PREVALENCE AND ANTIMICROBIAL SUSCEPTIBILITY PATTERNS OF CARBAPENEM-RESISTANT ACINETOBACTER SPP. AMONG INTENSIVE CARE UNIT PATIENTS IN BENGHAI, LIBYA

NAGWA KH. BEN-GHAZZI AND TAREK A. ABDULKAREEM*

College of Medical Technology-Benghazi, Benghazi City, Libya

*Corresponding Author: tareklab77@gmail.com

Received 15\05\2026 - Accepted 01\06\2026- Available online 15\06\2026

Abstract: Acinetobacter spp. are important healthcare-associated pathogens frequently implicated in intensive care unit (ICU) infections due to their ability to survive in hospital environments and develop multidrug resistance. The increasing emergence of carbapenem-resistant Acinetobacter strains has become a major therapeutic and infection control challenge worldwide. This study aimed to determine the prevalence and antimicrobial susceptibility patterns of Acinetobacter spp. isolated from ICU patients in Benghazi, Libya, focusing on resistance to carbapenems and other antimicrobials. A retrospective cross-sectional study used microbiological records of ICU specimens processed at Al-Jalaa Hospital, Benghazi, Libya, from January to August 2024. Specimens included wound and burn swabs, endotracheal tube tips, suction catheter tips, Foley catheter tips, and other device samples. Acinetobacter spp. were isolated and identified using standard microbiological and biochemical methods. Antimicrobial susceptibility was tested according to CLSI guidelines, and colistin susceptibility was determined by minimum inhibitory concentration (MIC) testing. A total of 111 *Acinetobacter spp.* isolates were recovered from ICU specimens. Swab samples accounted for 53.2% of isolates, while device-associated tip samples represented 46.8%. Wound swabs showed the highest isolation frequency (41.4%). Antimicrobial susceptibility testing revealed high resistance rates to carbapenems, including ertapenem (99.1%), meropenem (55.9%), and imipenem (48.6%). High resistance was also observed against ceftazidime (64.9%) and cefotaxime (56.8%). Colistin demonstrated the highest in vitro activity, with 43.2% of isolates categorized as susceptible and 5.4% as resistant. High prevalence of multidrug-resistant *Acinetobacter spp.* among ICU patients in Benghazi, with significant resistance to carbapenems and cephalosporins. Urgently need ongoing resistance surveillance, strengthened infection prevention measures, and implementation of effective antimicrobial stewardship programs in critical care settings.

Keywords: Acinetobacter; multidrug resistance; carbapenem resistance; intensive care unit; antimicrobial susceptibility.

1. Introduction

Acinetobacter spp. has emerged as a critical nosocomial pathogen and one of the most challenging causes of healthcare-associated infections, particularly in intensive care units (ICUs). It is strongly associated with ventilator-associated pneumonia, bloodstream infections, wound infections, urinary tract infections, and device-related infections in critically ill patients. Their clinical significance is largely attributed to their remarkable ability to survive for prolonged periods on environmental

surfaces, tolerate strict conditions, and rapidly acquire resistance determinants, facilitating persistent transmission within ICU settings (Jiang et al., 2022; Cavallo et al., 2023).

The burden of Acinetobacter infections has increased substantially over the past two decades due to the global emergence of multidrug-resistant (MDR) and carbapenem-resistant strains. ICUs represent high-risk environments for the development and dissemination of resistant organisms because of prolonged hospitalization, extensive antimicrobial exposure, mechanical ventilation, and frequent use of invasive medical devices. These conditions create selective pressure that promotes antimicrobial resistance and enhances the spread of resistant clones among hospitalized patients (Li et al., 2024; Jiang et al., 2022). Carbapenems have traditionally been considered among the most effective therapeutic agents against severe Acinetobacter infections. However, increasing resistance to carbapenems has become a major global public health concern. Carbapenem-resistant Acinetobacter spp. are now recognized by the World Health Organization as critical-priority pathogens due to their association with limited therapeutic options, prolonged hospitalization, increased healthcare costs, and high mortality rates. Resistance mechanisms are commonly associated with carbapenemase production, reduced membrane permeability, efflux pump activity, and other genetic determinants that compromise antimicrobial efficacy (Choi & Kim, 2024; Aruhomukama et al., 2019).

The therapeutic management of carbapenem-resistant Acinetobacter infections remains challenging. Although agents such as colistin and tigecycline continue to demonstrate activity against some resistant isolates, emerging resistance to these last-resort therapies has also been increasingly reported worldwide. Consequently, continuous surveillance of antimicrobial susceptibility patterns is essential for guiding empirical therapy, supporting antimicrobial stewardship programs, and strengthening infection prevention and control strategies in ICU settings (Mendes et al., 2023; Sacco et al., 2021).

Despite the growing global concern regarding multidrug-resistant Acinetobacter spp., limited epidemiological and antimicrobial resistance data are available from Libya, particularly among ICU patients. Local surveillance studies are necessary to better understand resistance trends and support evidence-based clinical management. Therefore, the present study aimed to determine the prevalence and antimicrobial susceptibility patterns of Acinetobacter spp. isolated from ICU patients in Benghazi, Libya, with particular emphasis on resistance to carbapenems and other commonly used antimicrobial agents.

2. Materials and Methods

2.1. Study Design and Setting

A retrospective cross-sectional laboratory-based study was conducted to evaluate the prevalence and antimicrobial susceptibility patterns of carbapenem-resistant Acinetobacter spp. among intensive care unit (ICU) patients in Benghazi, Libya. The study was based on microbiology laboratory records obtained from ICU clinical specimens processed at Al-Jalaa Hospital from January to August 2024.

2.2. Study Population and Specimen Collection

The study included clinical specimens collected from ICU patients with suspected healthcare-associated infections during the study period. Specimens were obtained as part of routine clinical care and included wound swabs, burn swabs, endotracheal tube tips, suction catheter tips, Foley’s catheter tips, central venous catheter (CVC) tips, chest tube tips, drainage tube tips, and other catheter-associated samples. Only culture-positive Acinetobacter isolates recovered from ICU specimens were included in the study. Duplicate isolates obtained from the same patient and specimen source within a short time interval were excluded to minimize repeated sampling bias. A total of 111 non-duplicate Acinetobacter spp. isolates were included in the final analysis.

2.3. Sample Collection and Processing

Clinical specimens were collected aseptically by trained healthcare personnel following standard infection prevention procedures. All samples were transported promptly to the microbiology laboratory and processed immediately to preserve bacterial viability and minimize contamination.

2.4. Isolation and Identification of *Acinetobacter spp.*

Clinical specimens were cultured manually using standard microbiological techniques. Samples were inoculated onto Blood agar and MacConkey agar media and incubated aerobically at 37°C for 18–24 hours. Preliminary identification was based on colony morphology, Gram staining characteristics, and cultural appearance. Further phenotypic identification was performed using conventional biochemical tests, including oxidase test, catalase test, citrate utilization test, urease test, indole test, motility test, triple sugar iron (TSI) agar reaction, and oxidative-fermentative (OF) glucose utilization test. Isolates demonstrating Gram-negative coccobacilli morphology, oxidase negativity, and catalase positivity were identified as *Acinetobacter spp.* according to standard microbiological reference procedures. Due to limited laboratory resources, molecular characterization and species-level identification were not performed; therefore, isolates were reported collectively as *Acinetobacter spp.*

2.5. Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar in accordance with the Clinical and Laboratory Standards Institute (CLSI) guidelines. Pure bacterial colonies were suspended in sterile normal saline and adjusted to the turbidity of a 0.5 McFarland standard before inoculation. The tested antimicrobial agents included carbapenems (ertapenem, imipenem, and meropenem), cephalosporins (ceftazidime and cefotaxime), and trimethoprim-sulfamethoxazole (Septrin). Antibiotic disks were applied to inoculated Mueller–Hinton agar plates, which were incubated aerobically at 37°C for 18–24 hours. Colistin susceptibility testing was determined using minimum inhibitory concentration (MIC) testing according to CLSI/EUCAST recommendations because disk diffusion testing is not considered reliable for colistin susceptibility assessment. Following incubation, inhibition zone diameters and MIC values were interpreted as susceptible, intermediate, or resistant according to CLSI interpretive criteria. Quality control procedures were performed using standard reference bacterial strains to ensure accuracy and reliability of antimicrobial susceptibility testing. Multidrug resistance (MDR) was defined as acquired non-susceptibility to at least one agent in three or more antimicrobial classes according to the standardized international criteria proposed by Magiorakos et al. (2012).

2.6. Data Analysis

Data were entered and analyzed using IBM SPSS Statistics version 26. Descriptive statistical analysis was performed using frequencies and percentages to summarize the distribution of specimen types, microbial isolates, and antimicrobial susceptibility patterns. Chi-square (χ^2) tests were used to evaluate associations between categorical variables. A p-value of less than 0.05 was considered statistically significant.

2.7. Ethical Considerations

The study used retrospective laboratory data collected as part of routine clinical practice. Patient data privacy were maintained throughout the study by anonymizing all laboratory records, which were maintained throughout data collection and analysis. Ethical approval for the study was obtained from the appropriate institutional review authority of Al-Jalaa Hospital prior to study initiation.

3. Results

3.1. Culture Examination Results of Clinical Specimens

A total of clinical specimens collected from ICU patients were processed during the study period to investigate the presence of healthcare-associated microbial pathogens. Among the investigated samples, 48.87% yielded positive bacterial growth, while 51.13% showed no detectable microbial growth following routine culture procedures (Figure 1).

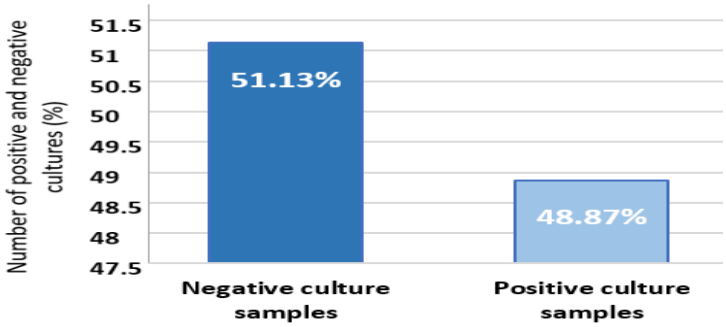

Figure 1. Proportion of positive and negative culture results among all investigated samples

3.2. Distribution of Acinetobacter Growth Across Sample Types (Tips vs Swabs)

The distribution of Acinetobacter growth across specimen types shows a relatively balanced pattern between tips and swabs. Swab samples accounted for a proportion (53.15%) of positive Acinetobacter isolates, which was slightly higher than the 46.85% for tip samples (Figure 2). This suggests that both specimen types are important sources for detecting Acinetobacter, with a marginal predominance in swabs that may reflect greater exposure to colonised or contaminated surfaces. Statistically, the analysis of the obtained data showed that there is no significant difference in the proportions of the two sample types in transmitting the infection.

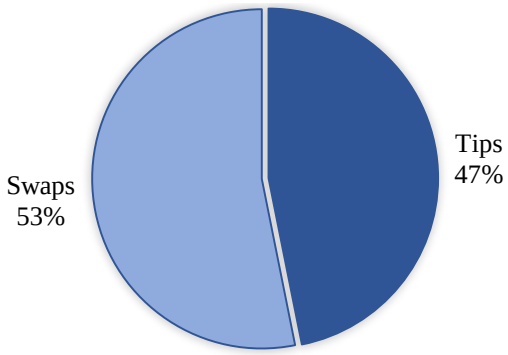

Figure 2. Distribution of Acinetobacter Growth Across Sample Types (Tips vs Swabs)

3. 3. Distribution of Identified Microbial Isolates Recovered from Clinical Specimens

A total of 779 microbial isolates were identified from the processed clinical specimens during the study period. *Klebsiella* spp. represented the most frequently isolated organisms, accounting for 243 isolates (31.2%), followed closely by *Staphylococcus* spp. with 239 isolates (30.7%). *Acinetobacter* spp. constituted 111 isolates (14.3%), ranking as the third most commonly identified pathogen. *Escherichia coli* accounted for 99 isolates (12.7%), while *Pseudomonas* spp. represented 32 isolates (4.1%). Lower frequencies were observed for *Candida* spp. (2.9%), *Enterobacter* spp. (2.4%), and *Bacillus* spp. (1.7%). These findings demonstrate that Gram-negative bacteria were the predominant pathogens isolated from clinical specimens, with *Klebsiella* spp. and *Acinetobacter* spp. representing major contributors to hospital-associated infections within the study setting (Table 1).

Table 1. Distribution and Frequency of Identified Microbial Isolates from Clinical Specimens

Isolated species	#	%
Klebsiella spp.	243	31.19
Staphylococcus spp.	239	30.68
Acinetobacter spp.	111	14.25
E. coli	99	12.71
Pseudomonas spp.	32	4.11
Enterobacter spp.	19	2.44
Bacillus spp.	13	1.67
Candida spp.	23	2.95
Total	**779**	**100**

Although high proportions of *Klebsiella* species and *Staphylococci* were observed among the recovered isolates, *Acinetobacter* species also represented a considerable proportion among the isolated organisms, highlighting their important role in ICU-associated infections. However, statistical analysis demonstrated no significant difference in the distribution of the isolated bacterial species ($p > 0.05$).

3.4. Distribution of *Acinetobacter* spp. Positive Cultures According to Specimen Source

Among the 111 confirmed *Acinetobacter* spp. isolates, swab specimens represented the predominant source of bacterial recovery, accounting for 59 isolates (53.2%). Wound swabs demonstrated the highest isolation rate with 46 isolates (41.4%), followed by burn swabs with 13 isolates (11.7%). Tip-related specimens accounted for 52 isolates (46.8%) of the total positive cultures. Endotracheal tube tips and suction catheter tips were the most common tip-associated sources, each yielding 14 isolates (12.6%). Foley's catheter tips contributed 13 isolates (11.7%), whereas catheter tips, central venous catheter (CVC) tips, and chest tube tips each accounted for 3 isolates (2.7%). Drain tube tips showed the lowest recovery rate (1.8%) among the samples, with 2 isolates (Table 2).

Table 2. Distribution of *Acinetobacter* spp. positive isolates according to specimen type and device-associated samples

Type of sample	#	%
Tips Samples		
Endotracheal Tube Tip	14	12.61
Catheter Tip	3	2.71
Suction Catheter Tip	14	12.61
CVC Tip	3	2.71

Draining Tube Tip	2	1.8
Chest Tube Tip	3	2.71
Foley's Catheter Tip	13	11.7
Swab Samples		
Wound Swab	46	41.44
Burn Swab	13	11.71
Total	**111**	**100**

3.5. Antimicrobial Susceptibility Profile of *Acinetobacter* spp. Isolates against Carbapenems and Cephalosporins

The antimicrobial susceptibility profile demonstrates a high level of multidrug resistance among the tested isolates. Carbapenems showed markedly reduced activity, with ertapenem exhibiting near-complete resistance (99.1%) and both imipenem and meropenem demonstrating substantial resistance rates (48.6% and 55.9%, respectively), indicating probable dissemination of carbapenemase-producing organisms. Cephalosporins were similarly compromised, particularly ceftazidime and cefotaxime, which showed high resistance rates (64.9% and 56.8%), consistent with extended-spectrum β-lactamase production, while cefotetan displayed an unusual predominance of intermediate susceptibility (91.9%), suggesting borderline MIC distributions or heterogeneous resistance expression. Trimethoprim-sulfamethoxazole showed limited clinical reliability, with a high proportion of intermediate responses (70.3%) and moderate resistance (29.7%). In contrast, colistin retained the highest in vitro activity, with 43.24% susceptibility and only 5.4% resistance, although the large intermediate proportion (51.4%) may indicate emerging reduced susceptibility and therapeutic uncertainty. Overall, the data reflect a concerning resistance landscape dominated by multidrug-resistant organisms, with limited effective therapeutic options remaining (Table 3).

Table 3. Antimicrobial Susceptibility Profile of *Acinetobacter* spp. Isolates Against Carbapenems, Cephalosporins, and Other Antibiotics

Tested Antibiotics	S		I		R	
	#	%	#	%	#	%
Carpapenems						
Ertapenem	0	0	1	0.90	110	99.10
Imipenem	9	8.11	48	43.24	54	48.65
Meropenem	1	0.9	48	43.24	62	55.86
Cephalosporins						
Ceftazidime	1	0.9	38	34.23	72	64.87
Cefotetan	0	0	102	91.89	9	8.11
Cefotaxime	0	0	48	43.24	63	56.76
Others						
Septrin	0	0	78	70.27	33	29.73
Cloistin	48	43.24	57	51.35	6	5.41

Comparison of antimicrobial susceptibility profiles revealed statistically significant variation among the tested antibiotics ($p < 0.05$), with colistin retaining the highest activity against the isolates, while carbapenems, particularly ertapenem, demonstrated markedly elevated resistance rates among all tested agents.

4. Discussion

The present study demonstrates a high burden of multidrug-resistant *Acinetobacter* isolates among ICU patients, consistent with its established role as a leading opportunistic pathogen in critical care settings. Intensive care units provide an ideal environment for persistence and transmission due to prolonged hospitalization, frequent invasive procedures, and extensive antimicrobial exposure, which collectively select for resistant strains. Similar epidemiological observations have been reported globally, where *Acinetobacter spp.* is frequently implicated in ventilator-associated pneumonia, bloodstream infections, and device-associated infections in ICUs (Chen et al., 2023; Kanafani et al., 2018). The high level of antimicrobial resistance observed in the present study is consistent with findings reported in several regional and international investigations involving ICU-associated A key finding in the present study is the markedly high resistance of *Acinetobacter spp.* isolates to carbapenems, particularly ertapenem (99.1%), followed by meropenem (55.9%) and imipenem (48.6%). These alarming resistance rates are consistent with the global emergence of carbapenem-resistant *Acinetobacter* strains, largely driven by the dissemination of carbapenemase-producing clones. Comparable resistance trends have been documented worldwide among ICU-associated *Acinetobacter spp.* isolates. A surveillance study from the Asia–Pacific region reported carbapenem resistance rates exceeding 80% among multidrug-resistant *Acinetobacter spp.* isolates, emphasizing the widespread dissemination of resistant strains (Chen et al., 2023). Similarly, Kipsang et al. (2023) reported that 83.3% of ICU-associated *Acinetobacter spp.* isolates in Kenya were carbapenem-resistant, while a Romanian ICU study documented carbapenem non-susceptibility in 89.3% of isolates (Stoian et al., 2025). In Italy, Zarrilli et al. (2021) also demonstrated the widespread circulation of carbapenem-resistant *Acinetobacter spp.* clones in hospital settings, highlighting the molecular epidemiological importance of resistant strains in healthcare-associated outbreaks. These findings collectively indicate that carbapenem-resistant strains have become a dominant and endemic phenotype among ICU-associated *Acinetobacter* isolates worldwide, severely limiting available first-line therapeutic options. Similarly, resistance to cephalosporins was highly prevalent in the present study, particularly against ceftazidime (64.9%) and cefotaxime (56.8%). These findings are consistent with previous reports describing widespread resistance to third-generation cephalosporins among ICU-derived *Acinetobacter* isolates worldwide. The observed resistance is mainly attributed to the production of extended-spectrum β-lactamases, AmpC β-lactamases, permeability alterations, and porin modifications. Comparable resistance patterns have been reported in several countries, including Egypt, China, Poland, and Lebanon. In Lebanon, Kanafani et al. (2018) documented a high prevalence of multidrug-resistant *Acinetobacter* species over a seven-year surveillance period in a tertiary care center, with marked resistance to β-lactam antibiotics and carbapenems among ICU-associated isolates. In Poland, ceftazidime resistance among *Acinetobacter spp.* isolates increased from 64% in 2021 to over 90% by 2024 (Bekier *et al*., 2026), while studies from Egypt and China similarly demonstrated high resistance rates among ICU-associated isolates (Ibrahim et al., 2023; Liu & Liu, 2021). The consistency between these studies and the present findings highlights the global persistence and dissemination of β-lactam-resistant *Acinetobacter* clones within hospital environments. In contrast, colistin demonstrated the highest retained antimicrobial activity in the present study, with 43.2% susceptibility and only 5.4% resistance. This finding is consistent with international reports indicating that colistin remains one of the few effective therapeutic agents against carbapenem-resistant *Acinetobacter* isolates. Chen et al. (2023) reported colistin resistance rates as low as 1.1% among multidrug-resistant isolates in the Asia–Pacific region, while Kipsang et al. (2023) found that carbapenem-resistant *Acinetobacter spp.* isolates in Kenyan ICUs remained largely susceptible to colistin. However, the relatively high proportion of intermediate susceptibility observed in the current study raises concern regarding the possible emergence of reduced colistin susceptibility, a growing global problem associated with selective antimicrobial pressure, limited therapeutic alternatives, and suboptimal dosing practices (Sacco et al., 2021). The nearly balanced distribution between swab (53.15%) and tip (46.85%) samples observed in the present study suggests that

Acinetobacter colonization and infection are not restricted to a single clinical source. This finding reflects the organism's remarkable ability to survive on both patient-derived and device-associated surfaces, contributing significantly to its persistence within ICU environments. Similar observations have been reported in ICU-based investigations demonstrating that *Acinetobacter* can colonize multiple clinical and environmental reservoirs, including respiratory secretions, wound swabs, catheter tips, invasive devices, and hospital surfaces (Stoian et al., 2025). Furthermore, the organism's prolonged survival on abiotic surfaces facilitates cross-transmission and enhances its dissemination within critical care settings, thereby increasing the risk of nosocomial infections among ICU patients. Overall, the findings of this study highlight a critical antimicrobial resistance scenario characterized by extensive carbapenem and cephalosporin resistance, with limited remaining therapeutic options. The results underscore the urgent need for strengthened antimicrobial stewardship, continuous resistance surveillance, and strict infection prevention and control measures to limit the spread of multidrug-resistant *Acinetobacter* in ICU settings (Chen *et al*., 2023; Liu & Liu, 2021; Zarrilli et al., 2021).

4. Conclusion and Recommendations

This study demonstrated a high prevalence of multidrug-resistant Acinetobacter spp. among ICU patients in Benghazi, Libya, with substantial resistance to carbapenems and cephalosporins. The findings highlight the growing challenge of antimicrobial resistance in critical care settings and emphasize the need for strengthened infection prevention measures, antimicrobial stewardship programs, and continuous local surveillance. Further molecular studies are required to characterize the underlying resistance mechanisms and transmission dynamics of Acinetobacter isolates in Libyan healthcare facilities. Strict infection prevention and control measures are strongly recommended and should be prioritized, including consistent hand hygiene, environmental decontamination, and proper disinfection of medical equipment. Special attention should be given to invasive devices through adherence to evidence-based insertion and maintenance bundles. Antimicrobial stewardship programs must be strengthened to ensure rational use of broad-spectrum antibiotics, particularly carbapenems and cephalosporins, guided by local susceptibility data and supported by timely de-escalation of therapy. Routine surveillance of resistance patterns and continuous staff education are also essential, alongside strict implementation of isolation precautions for infected or colonized patients to limit cross-transmission.

Future studies should employ molecular approaches such as whole-genome sequencing to identify resistance mechanisms, genetic determinants, and transmission pathways of Acinetobacter in ICU settings. Multicenter and large-scale surveillance studies are needed to better define regional resistance patterns and improve generalizability. Longitudinal research should assess temporal trends in resistance and evaluate the impact of infection control and stewardship interventions. Further work should also focus on clinical outcomes associated with resistant infections and explore new therapeutic options, including novel antimicrobials and combination or adjunctive treatment strategies. This study was conducted in a single center, which may limit generalizability. The absence of molecular characterization restricts insight into specific resistance mechanisms. In addition, incomplete clinical outcome data and the retrospective component of data collection may introduce bias and limit correlation between microbiological findings and patient outcomes.

5. Acknowledgements

The authors sincerely thank the ICU staff and the Microbiology Laboratory team for their valuable support in specimen collection, processing, and data management. We also acknowledge the hospital administration for facilitating access to clinical data and supporting this research. Appreciation is extended to all healthcare personnel involved in patient care and to the patients whose samples were included in this study.

References

Aruhomukama, D., Najjuka, C.F., Kajumbula, H., Okee, M., Mboowa, G., Sserwadda, I., Mayanja, R., Joloba, M.L., & Kateete, D.P. (2019). blaVIM- and blaOXA-mediated carbapenem resistance among Acinetobacter baumannii and Pseudomonas aeruginosa isolates from the Mulago hospital intensive care unit in Kampala, Uganda. BMC Infectious Diseases, 19(1), 853. https://doi.org/10.1186/s12879-019-4510-5

Cavallo, I., Oliva, A., Pages, R., & Sivori, F. (2023). Acinetobacter baumannii in the critically ill: complex infections get complicated. Frontiers in Microbiology, 14, 1196774. http://doi:10.3389/fmicb.2023.1196774

Chen, C.H., Wu, P.H., Lu, M.C., Ho, M.W., & Hsueh, P.R. (2023). Geographic patterns of carbapenem-resistant, multi-drug-resistant and difficult-to-treat Acinetobacter baumannii in the Asia-Pacific region: results from the Antimicrobial Testing Leadership and Surveillance (ATLAS) program, 2020. International journal of antimicrobial agents, 61(2), 106707. https://doi.org/10.1016/j.ijantimicag.2022.106707

Choi, S.J., & Kim, E.S. (2024). Optimizing treatment for carbapenem-resistant Acinetobacter baumannii complex infections. Infection & Chemotherapy, 56(2), 171–187; http://doi:10.3947/ic.2024.0055

Fam, N.S., Gamal, D., Mohamed, S.H., Wasfy, R.M., Soliman, M.S., El-Kholy, A.A., & Higgins, P. G. (2020). Molecular characterization of carbapenem/colistin-resistant Acinetobacter baumannii clinical isolates from Egypt by whole-genome sequencing. Infection and Drug Resistance, 13, 4487–4493; https://doi.org/10.2147/IDR.S288865

Ibrahim, M.A., Abdallah, S., Soliman, I.S., Afifi, N., & Allah, M.N.A.A. (2023). Hospital-acquired infection by carbapenem-resistant Acinetobacter species in ICUs in Assiut, Egypt. Egyptian Journal of Medical Microbiology, 32(1), 97–104. http://DOI:10.21608/ejmm.2023.277785

Jiang, Y., Ding, Y., Wei, Y., Jian, C., Liu, J., & Zeng, Z. (2022). Carbapenem-resistant Acinetobacter baumannii: A challenge in the intensive care unit. Frontiers in Microbiology, 13, 1045206. http://doi:10.3389/fmicb.2022.1045206

Kanafani, Z.A., Zahreddine, N., Tayyar, R., Sfeir, J., Araj, G.F., Matar, G.M., & Kanj, S. S. (2018). Multi-drug resistant Acinetobacter species: a seven-year experience from a tertiary care center in Lebanon. Antimicrobial Resistance & Infection Control, 7(1), 9. https://doi.org/10.1186/s13756-017-0297-6

Kipsang, F., Munyiva, J., Menza, N., & Musyoki, A. (2023). Carbapenem-resistant Acinetobacter baumannii infections: Antimicrobial resistance patterns and risk factors for acquisition in a Kenyan intensive care unit. International Journal of Infection and Global Health, 9, 111–116. https://doi.org/10.1016/j.ijregi.2023.10.007

Bekier, A., Bielec, F., Grędysa, M., Miaśkiewicz, E., Nowak, M., Pastuszak-Lewandoska, D., & Brauncajs, M. (2026). Changes in Susceptibility Profiles of Acinetobacter baumannii Clinical Isolates in a Multi-Profile Hospital in Years 2020–2024 in Lodz, Poland. Journal of Clinical Medicine, 15(9), 3505. https://doi.org/10.3390/jcm15093505

Li, Q., Zhou, X., Yang, R., Shen, X., Li, G., Zhang, C., & Yang, Y. (2024). Carbapenem-resistant Gram-negative bacteria (CR-GNB) in ICUs: resistance genes, therapeutics, and prevention–a comprehensive review. Frontiers in Public Health, 12, 1376513. http://doi:10.3389/fpubh.2024.1376513

Liu, B., & Liu, L. (2021). Molecular epidemiology and mechanisms of carbapenem-resistant Acinetobacter baumannii isolates from ICU and respiratory department patients of a Chinese university hospital. Infection and Drug Resistance, 14, 743–755. https://doi.org/10.2147/IDR.S299540

Mendes, S.G., Combo, S.I., Allain, T., Domingues, S., Buret, A.G., & Da Silva, G.J. (2023). Co-regulation of biofilm formation and antimicrobial resistance in Acinetobacter baumannii: from mechanisms to therapeutic strategies. European Journal of Clinical Microbiology & Infectious Diseases, 42(12), 1405-1423; https://doi.org/10.1007/s10096-023-04677-8

Sacco, F., Visca, P., Runci, F., Antonelli, G., & Raponi, G. (2021). Susceptibility testing of colistin for Acinetobacter baumannii: How far are we from the truth? Antibiotics, 10(1), 48. https://doi.org/10.3390/antibiotics10010048

Saharman, Y.R., Karuniawati, A., Sedono, R., Aditianingsih, D., Sudarmono, P., Goessens, W.H.F., Klaassen, C.H.W., Verbrugh, H.A., & Severin, J.A. (2018). Endemic carbapenem-nonsusceptible Acinetobacter baumannii-calcoaceticus complex in intensive care units of the national referral hospital in Jakarta, Indonesia. Antimicrobial Resistance & Infection Control, 7(1), 5. https://doi.org/10.1186/s13756-017-0296-7

Sodeifian, F., Zangiabadian, M., Arabpour, E., Kian, N., Yazarlou, F., Goudarzi, M., ... & Migliori, G.B. (2023). Tigecycline-containing regimens and multi drug-resistant Acinetobacter baumannii: a systematic review and meta-analysis. Microbial Drug Resistance, 29(8), 344-359. https://doi.org/10.1089/mdr.2022.0248

Stoian, M., Azamfirei, L., Stângaciu, A.C., Manea, S., Onisor, D., Manea, A., ... & Stoian, A. (2026). Six Years of Acinetobacter Species in Critical Care: Carbapenem Resistance and Non-Susceptibility, Clinical Outcomes, and Lessons for Stewardship. Antibiotics, 15(3), 267. https://doi.org/10.3390/antibiotics15030267

Zarrilli, R., Bagattini, M., Migliaccio, A., Esposito, E.P., & Triassi, M. (2021). Molecular epidemiology of carbapenem-resistant Acinetobacter baumannii in Italy. Ann Ig, 33(5), 401-9. http://doi:10.7416/ai.2020.2395