

# Antimicrobial Resistance of *Acinetobacter* Species and *Pseudomonas* Species in a Tertiary Care Center in Gandaki Province, Nepal

Bimala Sharma,<sup>1</sup> Simrin Kafle,<sup>2</sup> Krishna Koirala,<sup>3</sup> Dhurba Giri,<sup>4</sup> Shivahari Ghimire,<sup>4</sup> Bhudev Singh Rajput,<sup>4</sup> Bishnu Raj Tiwari<sup>4</sup>

<sup>1</sup>Department of Community Medicine and Public Health, Gandaki Medical College Teaching Hospital and Research Center, Pokhara, Kaski, Nepal. <sup>2</sup>Ministry of Health, Gandaki Province, Nepal, <sup>3</sup>Department of ENT, Manipal College of Medical Science, Pokhara, Kaski, Nepal, <sup>4</sup>School of Health and Allied Science, Pokhara University, Kaski Nepal.

## ABSTRACT

**Background:** This study aimed to assess the antimicrobial resistance rates of *Acinetobacter* species and *Pseudomonas* species isolated from clinical samples in an Antimicrobial Resistance (AMR) surveillance site in Gandaki Province, Nepal.

**Methods:** A retrospective analysis of data from an AMR surveillance site was extracted and analyzed, covering the time period from January 2020 to June 2024. A total of 575 *Acinetobacter* species and 687 *Pseudomonas* species were identified, with varying numbers tested for susceptibility against different antibiotics. Resistance rates were calculated for each pathogen-antibiotic combination.

**Results:** Resistance in *Acinetobacter* species was observed in 49.9% of isolates to amikacin and 42.7% to gentamicin, whereas *Pseudomonas* species showed resistance rates of 21.2% and 18.5%, respectively. Resistance to piperacillin-tazobactam was identified in 54.0% of *Acinetobacter* species and 24.6% of *Pseudomonas* species. Notably, 80.3% of *Acinetobacter* species and 62.6% of *Pseudomonas* species were resistant to ceftazidime, while carbapenem resistance was observed in 59.3% of *Acinetobacter* species and 14.8% of *Pseudomonas* species. Norfloxacin resistance was observed in 38.3% of *Acinetobacter* species and 43.5% of *Pseudomonas* species, whereas only 4.0% of *Acinetobacter* species and 11.4% of *Pseudomonas* species isolates were resistance to tigecycline. Resistance rates varied across sample types, with *Acinetobacter* species from respiratory samples and *Pseudomonas* species from urine samples exhibiting the highest resistance.

**Conclusions:** The study underscores alarming levels of antimicrobial resistance in *Acinetobacter* species and *Pseudomonas* species. *Acinetobacter* species demonstrated higher resistance to most antibiotics compared to *Pseudomonas* species. The variation in resistance patterns across sample types highlights the need of infection site and pathogen-specific antibiotic stewardship strategies.

**Keywords:** *Acinetobacter* species, AMR surveillance, antimicrobial resistance, *Pseudomonas* species

## INTRODUCTION

Antimicrobial resistance (AMR) occurs when bacteria, viruses, fungi, and parasites no longer respond to antimicrobial medicines.<sup>1</sup> Global evidence suggests an alarming resistance rates among prevalent bacterial pathogens.<sup>1,2</sup> *Acinetobacter baumannii* and *Pseudomonas* species are among the six leading pathogens for deaths associated with resistance.<sup>3</sup> *Acinetobacter* species and *Pseudomonas* species are commonly associated with healthcare infection.<sup>4,6</sup> Increasing rates of antibiotic

resistance among these pathogens are threatening the effectiveness of antibiotics used as last-resort therapeutic options.<sup>7</sup>

The rate of nosocomial infections in Nepal was found to be high; it showed that 53.5% of cases of such infection were due to *Acinetobacter* species and 39.6% due to *Pseudomonas aeruginosa*. More importantly, these pathogens exhibited a higher level of antibiotic resistance.<sup>8</sup> Resistance patterns of *Acinetobacter* species and *Pseudomonas* species should be identified

**Correspondence:** Prof Dr. Bishnu Raj Tiwari School of Health and Allied Science, Pokhara University, Kaski, Nepal. Email: bishnurajtiwari@gmail.com, Phone: +9779841349573.

to guide the basis for therapeutic decisions in clinical settings. Therefore, the objective of this study was to determine the antimicrobial resistance rates of *Acinetobacter* species and *Pseudomonas* species to commonly used antibiotics in an AMR surveillance site in Gandaki Province, Nepal.

## METHODS

A cross-sectional retrospective analysis of the secondary data was performed in one AMR surveillance site in Gandaki Province, located at Manipal College of Medical Science (MCoMS), Pokhara. The study duration was from January to June 2024.

Data collected for AMR monitoring by the AMR surveillance site were requested for the study. The data included the total isolates identified from different clinical samples and the antibiotics used for antimicrobial susceptibility testing of specific pathogens. Retrospective data from January 2020 to June 2024 were obtained and edited. From the surveillance records, *Acinetobacter* species and *Pseudomonas* species were selected for analysis. Data on isolates, sample types, patient age and sex, and antibiotics commonly tested for susceptibility tests against *Acinetobacter* and *Pseudomonas* species were extracted for analysis in the study.

A total of 575 isolates of *Acinetobacter* species and 687 of *Pseudomonas* species were identified during the study period. Various antibiotics were tested for antimicrobial susceptibility in different numbers each year at the AMR

surveillance site. All susceptibility tests performed for both pathogens across different antibiotics were pooled and analyzed. The antimicrobial resistance rate of each pathogen was calculated based on the number of susceptibility tests performed for each antibiotic against the respective isolate. The data was organized, entered, and cleaned in Excel. Analysis was done in SPSS version 24. Descriptive statistics were computed and presented in tabular form. Ethical approval was taken from Manipal College of Medical Science (MCOMS/IRC/41/GA). Anonymity was maintained of the data during compilation and analysis.

## RESULTS

A total of 575 isolates of *Acinetobacter* species and 687 of *Pseudomonas* species were included in the analysis. Resistance rates of these pathogens to commonly used antibiotics were calculated based on the number of susceptibility tests performed for each antibiotic.

Table 1 shows the demographic characteristics of patients and sample type distribution of isolates of *Acinetobacter* species and *Pseudomonas* species. Among the total isolates, 60.5% of *Acinetobacter* species and 63.0% of *Pseudomonas* species were from the male patients. Among total isolates, 7.0% of *Acinetobacter* species and 7.4% of *Pseudomonas* species were obtained from infant patients. Likewise, 24.7% of *Acinetobacter* species isolates and 39.3% of *Pseudomonas* species were isolated from blood samples.

Table 1. Demographic characteristics of patients and types of sample of *Acinetobacter* species and *Pseudomonas* species isolates

Variables	<i>Acinetobacter</i> species (n=575)		<i>Pseudomonas</i> species (n=687)	
	Number	Percent (%)	Number	Percent (%)
<b>Sex of the patients</b>				
Male	348	60.5	433	63.0
Female	227	39.5	254	37.0
<b>Age group of the patients (in years)</b>				
Up to one	40	7.0	51	7.4
2 to 5	25	4.3	69	10.0
6 to 18	65	11.3	125	18.2
19 to 60	273	47.5	275	40.0
>60 years	172	29.9	167	24.3
<b>Sample types</b>				
Blood	142	24.7	270	39.3
Urine	81	14.1	171	24.9
Respiratory	156	27.1	92	13.4
Pus	50	8.7	53	7.7
Others	146	25.4	101	14.7
Total	575	100.0	687	100.0

Table 2 shows the Antimicrobial resistance of *Acinetobacter* species and *Pseudomonas* species isolates to common antibiotics. Among aminoglycosides, 49.9% of isolates of *Acinetobacter* species were resistant to amikacin, 42.7% to gentamicin, and 61.8% to tobramycin; whereas 21.2% of *Pseudomonas* species were resistant to amikacin, 18.5% to gentamicin and 30.8% to tobramycin. Among quinolones, 50 and 81 isolates of *Acinetobacter* species were tested with levofloxacin and norfloxacin; among the tested, 56.0% and 38.3% isolates were resistant to levofloxacin and norfloxacin, respectively. Among the tested *Pseudomonas* isolates, 25.9% were resistant to levofloxacin and 43.5% to norfloxacin. Of the isolates tested, 54.0% of *Acinetobacter* species and 24.6% of *Pseudomonas* species were resistant to piperacillin-tazobactam.

Among cephalosporins, cefixime, cefoperazone sulbactam, and ceftazidime were commonly used for susceptibility tests. Of the isolates tested with cefixime (115 *Acinetobacter* species and 74 *Pseudomonas* species), 82.6% of *Acinetobacter* species and 89.2% *Pseudomonas* species showed resistance. For cefoperazone sulbactam, 42.9% of *Acinetobacter* species and 41.4% *Pseudomonas* species isolates were resistant. Similarly, resistance to ceftazidime was identified in 80.3% of *Acinetobacter* species and 62.2% *Pseudomonas* species isolates. Regarding carbapenems, 59.3% of *Acinetobacter* species and 14.8% of *Pseudomonas* species were resistant to imipenem/meropenem. Of the isolates tested, only 4.0% of *Acinetobacter* species and 11.4% of *Pseudomonas* species isolates were resistant to tigecycline (Table 2).

**Table 2. Antimicrobial resistance rates of *Acinetobacter* species and *Pseudomonas* species isolates to common antibiotics.**

Antibiotic classes	Antibiotics	<i>Acinetobacter</i> species isolates (n=575)		<i>Pseudomonas</i> species isolates (n=687)	
		Tested	Resistant, n (%)	Tested	Resistant, n (%)
Aminoglycosides	Amikacin	349	174 (49.9)	392	83 (21.2)
	Gentamicin	307	131(42.7)	363	67 (18.5)
	Tobramycin	34	21(61.8)	117	36 (30.8)
Quinolone	Levofloxacin	50	28 (56.0)	108	28 (25.9)
	Norfloxacin	81	31 (38.3)	85	37 (43.5)
Beta-lactam	Piperacillin-tazobactam	472	255 (54.0)	562	138 (24.6)
Cephalosporins	Cefixime	115	95(82.6)	74	66 (89.2)
	Cefoperazone sulbactam	238	102 (42.9)	304	126 (41.4)
	Ceftazidime	71	57(80.3)	139	87(62.6)
Carbapenem	Imipenem/meropenem	162	96 (59.3)	155	23 (14.8)
Glycylcycline	Tigecycline	375	15 (4.0)	158	18 (11.4)

Table 3 shows the antimicrobial resistance rates of *Acinetobacter* species derived from different sample types. Of the isolates tested for amikacin susceptibility, resistance was observed in 19.5% of blood isolates, 15.0% of urine isolates, and 64.6% of respiratory isolates. Resistance to gentamicin was found in 11.1% of blood isolates, 21.7% of urine, and 59.7% of respiratory isolates.

Only a few isolates of *Acinetobacter* species were tested for tobramycin, levofloxacin, and norfloxacin susceptibility. Resistance to piperacillin-tazobactam was observed in 15.1% of blood isolates, 27.7% of urine, and 72.2% of respiratory isolates of *Acinetobacter* species.

Among carbapenems, resistance to imipenem/meropenem was observed in 26.9% of *Acinetobacter* isolates from blood, 43.8% from urine, and 71.2% from respiratory samples. For cotrimoxazole, resistance was noted in 33.3% of blood isolates, 41.7% of urine, and 72.1% of respiratory isolates of *Acinetobacter* species.

Table 3. Antimicrobial resistance rates of *Acinetobacter* species isolates to common antibiotics in different clinical samples.

Antibiotic classes	Antibiotics	Blood (n=142)		Urine (n=81)		Respiratory samples (n=156)	
		Tested	Resistant, n (%)	Tested	Resistant, n (%)	Tested	Resistant, n (%)
Aminoglycosides	Amikacin	47	17 (19.5)	40	6 (15.0)	96	62 (64.6)
	Gentamicin	90	10 (11.1)	46	10 (21.7)	67	40 (59.7)
	Tobramycin	4	0 (0)	3	2 (66.7)	10	5 (50.0)
Quinolone	Levofloxacin	6	0 (0)	5	2 (40.0)	10	10 (58.8)
	Norfloxacin	7	0 (0)	62	25 (40.3)	4	2 (50.0)
Beta-lactam	Piperacillin-tazobactam	119	18 (15.1)	47	13 (27.7)	133	96 (72.2)
Cephalosporins	Cefixime	26	16 (61.5)	32	25 (78.1)	18	17 (94.4)
	Cefoperazon sulbactam	55	8 (14.5)	33	10 (30.3)	71	38 (53.5)
	Ceftazidime	20	13 (65)	10	7 (70.0)	14	13 (92.9)
Carbapenem	Imipenem/meropenem	26	7 (26.9)	16	7 (43.8)	52	37 (71.2)
Glycylcycline	Tigecycline	67	0 (0.0)	13	2 (15.4)	129	8 (6.2)
Others	Cotrimoxazole	18	6 (33.3)	36	15 (41.7)	43	31 (72.1)

Table 4 shows the antimicrobial resistance rates of *Pseudomonas* species isolated from different samples types. Of the isolates tested for amikacin susceptibility, resistance was observed in 15.6% of blood isolates, 39.6% of urine isolates, and 15.5% of respiratory isolates. Resistance to gentamicin was observed in 10.7% of blood, 35.6% of urine, and 10.6% of respiratory isolates of *Pseudomonas* species. Resistance to piperacillin-tazobactam was observed in 34.9% of *Pseudomonas* species isolates from blood, 28.7% from urine, and 10.0% from respiratory samples.

Among *Pseudomonas* species isolates tested with cefoperazone-sulbactam, resistance was recorded in 52.3% from blood, 43.8% from urine, and 25.7% from respiratory samples. For ceftazidime, resistance was identified in 55.8% of blood, 77.5% of urine, and 59.1% of respiratory isolates of *Pseudomonas* species. Among carbapenems, resistance to imipenem/meropenem was observed in 4.3% of *Pseudomonas* species isolates from blood, 33.3% from urine, and 12.1% from respiratory samples.

Table 4. Antimicrobial resistance rates of *Pseudomonas* species isolates to common antibiotics in different clinical samples

Antibiotic classes	Antibiotics	Blood (n=270)		Urine (n=171)		Respiratory samples (n=92)	
		Tested	Resistant, n (%)	Tested	Resistant, n (%)	Tested	Resistant, n (%)
Aminoglycosides	Amikacin	154	24 (15.6)	91	36 (39.6)	58	9 (15.5)
	Gentamicin	149	16 (10.7)	90	32 (35.6)	47	5 (10.6)
	Tobramycin	24	10 (41.7)	34	16 (47.1)	19	3 (15.8)
Quinolone	Levofloxacin	45	1 (2.2)	26	14 (53.8)	18	4 (22.2)
	Norfloxacin	8	1 (12.5)	73	35 (47.9)	0	NA
Beta-lactam	Piperacillin-tazobactam	218	76 (34.9)	129	37 (28.7)	80	8 (10.0)
Cephalosporins	Cefixime	23	20 (87.0)	26	22 (84.6)	6	6 (100)
	Cefoperazon sulbactam	130	68 (52.3)	80	35 (43.8)	35	9 (25.7)
	Ceftazidime	43	24 (55.8)	40	31 (77.5)	22	13 (59.1)
Carbapenem	Imipenem/Meropenem	46	2 (4.3)	39	13 (33.3)	33	4 (12.1)
Glycylcycline	Tigecycline	81	3 (3.7)	18	6 (33.3)	29	5 (17.2)

## DISCUSSION

This study assessed the antimicrobial resistance rates of *Acinetobacter* species and *Pseudomonas* species in clinical samples recorded at an AMR surveillance site against commonly used antimicrobial agents. Pathogens, *Acinetobacter* species and *Pseudomonas* species, are commonly associated with nosocomial infection.<sup>4-6</sup> Previous evidence states that the rate of infections of *Pseudomonas* species are significantly increasing in Nepal.<sup>9</sup> The situation gets worse when the antibiotic resistance of such pathogens also increases. Antimicrobial resistance trend analysis of *Acinetobacter* species also revealed resistance to highly potent antimicrobial agents in Hospitals and health care settings.<sup>10</sup> A study conducted in TU Teaching hospital also showed that highly resistant MDR strains of *Acinetobacter baumannii* are common in tertiary care hospitals in Nepal.<sup>11</sup>

Among aminoglycosides, amikacin is commonly used for several bacterial infections including intra-abdominal infections, meningitis, pneumonia, sepsis, urinary tract infections and multidrug-resistant tuberculosis.<sup>12,13</sup> In the study, 49.9% of *Acinetobacter* species and 21.2% of *Pseudomonas* species were resistant to amikacin. Similar to the study, a study done in Korea in 2009 showed that the resistance rates of *Acinetobacter* species to amikacin were 48%.<sup>14</sup> In contrast, a previous study showed that resistance rates of nosocomial *Acinetobacter baumannii* strains between 2009 and 2011 were higher than the rate in our study.<sup>15</sup> It indicates an alarming situation, especially when the infections are caused by *Acinetobacter* species. In the study, among aminoglycosides, more effective antimicrobial agent against *Acinetobacter* species was found gentamicine with a resistance rate of 42.75%; and the tobramycin was the least sensitive to the pathogen (61.8%). A similar finding was found in a study conducted in Malaysia.<sup>16</sup> In comparison to the present study, resistance rate of *Pseudomonas aeruginosa* to amikacin was observed slightly lower (17.4%) in a previous study conducted in Western Nepal in 2019.<sup>8</sup> These results suggest that amikacin is more effective for treating the infections caused by *Pseudomonas* species than the infections caused by *Acinetobacter* species.

Out of the isolates tested, 56% and 38.3% *Acinetobacter* species were resistant to levofloxacin and norfloxacin, respectively; whereas one-fourth (25.9%) of *Pseudomonas* species isolates were resistant to levofloxacin in the study. The findings suggest that levofloxacin is relatively more effective against

*Pseudomonas* species infections, while norfloxacin seems more effective against *Acinetobacter* species infections. Resistant rate of *Acinetobacter* species to piperacillin-tazobactam was 54.0%; whereas *Pseudomonas* species showed a lower resistance of 24.6%, less than half that of *Acinetobacter* species. In contrast to the study, the most sensitive antibiotic for *Pseudomonas aeruginosa* was a combination of piperacillin and tazobactam with a resistant rate of only 3.37% in a previous study.<sup>17</sup>

Among cephalosporins, *Acinetobacter* species showed the highest resistance to cefixime (82.6%) and ceftazidime (80.3%) in the study. In contrast, a lower resistance rate (66%) of *Acinetobacter* species to ceftazidime was observed in a surveillance study done in Korea in 2009<sup>14</sup> while an even lower rate (46%) of resistance to ceftazidime was reported in a study conducted in a tertiary care hospital of India.<sup>18</sup>

Regarding *Pseudomonas* species, resistance to cefixime was very high (89.2%), while resistance to ceftazidime was slightly lower (62.6%) in the study. A study from Bangladesh similarly reported high resistance of *Pseudomonas aeruginosa* to cephalosporins (89.85%).<sup>17</sup> Similarly, all isolates were cefixime resistant in a study conducted among pediatric population with febrile urinary tract infections in a previous study.<sup>19</sup> Evidence also indicates that resistance of third-generation cephalosporin is increasing as more than half of the isolated strains demonstrated resistance to these antibiotics; and, these strains also revealed multidrug resistance against clinically used antimicrobial agents.<sup>20</sup> This suggests that *Pseudomonas* species are intrinsically resistant to third-generation Cephalosporins. It is an important evidence that the Performance Standards for Antimicrobial Susceptibility Testing published by the Clinical and Laboratory Standards Institute (CLSI) in 2025 has not recommended Cefixime for *Pseudomonas* species susceptibility testing.<sup>21</sup> Based on the above findings, it can be concluded that third generation cephalosporins, except cefoperazone sulbactam, are not effective for treating infections caused by *Acinetobacter* species and *Pseudomonas* species.

Notably, more than half (59.3%) of *Acinetobacter* species isolates were resistant to carbapenems (imipenem/meropenem); whereas only 14.8% isolates of *Pseudomonas* species showed resistance to carbapenem in the study. Similar evidence is reported that non-susceptibility rates to carbapenems were highest in *Acinetobacter baumannii*, which also showed a trend of increasing carbapenem non-susceptibility over time.<sup>22</sup> Carbapenems resistance in *Acinetobacter* species

has been increasingly reported which has made MDR *Acinetobacter* species infections difficult to treat.<sup>23</sup> A previous study showed that rates of carbapenem resistance were up to 66% for *Pseudomonas aeruginosa* and as high as of 90% for *Acinetobacter baumannii* isolates across the different countries of Latin America, including the resistance rate of *Acinetobacter baumannii* greater than 50% in many countries.<sup>24</sup> Moreover, *Acinetobacter* species demonstrated a statistically significant increasing trend in carbapenem resistance in study conducted in Ethiopia.<sup>25</sup> In contrast to the study, *Pseudomonas aeruginosa* showed higher resistance to meropenem (30.6%) in a previous study.<sup>26</sup> The results suggest that carbapenems are effective for treating *Pseudomonas* species infections in the study area.

Remarkably, tigecycline was observed one of the most effect antimicrobial agents against both pathogens, exhibiting only 4% resistance in *Acinetobacter* species and 11.4% in *Pseudomonas* species isolates.

*Acinetobacter* species isolated from respiratory samples showed the highest rate of resistance to most of the antibiotics in the study, as compared to the isolates derived from other sample types. A previous study also reported the variation in resistance rates of *Acinetobacter* species according to the types of sample.<sup>16</sup> In the present study, amikacin resistance in *Acinetobacter* species was observed in one-fifth (19.5%) of isolates from blood, 15% from urine, and more than three-fifths (64.6%) from respiratory samples. These results suggest that amikacin is not effective for treating respiratory infections caused by *Acinetobacter* species. It is remarkable that the 35<sup>th</sup> edition of Performance Standards for Antimicrobial Susceptibility Testing published by the Clinical and Laboratory Standards Institute (CLSI) in 2025 has recommended amikacin susceptibility testing only for urine isolates of *Acinetobacter* species.<sup>21</sup>

*Pseudomonas* species isolated from urine samples showed the highest rate of resistance to most of the antibiotics in the study than the isolates from other sample types. The resistance rate of *Pseudomonas aeruginosa* isolated from different specimens to different antimicrobials varied greatly in a previous study too.<sup>17</sup> This indicates that antibiotic resistance rates differ not only by types of pathogens but also by the types of sample from which the isolates were obtained.

Conclusively, *Acinetobacter* species demonstrated higher resistance rates to most antimicrobial agents compared to *Pseudomonas* species. The lowest antimicrobial

resistance rates were observed with tigecycline for both groups of pathogens in the study.

The study reported antimicrobial resistance rates of two clinically important bacterial species against commonly used antibiotics, utilizing a relatively large sample size. An important limitation of the study is its reliance on recorded data from the AMR surveillance site, which excluded a detailed description of the methodology used for antibiotic susceptibility testing. Pathogen antibiotic resistance was analyzed based on the data available.

## CONCLUSIONS

The study revealed elevated resistance rates of *Acinetobacter* species and *Pseudomonas* species to commonly used antibiotics, particularly cephalosporins. *Acinetobacter* species exhibited consistently higher resistance across most antibiotics compared to *Pseudomonas* species, with notably high resistance observed against aminoglycosides, cephalosporins, piperacillin-tazobactam, and carbapenems. In contrast, both pathogens demonstrated relatively low resistance to tigecycline, indicating its potential utility as a treatment option. Resistance patterns also varied by specimen type: *Acinetobacter* isolates from respiratory samples showed markedly higher resistance to most antibiotics, whereas *Pseudomonas* species isolates from urine samples demonstrated higher resistance profiles. These variations underscore the importance of site specific and pathogen specific antibiotic stewardship strategies. Overall, the findings highlight the urgent need to address antibiotic resistance among common hospital-acquired pathogens.

## ACKNOWLEDGEMENTS

The study was supported by the Provincial Health Logistic Management Center, Gandaki Province. We also sincerely acknowledge Manipal College of Medical Sciences for providing the information required for the study.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

## REFERENCES

1. Antimicrobial resistance. 21 November 2023. <https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance>. Accessed on 26th August, 2024 [<https://www.who.int/news-room/>

- [fact-sheets/detail/antimicrobial-resistance\]](#)
- World Health Organization. Global antimicrobial resistance and use surveillance system (GLASS) report 2022. World Health Organization; 2022 Dec 8 [<https://www.who.int/publications/item/9789240062702>]
  - Murray CJ, Ikuta KS, Sharara F, Swetschinski L, Aguilar GR, Gray A, Han C, Bisignano C, Rao P, Wool E, Johnson SC. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *The lancet*. 2022 Feb 12; 399(10325):629-55. [<https://pmc.ncbi.nlm.nih.gov/articles/PMC8841637/>]
  - Almasaudi SB. *Acinetobacter* spp. as nosocomial pathogens: Epidemiology and resistance features. *Saudi journal of biological sciences*. 2018 Mar 1;25(3):586-96. [<https://pmc.ncbi.nlm.nih.gov/articles/PMC5910652/>]
  - Biglari S, Hanafiah A, Ramli R, Rahman MM, Khaithir TM. Clinico-epidemiological nature and antibiotic susceptibility profile of *Acinetobacter* species. *Pakistan journal of medical sciences*. 2013 Apr; 29(2):469. [<https://pmc.ncbi.nlm.nih.gov/articles/PMC3809237/>]
  - Brinkwirth S, Ayobami O, Eckmanns T, Markwart R. Hospital-acquired infections caused by enterococci: A systematic review and meta-analysis, WHO European Region, 1 January 2010 to 4 February 2020. *Euro surveillance*. 2021 Nov 11;26(45):2001628. [<https://pmc.ncbi.nlm.nih.gov/articles/PMC8646982/>]
  - Potron A, Poirel L, Nordmann P. Emerging broad-spectrum resistance in *Pseudomonas aeruginosa* and *Acinetobacter baumannii*: mechanisms and epidemiology. *International journal of antimicrobial agents*. 2015 Jun 1;45(6):568-85. [<https://doi.org/10.1016/j.ijantimicag.2015.03.001>]
  - Baral S, Pokharel A, Subramanya SH, Nayak N. Clinico-epidemiological profile of *Acinetobacter* and *Pseudomonas* infections, and their antibiotic-resistant pattern in a tertiary care center, Western Nepal. *Nepal Journal of Epidemiology*. 2019 Dec;9(4):804. [<https://pmc.ncbi.nlm.nih.gov/articles/PMC6964802/>]
  - Hamal D, Bhatt DR, Shrestha R, Supram HS, Nayak N, Gokhale S, Parajuli S. Changing trends in antibiotic susceptibility pattern among clinical isolates of *Pseudomonas* species in a tertiary care hospital in Nepal. *Annals of Clinical Chemistry and Laboratory Medicine*. 2021 Dec 31;4(1):6-12. [<https://www.nepjol.info/index.php/ACCLM/article/view/42674>]
  - Ayew Z, Tigabu E, Syoum E, Ebrahim S, Assefa D, Tsige E. Multidrug resistance pattern of *Acinetobacter* species isolated from clinical specimens referred to the Ethiopian Public Health Institute: 2014 to 2018 trend analysis. *PLoS one*. 2021 Apr 29;16(4):e0250896 [<https://pmc.ncbi.nlm.nih.gov/articles/PMC8084144/>]
  - Yadav SK, Bhujel R, Hamal P, Mishra SK, Sharma S, Sherchand JB. Burden of multidrug-resistant *Acinetobacter baumannii* infection in hospitalized patients in a tertiary care hospital of Nepal. *Infection and drug resistance*. 2020 Mar 3:725-32. [<https://pmc.ncbi.nlm.nih.gov/articles/PMC7061726/>]
  - Ramirez MS, Tolmasky ME. Amikacin: uses, resistance, and prospects for inhibition. *Molecules*. 2017 Dec 19;22(12):2267. [<https://pmc.ncbi.nlm.nih.gov/articles/PMC5889950/>]
  - World Health Organization, Stuart, Marc C, Kouimtzi, Maria & Hill, Suzanne. (2009). WHO model formulary 2008 / editors: Marc C. Stuart, Maria Kouimtzi, Suzanne R. Hill. World Health Organization. <https://iris.who.int/handle/10665/44053> [<https://iris.who.int/handle/10665/44053>]
  - Lee K, Yong D, Jeong SH, Chong Y. Multidrug-resistant *Acinetobacter* species: increasingly problematic nosocomial pathogens. *Yonsei medical journal*. 2011 Nov 1;52(6):879-91 [<https://ejournal.yonsei.ac.kr/journal/view.html?doi=10.3349/ymj.2011.52.6.879>]
  - Hakyemez IN, Kucukbayrak A, Tas T, Yikilgan AB, Akkaya A, Yasayacak A, Akdeniz H. Nosocomial *Acinetobacter baumannii* infections and changing antibiotic resistance. *Pakistan journal of medical sciences*. 2013 Sep;29(5):1245. [<https://pmc.ncbi.nlm.nih.gov/articles/PMC3858953/>]

16. Nazmul MH, Jamal H, Fazlul MK. *Acinetobacter* species-associated infections and their antibiotic susceptibility profiles in Malaysia. *Biomed Res-India*. 2012 Oct 1;23(4):571-5. [[https://www.researchgate.net/publication/328759120\\_Antibiotic\\_susceptibility\\_profiles\\_of\\_clinical\\_isolates\\_of\\_Acinetobacter\\_species\\_isolated\\_from\\_Selayang\\_hospital\\_Malaysia](https://www.researchgate.net/publication/328759120_Antibiotic_susceptibility_profiles_of_clinical_isolates_of_Acinetobacter_species_isolated_from_Selayang_hospital_Malaysia)]
17. Hoque MM, Ahmad M, Khisa S, Uddin MN, Jesmine R. Antibiotic resistance pattern in *Pseudomonas aeruginosa* isolated from different clinical specimens. *Journal of Armed Forces Medical College, Bangladesh*. 2015;11(1):45-9. [<https://www.banglajol.info/index.php/JAFMC/article/view/30669>]
18. Gupta N, Gandham N, Jadhav S, Mishra RN. Isolation and identification of *Acinetobacter* species with special reference to antibiotic resistance. *Journal of natural science, biology, and medicine*. 2015 Jan;6(1):159. [<https://pmc.ncbi.nlm.nih.gov/articles/PMC4367029/>]
19. Birgy A, Madhi F, Jung C, Levy C, Cointe A, Bidet P, et al. Clavulanate combinations with mecillinam, cefixime or cefpodoxime against ESBL-producing Enterobacterales frequently associated with bla OXA-1 in a paediatric population with febrile urinary tract infections. *Journal of Antimicrobial Chemotherapy*. 2021 Nov 1;76(11):2839-46. [<https://pubmed.ncbi.nlm.nih.gov/34453533/>]
20. Gashe F, Mulisa E, Mekonnen M, Zeleke G. Antimicrobial resistance profile of different clinical isolates against third-generation cephalosporins. *Journal of pharmaceuticals*. 2018;2018(1):5070742. [<https://onlinelibrary.wiley.com/doi/10.1155/2018/5070742>]
21. Clinical and Laboratory Standards Institute (CLSI). *Performance Standards for Antimicrobial Susceptibility Testing*. 35th ed. CLSI supplement M100. Clinical and Laboratory Standards Institute; 2025.
22. Liang-Yu C, Kuo SC, Liu CY, Luo BS, Huang LJ, Lee YT, Chen CP, Chen TL, Fung CP. Difference in imipenem, meropenem, sulbactam, and colistin nonsusceptibility trends among three phenotypically undifferentiated *Acinetobacter baumannii* complex in a medical center in Taiwan, 1997-2007. *Journal of Microbiology, Immunology and Infection*. 2011 Oct 1;44(5):358-63. [<https://pubmed.ncbi.nlm.nih.gov/21524973/>]
23. Manchanda V, Sanchaita S, Singh NP. Multidrug resistant *Acinetobacter*. *Journal of global infectious diseases*. 2010 Sep 1;2(3):291-304. [<https://pmc.ncbi.nlm.nih.gov/articles/PMC2946687/>]
24. Labarca JA, Salles MJ, Seas C, Guzmán-Blanco M. Carbapenem resistance in *Pseudomonas aeruginosa* and *Acinetobacter baumannii* in the nosocomial setting in Latin America. *Critical reviews in microbiology*. 2016 Mar 3;42(2):276-92. [<https://www.tandfonline.com/doi/full/10.3109/1040841X.2014.940494>]
25. Abdeta A, Negeri AA, Beyene D, Adamu E, Fekede E, Fentaw S, et al. Prevalence and trends of carbapenem-resistant *Pseudomonas aeruginosa* and *Acinetobacter* species isolated from clinical specimens at the Ethiopian public health institute, Addis Ababa, Ethiopia: A Retrospective Analysis. *Infection and Drug Resistance*. 2023 Dec 31;1381-90. [<https://pubmed.ncbi.nlm.nih.gov/36937143/>]
26. Khan MA, Faiz A. Antimicrobial resistance patterns of *Pseudomonas aeruginosa* in tertiary care hospitals of Makkah and Jeddah. *Annals of Saudi medicine*. 2016 Jan;36(1):23-8. [<https://pmc.ncbi.nlm.nih.gov/articles/PMC6074268/>]