

Original Research

Received 01 July 2026

Revised 09 Aug 2026

Accepted 22 Aug 2026

Natural Resources for Human Health 2026, Vol. 6 (17s): 165–174

KEYWORDS:

Antimicrobial resistance; Antibiotic prescribing; WHO/INRUD prescribing indicators; AWaRe classification; Antimicrobial stewardship; Iraq.

Antibiotic Prescribing and Antimicrobial Resistance in Outpatient Facilities in Missan Province, Iraq: A Cross-Sectional Study

Raad Kareem Alwan Al Darraji¹, Mohammed Amran^{1,2}, Adiba Saaduldeen Ali¹, Mohsen Hamoud Jasim^{3,*}

¹College of Pharmacy, University of Manara, Maysan 62001, Iraq

²Department of Pharmacy, Faculty of Health Sciences, Thamar University, Thamar 87246, Yemen

³Department of Medical Devices Engineering, Al-Salam University College, Baghdad, Iraq

*Corresponding author: Mohsen Hamoud Jasim, Department of Medical Devices Engineering, Al-Salam University College, Baghdad, Iraq. E-mail: mohsen07829431518@gmail.com; ORCID: 0009-0001-7879-562X.

ABSTRACT: Iraqi evidence linking antibiotic prescribing indicators to resistance data is scarce. This cross-sectional study evaluated outpatient prescribing using the WHO/INRUD core indicators and characterised antimicrobial resistance in Missan Province, Iraq. Twelve facilities were studied in 2023: four each of primary healthcare centres, hospital outpatient departments and private clinics. 1,847 consecutive prescriptions from January–June 2023 were reviewed against these indicators and the WHO AWaRe classification; during July–December 2023, 380 specimens from prospectively recruited adults were cultured and tested by disk diffusion per CLSI M100, with extended-spectrum beta-lactamase (ESBL) production and methicillin resistance confirmed phenotypically. Analyses used ANOVA and chi-square tests ($P < 0.05$). All five indicators fell outside WHO reference values: antibiotics were prescribed at 68.4% of encounters (95% CI 66.3–70.5%; reference 30%) and injections at 24.2% (reference 10%), with 3.2 ± 0.9 medicines per encounter; 40.7% of medicines were generic and 66.4% of prescriptions conformed to the national essential medicines list. Private clinics performed worst and primary healthcare centres best on every indicator, antibiotic prescribing differing by 10.4 percentage points. At least 36.5% of antibiotics were Watch group and none Reserve. 284 specimens (74.7%) were culture-positive: *Escherichia coli* 90 (31.7%), *Staphylococcus aureus* 53 (18.7%) and *Klebsiella pneumoniae* 41 (14.4%). ESBL production occurred in 34.4% of *E. coli* and 46.3% of *K. pneumoniae*, and methicillin resistance in 31.1% of *S. aureus*. Prescribing greatly exceeded WHO reference values, most markedly in private clinics, alongside substantial resistance among common pathogens; stewardship across public and private outpatient care with sustained surveillance is required.

1. INTRODUCTION

Antimicrobial resistance (AMR) is among the leading infectious causes of death worldwide. Global estimates attribute 1.14 million deaths directly to bacterial AMR in 2021 and associate it with a further 4.71 million, with attributable deaths projected to reach 1.91 million annually by 2050 (GBD 2021 Antimicrobial Resistance Collaborators, 2024; Murray et al., 2022). The burden falls disproportionately on low- and middle-income countries (LMICs), where limited diagnostic capacity and weak

surveillance allow resistant organisms to spread undetected (Laxminarayan et al., 2013). The World Health Organization (WHO) has accordingly identified AMR as a priority requiring action on both antibiotic consumption and surveillance (WHO, 2023a).

Antibiotic consumption is the principal modifiable driver of that burden, and global consumption rose substantially between 2000 and 2018, most steeply in LMICs (Browne et al., 2021). The link with resistance is established at population level, where national outpatient use correlates with resistance prevalence (Goossens et al., 2005), and at individual level, where recent exposure predicts carriage of resistant organisms for up to twelve months (Costelloe et al., 2010). Because most antibiotics are dispensed in ambulatory care, outpatient prescribing disproportionately shapes community resistance, and its quality is frequently poor: a systematic review of LMIC primary care found a pooled prescribing prevalence of 52% (95% CI 51–53%), much of it inappropriate (Sulis et al., 2020).

Two standardised instruments allow prescribing quality to be compared. The WHO and International Network for Rational Use of Drugs (WHO/INRUD) core indicators quantify medicines per encounter, generic prescribing, encounters involving an antibiotic or injection, and adherence to the national essential medicines list (Ofori-Asenso et al., 2016; WHO, 1993). The WHO Access, Watch and Reserve (AWaRe) classification groups agents by spectrum and resistance-selection potential, and underpins the target that Access-group agents constitute at least 70% of consumption (WHO, 2023b).

Iraq shows the regional pattern: empirical prescribing predominates, microbiological confirmation is seldom obtained before treatment, over-the-counter supply is widespread and stewardship is applied unevenly (Al-Jumaili and Ahmed, 2024). Iraq participates in the WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS), but national figures conceal variation between provinces and between the public and private sectors (WHO, 2024). Iraqi studies have generally examined either prescribing or resistance within one facility type, and rarely include the private sector. This study therefore evaluated outpatient antibiotic prescribing using the WHO/INRUD indicators and the AWaRe classification, and characterised the resistance profiles of bacterial isolates from patients attending primary healthcare centres, hospital outpatient departments and private clinics across Missan Province, for which no provincial data have been published.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

This cross-sectional observational study was conducted during 2023 in Missan Province, south-eastern Iraq, a province of about 1.3 million people served by one teaching hospital, six district hospitals, some 60 primary healthcare centres and a large private sector. It comprised two components (Figure 1): a retrospective review of outpatient prescriptions issued between January and June 2023, and a microbiological investigation between July and December 2023. These covered different six-month periods and did not involve the same patients, so the datasets are not linked at patient level and no association between individual exposure and resistance was examined.

Twelve facilities were selected purposively: four primary healthcare centres, four hospital outpatient departments (two teaching, two district) and four private general practices, across urban Al-Amarah ($n = 6$) and rural sub-districts ($n = 6$). Facilities were eligible if they kept legible prescription records, could transport specimens to the provincial laboratory within two hours, and consented; those with fewer than 50 weekly outpatient encounters were excluded.

2.2 Prescription Review and WHO/INRUD Indicators

In total, 1,847 consecutive prescription records were reviewed, distributed proportionally to facility patient volume; incomplete, illegible or duplicated records were excluded. A structured form captured age, sex, prescriber qualification, diagnosis, and every prescribed medicine with dose, route and duration. Five WHO/INRUD core indicators were computed and compared with WHO optimal reference values (WHO, 1993): mean medicines per encounter; the percentage of encounters containing at least one antibiotic and at least one injectable medicine; the percentage of medicines prescribed by generic name (denominator: total medicines); and the percentage of prescriptions conforming to the Iraqi National Essential Medicines List (NEML, 2021 edition). To assess extraction reliability, 10% of records were re-abstracted by a second reviewer blinded to the original entry, with very good agreement (Cohen's kappa = 0.91). Prescribed antibiotics were classified by pharmacological class and mapped to the WHO AWaRe categories (WHO, 2023b); because AWaRe is assigned per agent rather than per class, classes spanning two categories are reported as such and the Access-group share could not be computed exactly.

2.3 Patient Recruitment and Specimen Collection

Adults aged 18 years or older with clinical features of bacterial infection warranting antibiotic treatment were recruited prospectively; those who had taken antibiotics within the preceding 14 days, were immunosuppressed or were pregnant were excluded. Specimens were obtained from 380 patients before antibiotics were started: mid-stream urine ($n = 142$), throat or nasal swabs ($n = 88$), wound swabs ($n = 86$) and expectorated sputum ($n = 64$). All reached the provincial teaching hospital microbiology laboratory within two hours.

2.4 Bacterial Identification

Urine was cultured on cystine–lactose–electrolyte-deficient agar and other specimens on blood, MacConkey and chocolate agar (37 °C, 24–48 h). Isolates were identified by colony morphology, Gram staining and biochemical testing, supplemented by API 20E/NE strips where available. Significant bacteriuria was at least 10^5 colony-forming units/mL; sputum with more than 10 squamous epithelial cells per low-power field was rejected, and mixed or contaminated cultures were excluded.

2.5 Antimicrobial Susceptibility Testing and Resistance Phenotypes

Susceptibility was determined by Kirby–Bauer disk diffusion on Mueller–Hinton agar using a 12-agent panel, with a 0.5 McFarland inoculum read after 16–18 h at 37 °C and interpreted per Clinical and Laboratory Standards Institute (CLSI) M100 breakpoints (CLSI, 2023). Resistance is the percentage of isolates categorised resistant. Daily quality control used ATCC reference strains 25922, 25923 and 27853. Extended-spectrum beta-lactamase (ESBL) production was screened in all Enterobacterales by the combined disk test (cefotaxime with and without clavulanic acid) and confirmed by a zone-diameter increase of at least 5 mm. Methicillin resistance was detected by oxacillin disk and confirmed by cefoxitin disk. Both are phenotypic; no molecular confirmation was performed.

2.6 Statistical Analysis

Data were analysed in IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean $\pm$ standard deviation (SD) and categorical variables as frequencies and percentages. Continuous variables were compared by one-way analysis of variance (ANOVA); with more than 480 prescriptions per group this is robust to the moderate non-normality expected of count data, although distributional assumptions were not formally tested. Categorical variables were compared by Pearson chi-square test, the smallest expected cell frequency exceeding 100 throughout. Ninety-five per cent confidence intervals (CI) for proportions used the normal-approximation method, and absolute differences between private clinics and primary healthcare centres are reported with 95% CIs. Pooled all-facility values for the injection, generic-name and NEML indicators were obtained by weighting setting-specific values by the corresponding denominator. A two-tailed $P < 0.05$ was considered significant.

2.7 Ethical Considerations

Ethics approval has been obtained with letter number 2022/1850 dated 27 August 2022 from the Research Ethics Committee, Missan Health Directorate, Ministry of Health, Iraq. Administrative permission to access prescription records and laboratory data was granted by the participating facilities through the Directorate. All patients providing specimens gave written informed consent. Patient identifiers were excluded from the prescription review and all data were anonymised before analysis. The study followed the Declaration of Helsinki.

3. RESULTS AND DISCUSSION

3.1 Characteristics of the Study Sample

The analysis included 1,847 encounters: 612 (33.1%) from primary healthcare centres, 748 (40.5%) from hospital outpatient departments and 487 (26.4%) from private clinics. Mean age was 34.7 ± 14.2 years, highest in hospital outpatient departments (36.8 ± 15.1) and lowest in primary healthcare centres (32.1 ± 13.4); 54.3% were female. Respiratory tract infections were the commonest recorded diagnosis (32.6%), followed by urinary tract infections (18.4%), gastrointestinal complaints (14.7%) and wound or skin infections (9.8%); the remaining 24.5% were other or unspecified.

3.2 WHO/INRUD Prescribing Indicators

Every core indicator fell outside the WHO optimal range and all five differed significantly across facility types (Table 1). Antibiotics were prescribed at 68.4% of encounters (95% CI 66.3–70.5%) against a reference of 30% ($\chi^2 = 12.34$, $P = 0.002$), injections at 24.2% against a reference of 10%, and a mean of 3.2 ± 0.9 medicines per encounter against a reference of two. Only 40.7% of medicines were prescribed by generic name, and 66.4% of prescriptions conformed to the NEML, against a reference of 100% for both.

Private clinics performed worst on all five indicators and primary healthcare centres best, differing by 10.4 percentage points for antibiotic prescribing, 13.4 for injections, 30.9 for generic prescribing and 34.6 for NEML conformity, all with 95% CIs excluding zero (Table 1). Hospital outpatient departments were intermediate except for medicines per encounter, which was highest in that setting (3.4 ± 1.0).

Table 1. WHO/INRUD core prescribing indicators across outpatient healthcare settings, Missan Province, Iraq, January–June 2023 (1,847 prescriptions).

Indicator	Primary healthcare centres (n = 612)	Hospital outpatient departments (n = 748)	Private clinics (n = 487)	All facilities (n = 1,847)	WHO optimal value	P	Private clinics vs primary healthcare centres, difference (95% CI)
Mean medicines per prescription (SD)	2.9 (0.7)	3.4 (1.0)	3.3 (0.9)	3.2 (0.9)	≤ 2.0	0.001	+0.4 (0.30 to 0.50)
Encounters with ≥ 1 antibiotic (%)	64.2	66.7	74.6	68.4	≤ 30	0.002	+10.4 (5.0 to 15.8)
Encounters with ≥ 1 injection (%)	18.3	24.1	31.7	24.2	≤ 10	< 0.001	+13.4 (8.3 to 18.5)
Medicines prescribed by generic name (%)	52.3	44.7	21.4	40.7	100	< 0.001	−30.9 (−34.0 to −27.8)
Prescriptions conforming to the NEML (%)	78.4	71.2	43.8	66.4	100	< 0.001	−34.6 (−40.1 to −29.1)

CI, confidence interval; INRUD, International Network for Rational Use of Drugs; NEML, Iraqi National Essential Medicines List; SD, standard deviation; WHO, World Health Organization. Continuous variables were compared by one-way ANOVA and categorical variables by Pearson chi-square test (antibiotic indicator: $\chi^2 = 12.34$, $P = 0.002$). Denominators differ by indicator: the antibiotic, injection and NEML indicators are prescription-based ($n = 1,847$) and the generic-name indicator is medicine-based (total medicines prescribed). All-facility values for the injection, generic-name and NEML indicators were obtained by weighting setting-specific values by the corresponding denominator. Differences are absolute (percentage points, or medicines per prescription for the first row).

3.3 Antibiotic Prescribing Patterns and the AWaRe Classification

Beta-lactams were the most frequently prescribed class overall (42.3%), followed by fluoroquinolones (21.7%) and macrolides (14.8%); together these accounted for 78.8% of antibiotic prescribing, and beta-lactams predominated in all three settings (Table 2). Fluoroquinolones and macrolides are Watch-group agents in their entirety, so at least 36.5% of prescribed antibiotics were Watch group; the remaining classes contain both Access and Watch agents, so the Access-group share could not be compared with the WHO 70% target. No Reserve-group agent was prescribed.

Table 2. Distribution of prescribed antibiotic classes across outpatient healthcare settings according to the WHO AWaRe classification.

Antibiotic class	Primary healthcare centres (%)	Hospital outpatient departments (%)	Private clinics (%)	All facilities (%)	WHO AWaRe category
Beta-lactams (penicillins and cephalosporins)	44.8	41.2	40.6	42.3	Access / Watch
Fluoroquinolones	19.3	23.4	22.1	21.7	Watch
Macrolides	16.2	13.9	14.4	14.8	Watch
Aminoglycosides	6.4	9.8	7.2	7.9	Access / Watch
Sulfonamide combinations (co-trimoxazole)	7.3	6.2	8.4	7.1	Access
Tetracyclines	3.8	3.1	4.7	3.7	Access
Other (metronidazole, chloramphenicol)	2.2	2.4	2.6	2.4	Access / Watch

AWaRe, Access, Watch and Reserve; WHO, World Health Organization. Percentages are of all antibiotics prescribed within each setting and may not total 100 because of rounding. No Reserve-group agent was prescribed in any setting. Classes are shown as spanning two AWaRe categories where they contain agents assigned to both, because AWaRe is defined at the level of the individual agent rather than the class; the Access-group share of total prescribing could not therefore be determined exactly.

3.4 Microbiological Findings

Of 380 specimens, 284 (74.7%) yielded significant monomicrobial growth. *Escherichia coli* predominated (90; 31.7%), followed by *Staphylococcus aureus* (53; 18.7%), *Klebsiella pneumoniae* (41; 14.4%) and *Pseudomonas aeruginosa* (28; 9.9%); *Streptococcus pyogenes* (22; 7.7%), *Proteus mirabilis* (19; 6.7%) and other species (31; 11.0%) made up the remainder. Enterobacterales accounted for 150 isolates (52.8%) (Table 3).

Table 3. Distribution of bacterial isolates recovered from 380 clinical specimens, July–December 2023.

Bacterial isolate	n	%
<i>Escherichia coli</i>	90	31.7
<i>Staphylococcus aureus</i>	53	18.7
<i>Klebsiella pneumoniae</i>	41	14.4
<i>Pseudomonas aeruginosa</i>	28	9.9
<i>Streptococcus pyogenes</i>	22	7.7
<i>Proteus mirabilis</i>	19	6.7
Other species	31	11.0
Total	284	100.0

Specimens comprised mid-stream urine (n = 142), throat or nasal swabs (n = 88), wound swabs (n = 86) and expectorated sputum (n = 64). Culture positivity was 284/380 specimens (74.7%); all culture-positive specimens yielded monomicrobial growth. Percentages are of the 284 isolates and may not total 100 because of rounding.

3.5 Antimicrobial Resistance Profiles

Resistance among the four principal isolates is shown in Table 4. Both Enterobacterales species exceeded 60% resistance to ampicillin, trimethoprim–sulfamethoxazole and tetracycline; resistance to amoxicillin–clavulanate (*E. coli* 52.2%, *K. pneumoniae* 68.3%) and cefotaxime (41.1% and 53.7%) was also substantial, and ciprofloxacin resistance approached 50% in both. Imipenem resistance was low but not absent (3.3%, 8.5% and 18.2% in *E. coli*, *K. pneumoniae* and *P. aeruginosa*). Among *S. aureus*, resistance was highest to tetracycline (66.0%), trimethoprim–sulfamethoxazole (52.8%) and erythromycin (47.2%), and no isolate was resistant to vancomycin.

Table 4. Antimicrobial resistance among the major bacterial isolates (percentage of isolates tested that were resistant).

Antimicrobial agent	<i>E. coli</i> (n = 90)	<i>K. pneumoniae</i> (n = 41)	<i>S. aureus</i> (n = 53)	<i>P. aeruginosa</i> (n = 28)
Ampicillin	87.8	90.2	–	–
Amoxicillin–clavulanate	52.2	68.3	43.4	–
Cefazolin	44.4	56.1	–	–
Cefotaxime	41.1	53.7	–	–
Ciprofloxacin	48.9	46.3	30.2	39.3
Gentamicin	38.9	43.9	26.4	32.1
Trimethoprim–sulfamethoxazole	68.9	75.6	52.8	–
Tetracycline	61.1	68.3	66.0	–
Erythromycin	–	–	47.2	–
Clindamycin	–	–	34.0	–
Imipenem	3.3	8.5	–	18.2
Vancomycin	–	–	0.0	–
ESBL-producing isolates	34.4	46.3	–	–
Methicillin-resistant isolates (MRSA)	–	–	31.1	–

ESBL, extended-spectrum beta-lactamase; MRSA, methicillin-resistant *Staphylococcus aureus*. Susceptibility was determined by Kirby–Bauer disk diffusion on Mueller–Hinton agar and interpreted according to CLSI M100. A dash (–) indicates that the agent is not applicable to that species or was not tested. ESBL production was screened by the combined disk test (cefotaxime with and without clavulanic acid) and confirmed by a zone-diameter increase of at least 5 mm; methicillin resistance was detected by oxacillin disk and confirmed by ceftiofloxacin disk. Both are phenotypic determinations; no molecular confirmation was performed.

3.6 ESBL and MRSA Findings

ESBL production was confirmed in 34.4% of *E. coli* and 46.3% of *K. pneumoniae*, and methicillin resistance in 31.1% of *S. aureus* (Table 4). Cefotaxime resistance exceeded the corresponding ESBL proportion in both species, indicating that cephalosporin resistance was not confined to ESBL-producing isolates.

3.7 Discussion

Across 12 outpatient facilities in Missan Province, every WHO/INRUD core indicator fell outside the WHO optimal range, prescribing quality declined from primary healthcare centres through hospital outpatient departments to private clinics, and isolates from the same facilities carried substantial resistance to most orally available first-line agents. The datasets come from different periods and patients and cannot be linked causally, but together they describe a setting where broad empirical use coincides with resistance sufficient to compromise it.

An antibiotic prescribing rate of 68.4% is more than double the WHO reference value and well above the pooled LMIC primary care estimate of 52% (Sulis et al., 2020). It also exceeds values reported with the same indicators from comparable facilities in Tanzania (Kilipamwambu et al., 2021) and Jordan (Al-Niemat et al., 2008), so the excess is marked even regionally. Low generic (40.7%) and NEML (66.4%) prescribing matters beyond cost: it fragments procurement and makes prescribing harder to audit, weakening the infrastructure stewardship depends on (Holloway et al., 2017).

The gradient between sectors was the most consistent finding and the effect sizes were large. Fee-for-service incentives, patient demand, shorter consultations and the limited reach of public-sector formularies and audit into private practice could each contribute, but this study was not designed to test these explanations. What the data establish is that a sector delivering much of outpatient care sits furthest from every benchmark while remaining outside existing stewardship arrangements.

At least 36.5% of prescribed antibiotics were Watch-group agents, driven by fluoroquinolones and macrolides, the classes whose empirical use WHO recommends restricting (WHO, 2023b). Recording antibiotics at agent level would allow the Access share to be measured against the 70% target.

The organisms recovered were those expected of community-acquired outpatient infection, and the isolate mix mirrors the specimen mix, dominated by suspected urinary and respiratory infection. Because recruitment required features judged to warrant antibiotics, these isolates represent infection severe enough to treat, not the full community spectrum.

The resistance profiles are the more consequential finding. Resistance above 60% to ampicillin, trimethoprim–sulfamethoxazole and tetracycline among Enterobacterales, approaching 50% to ciprofloxacin and above 40% to cefotaxime, means most orally available agents suitable for community prescribing would fail in a large minority to a majority of culture-confirmed infections. That amoxicillin–clavulanate resistance reached 68.3% in *K. pneumoniae* is notable given the predominance of beta-lactam prescribing in the same facilities, and these levels match the global picture of escalating Gram-negative resistance (Prestinaci et al., 2015). ESBL production in 34.4% of *E. coli* and 46.3% of *K. pneumoniae* is high for community isolates and carries the greatest implication for empirical therapy, since it confers resistance across penicillins and cephalosporins at once (Paterson, 2006); cefotaxime resistance exceeding the ESBL proportion suggests further mechanisms not characterised here. Methicillin resistance in 31.1% of *S. aureus* removes the antistaphylococcal beta-lactams from reliable empirical use in skin and soft tissue infection (Lowy, 2003).

These data bear on empirical prescribing policy rather than individual treatment decisions, which require susceptibility results. Low imipenem and absent vancomycin resistance should not be read as endorsing wider empirical use of these agents; reserving them is what preserves the activity observed. The appropriate response is the opposite of escalation: local antibiograms should inform facility-level guidelines, audit with feedback should reach the private sector, injectable and Watch-group agents be restricted to defined indications, and generic and NEML prescribing addressed through procurement policy (Davey et al., 2017). Sustaining susceptibility testing and reporting into GLASS returns is a prerequisite, not an adjunct (Dellit et al., 2007; WHO, 2024).

3.8 Strengths and Limitations

The study applies standardised, internationally comparable indicators across 12 facilities, includes the private sector alongside public care, pairs prescribing with microbiological data from the same facilities within one year, and used duplicate extraction and phenotypic confirmation of ESBL and methicillin resistance. Its limitations are equally clear. The setting was a single province with purposively selected facilities, so findings should not be extrapolated to Iraq as a whole. The prescription review was retrospective and clinical indication could not be verified, so appropriateness was not assessed and the prescribing rate measures volume, not correctness. The components covered different periods and patients, and the cross-sectional design precludes inference about trends or causation. Excluding patients treated with antibiotics in the preceding 14 days may have

removed treatment failures and understated resistance. ESBL and methicillin resistance were confirmed phenotypically but not molecularly, and AWaRe was applied at class level.

Future work should extend this design to further provinces, record antibiotics at agent level, characterise resistance determinants molecularly, and move to longitudinal surveillance. These data provide a baseline against which a stewardship intervention targeting private practice could be evaluated.

4. CONCLUSION

Outpatient antibiotic prescribing across 12 facilities in Missan Province, Iraq, fell outside every WHO/INRUD reference value, with antibiotics at 68.4% of encounters and quality poorest in private clinics on all five indicators. Isolates from the same facilities showed high resistance to most orally available first-line agents, with ESBL production in 34.4% of *E. coli* and 46.3% of *K. pneumoniae* and methicillin resistance in 31.1% of *S. aureus*. These findings support antimicrobial stewardship spanning public and private outpatient care, empirical guidelines informed by local antibiograms, and sustained surveillance in Missan Province and comparable Iraqi settings.

ACKNOWLEDGEMENTS

The authors thank the Missan Health Directorate and the staff of the participating outpatient healthcare facilities and the provincial microbiology laboratory for facilitating access to prescription and laboratory records.

AUTHOR CONTRIBUTIONS

Raad K. A. Al Darraji: Conceptualization, Methodology, Investigation, Data Curation, Writing — Original Draft.

Mohammed Amran: Methodology, Laboratory Analysis, Validation, Writing — Review & Editing.

Adiba S. Ali: Investigation, Data Curation, Formal Analysis, Writing — Review & Editing.

Mohsen H. Jasim: Formal Analysis, Visualization, Supervision, Project Administration, Writing — Review & Editing.

All authors read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ETHICS STATEMENT

Ethics approval has been obtained with letter number 2022/1850 dated 27 August 2022 from the Research Ethics Committee, Missan Health Directorate, Ministry of Health, Iraq. Administrative permission to access prescription records and laboratory data was granted by the participating facilities through the Missan Health Directorate. Written informed consent was obtained from all patients who provided clinical specimens; the prescription review used anonymised records only. The study was conducted in accordance with the Declaration of Helsinki.

FUNDING

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

DATA AVAILABILITY STATEMENT

The anonymised data supporting the findings of this study are available from the corresponding author on reasonable request, subject to the approval of the Missan Health Directorate.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work the authors used a generative AI-assisted language tool to improve the readability and language of the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

REFERENCES

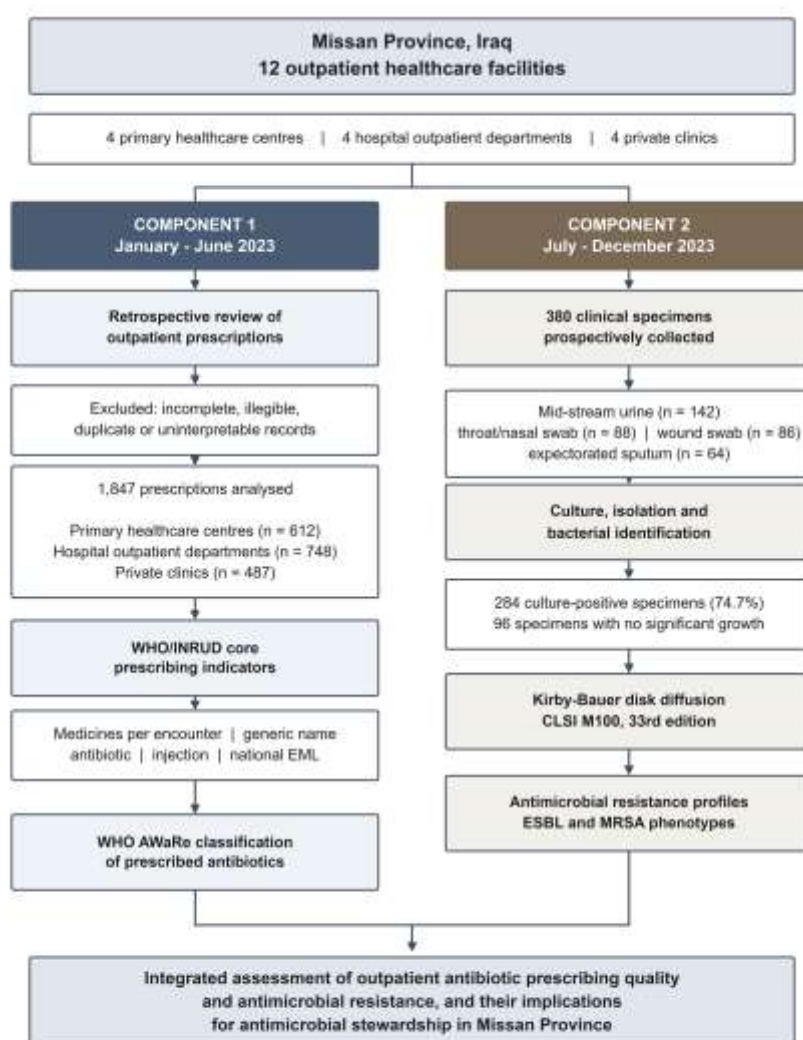
- [1] Al-Jumaili, A.A., Ahmed, K.K., 2024. *A review of antibiotic misuse and bacterial resistance in Iraq*. Eastern Mediterranean Health Journal 30(10), 663–670.
- [2] Al-Niemat, S.I., Bloukh, D.T., Al-Harasis, M.D., Al-Fanek, A.F., Salah, R.K., 2008. *Drug use evaluation of antibiotics prescribed in a Jordanian hospital outpatient and emergency clinics using WHO prescribing indicators*. Saudi Medical Journal 29(5), 743–748.
- [3] Browne, A.J., Chipeta, M.G., Haines-Woodhouse, G., Kumaran, E.P.A., Hamadani, B.H.K., Zarea, S., et al., 2021. *Global antibiotic consumption and usage in humans, 2000–18: a spatial modelling study*. The Lancet Planetary Health 5(12), e893–e904. [https://doi.org/10.1016/S2542-5196\(21\)00280-1](https://doi.org/10.1016/S2542-5196(21)00280-1)
- [4] CLSI, 2023. *Performance standards for antimicrobial susceptibility testing, 33rd ed.* CLSI supplement M100. Clinical and Laboratory Standards Institute, Wayne, PA, USA.
- [5] Costelloe, C., Metcalfe, C., Lovering, A., Mant, D., Hay, A.D., 2010. *Effect of antibiotic prescribing in primary care on antimicrobial resistance in individual patients: systematic review and meta-analysis*. BMJ 340, c2096. <https://doi.org/10.1136/bmj.c2096>
- [6] Davey, P., Marwick, C.A., Scott, C.L., Charani, E., McNeil, K., Brown, E., et al., 2017. *Interventions to improve antibiotic prescribing practices for hospital inpatients*. Cochrane Database of Systematic Reviews 2, CD003543. <https://doi.org/10.1002/14651858.CD003543.pub4>
- [7] Dellit, T.H., Owens, R.C., McGowan, J.E., Gerding, D.N., Weinstein, R.A., Burke, J.P., et al., 2007. *Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship*. Clinical Infectious Diseases 44(2), 159–177. <https://doi.org/10.1086/510393>
- [8] GBD 2021 Antimicrobial Resistance Collaborators, 2024. *Global burden of bacterial antimicrobial resistance 1990–2021: a systematic analysis with forecasts to 2050*. The Lancet 404(10459), 1199–1226. [https://doi.org/10.1016/S0140-6736\(24\)01867-1](https://doi.org/10.1016/S0140-6736(24)01867-1)
- [9] Goossens, H., Ferech, M., Vander Stichele, R., Elseviers, M., 2005. *Outpatient antibiotic use in Europe and association with resistance: a cross-national database study*. The Lancet 365(9459), 579–587. [https://doi.org/10.1016/S0140-6736\(05\)17907-0](https://doi.org/10.1016/S0140-6736(05)17907-0)
- [10] Holloway, K.A., Kotwani, A., Batmanabane, G., Puri, M., Tisocki, K., 2017. *Antibiotic use in South East Asia and policies to promote appropriate use: reports from country situational analyses*. BMJ 358, j2291. <https://doi.org/10.1136/bmj.j2291>
- [11] Kilipamwambu, A., Bwire, G.M., Myemba, D.T., Njiro, B.J., Majigo, M.V., 2021. *WHO/INRUD core prescribing indicators and antibiotic utilization patterns among primary health care facilities in Ilala district, Tanzania*. JAC-Antimicrobial Resistance 3(2), dlab049. <https://doi.org/10.1093/jacamr/dlab049>
- [12] Laxminarayan, R., Duse, A., Wattal, C., Zaidi, A.K.M., Wertheim, H.F.L., Sumpradit, N., et al., 2013. *Antibiotic resistance – the need for global solutions*. The Lancet Infectious Diseases 13(12), 1057–1098. [https://doi.org/10.1016/S1473-3099\(13\)70318-9](https://doi.org/10.1016/S1473-3099(13)70318-9)
- [13] Lowy, F.D., 2003. *Antimicrobial resistance: the example of Staphylococcus aureus*. Journal of Clinical Investigation 111(9), 1265–1273. <https://doi.org/10.1172/JCI18535>
- [14] Murray, C.J.L., Ikuta, K.S., Sharara, F., Swetschinski, L., Robles Aguilar, G., Gray, A., et al., 2022. *Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis*. The Lancet 399(10325), 629–655. [https://doi.org/10.1016/S0140-6736\(21\)02724-0](https://doi.org/10.1016/S0140-6736(21)02724-0)
- [15] Ofori-Asenso, R., Brhlikova, P., Pollock, A.M., 2016. *Prescribing indicators at primary health care centers within the WHO African region: a systematic analysis (1995–2015)*. BMC Public Health 16, 724. <https://doi.org/10.1186/s12889-016-3428-8>
- [16] Paterson, D.L., 2006. *Resistance in gram-negative bacteria: Enterobacteriaceae*. American Journal of Infection Control 34(5, Suppl. 1), S20–S28. <https://doi.org/10.1016/j.ajic.2006.05.238>
- [17] Prestinaci, F., Pezzotti, P., Pantosti, A., 2015. *Antimicrobial resistance: a global multifaceted phenomenon*. Pathogens and Global Health 109(7), 309–318. <https://doi.org/10.1179/2047773215Y.0000000030>
- [18] Sulis, G., Adam, P., Nafade, V., Gore, G., Daniels, B., Daftary, A., et al., 2020. *Antibiotic prescription practices in primary care in low- and middle-income countries: a systematic review and meta-analysis*. PLoS Medicine 17(6), e1003139. <https://doi.org/10.1371/journal.pmed.1003139>
- [19] WHO, 1993. *How to investigate drug use in health facilities: selected drug use indicators*. WHO/DAP/93.1. World Health Organization, Geneva, Switzerland.
- [20] WHO, 2023a. *Antimicrobial resistance*. World Health Organization. <https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance>. Date accessed: 04th September 2026.

- [21] WHO, 2023b. *The WHO AWaRe (Access, Watch, Reserve) antibiotic book*. World Health Organization, Geneva, Switzerland.
- [22] WHO, 2024. *GLASS country participation*. World Health Organization. <https://www.who.int/initiatives/glass/country-participation>. Date accessed: 04th September 2026.

FIGURE LEGENDS

Figure 1. Study workflow. Component 1 was a retrospective review of 1,847 consecutive outpatient prescriptions issued between January and June 2023 across 12 outpatient healthcare facilities in Missan Province, Iraq, evaluated against the WHO/INRUD core prescribing indicators and the WHO AWaRe classification. Component 2 was a microbiological investigation between July and December 2023 in which 380 specimens from prospectively recruited adults underwent culture, bacterial identification and antimicrobial susceptibility testing interpreted according to CLSI M100, 33rd edition. AWaRe, Access, Watch and Reserve; CLSI, Clinical and Laboratory Standards Institute; EML, essential medicines list; ESBL, extended-spectrum beta-lactamase; INRUD, International Network for Rational Use of Drugs; MRSA, methicillin-resistant *Staphylococcus aureus*; WHO, World Health Organization.

Figure 1



The two components covered different six-month periods and did not necessarily involve the same patients; the prescription and microbiological datasets are therefore not linked at patient level.

CLSI: Clinical and Laboratory Standards Institute; EML, essential medicines list; ESBL, extended-spectrum beta-lactamase; INRUD, International Network for Rational Use of Drugs; MRSA, methicillin-resistant *Staphylococcus aureus*; WHO, World Health Organization.