcillin in the present work may indicate the wide dissemination of β-lactamase producing Gram-negative organisms in Nineveh Governorate health care institutions. It is highly susceptible to hydrolysis by many β-lactamases and for this it is no longer widely used as a sole agent in treatment of infections[17]. The observed high resistance rates to β-lactam antibiotic in this study augment that β-lactamase-mediated resistance mechanism is the cause of ticarcillin resistance.

Widespread and poorly regulated dispensing of antimicrobial agents without a prescription is considered a significant contributing factor[11]. Resistance to fluoroquinolones such as ciprofloxacin and levofloxacin was also very high in this study. These drugs are widely used for urinary, respiratory, and gastrointestinal infections. The development of resistance against them reduce their usefulness. Same findings were obtained in previous Iraqi studies. These studies linked this pattern to the repeated and uncontrolled use of broad-spectrum antibiotics especially during the conflict time when health services were unstable and many medications were used without regulation[18]. The result of the present study concerning cephalosporins and fluoroquinolones are in agreement with previous studies in Iraq. Al-Fahad et al. stated a high resistance rates to these antimicrobials[19].

Another point which is very important is the detection of resistance to last-line antibiotics like carbapenems and polymyxins. Although the percentage of resistant isolates to imipenem and meropenem was lower when compared to other antibiotics, but it is still considered a major concern. The presence of carbapenem-resistant strains means that the available treatment options are very limited, and patients may have prolonged illness or even poor outcomes. colistin is one of the last therapeutic options used to treat severe infections caused by multidrug-resistant organisms and the appearance of colistin resistance is particularly worrying. The appearance of resistance to both carbapenems and colistin could lead to infections that are almost untreatable[15,16,18].

Overall, this study encourages the urgent need for making strong AMR surveillance programs in Nineveh for promoting rational antibiotic use among healthcare workers. To reduce the spread of resistant bacteria continuous education of medical staff, strict regulation of antibiotic dispensing, and reinforcement of infection prevention and control (IPC) measures are necessary. Future studies with larger and more detailed dataset are also needed to monitor changes in resistance trends over time and examine the usefulness of applied measures. War severely impairs the healthcare infrastructures in conflict areas. It is difficult to reduce antibiotic resistance without repairing the ruined hospitals and clinics. Local doctors, government, and international partners all should work simultaneously to rebuild Nineveh's health sector for controlling these dangerous infections.

STUDY LIMITATIONS

The design of this study is retrospective based on data collected from laboratory records with limited access to the important information such as patient age, sex and weight, concomitant diseases, previous antimicrobial exposure, type and source of infection and finally treatment outcomes.

Since the study was based on data from antimicrobial susceptibility tests, organism-

specific resistance pattern and classification of multidrug-resistance bacteria were not assessed.

CONCLUSIONS

We concluded that AMR patterns that are showed by the results of this study may be due to irrational use of the first-line and last-line antibiotics, unreasonable and frequent dispensing of antibiotics in prescriptions, and the difficulties in upholding IPC requirements in a post-conflict region.

ACKNOWLEDGEMENTS

The author would like to thank the lab and health care staff of Nineveh Hospitals and the staff of the University of Mosul/ College of Medicine, Department of Pharmacology who helped to make this research possible by their support.

CONFLICTS OF INTEREST

The author declare that there is no conflict of interest.

FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sector.

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