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Systematic review of urinary tract infections caused by *Acinetobacter baumannii*: Resistance patterns and clinical outcomes (2020–2025)

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Abstract. *Urinary tract infections (UTIs) caused by Acinetobacter baumannii have become an important public health concern due to the pathogen's multidrug-resistant (MDR) nature. Its increasing prevalence in clinical and environmental settings underscores the need to better understand resistance mechanisms, epidemiology, and therapeutic challenges.*
Objectives. To systematically review studies published between 2020 and 2025 that investigated the prevalence, antimicrobial resistance patterns, genomic characteristics, and therapeutic strategies for A. baumannii-associated UTIs, with the aim of identifying regional and global trends, resistance determinants, and emerging interventions.
Eligibility criteria. Studies were included if they focused on A. baumannii isolated from UTI cases and reported antimicrobial resistance profiles, genomic analyses, or therapeutic aspects. Only peer-reviewed articles published between January 2020 and May 2025 were considered.
Sources of evidence. Data were retrieved from PubMed, Scopus, and Web of Science using predefined keywords (e.g., "Acinetobacter baumannii," "urinary tract infection").
Methods. A standardized data extraction template was used to collect information on study design, geographic location (Iraq [Baghdad, Diyala, Duhok], China, South Korea, and South-East Nigeria), resistance patterns, molecular findings, and potential therapeutic strategies. Study selection and review processes followed PRISMA 2020 guidelines.
Results. The review demonstrates a high prevalence of multidrug-resistant A. baumannii in UTIs across diverse regions. Genomic data revealed multiple resistance determinants, while therapeutic options remain limited, with few promising alternatives under evaluation.
Limitations. The number of eligible studies was relatively small, and regional representation was uneven, limiting generalizability.
Conclusions. Multidrug-resistant A. baumannii represents a growing challenge in the management of UTIs. Enhanced surveillance, genomic monitoring, and the development of innovative therapies are urgently needed. Multinational collaboration is essential to mitigate the global burden of A. baumannii infections.
Systematic review registration: PROSPERO, CRD420251041315.

Keywords: *urinary tract infection, multidrug-resistant, Acinetobacter baumannii, systematic review.*

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Систематичний огляд інфекцій сечової системи, спричинених *Acinetobacter baumannii*: патерни резистентності та клінічні наслідки (2020–2025)

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Резюме. *Інфекції сечової системи (ІСС), спричинені Acinetobacter baumannii, є серйозною проблемою громадського здоров'я через мультирезистентність цього збудника. Зростання його поширеності у клінічних умовах та довкіллі підкреслює необхідність глибшого розуміння механізмів резистентності, епідеміології та терапевтичних викликів.*

Мета. Систематично проаналізувати дослідження, опубліковані у 2020–2025 рр., що вивчали поширеність, профілі антимікробної резистентності, геномні характеристики та терапевтичні стратегії ІСС, зумовлених A. baumannii, з метою визначення регіональних і глобальних тенденцій, детермінант резистентності та новітніх підходів до лікування.

Критерії включення. У дослідження включали роботи, присвячені A. baumannii, виділеному від хворих на ІСС, які містили дані про антимікробну резистентність, геномні аналізи чи терапевтичні аспекти. Розглядали лише рецензовані публікації, опубліковані з січня 2020 по травень 2025 р.

Джерела даних. Інформацію отримували з PubMed, Scopus та Web of Science із використанням заздалегідь визначених ключових слів ("Acinetobacter baumannii", "urinary tract infection").

Методи. Використовували стандартизовану форму для збору даних щодо дизайну досліджень, географічної локалізації (Ірак [Багдад, Діяла, Духок], Китай, Південна Корея, Південно-Східна Нігерія), патернів резистентності, молекулярних знахідок та можливих терапевтичних стратегій. Відбір і аналіз публікацій здійснювали відповідно до керівництва PRISMA 2020.

Результати. Огляд засвідчив високий рівень поширеності мультирезистентного A. baumannii у хворих на ІСС в різних регіонах. Геномні дані виявили численні детермінанти резистентності, тоді як терапевтичні можливості залишаються обмеженими, і лише окремі нові підходи перебувають на стадії оцінки.

Обмеження. Кількість відповідних досліджень була відносно невеликою, а регіональне представництво нерівномірним, що знижує узагальнюваність висновків.

Висновки. Мультирезистентний A. baumannii дедалі частіше ускладнює перебіг ІСС, що вимагає глобальної співпраці та пошуку нових терапевтичних рішень. Ефективна протидія інфекціям, спричиненим A. baumannii, можлива лише за умови посиленого епіднагляду та міжнародної координації.

Реєстрація систематичного огляду: PROSPERO, CRD420251041315.

Ключові слова: *інфекції сечових шляхів, мультирезистентність, Acinetobacter baumannii, систематичний огляд.*

Introduction. Urinary tract infections (UTIs), one of the most common infectious disorders, affect around 150 million people worldwide [1]. They represent a major public health problem, particularly among women, the elderly, and immunocompromised individuals. UTIs can cause delirium, leading to cognitive dysfunction, agitation, and memory loss due to disruptions in the frontal cortex and hippocampus [2, 3]. Pyelonephritis involves the upper urinary tract, while cystitis and urethritis affect the lower tract [4]. Pregnancy-related UTIs affect 2–10% of women globally [5]. Untreated bacteriuria can result in premature delivery and neonatal morbidity [6]. Physiological alterations during pregnancy, including glycosuria and urethral dilatation, promote bacterial growth and infection [7].

Typical UTI symptoms include dysuria, frequent urination, lower abdominal pain, and foul-smelling urine. When bacteria reach the kidneys, fever, nausea, and systemic involvement may occur [5]. Uropathogens employ pili, adhesins, capsular polysaccharides, and biofilm formation to establish infection and evade host defenses [8, 9]. Because clinical symptoms are often nonspecific, laboratory testing is essential for accurate diagnosis [10]. Escherichia coli is the most common uropathogen, but antimicrobial resistance (AMR) complicates therapy and increases mortality [11, 12]. Multidrug-resistant (MDR) pathogens such as Acinetobacter baumannii are increasingly associated with both community- and hospital-acquired UTIs [13]. This is particularly concerning in healthcare settings, where catheter-associated UTIs facilitate the entry of MDR bacteria [14–16]. In developing countries, limited access to

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drugs and healthcare infrastructure amplifies the impact [11]. Due to these challenges, herbal medicines are being explored as potential antibacterial adjuvants [17].

A. baumannii is a leading MDR pathogen in UTI management. Initially isolated in calcium acetate-enriched minimal media [18], it is now recognized as a prominent nosocomial pathogen, especially in intensive care units (ICUs) [23]. It is highly versatile, capable of colonizing soil, water, animals, and humans [19]. Rising antibiotic resistance has made A. baumannii a "red alert" pathogen since the early 2000s [20–22]. Its resistance to most commercial antibiotics makes it a major threat to infection management, particularly in ICUs [23]. MDR, extensively drug-resistant (XDR), and pandrug-resistant (PDR) strains resist multiple antibiotics. The structure of the outer membrane limits porin-mediated penetration, contributing to resistance [24]. Genomic resistance islands harbor over 45 resistance-related genes, enabling rapid acquisition of new resistance determinants [25, 26]. Enzymes encoded by resistance genes, such as methyltransferases, increase aminoglycoside resistance, further limiting therapeutic options [27, 28].

The A. baumannii complex includes A. calcoaceticus and Acinetobacter genomic species 13TU, complicating identification but remaining clinically important [29]. Its oxidase-negative reaction distinguishes it from other Moraxellaceae [30]. Biofilm formation shields bacteria from antimicrobials and harsh environments [31]. Biofilms formed via poly-(1,6)-N-acetylglucosamine enhance adhesion and resistance [32]. Biofilm development proceeds through bacterial attachment, monolayer formation, extracellular matrix production, and detachment, facilitating infection spread [33, 34]. Contamination of medical devices by biofilms enables survival and resistance to most antibiotics [35].

New therapeutic approaches are being developed to address biofilm-associated infections. Polyphenol-based therapies appear to disrupt quorum sensing and membrane integrity, reducing biofilm formation and enhancing antibiotic effectiveness [36, 37]. The polysaccharide capsule of A. baumannii further promotes immune evasion and antimicrobial resistance [38]. Its densely packed oligosaccharide subunits confer environmental resilience, reduce immunological recognition, and resist disinfectants [39, 40]. Survival on hospital surfaces such as bed rails and medical equipment enhances its spread [41, 42].

The global rise in MDR A. baumannii infections is driven by its ability to acquire and disseminate antibiotic resistance genes (ARGs) [43]. These infections are associated with high morbidity and mortality [44]. Resistance to last-line antibiotics such as imipenem and meropenem makes alternative therapies urgently necessary [45, 46]. However, last-resort agents such as polymyxin B and fosfomycin are limited by nephrotoxicity and neurotoxicity [47, 48].

A systematic review approach enables a comprehensive evaluation of current knowledge, identifying key themes and novel advances in UTI management. Given the capacity of MDR A. baumannii to evade existing antibiotics, new therapeutic strategies are essential. Future directions include genomic surveillance to monitor resistance, anti-biofilm interventions to improve outcomes, and the exploration of metal-based antimicrobials, phage therapy, and immunotherapeutics.

Methods. *Protocol and registration.* This systematic review was conducted in accordance with PRISMA guidelines. The protocol was registered in PROSPERO (CRD420251041315, 2025) and was designed to comprehensively assess Acinetobacter baumannii in urinary tract infections, with a particular focus on antimicrobial resistance, genomic characteristics, and therapeutic approaches.

Eligibility Criteria. The inclusion criteria for this review were as follows:

- Study Type: Peer-reviewed original research articles investigating A. baumannii in UTIs.
- Population: Studies that included patients with UTIs.
- Publication Period: Studies published between January 2020 and January 2025.
- Language: Articles published in English
- Focus Areas: Research focusing on antimicrobial resistance.
- Rationale: The eligibility criteria were designed to capture recent advancements and trends in the epidemiology and management of A. baumannii UTIs. The focus on the last five years aligns with the goal of understanding contemporary challenges and therapeutic innovations.

Information sources. The information for this systematic review includes:

- Search: Database PubMed, google scholar, science direct, MDPI Microorganisms, BMC, Scopus, Web of Science.
- Search terms "A. baumannii" AND "urinary tract infection" AND ("multidrug resistance" OR "MDR") "A. baumannii" AND "UTI" Acinetobacter" AND "UTI" AND ("antimicrobial susceptibility" OR "resistance patterns").
- Filters applied (January 2020 to January 2025), English language, Peer-reviewed articles.

Selection of sources of evidence.

- Initial screening:
  - All identified articles from the search were reviewed independently by researchers.
  - Studies were included if they investigated MDR A. baumannii and UTIs within the scope of the inclusion criteria, including the years 2020-2025.
- Eligibility assessment:
  - Full text examined MDR A. baumannii in UTIs. Relevance to resistance mechanisms, clinical consequences, environmental diffusion, or therapeutic techniques. Studies in Iraq (Baghdad, Diyala, Duhok), Southeast Spain, China, South Korea, and South-East Nigeria. English articles from 2020-2025.
  - Studies missing sufficient data on A. baumannii or outside the scope of UTIs were excluded.

- **Data management:** Duplicates were removed.
- **Final selection:** 11 studies.

Data extraction was done methodically. Each study's pertinent data was gathered using a standardized extraction form, which included:

- Features of the study: publication year, study site, and study design
- Microbiological information: techniques for identifying A. baumannii, such as molecular, biochemical, or culture-based approaches.
- Patterns of antibiotic susceptibility: A. baumannii resistance patterns to widely used antibiotics.
- How well do antibiotics or other therapy approaches work to treat UTIs linked to A. baumannii.

Quality assessment. A formal risk of bias assessment was not performed because the included studies were highly heterogeneous in design (ranging from molecular laboratory investigations to clinical observational studies). Instead, methodological aspects such as study design, sample size, laboratory techniques, and completeness of reporting were narratively considered when interpreting findings.

Data items. Data extraction followed PRISMA standards and included study information (country, year, design, and population). Studies were identified, screened, and selected from Iraq (Baghdad, Diyala, Duhok), Southeast Spain, China, South Korea, and South-East Nigeria.

Synthesis of results. Data were synthesized narratively because of the heterogeneity in study designs, populations, and reported outcomes. Findings were grouped by study location, resistance patterns, genomic characteristics, and therapeutic approaches. Where possible, similarities and differences across regions (Iraq, Southeast Spain, China, South Korea, and South-East Nigeria) were highlighted to identify trends in antimicrobial resistance and potential interventions.

Results. *Study selection.* The database search yielded 645 records. After removing 145 duplicates and 20 records for ineligible or other reasons, 480 records remained for screening. Of these, 390 were excluded based on title and abstract. A total of 90 full-text articles were as-sessed for eligibility; 79 reports were excluded. Following full-text review, 32 ar-ticles were excluded for reason 1, 24 for reason 2, 13 for reason 3, and 10 for reason 4. Ultimately, 11 studies met the inclusion criteria and were included in the systematic review. The PRISMA flow diagram (Fig. 1) summarizes the study selection process.

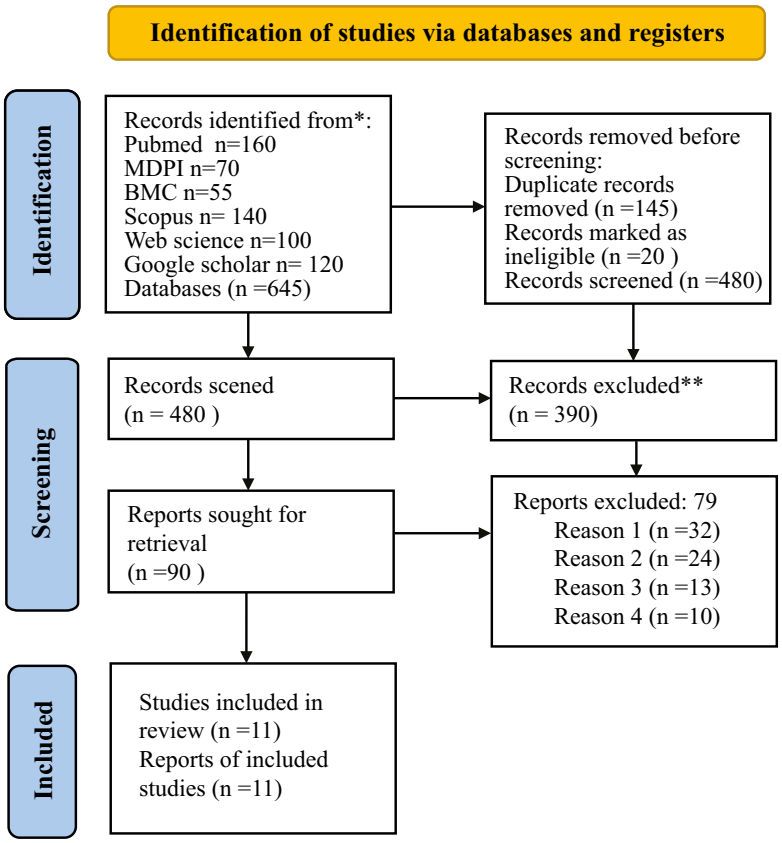

Fig. 1. PRISMA flow diagram of studies on Acinetobacter baumannii-induced UTI.

Characteristics of included studies. The 11 included studies were published between 2020 and 2025 and were conducted in Iraq (Baghdad, Diyala, Duhok), Southeast Spain, China, South Korea, and South-East Nigeria. Study designs included laboratory-based investigations, molecular epidemiology studies, and clinical observational reports. Sample sizes ranged from single clinical isolates to over 200 patient-derived samples. Table 1 presents the characteristics and major findings of each study.

Table 1

Characteristics of the 11 studies on Acinetobacter baumannii in UTIs, 2020–2025

Reference	Location	Sample size	Prevalence of A. baumannii in UTIs (%)	Pathogen(s)	Population / Source	Objective	Study type / Intervention	Comparison	Main findings	Antibiotic resistance profile
Alrifai et al. [49]	Baghdad, Iraq	150	25%	A. baumannii	UTI patients	To assess prevalence and resistance patterns	Surveillance study	No intervention	High prevalence of MDR A. baumannii; >70% resistance to carbapenems; resistance to fluoroquinolones and aminoglycosides	Carbapenems (70%), fluoroquinolones, aminoglycosides
Dong et al. [50]	China	30 (in vitro)	20%	A. baumannii	UTI isolates	To test ebselen + silver ions as antimicrobials	Combination therapy	Ebselen alone	Combination reduced bacterial load by 90% vs. 40% with ebselen alone; biofilm inhibition observed	MDR
AlYais & Al-Shammary [51]	Baghdad, Iraq	100	30%	A. baumannii	UTI + dairy isolates	To compare human and dairy isolates	Genomic & resistance analysis	Human vs. dairy strains	Evidence of possible zoonotic transmission; >80% resistance to -lactams	High -lactam resistance
Kim et al. [52]	South Korea	1	100%	A. baumannii	Clinical isolate (NCCP 16007)	To investigate genomic & phenotypic traits	Whole-genome sequencing	Comparison with MDR strains	Resistance genes for carbapenems, tetracyclines, aminoglycosides; strong biofilm formation	Carbapenem-resistant, MDR
Raheem Hassooni et al. [53]	Diyala, Iraq	75	22%	A. baumannii	UTI patients	To characterize isolates	PCR + culture	Conventional vs. molecular	45% PCR-confirmed; 75% carbapenem resistant	High carbapenem resistance, MDR
Ahmed et al. [54]	Baghdad, Iraq	50	28%	A. baumannii	UTI patients	To examine IL-6 and biofilm strains	IL-6 assays & drug testing	Biofilm vs. non-biofilm	Elevated IL-6 in biofilm strains; some compounds reduced biofilm	MDR (-lactams, aminoglycosides, carbapenems)
Naqid et al. [55]	Duhok, Iraq	200	18%	A. baumannii + others	Female UTI patients	To assess resistance profiles	Susceptibility testing	Among uropathogens	High resistance to cephalosporins & aminoglycosides; tigecycline remained active	MDR
Hussain et al. [56]	Iraq	80	40%	A. baumannii	UTI patients	To assess resistance	Resistance profiling	Across antibiotics	High resistance to -lactams, aminoglycosides, carbapenems; polymyxins effective	MDR, XDR
Echendu et al. [57]	SE Nigeria	150	15%	A. baumannii, K. pneumoniae	Pregnant women with UTIs	To assess MDR pathogens	Culture & susceptibility	K. pneumoniae vs. A. baumannii	60% resistant to amoxicillin; 50% resistant to gentamicin; maternal-fetal risk	MDR (amoxicillin, gentamicin)
Salman et al. [58]	Baghdad, Iraq	100	12%	A. baumannii + others	Pediatric UTI patients	To examine MDR prevalence	Bacterial ID & resistance profiling	MDR vs. non-MDR	MDR A. baumannii associated with prolonged hospital stays; 68% resistant to ciprofloxacin/gentamicin	High -lactam, ciprofloxacin, gentamicin resistance
Tamadonfar et al. [59]	Baghdad, Iraq	50 (in vitro)	100%	A. baumannii	Catheter-associated UTI isolates	To study adhesins in biofilms	Structural analysis	Biofilm vs. non-biofilm	Fibrinogen binding biofilm formation by 75%; key mechanism in catheter UTIs	MDR

Risk of bias within studies. A formal risk of bias assessment was not conducted because of the heterogeneity of study designs, which ranged from molecular laboratory investigations to small-scale clinical studies. Instead, methodological aspects such as sample size, study design, microbiological methodology, and completeness of reporting were considered narratively when interpreting findings.

Results of individual studies. The findings from the 11 included studies provide important insights into the role of Acinetobacter baumannii in UTIs. Alrifai et al. [49] reported a high prevalence of multidrug-resistant (MDR) A. baumannii in UTI patients, with resistance rates exceeding 70% for carbapenems and significant resistance also observed to fluoroquinolones and aminoglycosides, highlighting the urgent need for effective infection control. Dong et al. [50] demonstrated synergistic activity of ebselen combined with silver ions in both in vitro and in vivo models, where the combination inhibited biofilm formation and reduced bacterial colonies by 90% compared to 40% with ebselen alone, suggesting potential therapeutic value. AlYais and Al-Shammary [51] identified A. baumannii in both human UTI cases and local dairy samples, raising the possibility of zoonotic transmission, with resistance to β-lactams found in more than 80% of isolates and no significant difference between human and dairy strains. Kim et al. [52] identified resistance genes for carbapenems, tetracyclines, and aminoglycosides through whole-genome sequencing of an A. baumannii isolate, while phenotypic analysis revealed strong biofilm formation associated with chronic UTIs and increased resistance. Raheem Hassooni et al. [53] confirmed A. baumannii in 45% of UTI cases using PCR, with 75% of isolates resistant to carbapenems and high resistance also reported to β-lactams. Ahmed et al. [54] found that biofilm-forming A. baumannii strains in UTI patients were associated with elevated IL-6 levels, and some pharmaceutical compounds were able to reduce biofilm formation, indicating potential adjunctive therapies. Naqid et al. [55] identified A. baumannii as a significant uropathogen with high resistance to cephalosporins and aminoglycosides but sensitivity to tigecycline, while resistance to ceftriaxone exceeded 50%. Hussain et al. [56] reported extremely high levels of resistance in Iraqi isolates, with carbapenem resistance above 70% and high resistance to aminoglycosides, fluoroquinolones, and cephalosporins; polymyxins remained effective, emphasizing their role as last-resort antibiotics. Echendu et al. [57] observed MDR A. baumannii in urine samples from pregnant women, with 60% of isolates resistant to amoxicillin and 50% resistant to gentamicin, raising concerns for maternal and neonatal health. Salman et al. [58] reported high levels of MDR A. baumannii in children with UTIs, with 68% of isolates resistant to ciprofloxacin and gentamicin and a significant association between MDR infection and prolonged hospitalization. Finally, Tamadonfar et al. [59] investigated bacterial adhesins and found that fibrinogen binding increased biofilm formation by 75% in catheter-associated isolates, suggesting a critical role of adhesins in resistance and persistence in catheter-associated UTIs.

Discussion. *Summary of evidence.* This systematic review synthesized data on the prevalence, resistance mechanisms, and clinical and molecular characteristics of Acinetobacter baumannii in UTIs. The findings highlight A. baumannii as a major uropathogen in both hospital and community settings, with particularly high prevalence in regions such as Iraq (Baghdad, Diyala, Duhok), South-East Nigeria, China, and South Korea. Across studies, MDR and XDR strains were consistently reported, underscoring the growing public health threat of this pathogen [49–59].

Comparison with existing knowledge. The reviewed studies are in line with global evidence showing that A. baumannii is highly resistant to carbapenems, aminoglycosides, fluoroquinolones, and β-lactams, while retaining susceptibility mainly to polymyxins and tigecycline. Similar to other reports, biofilm formation emerged as a critical factor in persistence and resistance, complicating eradication in catheter-associated infections. Genomic findings confirmed the presence of multiple resistance determinants, consistent with previous literature identifying A. baumannii as a "red alert" pathogen for healthcare systems. Importantly, several studies in this review extended knowledge by examining host–pathogen interactions, such as IL-6 responses [54], and by exploring novel therapeutic approaches, including ebselen combined with silver ions [50], which demonstrated strong synergistic antimicrobial and antibiofilm effects.

Strengths and limitations. This review is among the few to systematically compile recent evidence (2020–2025) on A. baumannii in UTIs, providing both clinical and molecular perspectives. The inclusion of studies from diverse regions adds value by highlighting geographic differences in resistance profiles. However, limitations must be acknowledged. Many studies had relatively small sample sizes, restricting generalizability. Several investigations focused on narrow laboratory outcomes rather than patient-level data, limiting clinical applicability. Geographic bias was also evident: most data originated from Iraq, with fewer studies from other regions, potentially underrepresenting global epidemiology. Finally, no formal risk of bias tool was applied due to heterogeneity in study designs, although methodological aspects such as study size, laboratory quality, and reporting were considered narratively.

Implications for clinical practice and policy. The findings have important implications for infection control and clinical management. High levels of carbapenem resistance (>70% in several studies [49, 56]) highlight the urgent need to preserve last-line antibiotics such as polymyxins through strict stewardship. The identification of MDR A. baumannii in vulnerable populations, including pregnant women [57] and children [58], underscores the need for targeted preventive strategies in high-risk groups. Surveillance systems should

be strengthened to monitor emerging resistance trends, particularly in regions where A. baumannii is endemic. At the policy level, ministries of health and international agencies must invest in antimicrobial stewardship programs, genomic monitoring, and development of therapeutic alternatives.

Future research directions. Further research is needed to expand geographic coverage and include larger, multicenter cohorts to better capture the epidemiology of A. baumannii UTIs. Clinical trials are essential to evaluate the safety and efficacy of novel or adjunctive therapies, such as ebselen–silver combinations [50], tigecycline, and anti-biofilm agents. More work is also required to clarify the role of host immune responses, such as IL-6 elevation in biofilm-forming infections [54], and to assess the clinical significance of adhesins in catheter-associated UTIs [59]. Integration of genomic data with clinical surveillance will be key to developing precision-targeted therapies and to slowing the spread of MDR and XDR strains.

Conclusions. MDR and XDR A. baumannii are increasingly recognized as major causes of urinary tract infections worldwide. The pathogen's complex resistance mechanisms, including biofilm formation and genetic adaptability, combined with its high prevalence in vulnerable populations, pose a serious global health challenge. Enhanced surveillance, rational antibiotic use, and accelerated development of alternative therapies are urgently required to reduce the burden of A. baumannii-associated UTIs and improve patient outcomes.

Conflict of interest statement. The authors have no conflict of interest to declare.

Authors' contributions. Zainab Sadeq Ali, Raya Ezat Maroof, and Issam Jumaa Nasser contributed equally to the conception and design of the study, data collection, analysis, and interpretation. All authors were involved in drafting and critically revising the manuscript, approved the final version, and agree to be accountable for all aspects of the work.

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Data availability statement. The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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