A review of antibiotic misuse and bacterial resistance in Iraq

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Abstract

Background: Antimicrobial resistance poses a serious threat to healthcare globally. Reviewing current practice regarding antibiotic prescription and use is crucial to understanding antimicrobial resistance issues in Iraq and how to tackle them.

Aim: To review and analyse studies addressing antimicrobial resistance as well as antibiotic prescription, dispensing and use in Iraq.

Methods: In June 2023, we searched Google Scholar for, and reviewed, empirical studies related to antibiotic use and antimicrobial resistance in Iraq.

Results: Thirty-seven eligible studies published between 2012 and 2023 were included in the review. Multi-drug-resistant bacteria, such as *E. coli* and *P. aeruginosa*, were commonly reported by the studies. Most physicians in public hospitals prescribed antibiotics frequently and empirically without relying on culture and sensitivity tests, and community pharmacists often dispensed antibiotics to patients without prescriptions, indicating self-medication and misuse of antibiotics in Iraq. Antibiotic residuals were found in raw meat and drinking water. Although there were antimicrobial resistance control regulations and plans, they were not fully implemented.

Conclusion: This review shows that antimicrobial resistance and antibiotic misuse are serious problems in Iraq. The responsible authorities should work together to implement and enforce compliance to the antimicrobial resistance control plans using the One Health approach.

Keywords: antibiotic, antimicrobial resistance, multi-drug resistance, One Health, infectious disease, self-medication, Iraq

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Introduction

Antimicrobial resistance (AMR) presents a serious threat to all lifeforms—plants, animals, and humans—emphasizing the importance of viewing ecosystems as interconnected systems through the One Health approach. Antibiotic resistance emerged and was identified early, along with the widespread clinical use of antibiotics (*4*). Antibiotic resistance continues to increase in incidence with overuse and improper use of antibiotics in humans, animals, and agriculture (*4*). When infectious agents no longer respond to antibiotic treatment medicines become ineffective. Studies have shown that AMR causes longer hospital stays, increased resource consumption, cancellation of elective surgeries, complications with chemotherapy and organ transplants, higher rates of readmission and increased mortality (*1,2*).

A recently published report from the Iraqi Ministry of Health (MOH) shared alarming results on antibiotic resistance in Iraq. This report indicated widespread resistance to end-line antibiotics such as meropenem and high prevalences of drug-resistant strains of common bacterial diseases (*7*).

Antibiotic stewardship has been implemented in Iraq as a step towards more rational clinical use of antibiotics, including proper dosage and avoiding the use of antibiotics without culture or sensitivity analysis (*8*). The Iraqi Ministry of Health maintains an antimicrobial surveillance system as part of the global system established by the World Health Organization. The World Health Organization's Global Antimicrobial Resistance and Use Surveillance System (WHO GLASS) was launched in 2015 to standardize the collection and sharing of data on antimicrobial resistance across countries (*50*). GLASS supports global efforts to track AMR trends and implement strategies to control resistance. GLASS promotes the collection of data not only from laboratories but also from clinical and epidemiological sources, enabling a more comprehensive approach to understanding AMR across human, animal, and environmental health sectors (*50*).

Understanding current practices regarding antibiotic prescription, self-medication, veterinary and agricultural usage, and the monitoring of antibiotic levels in food and drink are essential for identifying the factors contributing to AMR in Iraq and informing policy and response. This review is the first to comprehensively summarize antibiotic-related studies in Iraq, outlining the status and offering recommendations for improvement.

Our objective was to present an overview of Iraqi studies on AMR, antibiotic prescription and dispensing practices by healthcare providers, and antibiotic usage

by the general population, including non-human applications (One Health Approach).

Methods

Study design

This study is a systematic review that synthesizes data from previously published research on antibiotic misuse and bacterial resistance in Iraq. The review follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for reporting systematic reviews and meta-analyses and adheres to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) criteria for observational data inclusion.

Data sources and search strategy

A comprehensive search was conducted in June 2023 using the Google Scholar database. Search terms included: "antibiotic use in Iraq," "bacterial resistance," "self-medication," "prescribing practices," and "veterinary antibiotics in Iraq." The search was limited to studies published between 2012 and 2023 and to articles written in English.

Inclusion criteria

The inclusion criteria were: studies conducted in Iraq related to antibiotic usage or bacterial resistance; peer-reviewed articles published between 2012 and 2023; and studies examining antibiotic prescription patterns, self-medication practices, and the prevalence of bacterial resistance in healthcare, community, veterinary, and agricultural settings.

Exclusion criteria

The exclusion criteria were: studies focused on antibiotic resistance outside of Iraq; articles without sufficient data or unclear methodologies; and reports, editorials, or opinion pieces without empirical data.

Study selection

All studies identified through the search were screened by 2 independent reviewers. Titles and abstracts were assessed for relevance, and full texts of potentially eligible studies were obtained for detailed evaluation. Any disagreements regarding study inclusion were resolved through consensus.

Data extraction

Data extracted from the studies included study design and setting (hospital, community, agricultural or veterinary); sample size and population characteristics; outcome measures such as antibiotic usage, resistance patterns and knowledge regarding antibiotics; and key findings related to antibiotic misuse and resistance.

Assumptions

Given the scarcity of regional data, we assume generalizability for Iraq but acknowledge potential limitations in extending findings to rural areas where fewer studies were conducted. Studies may not have fully captured resistance patterns in the private healthcare sector and cross-sectional designs may have limited causality assessment.

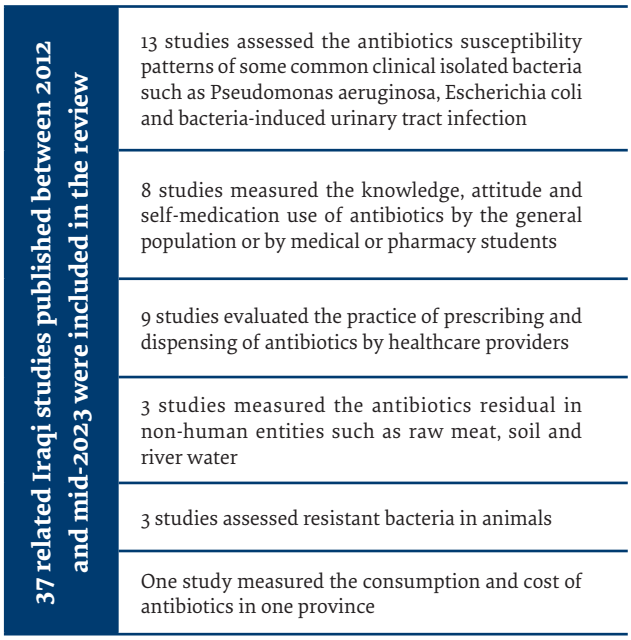
Statistical analysis

Data synthesis was conducted narratively due to the heterogeneity of the study designs. Where applicable, proportions and percentages were reported for specific outcomes such as resistance rates and prescription practices. No formal meta-analysis was conducted due to the diverse nature of the included studies.

Results

Of the 37 selected studies, 13 (35.1%) assessed antibiotic susceptibility patterns of commonly isolated bacteria, such as *Pseudomonas aeruginosa, Escherichia coli, Proteus mirabilis, Pseudomonas aeruginosa, Staphylococcus aureus and Klebsiella pneumoniae* (Figure 1). Eight out of 37 studies (21.6%) measured knowledge, attitudes and patterns of self-treatment with antibiotics by population type. Nine of 37 studies (24.3%) evaluated antibiotics prescription and dispensing practices by healthcare providers. One study (2.7%) measured the consumption and cost of antibiotics in one province in Iraq. Three studies (8.1%) measured antibiotic residuals in raw meat sold in shops and butcheries, soil and river water, and 3 studies (8.1%) assessed levels of bacterial resistance in domesticated animals. We did not find any national or institutional

Figure 1. Types and numbers of studies included in the review



guidelines on antibiotic prescription and use for the treatment of infectious diseases in Iraq (*9*).

Antibiotic prescription behaviour and use

We identified 6 retrospective and cross-sectional studies on antibiotic prescription practices conducted in Baghdad Province, Iraq. Five of the 6 studies (83.3%) reported overuse of antibiotics in public hospitals; and in the majority of cases, antibiotics were prescribed without conducting laboratory tests (*10-14*). We found 9736 inpatients from hospitals in different provinces and found that only 9% of cases had bacterial culture and sensitivity testing before prescription end-line antibiotics (meropenem injection or infusion; 12).

Another study that assessed 9440 prescriptions in a public paediatric hospital found that 99.9% of admitted children subsequently received antibiotics (*14*). In a public hospital in Kerbala, a study of 302 inpatients reported 83.3% of irrational prescription of antibiotics. Surgical wards reported 91.8% inappropriate antibiotic use cases while antibiotics prescription was 100% empirical in the medical wards (*11*). A recent study in 3 large public hospitals in Baghdad, with 100 inpatients revealed that only 2% of antibiotic prescriptions were written based on bacterial culture and sensitivity testing (*10*). A point prevalence survey (PPS) in 5 main hospitals in Baghdad indicated that 98.8% of antibiotics were prescribed empirically, while culture and sensitivity tests were only conducted for 1.2% of patients. Iraqi physicians did not follow institutional guidelines in the treatment of infectious diseases (*9*). Only one study indicated that all patients in the intensive care unit were administered culture and sensitivity tests on admission (*15*).

Community pharmacists dispensed antibiotics without prescription and had inadequate knowledge of bacterial resistance and appropriate antibiotic stewardship (*16,17*). A cross-sectional study in Baghdad reported that among 300 community pharmacists, 45% dispensed antibiotics to patients known to have viral infections (*16*). Although there were health regulations about prescribing and dispensing antibiotics (*18*), the majority of physicians and community pharmacists did not follow antibiotics stewardship instructions and prescribed or dispensed antibiotics more frequently than expected.

Table 1. Licensing by type of healthcare setting, Iraq, 2023

Healthcare setting	Licensing	Inspection
Private community pharmacies	The Syndicate of Iraqi Pharmacists	Ministry of Health and The Syndicate of Iraqi Pharmacists
Private physician clinics	Iraqi Medical Association	Ministry of Health and Iraqi Medical Association
Public and private hospitals	Ministry of Health	Ministry of Health

Oral preparations and intramuscular were the most commonly dispensed forms in community pharmacies (*19*), irrespective of whether they required a prescription or not. However, in public hospitals and clinics run by the government, dispensing any form of antibiotics required a doctor's prescription, suggesting that in Iraq antibiotics dispensing is more controlled in the public sector than in the private sector. Implementing an electronic referencing system in community pharmacies was beyond the scope of this study and capabilities of the Syndicate of Iraqi Pharmacists (Table 1).

Antibiotic availability and affordability

Kimadia, officially known as the State company for marketing drugs and medical appliances, operates under the Ministry of Health in Iraq. It is responsible for the procurement and distribution of pharmaceuticals and medical supplies for Iraq's public healthcare sector. Any medications including antibiotics must be approved, registered and tested before being procured for public healthcare facilities (*18*). Kimadia plays a central role in ensuring availability of medications, including antibiotics, in public hospitals. Antibiotics availability in the public sector depends on Kimadia's limited budget which is not sustainable and causes occasional shortages of medications, including antibiotics, in public hospitals..

Regarding availability, the private sector has more types and suppliers of antibiotics the public sector. Regarding sustainability, the public sector may suffer from shortage of medications because of reliance on the Kimadia budget which is usually around US$ 1 billion annually (*3*). Since the comprehensive list of medications approved for the private sector includes a wider range of drugs compared than the Essential Medicines List used in public healthcare settings, the private sector benefits from more sustainable supplies of medications, including antibiotics, which are procured by scientific drug bureaux (*18-21*).

The scientific drug bureaux are the main suppliers of medications to the private sector (*22*). Due to the large number of drug bureaux, antibiotics in the private sector are typically procured from various sources and companies, ensuring a more sustainable supply. However, while regulations require prescriptions for antibiotic dispensing, these laws are not consistently enforced, largely due to the lack of electronic systems in community pharmacies. This makes it difficult for official audits to monitor paper records and bills in a timely manner. Therefore, it is crucial that community pharmacists receive training on antibiotic stewardship, and health officials must enforce regulations to prevent the dispensing of antibiotics without a prescription.

Antibiotics are subsidized by the Iraqi government in the public healthcare sector. In contrast, patients need to pay full costs out-of-pocket to purchase antibiotics from community pharmacies (*18*). The costs of antibiotics depend on where the medication is sourced from and manufactured (*20*). Brand name antibiotics and those manufactured in

North America and Europe are typically more expensive than those manufactured in Africa and Asia.

Self-medication and knowledge/attitudes towards antibiotic use

The general population, along with medical and pharmacy students, showed inadequate knowledge of antibiotic resistance, which agreed with the high rate of self-medication. Eight cross-sectional studies conducted across 5 provinces (Baghdad, Mosul, Erbil, Anbar and Wassit) assessed antibiotic knowledge, attitudes and self-medication practices. Sample sizes ranged from 100 to 500 participants (23-26). Four of the 8 studies focused on self-medication and revealed a significant prevalence of antibiotic use without a prescription among the general population and medical or pharmacy students (*23-26*). A high percentage (88-90%) of people in Baghdad, Mosul and Erbil used antibiotics without a prescription (*23,25*). Four studies indicated inadequate knowledge about antibiotics and their use among the general population, medical and pharmacy students, and even some practicing pharmacists (*23,27-29*).

A study in Wassit Province of 102 community members, pharmacists and healthcare providers reported inadequate knowledge of antibiotic resistance and rational use (*27*). Only 20% of the final-year pharmacy students at a leading college of pharmacy in Baghdad had adequate knowledge of antibiotic resistance (*29*). A study of 2 medical colleges found that 73% of the participating students had self-medicated with antibiotics in the previous few months (*26*). All 8 studies confirmed that the general population including medical, or pharmacy students required further training on antibiotic resistance and rational use.

Antibiotic susceptibility

Thirteen national studies investigated antibiotic susceptibility profiles of clinically isolated bacteria, including bacteria-induced urinary tract infection (UTI), *Escherichia coli, and Pseudomonas aeruginosa* by province (*33-34,38-41*). Three provincial studies (Thi-qar, Sulaimaniyah and Kirkuk) assessed the susceptibility pattern of *Pseudomonas aeruginosa*. These studies found multi-drug-resistant strains that were resistant to penicillin (100% to ticarcillin, 95% to amoxiclav, 92.5% to amoxicillin and 95% to ampicillin), third generation cephalosporins (95% to cefixime and 100% to ceftazidime) and aminoglycosides (85.3% to gentamycin and 76.2% to tobramycin) (*30-32*). Seven studies from Duhok, Tikrit, Al-Najaf, Maysan, and Al-Diwaniya provinces, evaluated the susceptibility of bacterial UTIs to different antibiotics. *Escherichia coli* was identified as the most common cause of UTI and was multi-drug resistant (*33,34*). A study in Duhok Province, including 1585 patients with UTI found that 80.56% of identified *E. coli* was multidrug resistant to β-lactamase and macrolides antibiotics (*35*). Similarly, a study in 4 public hospitals in Maysan Province found that *E. Coli* was resistant to multiple beta-lactam antibiotics, including but not limited to: piperacillin (92%), ticarcillin (91%) and amoxicillin-clavulanic acid (88%; 36). Al-Diwaniya Province reported multidrug resistant UTIs caused by *E. coli*, with resistance to ampicillin (97.9%) and ceftriaxone (81.3%) (*37*).

A study in Erbil, which compared clinical and soil isolates of *Acinetobacter baumannii* found that the clinical isolates were 100% resistant to ciprofloxacin, ceftazidime, and piperacillin, 96.15% resistant to gentamicin, 96.15% resistant to imipenem, 92.31% resistant to meropenem and 78.85% resistant to amikacin (*42*). We reviewed one study that investigated the consumption and cost of antibiotics. This study measured the total consumption and cost of antibiotics in Al-Najaf Province in both the public and private sectors, indicating that antibiotic consumption in this single Iraqi Province was higher in one year than in an entire European country (*19*).

This high prevalence of multi-drug-resistant bacteria was confirmed by an unpublished national AMR report of the Iraqi Ministry of Health in 2022 (*7*). Important antibiotics including third generation cephalosporines (cefotaxime and ceftriaxone) were reported to be ineffective for some bacteria (*Acinetobacter, Salmonella, Escherichia coli, Klebsiella pneumoniae and Neisseria gonorrhoeae*) with multi-drug resistance reaching 70%. Some strains displayed pan-drug resistance where they were resistant to nearly all available antibiotics (*7*). These data demand immediate action that will address the underlying causes of AMR in Iraq.

Antibiotic resistance and residue in domestic animals, animal products and drinking water

Three studies detected antibiotic resistance or residues in agricultural and veterinary settings including river water, drinking water and raw beef (*43-45*). *E. coli* resistance to β-lactam antibiotic was found in 61 samples of river water in Babylon (*43*). In 2 water sanitation facilities in Baghdad, antibiotics were found in raw and treated water (*45*). A study in Erbil detected antibiotic residues in raw beef after testing 250 samples from the retail market (*44*).

There was no safe disposal of antibiotics in private pharmacies or at home, which made people to dispose antibiotics in water bodies or soil (*46*). Three studies found multi-antibiotic-resistant bacteria between animals and humans. Some recent studies in Basra and Babylon provinces detected antibiotic-resistance bacteria in domesticated animals (*47-48*). Similar to humans, a study of 77 dogs with diarrhoea found resistant *E. Coli* (9.5–81%) to be the common cause. A study which collected 75 swabs from different animal wounds treated in veterinary clinics found 100% resistance in *Pseudomonas aeruginosa* when tested for susceptibility to 9 commonly used antibiotics including Ampicillin, Piperacillin, Amoxicillin, Cefepime, Cefotaxime, Ceftazidime, Aztreonam, Trimethoprim and Chloramphenicol (*48*). A phylogenetic analysis of 300 samples from 6 sources (100 from humans, 100 from animals, and 100 from animal houses) in Basra and Baghdad revealed that resistant

strains of *Salmonella* showed similar patterns among humans and animals (*49*).

Discussion

Multi-drug-resistant bacteria, such as *E. coli* and *P. aeruginosa*, were detected in all Iraqi public and private healthcare settings. Our review indicates that physicians in Iraq prescribe antibiotics empirically (*10-11,13*), particularly for acutely ill patients. A majority of Iraqi physicians working in public hospitals prescribe antibiotics frequently and empirically, without relying on culture and sensitivity tests, and community pharmacists commonly diagnose and dispense antibiotics without prescriptions. We suggest that Iraqi Ministry of Health (MOH) regulations about antibiotic stewardship should be enforced in private and public hospitals.

Several studies have reported high levels of antibiotic self-medication in Iraq. Although AMR stewardship regulations exist, they are not fully implemented by prescribers. In general, AMR stewardship is better adopted in public hospitals than the private sector (private hospitals and clinics), and there is no safe disposal of antibiotics in private pharmacies or homes.

Our review has several limitations. We used only one search engine (Google Scholar) with limited keywords to collate articles for our review. This may have limited the scope and accuracy of our search and our review did not evaluate the quality of the included studies. Systematic review with meta-analysis of antibiotic misuse in Iraq is recommended for future studies.

Conclusion and recommendations

Antibiotic stewardship requires a stronger and more coordinated effort, particularly by health officials in both public and private healthcare sectors. It is imperative for health authorities to evaluate antibiotic residues in food, water, and animals, as misuse and improper disposal contribute to environmental contamination. Public awareness campaigns are crucial in reducing antibiotic misuse and universities should incorporate AMR-related courses into the core curricula for medical, pharmacy, dentistry, veterinary, biology and nursing training. Stricter enforcement of regulations is needed to curb the irrational sale of antibiotics in the veterinary sector. The establishment of facilities for the safe disposal of expired antibiotics in community and private pharmacies is essential. Significant attention must be given to the private sector, where antibiotics dispensing without prescriptions remains a major concern. Finally, securing funding from national and international sources will be critical to support Iraqi AMR awareness and monitoring.

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Conflict of interest: None declared.

Analyse du mauvais usage des antibiotiques et de la résistance bactérienne en Iraq

Résumé

Contexte : La résistance aux antimicrobiens représente un risque sérieux pour les soins de santé dans le monde entier. Il est primordial d'analyser les pratiques actuelles concernant la prescription et l'usage des antibiotiques afin de comprendre les problèmes liés à la résistance aux antimicrobiens en Iraq et de trouver des solutions pour y remédier.

Objectifs : Passer en revue et analyser des études portant sur la résistance aux antimicrobiens ainsi que sur la prescription, la délivrance et l'usage des antibiotiques en Iraq.

Méthodes : En juin 2023, nous avons effectué des recherches dans Google Scholar et passé en revue des études empiriques relatives à l'usage des antibiotiques et à la résistance aux antimicrobiens en Iraq.

Résultats : Trente-sept études éligibles publiées entre 2012 et 2023 ont été passées en revue. Des bactéries multirésistantes, telles qu'*E. coli* et *P. aeruginosa*, étaient fréquemment mentionnées dans les études. La plupart des médecins exerçant dans les hôpitaux publics prescrivaient souvent des antibiotiques de manière empirique sans se fier aux tests de culture et de sensibilité et les pharmaciens communautaires délivraient couramment des antibiotiques aux patients sans prescription, ce qui indique une automédication et un mauvais usage des antibiotiques en Iraq. Des résidus d'antibiotiques ont été signalés dans la viande crue et l'eau potable. Bien qu'il existe des réglementations et des plans de contrôle en matière de résistance aux antimicrobiens, ils n'ont pas été pleinement mis en œuvre.

Conclusion : La présente analyse montre que la résistance aux antimicrobiens et le mauvais usage des antibiotiques constituent de graves problèmes en Iraq. Les autorités responsables devraient collaborer dans le but de mettre en œuvre et de faire appliquer les plans de contrôle en matière de résistance aux antimicrobiens dans le cadre de l'approche « Une seule santé ».

استعراض لإساءة استخدام المضادات الحيوية ومقاومة البكتيريا في العراق

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الخلاصة

الخلفية: إن مقاومة مضادات الميكروبات تهديد خطير للرعاية الصحية على مستوى العالم، ولهذا، فإن استعراض الممارسات الحالية المتصلة بالوصفات الطبية للمضادات الحيوية، واستخدام تلك المضادات الحيوية، يعد أمرا بالغ الأهمية لفهم قضايا مقاومة مضادات الميكروبات في العراق، وكيفية معالجتها.

الهدف: هدفت هذه الدراسة الى استعراض وتحليل الدراسات التي تتناول مقاومة مضادات الميكروبات، وكذلك الوصفات الطبية للمضادات الحيوية في العراق، وصرفها واستخدامها في العراق.

طرق البحث: في يونيو/ حزيران 2023، بحثنا في Google Scholar عن دراسات تجريبية متصلة باستخدام المضادات الحيوية ومقاومة مضادات الميكروبات في العراق، كما استعرضنا هذه الدراسات.

النتائج: شمل الاستعراض سبعًا وثلاثين دراسة مؤهلة نُشرت بين عامَي 2012 و2023. ويشيع في هذه الدراسات الإشارة إلى وجود بكتيريا مقاومة لأدوية متعددة، مثل "الإشريكية القولونية" و"الزائفة الزَّنجاريَّة". ووصَفَ معظم الأطباء في المستشفيات العامة المضادات الحيوية لمرضاهم بشكَل متكرر وتجريبي دون الاعتماد على اختبارات الزرع والتحسس، وغالبًا ما يصرف الصيادلة المجتمعيون المضادات الحيوية للمرضى دون وصفات طبية، الأمر الذي يشير إلى التداوي الذاتي وإساءة استخدام المضادات الحيوية في العراق. كما أُبلغَ عن وجود بقايا من المضادات الحيوية في اللحوم النيئة ومياه الشرب. وعلى الرغم من وجود لوائح وخطط لمكافحة مقاومة مضادات الميكروبات، فإنها لم تُنفَّذ تنفيذًا كاملاً.

الاستنتاجات: يبين هذا الاستعراضُ أن مقاومة مضادات الميكروبات وإساءة استخدام المضادات الحيوية تعد مشكلات خطيرة في العراق. وينبغي للسلطات المسؤولة أن تتعاون معًا لتنفيذ وإنفاذ الامتثال لخطط مكافحة مقاومة مضادات الميكروبات من خلال نهج الصحة الواحدة.

References

1. Poudel AN, Zhu S, Cooper N, Little P, Tarrant C, Hickman M, et al. The economic burden of antibiotic resistance: a systematic review and meta-analysis. PLoS One. 2023;18(5): doi: 10.1371/journal.pone.0285170
2. Dadgostar P. Antimicrobial resistance: implications and costs. Infection and drug resistance. 2019 Dec 20:3903-10. doi: 10.2147/IDR.S234610.
3. Brotherton AL. Metrics of antimicrobial stewardship programs. Medical Clinics of North America. 2018;102(5):965-76. DOI: 10.1016/j.mcna.2018.05.008
4. Ventola CL. The antibiotic resistance crisis: part 1: causes and threats. Pharmacy and therapeutics. 2015 Apr;40(4):277. PMID: 25859123
5. Wozniak TM, Dyda A, Merlo G, Hall L. Disease burden, associated mortality and economic impact of antimicrobial resistant infections in Australia. The Lancet Regional Health – Western Pacific. 2022;27. doi: 10.1016/j.lanwpc.2022.100521.
6. Shrestha P, Cooper BS, Coast J, Oppong R, Do Thi Thuy N, Phodha T, et al. Enumerating the economic cost of antimicrobial resistance per antibiotic consumed to inform the evaluation of interventions affecting their use. Antimicrobial Resistance & Infection Control. 2018;7(1):98. doi: 10.1186/s13756-018-0384-3
7. Rana Abdulmahdi Nahi, Basma Abdulrazzaq Atta, Asmaa A. Tawfeeq. Annual report of Iraq antimicrobial resistance surveillance system. In: program A, editor. Public Health Directorate, Ministry of Health; Baghdad, Iraq 2022. (This is a governmental report and not available online).
8. Dyar OJ, Huttner B, Schouten J, Pulcini C. What is antimicrobial stewardship? Clinical Microbiology and Infection. 2017;23(11):793-8. doi: 10.1016/j.cmi.2017.08.026.
9. Kurmanji J, Hassali A, Versporten A, Younus M, Pauwels I, Goossens H, et al. Global point prevalence survey in five teaching hospitals in Baghdad, Iraq. Mediterranean Journal of Infection Microbes and Antimicrobials. 2021;10. DOI: 10.4274/mjima.galenos.2021.2020.17

10. Al-Jumaili AA, Khalid K, Mawla E, Majeed I, Alrekabi M. Irrational use of antibiotics in Iraqi public hospitals. Latin American Journal of Pharmacy. 2023;42:178-83. Available from: https://www.researchgate.net/profile/Ali-Azeez-Al-Jumaili/publication/371263886_Irrational_Use_of_Antibiotics_in_Iraqi_Public_Hospitals/links/64a18577c41fb852dd45c52e/Irrational-Use-of-Antibiotics-in-Iraqi-Public-Hospitals.pdf

11. Abutiheen A, Sallum H, Obaid N. Misuse of antibiotics in Al-Hussein Teaching Hospital in Kerbala. Karbala Journal of Medicine. 2017;10:2732-9. Available from: https://www.iasj.net/iasj/download/5592d22eeff2802f

12. Al-Jawadi H, Alwiswasi N. An assessment study of using meropenem injection in Iraqi hospitals. International Journal of Pharmaceutical Science and Research. 2017;2(5):14-7. Available from: https://www.researchgate.net/publication/330874405_An_assessment_study_of_using_Meropenem_Injection_in_Iraqi_Hospitals

13. Salih N, Kadhim D. Adherence to American Society of Health-System Pharmacists surgical antibiotic prophylaxis guideline in medical city teaching hospitals/Baghdad. Iraqi Journal of Pharmaceutical Sciences. 2016;25:2016. DOI: https://doi.org/10.31351/vol25iss2pp40-45

14. Hussein M, Majeed B. Prescribing pattern of antibiotics in Al-Elwia Pediatric Teaching Hospital, Baghdad, 2016. Al-Kindy College Medical Journal. 2017;13:117-26. DOI: https://doi.org/10.47723/kcmj.v13i2.108

15. Al-Nema Z. Trend of antibiotics usage in the intensive care unit in the medical city in Baghdad. Iraqi Journal of Pharmaceutical Sciences. 2016;25. DOI: https://doi.org/10.31351/vol25iss1pp50-58

16. Mikhael EM. Evaluating the rationality of antibiotic dispensing in treating common cold infections among pharmacists in Baghdad – Iraq. Journal of Pharmaceutical Research International. 2014;4(23):2653-61. DOI: 10.9734/BJPR/2014/13586

17. Alkadhimi A, Dawood OT, Hassali MA. Dispensing of antibiotics in community pharmacy in Iraq: a qualitative study. Pharmacy practice. 2020;18(4):2095. doi: 10.18549/PharmPract.2020.4.2095.

18. Ali Azeez Al-Jumaili MMY, Yasmine J.A. Kannan, Zinah E. Nooruldeen, Adi Al-Nuseirat. Pharmaceutical regulations in Iraq: from medicine approval to post-marketing. East Mediterranean Health Journal. 2021;27(doi.org/10.26719/emhj.21.025). doi: 10.26719/emhj.21.025

19. Al-Jumaili AA, Hussein AH, Al-Rekabi MD, Raheem SA, Ernst EJ. Antimicrobial utilization in an Iraqi province: a comprehensive evaluation of antibiotic source and cost. International Journal of Pharmacy Practice. 2017;25(1):81-8. DOI: 10.1111/ijpp.12338 doi: 10.1111/ijpp.12338

20. Al-Jumaili AA. Iraq pharmaceutical country profile 2020. Available from: https://www.researchgate.net/publication/350043204_IRAQ_PHARMACETUICAL_COUNTRY_PROFILE_2020

21. Ahmed KK, Younus MM, Al-Jumaili AA. Pharmacy education, practice, and research in Iraq. In: Al-Worafi YM, editor. Handbook of Medical and Health Sciences in Developing Countries: education, practice, and research. Cham: Springer International Publishing; 2023. p. 1-27.

22. Al-Jumaili AA, Hussain SA, Sorofman B. Pharmacy in Iraq: history, current status, and future directions. American Journal of Health-System Pharmacy. 2013;70(4):368-72. DOI: 10.2146/ajhp120415

23. Al-Tukmagi H, Al-Qazaz H, Shanshal S, Al-Kaisey M. Self-medication towards antibiotic use among non-medical university staff. Iraqi Journal of Pharmaceutical Sciences. 2023;31. DOI: https://doi.org/10.31351/vol31issSuppl.pp9-17

24. Salim KS, Hasan EK, Numan IT. Prevalence of antibiotic use among medical students in Iraq. Systematic Reviews in Pharmacy. 2021;12(2). doi: 10.31838/srp.2021.2.70

25. Muhammed R, Al-Ani A, Yassen A. Self-medication with antibiotics among public population in Erbil City. Journal of Pharmaceutical Research International. 2021;33:25-33. DOI: 10.9734/jpri/2021/v33i44B32649

26. Al Shawi AF, Ali AF, Enad MM, Salih JA. Self-medication among medical students in Anbar and Fallujah universities–Iraq. Journal of the Faculty of Medicine Baghdad. 2018 Dec 31;60(3):156-9. DOI: https://doi.org/10.32007/jfacmedbagdad.603606

27. Kanaan MH, Tarek AM, Abdullah SS. Knowledge and attitude among samples from community members, pharmacists and health care providers about antibiotic resistance in Al-Suwaria City/Wassit Province/Iraq. In IOP Conference Series: Earth and Environmental Science. 2021 Jun 1 (Vol. 790, No. 1, p. 012059). IOP Publishing. DOI: 10.1088/1755-1315/790/1/012059

28. Al-Yasseri BJH, Hussain NAJ. Public knowledge and attitudes towards antibiotics use and resistance in Baghdad, Iraq: a survey conducted in the outpatient department of a university teaching hospital. The Open Public Health Journal. 2019;12(1). DOI: 10.2174/1874944501912010567

29. Mikhael E, Khudair Hassan M, Abdulridha S. Assessment of antibiotic knowledge among final year pharmacy students at Baghdad University. The Open Public Health Journal. 2019;12:379-83. DOI: 10.2174/1874944501912010379

30. Alzaidi JR. Antibiotic susceptibility patterns of Pseudomonas aeruginosa isolated from clinical and hospital environmental samples in Nasiriyah, Iraq. African Journal of Microbiology Research. 2016;10:844-9. DOI: 10.5897/AJMR2016.8042

31. Othman N, Babakir-Mina M, Noori CK, Rashid PY. Pseudomonas aeruginosa infection in burn patients in Sulaimaniyah, Iraq: risk factors and antibiotic resistance rates. The Journal of Infection in Developing Countries. 2014;8(11):1498-502. doi: 10.3855/jidc.4707

32. Hasan SA, Najati AM, Abass KS. Prevalence and antibiotic resistance of Pseudomonas aeruginosa isolated from clinical samples in Kirkuk City, Iraq. Eurasia Journal of Biosciences. 2020 Jan 1;14(1):1821-5. Available from: https://www.researchgate.net/publication/342898198_Prevalence_and_antibiotic_resistance_of_pseudomonas_aeruginosa_isolated_from_clinical_samples_in_Kirkuk_City_Iraq

33. Majeed HT, Aljanaby AA. Antibiotic susceptibility patterns and prevalence of some extended-spectrum beta-lactamases genes in gram-negative bacteria isolated from patients infected with urinary tract infections in Al-Najaf City, Iraq. Avicenna Journal of Medical Biotechnology. 2019 Apr;11(2):192. PMID: 31057723.

34. Al-Jebouri MM, Mdish SA. Antibiotic resistance pattern of bacteria isolated from patients of urinary tract infections in Iraq. Open Journal of Urology. 2013;3:124-31. DOI: 10.4236/oju.2013.32024

35. Assafi M, Ali F, Polis R, Sabaly N, Qarani S. An epidemiological and multidrug resistance study for E. coli isolated from urinary tract infection (three years of study). Baghdad Science Journal. 2021;19:7-15. DOI: https://doi.org/10.21123/bsj.2022.19.1.0007

36. Allami M, Bahreini M, Sharifmoghadam MR. Antibiotic resistance, phylogenetic typing, and virulence genes profile analysis of uropathogenic Escherichia coli isolated from patients in southern Iraq. Journal of Applied Genetics. 2022;63(2):401-12. doi: 10.1007/s13353-022-00683-2

37. Al-Fatlawi B, Jasim A. Determining the prevalence of upper and lower urinary tract infections' pathogens and their antibiotic susceptibility profile for adult patients in Al-Diwaniya, Iraq. Iraqi Journal of Pharmaceutical Sciences. 2022;31. DOI: https://doi.org/10.31351/vol31issSuppl.pp86-91

38. Assafi MS, Ibrahim NM, Hussein NR, Taha AA, Balatay AA. Urinary bacterial profile and antibiotic susceptibility pattern among patients with urinary tract infection in Duhok City, Kurdistan Region, Iraq. International Journal of Pure and Applied Sciences and Technology. 2015 Oct 1;30(2):54. Available from: https://www.researchgate.net/publication/292605642_Urinary_Bacterial_Profile_and_Antibiotic_Susceptibility_Pattern_among_Patients_with_Urinary_Tract_Infection_in_Duhok_City_Kurdistan_Region_Iraq

39. Naqid IA, Balatay AA, Hussein NR, Saeed KA, Ahmed HA, Yousif SH. Antibiotic susceptibility pattern of Escherichia coli isolated from various clinical samples in Duhok City, Kurdistan Region of Iraq. International Journal of Infection. 2020 Apr 30;7(3). https://doi.org/10.5812/iji.103740

40. Hussein NR, Daniel S, Salim K, Assafi. Urinary tract infections and antibiotic sensitivity patterns among women referred to Azadi Teaching Hospital, Duhok, Iraq. Avicenna Journal of Clinical Microbiology and Infection. 2018;5(2):27-30. doi: 10.34172/ajcmi.2018.05

41. Aljanaby AA, Gafil FA. Effect of different antibiotics on aerobic pathogenic bacteria and urinary tract infection in Al-Manathera City, Iraq: a comparative study. Research on Chemical Intermediates. 2013 Oct;39:3679-87. https://doi.org/10.1007/s11164-012-0871-8

42. Hassan PA, Khider AK. Correlation of biofilm formation and antibiotic resistance among clinical and soil isolates of Acinetobacter baumannii in Iraq. Acta Microbiologica et Immunologica Hungarica. 2020;67(3):161-70. https://doi.org/10.1556/030.66.2019.026

43. Alwash MS, Al-Rafyai HM. Antibiotic resistance patterns of diverse Escherichia coli phylogenetic groups isolated from the Al-Hillah River in Babylon Province, Iraq. The Scientific World Journal. 2019. 5927059:8 pages. https://doi.org/10.1155/2019/5927059

44. Al-Mashhadany DA. Detection of antibiotic residues among raw beef in Erbil City (Iraq) and impact of temperature on antibiotic remains. Italian Journal of Food Safety. 2019 Mar 18;8(1):7897. doi: 10.4081/ijfs.2019.7897

45. Mahmood AR, Al-Haideri HH, Hassan FM. Detection of antibiotics in drinking water treatment plants in Baghdad City, Iraq. Advances in Public Health. 2019, 7851354:10 pages. https://doi.org/10.1155/2019/7851354

46. Ahmad Al-Jalehawi, Radhwan Nidal Al-Zidan, Sumayah Al-Mahmood et al. Exploring household medicine waste in Iraq. 2022 May 05. PREPRINT (Version 1). Available from: Research Square. https://doi.org/10.21203/rs.3.rs-1613875/v1

47. Naji H, Saleh W, Saud Z, Mhahal T, Alhasson F, Reddy G, et al. Prevalence of resistance and virulence genes in Escherichia coli isolates from diarrheic dogs. Iraqi Journal of Veterinary Sciences. 2023;37:355-61. DOI: 10.33899/IJVS.2022.133514.2243

48. Hussein A, Al-Yassari AK. Phylogenic diversity of some Pseudomonas isolates from wound infection in Babylon Province. International Journal of Health Sciences. 2022;6(S6):2932-43. https://doi.org/10.53730/ijhs.v6nS6.10520

49. Al-Hamami M, Othman R. Phylogenetic tree constructed of Salmonella enterica subspecies enterica isolated from animals and humans in Basrah and Baghdad governorates, Iraq. Iraqi Journal of Veterinary Sciences. 2022;36:895-903. DOI: 10.33899/IJVS.2022.132478.2096

50. World Health Organization. Global antimicrobial resistance and use surveillance system (GLASS) report 2022. Geneva: World Health Organization; 2022. Available from: https://www.who.int/publications/i/item/9789240062702