Electronic Journal of Medical Research
https://ejmr.respublishers.com
ISSN: 3106-1362/3106-1370

Research article

Antimicrobial Resistance and Susceptibility Patterns of Clinical *Pseudomonas aeruginosa* Isolates from a Tertiary Care Hospital in Lahore, Pakistan

Malaika Jameel Butt [1,*], Ehsan Ahmad [2], Iqra Maqsood [3] and Ayesha Khaliq [1]

[1] Institute of Molecular Biology and Biotechnology, The University of Lahore, Lahore, Punjab, Pakistan
[2] Ayesha Sakeena Medical Complex Hospital, Lahore, Punjab, Pakistan
[3] Shaikh Zayed Medical Complex, Lahore, Punjab, Pakistan

*Correspondence: malaikabutt128@gmail.com

Article information:
Received: 26-07-2026
Revised: 17-08-2026
Accepted: 19-08-2026
Published: 21-08-2026

Academic Editor:
Dr. Mai Abusalah

Keywords:
Drug Resistance
Kirby–Bauer
Multidrug Resistance
Antimicrobials
Clinical Isolates

Abstract: *Pseudomonas aeruginosa* is a leading opportunistic pathogen in hospital settings and is increasingly associated with multidrug resistance (MDR), which narrows therapeutic options and worsens patient outcomes. Local surveillance data from tertiary care settings in Pakistan remain limited. This study aimed to determine the frequency of MDR *P. aeruginosa* among clinical isolates and to characterize their antibiotic susceptibility profile. We conducted a cross-sectional study over three months (March–May 2021) in the microbiology laboratory of a tertiary care hospital in Lahore. A total of 53 non-duplicate clinical specimens yielding *P. aeruginosa* were included. We identified isolates by standard morphological and biochemical methods. Antimicrobial susceptibility was determined by the Kirby–Bauer disc-diffusion method on Mueller–Hinton agar against eight antibiotics, with each assay performed in triplicate. Of the 53 isolates, 22 (41.5%) were multidrug-resistant. The cohort comprised 33 males (62.3%) and 20 females (37.7%), with most isolates recovered from patients aged 31–50 years. Resistance was highest to cefepime (45.3%) and lowest to amikacin and meropenem (30.2% each). Amikacin and meropenem were the most effective agents (69.8% susceptibility each), followed by imipenem (67.9%). Cefepime was the least effective agent tested. A high burden of MDR *P. aeruginosa* (41.5%) was observed. Aminoglycosides (amikacin) and carbapenems (meropenem, imipenem) retained the greatest activity and represent the most reliable empirical options in this setting, whereas cefepime should be used with caution. Continued antimicrobial stewardship and periodic local surveillance are warranted.

Article citation: Butt, M.J., Ahmad, E., Maqsood, I. et al. Antimicrobial Resistance and Susceptibility Patterns of Clinical *Pseudomonas aeruginosa* Isolates from a Tertiary Care Hospital in Lahore, Pakistan. Electron J Med Res. 2026. 2(3): 85-91. https://doi.org/10.64813/ejmr.2026.132

Introduction

Pseudomonas aeruginosa is a Gram-negative, aerobic, non-fermenting bacillus that ranks among the most important opportunistic pathogens in healthcare environments [1]. Its remarkable metabolic versatility, capacity to survive on moist surfaces and medical devices, and intrinsic resistance to numerous antimicrobial classes make it a frequent cause of nosocomial infections, including ventilator-associated pneumonia, catheter-associated urinary tract infections, bloodstream infections, and burn-wound sepsis [2, 3]. The clinical threat posed by this organism is compounded by its ability to acquire and express diverse resistance mechanisms, including efflux pump overexpression [4], reduced outer-membrane permeability through porin loss [5], production of AmpC β-lactamases and carbapenemases [6], and target-site modification [7]. The convergence of these mechanisms gives rise to multidrug-resistant (MDR) phenotypes, conventionally defined as acquired non-

Copyright © 2026 Butt, M.J. et al. This work is published and licensed by RES Publishers.
The full terms of this license are available at https://www.respublishers.com/terms_conditions.php.

susceptibility to at least one agent in three or more antimicrobial categories [8]. MDR *P. aeruginosa* infections are associated with prolonged hospitalization, higher treatment costs, and increased mortality [9]. Antimicrobial resistance is a particularly pressing concern in low- and middle-income countries, where over-the-counter antibiotic availability, incomplete treatment courses, and limited stewardship infrastructure accelerate the emergence of resistant strains [10, 11]. Local, setting-specific susceptibility data are essential for guiding rational empirical therapy, yet such data remain sparse for many tertiary care hospitals in Pakistan [12].

This study was therefore undertaken to determine the frequency of MDR *P. aeruginosa* among clinical isolates at a tertiary care hospital in Lahore and to characterize the in vitro susceptibility of these isolates to eight commonly used anti-pseudomonal antibiotics spanning the cephalosporin, carbapenem, aminoglycoside, and fluoroquinolone classes. The findings are intended to inform local empirical prescribing and to contribute to the broader antimicrobial-resistance surveillance evidence base.

Materials and Methods

Study design and setting

This was a cross-sectional study conducted in the microbiology laboratory of a tertiary care hospital in Lahore, Pakistan, over a three-month period from March to May 2021.

Sample size and eligibility

A total of 53 non-duplicate clinical specimens yielding P. aeruginosa were included by consecutive sampling. All *P. aeruginosa* isolates recovered during the study period, regardless of patient age or sex, were eligible for inclusion; both susceptible and multidrug-resistant isolates were retained. Specimens yielding organisms other than *P. aeruginosa* were excluded.

Specimen collection and transport

Urine specimens and burn, wound, ear, hand, nasal and throat swabs were collected aseptically into sterile containers and on sterile swabs from various wards and units of the hospital [13]. All specimens were transported to the microbiology laboratory at room temperature and processed as soon as possible after collection [14].

Isolation and identification

Specimens were inoculated onto cysteine–lactose–electrolyte-deficient (CLED) agar, nutrient agar, blood agar, and MacConkey agar and incubated aerobically [15]. Colonies were identified as *P. aeruginosa* using standard microbiological procedures, including colonial morphology, Gram staining, and a panel of biochemical tests: catalase, oxidase, indole, citrate utilization, urease, triple-sugar-iron (TSI) reaction, and lactose fermentation [16].

Antimicrobial susceptibility testing

Antimicrobial susceptibility was determined by the Kirby–Bauer disc-diffusion method on Mueller–Hinton (MH) agar. The following antibiotic discs were tested: cefepime (30 µg), ceftazidime (30 µg), imipenem (10 µg), meropenem (10 µg), amikacin (30 µg), gentamicin (10 µg), tobramycin (10 µg), and ciprofloxacin (5 µg) [17]. Discs were applied to freshly prepared MH plates and incubated at 37°C for 24 hours. Zones of inhibition were measured and interpreted as susceptible or resistant according to standard reference criteria. To ensure reproducibility, each assay was performed in triplicate. Isolates non-susceptible to agents in three or more antimicrobial categories were classified as multidrug-resistant [18].

Data analysis

Data were entered and analyzed using standard statistical software. Categorical variables, including susceptibility and resistance frequencies for each antibiotic and the distribution of isolates by age and sex, were summarised as frequencies and percentages and are presented in tabular and graphical form [19].

Results

Pseudomonas aeruginosa was isolated from all 53 clinical specimens. Of these, 22 isolates (41.5%) were multidrug-resistant. The specimen distribution comprised 17 urine specimens, 11 burn swabs, 6 wound swabs, 7 ear swabs, and 12 specimens obtained collectively from hand, nasal, and throat swabs.

Demographic distribution

The study population consisted of 33 males (62.3%) and 20 females (37.7%). Isolates were recovered across all age groups except the 71–80-year band, from which no specimens were obtained. The highest number of isolates originated from patients aged 31–40 years (n = 12) and 41–50 years (n = 11) **(Figures 1**

and 2. **Table 1** summarises the age- and sex-wise distribution.

Table 1. Distribution of *P. aeruginosa* isolates by patient age group and sex.

Age group (years)	Male	Female	Total
0–10	7	1	8
11–20	1	1	2
21–30	6	2	8
31–40	5	7	12
41–50	5	6	11
51–60	5	2	7
61–70	3	1	4
71–80	0	0	0
81–90	1	0	1
Total	33	20	53

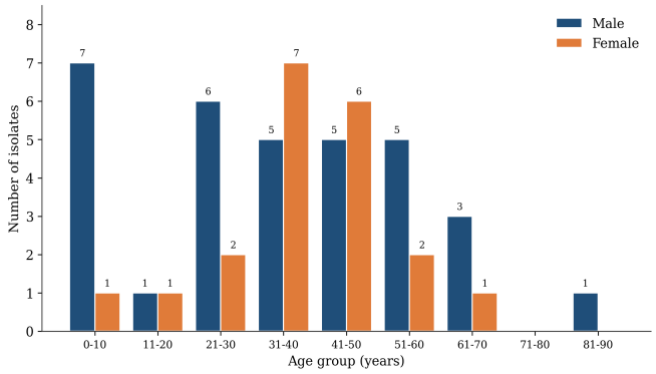

Figure 1. Distribution of male and female *P. aeruginosa* isolates across age groups.

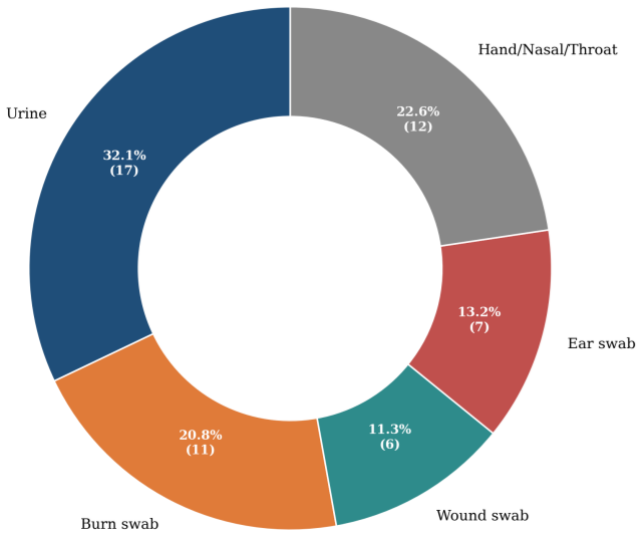

Figure 2. Distribution of clinical specimen types (n=53).

Antibiotic susceptibility and resistance profile

Table 2 presents the susceptibility and resistance frequencies of *P. aeruginosa* to each of the eight antibiotics tested, and **Figure 3** visualizes these results. Susceptibility ranged from 54.7% (cefepime) to 69.8% (amikacin and meropenem).

Table 2. Summary of susceptibility and resistance of *P. aeruginosa* to all eight antibiotics.

No.	Antibiotic	Susceptible (%)	Resistant (%)
1	Cefepime	54.7	45.3
2	Ceftazidime	64.2	35.8
3	Imipenem	67.9	32.1
4	Meropenem	69.8	30.2
5	Amikacin	69.8	30.2
6	Gentamicin	64.2	35.8
7	Tobramycin	62.3	37.7
8	Ciprofloxacin	60.4	39.6

Most and least effective agents

Amikacin and meropenem demonstrated the highest in-vitro activity, with 69.8% of isolates susceptible to each, closely followed by imipenem (67.9%). Conversely, the highest resistance was observed against cefepime (45.3%), which was the least effective agent tested. The lowest resistance was recorded against amikacin and meropenem (30.2% each), identifying amikacin as the single most effective anti-pseudomonal agent in this cohort. When resistance rates were aggregated by antimicrobial class **(Figure 3D)**, the carbapenems showed the tightest and lowest resistance distribution, whereas the cephalosporins exhibited the highest and most variable resistance.

Discussion

This study documented a substantial burden of multidrug resistance among *P. aeruginosa* clinical isolates at a tertiary care hospital in Lahore, with 41.5% of isolates classified as MDR [20, 21]. This frequency is consistent with reports from other tertiary care centers in Pakistan and comparable low- and middle-income settings [22], where MDR *P. aeruginosa* prevalence has frequently been reported in the range of 30–60%, and reinforces the concern that anti-pseudomonal resistance is now firmly established in the region [23].

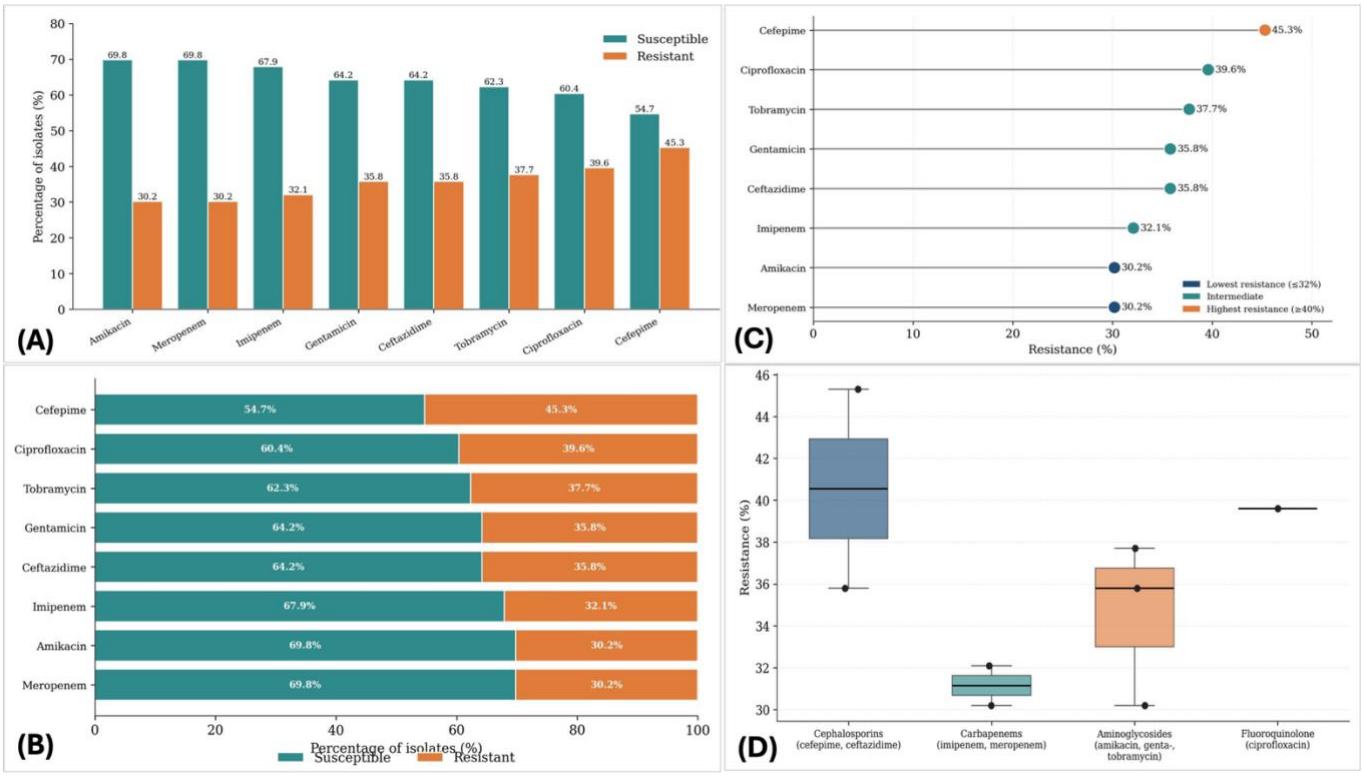

Figure 3. (A) Comparative susceptibility and resistance of *P. aeruginosa* across the eight antibiotics tested (ranked by susceptibility). (B) Antibiotic effectiveness ranking shown as stacked susceptibility versus resistance. (C) Resistance rate of *P. aeruginosa* by antibiotic, ranked from lowest to highest. (D) Distribution of resistance rates grouped by antibiotic class. Boxes summarise the constituent agents within each class; individual agents are overlaid as points.

The susceptibility profile observed here has direct implications for empirical therapy [24]. Amikacin and meropenem retained the greatest activity (69.8% susceptibility each), with imipenem close behind (67.9%). The strong performance of the aminoglycoside amikacin is a recurring finding in the regional literature [25] and supports its continued role, whether as part of combination therapy or as a targeted agent, in managing suspected pseudomonal infection [26].

The carbapenems likewise remained comparatively effective; however, the observation that roughly one-third of isolates were already carbapenem-resistant is an early warning that this class must be preserved through judicious use [27]. The comparatively poor performance of cefepime, to which nearly half of the isolates were resistant, is noteworthy and suggests that this fourth-generation cephalosporin may be an unreliable empirical choice in this setting [28].

Ceftazidime and gentamicin occupied an intermediate position (64.2% susceptibility each), while the fluoroquinolone ciprofloxacin showed relatively high resistance (39.6%), likely reflecting the widespread and often unregulated use of fluoroquinolones in the community [28]. The predominance of male patients (62.3%) and the clustering of isolates in the 31–50-year age range is in keeping with the demographic patterns reported in several hospital-based studies [29], and may reflect differences in exposure to trauma, burns, and invasive procedures rather than an intrinsic biological susceptibility [30].

The recovery of isolates from a range of specimen types, including urine and burn, wound, ear, and respiratory-tract swabs, underscores the versatility of P. aeruginosa as a pathogen across multiple body sites [31]. Taken together, these findings argue for a stewardship strategy that prioritizes amikacin- and carbapenem-based regimens for serious pseudomonal infection while restricting empirical reliance on cefepime and ciprofloxacin, pending culture and susceptibility confirmation [32]. Regular local antibiograms are essential, as susceptibility patterns evolve and cannot be reliably inferred from national or international data alone [33].

Study limitations: Several limitations should be acknowledged. The study was conducted at a single center over a relatively short three-month period with a modest sample size of 53 isolates, which limits the generalisability of the findings and the precision of the reported estimates. Susceptibility was assessed by disc

diffusion alone, without confirmatory minimum inhibitory concentration determination or molecular characterization of resistance genes. Clinical outcome data and information on prior antibiotic exposure were not collected, precluding analysis of MDR risk factors. Larger, multicentre, longitudinal studies incorporating molecular methods are recommended to build on these observations.

Conclusion

A high frequency of multidrug-resistant P. aeruginosa (41.5%) was identified among clinical isolates at a tertiary care hospital in Lahore. Amikacin and meropenem, followed by imipenem, were the most effective agents and represent the most dependable empirical options in this setting, whereas cefepime and ciprofloxacin showed limited activity and should be used cautiously. These findings highlight the urgent need for sustained antimicrobial stewardship, infection-control measures, and continued local surveillance to preserve the effectiveness of the remaining active agents.

Author Contributions: Conceptualization, M.J.B.; methodology, M.J.B. E.A. and I.M.; software, A.K. and M.J.B.; validation, A.K.; formal analysis, S M.J.B. E.A. and I.M.; investigation, M.J.B. E.A. and I.M.; resources, M.J.B.; data curation, M.J.B.; writing—original draft preparation, M.J.B. and E.A.; writing—review and editing, I.M. and A.K.; supervision, M.J.B.; project administration, M.J.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Health Research Ethics Committee of the Shaikh Zayed Medical Complex, Lahore, Punjab, Pakistan, and the Health Research Ethics Committee of the University of Lahore, Lahore, Punjab, Pakistan.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study for collecting data and to publish this paper.

Data Availability Statement: Additional data will be made available upon reasonable request to the corresponding author.

Acknowledgments: The authors thank the Health Research Ethics Committee of the Shaikh Zayed Medical Complex, Lahore, Punjab, Pakistan, for providing research facilities for this study.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Di Pilato, V., Willison, E., and Marchese, A. The microbiology and pathogenesis of nonfermenting Gram-negative infections. Current Opinion in Infectious Diseases. **2023**. 36(6): 537 https://doi.org/10.1097/QCO.0000000000000969.
2. Ambreetha, S., Zincke, D., et al. Genomic and metabolic versatility of Pseudomonas aeruginosa contributes to its inter-kingdom transmission and survival. Journal of Medical Microbiology. **2024**. 73(2): 001791 https://doi.org/10.1099/jmm.0.001791.
3. Bhardwaj, S., Bhatia, S., et al. Growing emergence of drug-resistant Pseudomonas aeruginosa and attenuation of its virulence using quorum sensing inhibitors: A critical review. Iranian journal of basic medical sciences. **2021**. 24(6): 699 https://doi.org/10.22038/IJBMS.2021.49151.11254.
4. Nusrat, S., Aliyu, M., and Zohora, F.T. Mechanisms of antimicrobial resistance: From genetic evolution to clinical manifestations. AIMS microbiology. **2025**. 11(4): 1007.
5. Dam, S., Pages, J.-M., and Masi, M. Stress responses, outer membrane permeability control and antimicrobial resistance in Enterobacteriaceae. Microbiology. **2018**. 164(3): 260–267 https://doi.org/10.1099/mic.0.000613.
6. Tamma, P.D., Doi, Y., et al. A primer on AmpC β-lactamases: necessary knowledge for an increasingly multidrug-resistant world. Clinical infectious diseases. **2019**. 69(8): 1446–1455 https://doi.org/10.1093/cid/ciz173.
7. Browne, C.M., Jiang, B., et al. A chemoproteomic strategy for direct and proteome-wide covalent inhibitor target-site identification. Journal of the American Chemical Society. **2019**. 141(1): 191–203 https://doi.org/10.1021/jacs.8b07911.
8. Abdelmoneim, H.M., Alhudhaibi, A.M., et al. Integrating resistance biology, virulence networks, and precision therapeutics against multidrug-resistant Pseudomonas aeruginosa. Infection. **2026**: 1–22 https://doi.org/10.1007/s15010-026-02817-8.
9. Reynolds, D. and Kollef, M. The epidemiology and pathogenesis and treatment of Pseudomonas aeruginosa infections: an update. Drugs. **2021**. 81(18): 2117–2131 https://doi.org/10.1007/s40265-021-01635-6.
10. Sulis, G., Sayood, S., and Gandra, S. Antimicrobial resistance in low-and middle-income countries: current status and future directions. Expert

review of anti-infective therapy. **2022**. 20(2): 147–160 https://doi.org/10.1080/14787210.2021.1951705.

11. Oliveira, M., Antunes, W., et al. An overview of the recent advances in antimicrobial resistance. Microorganisms. **2024**. 12(9): 1920 https://doi.org/10.3390/microorganisms12091920.
12. Altaf, I., Wani, S.M., et al. Antibiotic Susceptibility Patterns of Bacterial Isolates from Routine Clinical Specimens: A Contemporary Analysis to Guide Empirical Antimicrobial Therapy to Address Antimicrobial Resistance. Journal of Microscopy and Ultrastructure. **2026**: 10.4103 10.4103/jmau.jmau_20_25.
13. Ramanisankar, A., Shanmugasundaram, N., et al. Antimicrobial Resistance Patterns and the Role of Antibiotic Stewardship in a Secondary Care Hospital. Recent Advances in Anti-Infective Drug Discovery. **2025**. 20(3): 203–222 10.2174/0127724344369266250310084603.
14. Miller, J.M., Binnicker, M.J., et al. A guide to utilization of the microbiology laboratory for diagnosis of infectious diseases: 2018 update by the Infectious Diseases Society of America and the American Society for Microbiology. Clinical infectious diseases. **2018**. 67(6): 813–816 https://doi.org/10.1093/cid/ciy584.
15. Tigabu, A., Ferede, W., et al. Prevalence of asymptomatic bacteriuria and antibiotic susceptibility patterns of bacterial isolates among cancer patients and healthy blood donors at the University of Gondar Specialized Hospital. International Journal of Microbiology. **2020**. 2020(1): 3091564 https://doi.org/10.1155/2020/3091564.
16. Ahmed, A., Ahmad, W., et al. Characterization of Aminoglycoside-Resistant Pseudomonas aeruginosa in Respiratory Specimens: Phenotypic and Molecular Insights. Pak-Euro Journal of Medical and Life Sciences. **2024**. 7(2): 239–246 https://doi.org/10.31580/pjmls.v7i2.3079.
17. Zainab, M., Khan, I.U., and Fatima, F. Frequency of Susceptibility to Cefiderocol in Carbapenem-Resistant Gram-Negative Bacteria by Kirby-Bauer Disc Diffusion Method; A Study in Tertiary Care Hospital of Southern Punjab. Journal of Postgraduate Medical Institute. **2025**. 39(3) https://doi.org/10.54079/jpmi.39.3.3720.
18. Gadisa, E., Weldearegay, G., et al. Combined antibacterial effect of essential oils from three most commonly used Ethiopian traditional medicinal plants on multidrug resistant bacteria. BMC Complementary and Alternative Medicine. **2019**. 19(1): 24 https://doi.org/10.1186/s12906-019-2429-4.
19. Baker, G.J., Muhlich, J.L., et al. SYLARAS: A platform for the statistical analysis and visual display of systemic immunoprofiling data and its application to glioblastoma. Cell systems. **2020**. 11(3): 272–285. e9 https://doi.org/10.1016/j.cels.2020.08.001 ll.
20. Ahmed, D., Javed, H., et al. Determination of Multidrug Resistance and Extended Drug Resistance Pattern of Pseudomonas aeruginosa in Clinical Isolates of Tertiary Care Hospital Lahore. Annals of King Edward Medical University. **2023**. 29(2): 98 10.21649/akemu.v29i2.5453.
21. Zahoor, S., Mahboob, H.M., et al. Frequency and Antimicrobial Susceptibility Pattern of Pseudomonas aerugonisa Clinical Isolates at a Large Teaching Hospital In Lahore, Pakistan. Pakistan Postgraduate Medical Journal. **2020**. 31(04): 168–171.
22. Rowe, A.K., Rowe, S.Y., et al. Effectiveness of strategies to improve health-care provider practices in low-income and middle-income countries: a systematic review. The Lancet Global Health. **2018**. 6(11): e1163–e1175 http://dx.doi.org/10.1016/ S2214-109X(18)30398-X.
23. Obaid, F.H. MDR Pseudomonas aeruginosa in Burn Units of Iraq: Resistance Trends, Biofilm Quantification Using Microtiter OD, Predictor of Clinical Outcomes. Libyan Open University Journal of Applied Sciences (LOUJAS). **2026**: 246–258 https://doi.org/10.65422/loujas.v2i1.231.
24. Santella, B., Folliero, V., et al. Sepsis—A retrospective cohort study of bloodstream infections. Antibiotics. **2020**. 9(12): 851 https://doi.org/10.3390/antibiotics9120851.
25. Orzechowski, D., Mroczkowska, A., et al. Clinical Considerations of Amikacin Pharmacotherapy in Adults-A Narrative Review with Focus on Safety and TDM. Antibiotics (Basel). **2026**. 15(6) 10.3390/antibiotics15060534.
26. Losito, A.R., Raffaelli, F., et al. New Drugs for the Treatment of Pseudomonas aeruginosa Infections with Limited Treatment Options: A Narrative Review. Antibiotics. **2022**. 11(5): 579 https://doi.org/10.3390/antibiotics11050579.
27. Iftekhar, A., Zafar, A., et al. Descriptive analysis of frequency and antimicrobial susceptibility of pathogens isolated from acute leukemia patients with febrile neutropenia over a four-year period

at a tertiary hospital. BMC Infectious Diseases. **2026**. 26(1): 730 https://doi.org/10.1186/s12879-026-12918-2.

28. Carcione, D., Brigante, G., et al. Cefepime and New Cefepime/Beta-Lactamase Inhibitor Combination for the Treatment of Gram-Negative Bacteria: Chemical Structure and Mechanism of Action, Microbiological Target, Clinical Use and PK/PD Characteristics. Pharmaceuticals. **2026**. 19(2): 283 https://doi.org/10.3390/ph19020283.
29. Abdel Halim, R.M., Kassem, N.N., and Elsayed, E.Y. Molecular detection of clarithromycin-resistant Helicobacter pylori in stool samples using real-time PCR. Microbes and Infectious Diseases. **2025**. 6(3): 3051–3064 https://doi.org/10.1002/mds.10385.
30. Cramer, M.N., Gagnon, D., et al. Human temperature regulation under heat stress in health, disease, and injury. Physiological reviews. **2022** https://doi.org/10.1152/physrev.00047.2021.
31. Al-Ouqaili, M.T., Salman, S.M., et al. Molecular and genomic characterization of biofilm associated antimicrobial resistance in clinical and resistant isolates of Pseudomonas aeruginosa in Iraq. Scientific Reports. **2026** https://doi.org/10.1038/s41598-026-65893-8.
32. Horcajada, J.P., Gales, A.C., et al. Current and future options for the treatment of serious infections due to carbapenem-resistant Pseudomonas aeruginosa. Clinical microbiology reviews. **2025**. 38(4): e00233–24 https://doi.org/10.1128/cmr.00233-24.
33. Yan, Z., Liu, L., et al. A mini review of genome-predicted β-lactam susceptibility in Streptococcus pneumoniae: from PBP profiles to potential clinical interpretation. Frontiers in Cellular and Infection Microbiology. **2026**. 16: 1901030 https://doi.org/10.3389/fcimb.2026.1901030.

Disclaimer/Publisher's Note: The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of RES Publishers and/or the editor(s). RES Publishers and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.