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Prevalence and Antimicrobial Susceptibility Pattern of Multidrug-Resistant *Pseudomonas* spp. Isolated from Pus and Wound Swabs in a Tertiary Care Hospital

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ABSTRACT

Background: *Pseudomonas aeruginosa* is a major opportunistic pathogen commonly associated with wound and soft-tissue infections, particularly among hospitalized and immunocompromised individuals. The growing prevalence of multidrug-resistant (MDR) strains has increased the complexity of treatment and negatively affected patient outcomes.
Objective: This study aimed to determine the incidence of MDR *Pseudomonas* infections from pus and wound swab samples, analyse demographic patterns, and examine antimicrobial susceptibility profiles, including the efficacy of second- and third-line agents such as colistin.
Methods: A prospective observational study was carried out in a tertiary care hospital, evaluating 1132 pus and wound swab samples. Standard microbiological techniques—including Gram staining, culture, biochemical identification, and antimicrobial susceptibility testing following CLSI guidelines—were employed. MDR was defined as resistance to at least one drug in three or more antimicrobial categories.
Results: Among the 1132 samples, *Pseudomonas* spp. were isolated in 103 cases (9.1%). Of these, 85 isolates were identified as *P. aeruginosa* and 18 as non-aeruginosa *Pseudomonas* species. MDR strains were found in 32 of 85 *P. aeruginosa* isolates (37.6%) and 8 of 18 non-aeruginosa isolates (44.4%). High resistance levels were seen against piperacillin–tazobactam, cefoperazone–sulbactam, and carbapenems. All MDR isolates tested were fully susceptible to colistin.
Conclusion: The study reveals a considerable prevalence of MDR *Pseudomonas* infections, underscoring the importance of robust antimicrobial stewardship, stringent infection control measures, and ongoing surveillance. Colistin continues to be a reliable last-line therapeutic option.
Keywords: *Pseudomonas aeruginosa*, MDR, wound infection, antimicrobial resistance, Colistin.

INTRODUCTION

Wound and soft-tissue infections remain a significant medical and public health issue worldwide, contributing to substantial morbidity, prolonged hospitalization, and higher healthcare costs. Among the

organisms associated with these infections, *Pseudomonas aeruginosa* is particularly challenging because of its exceptional environmental adaptability, widespread occurrence, and opportunistic nature [1,2]. It is commonly recovered from burn injuries, postoperative wound infections, diabetic foot ulcers, and chronic non-healing wounds, making it a leading cause of hospital-acquired infections globally [3].

P. aeruginosa harbours numerous virulence factors—including exotoxin A, elastases, proteases, haemolysins, and type III secretion systems—that promote tissue damage, immune evasion, and long-term colonization [4]. Its capacity to form biofilms on wound surfaces and medical devices further enhances its survival and resistance, contributing to persistent and recurrent infections [5]. Biofilms also create a protective barrier that restricts antibiotic penetration and facilitates horizontal gene transfer, accelerating the dissemination of resistance genes within bacterial communities [6]. A major concern with *P. aeruginosa* is its strong ability to develop antimicrobial resistance. The pathogen exhibits natural resistance to several antibiotics due to reduced outer membrane permeability, active efflux pumps, and chromosomally encoded enzymes such as AmpC β-lactamase [7]. Beyond these intrinsic mechanisms, it can easily acquire additional resistance traits through mutations and horizontal gene transfer, leading to multidrug-resistant (MDR), extensively drug-resistant (XDR), and even pan drug-resistant (PDR) variants [8].

The increasing prevalence of MDR *P. aeruginosa* is especially concerning in wound management, where infections tend to be severe and often require combination therapy. These strains typically show resistance to multiple key antimicrobial groups, including β-lactams, fluoroquinolones, aminoglycosides, and carbapenems—drugs that have long been central to treatment [9]. Carbapenem resistance, commonly caused by carbapenemase production (e.g., VIM, IMP, NDM) or alterations in porin proteins such as OprD, poses a significant therapeutic challenge and greatly limits available treatment options [10].

With the increasing trend of antimicrobial resistance, colistin—a polymyxin antibiotic—has re-emerged as a critical last-line therapeutic option for treating MDR Gram-negative infections, including those caused by *P. aeruginosa* [11]. Although resistance to colistin remains relatively uncommon in many areas, the detection of plasmid-mediated *mcr* genes has raised serious concerns regarding the long-term effectiveness of this drug [12]. This underscores the importance of ongoing surveillance of antimicrobial susceptibility patterns to guide appropriate empirical therapy and reinforce antibiotic stewardship initiatives.

Considering that resistance profiles can differ significantly across healthcare facilities, geographic locations, and patient populations, institution-specific surveillance data are essential for informed clinical decision-making. Therefore, the present study seeks to determine the prevalence of *Pseudomonas* species isolated from pus and wound swab specimens in a tertiary care hospital and to assess their antimicrobial susceptibility patterns, with particular emphasis on the prevalence of multidrug-resistant strains. The results are expected to assist clinicians in selecting optimal empirical treatments and support the formulation of institutional antibiotic policies aimed at curbing the spread of resistant pathogens

MATERIALS AND METHODS

Study Population and Clinical Data Collection

All patients from whom pus or wound swab samples were collected during the study period were included irrespective of age, sex, or comorbidities. Relevant demographic and clinical information—including patient age, sex, type of wound, hospital ward, presence of comorbidities (e.g., diabetes, trauma, burns), and prior

antibiotic therapy—was obtained from medical records using a structured proforma [13]. Clinical correlation was performed in accordance with recommended guidelines to ensure accurate interpretation of culture results [14].

Study Population and Sample Size

A total of **1132** pus and wound swab specimens were included. Samples were collected from patients of all age groups and both genders, attending outpatient departments (OPDs) as well as those admitted in surgical wards, ICU, orthopaedics, and general medicine units. No specific sampling restriction was applied, allowing comprehensive surveillance of wound pathogens in the hospital setting [15].

Sample Collection Procedure

Pus aspirates were preferred over swabs whenever possible due to their higher diagnostic yield. For wound swabs, the area was first cleansed with sterile normal saline to eliminate surface contaminants. Samples were collected from the depth or active edge of the wound using sterile cotton swabs and immediately placed into sterile containers or transport media when necessary [16]. All samples were transported promptly to the laboratory and processed within 1–2 hours, adhering to WHO recommendations for optimal recovery of non-fastidious organisms [17].

Inclusion Criteria

- Pus and wound swab samples submitted for microbiological evaluation.
- Samples yielding pure or significant growth of *Pseudomonas* species.

Exclusion Criteria

- Duplicate samples from the same patient.
- Samples showing mixed flora without clinical significance.
- Inadequately labelled, leaking, or dried swabs.

Laboratory Processing

All specimens were handled using standard microbiological techniques described by CLSI and conventional diagnostic manuals [13,18].

1. Macroscopic Assessment

Samples were examined for volume, colour, odour, and presence of necrotic tissue or granulation material to support clinical correlation.

2. Microscopy

Gram staining was performed on all samples to assess:

- Presence of Gram-negative bacilli
- Pus cells
- Tissue debris or epithelial cells
- Microscopy also guided the selection of culture media and aided early presumptive diagnosis [19].
- Pseudomonas aeruginosa and few Pseudomonas species were actively motile.

3. Culture and Incubation

Each sample was inoculated onto:

- **Nutrient agar-** Pseudomonas aeruginosa showed greenish pigment and few Pseudomonas species showed yellowish-green and yellow colonies.
- **Blood agar-** Pseudomonas aeruginosa showed β-hemolysis (with or without metallic sheen) or grey moist, large colonies with a metallic sheen.
- **MacConkey agar-** Pseudomonas aeruginosa produces flat, large, spreading colonies which have a pale colour.
- **Cetrimide agar** (selective for *Pseudomonas*)- Pseudomonas aeruginosa: Colonies appear blue-green in colour.

Plates were incubated aerobically at **37°C for 18–24 hours**. Suspected colonies were identified based on characteristic morphology:

- Greenish pigment (pyocyanin)
- Grape-like odour
- Non-lactose fermenting colonies

These phenotypic traits are highly suggestive of *Pseudomonas aeruginosa* [20].

Biochemical Identification

Presumptive isolates were confirmed by standard biochemical reactions:

- Pseudomonas aeruginosa showed surface pellicle and turbidity (growth after incubation).
- Oxidase positivity
- Catalase test- positive.
- Oxidative/fermentative (OF) glucose test- It only metabolises glucose by oxidative processes, resulting in the formation of acid. Lactose and maltose are not metabolised.
- Citrate utilization- positive.
- Nitrate reduction- positive.
- Urease test- positive.
- Gelatin liquefaction
- Growth at 42°C (supports identification of *P. aeruginosa*)

Identification procedures followed guidelines outlined by McFarland and CLSI [18,21].

Antimicrobial Susceptibility Testing (AST)

AST was performed using the **Kirby–Bauer disk diffusion technique** on Mueller–Hinton agar, following CLSI M100 performance standards [13].

Antibiotics Tested included:

- **β-lactam/β-lactamase inhibitor:** Piperacillin-Tazobactam, Cefoperazone-Sulbactam
- **Cephalosporins:** Ceftazidime, Cefepime
- **Carbapenems:** Meropenem, Imipenem
- **Aminoglycosides:** Amikacin, Gentamicin, Tobramycin
- **Fluoroquinolones:** Ciprofloxacin, Levofloxacin

Colistin MIC Testing

Because disk diffusion is unreliable for polymyxins, Colistin susceptibility for MDR isolates was determined using:

- **Broth microdilution (BMD)** – gold standard
- **E-test MIC strips** where applicable

Testing followed CLSI–EUCAST joint guidelines for polymyxin susceptibility methods [22,23].

Definition of Multidrug Resistance

MDR *Pseudomonas* was defined using the standard criteria proposed by ECDC and CDC:

- **Resistance to at least one antimicrobial agent in three or more antimicrobial categories** [8].

Quality Control

The following ATCC strains were used for validation of culture and AST results:

- *Pseudomonas aeruginosa* ATCC 27853
- *Escherichia coli* ATCC 25922

QC procedures ensured accuracy of disk diffusion zone diameters and MIC testing, according to CLSI recommendations [13].

Data Management and Statistical Analysis

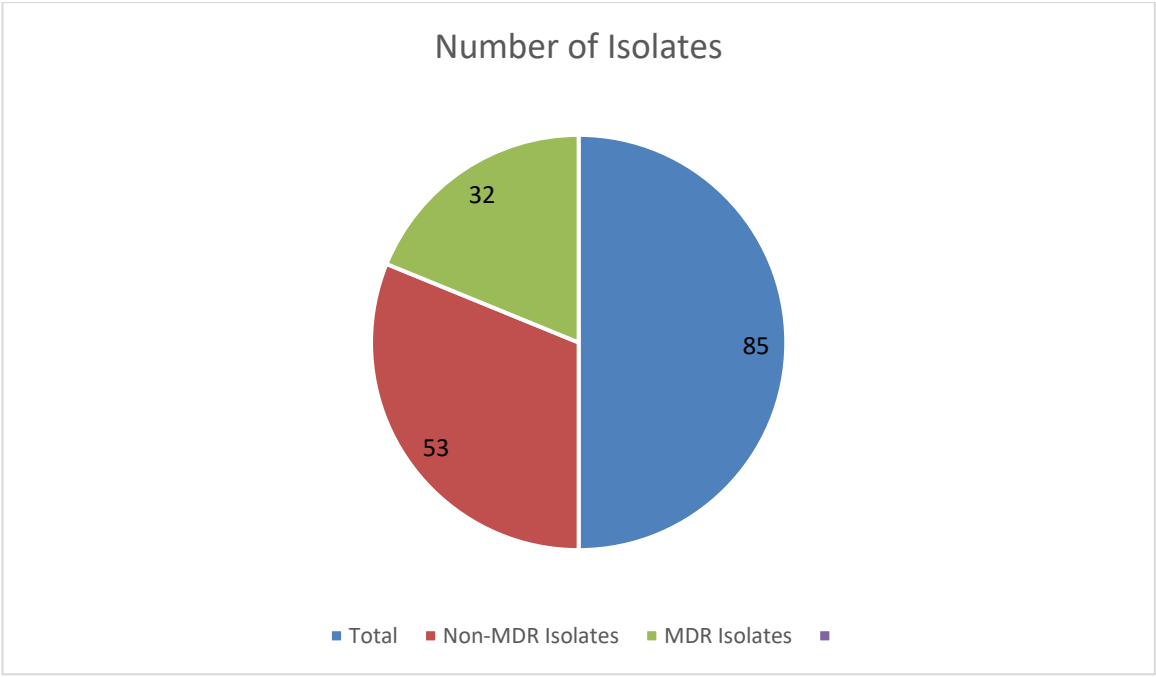
Data were entered into Microsoft Excel and analyzed using descriptive statistics. Frequencies, percentages, and distribution charts were generated. Antibiotic resistance patterns were compared across species and MDR categories. Graphical representation of results followed recommendations for reporting antimicrobial resistance data in clinical microbiology [24].

RESULTS

Distribution of MDR *Pseudomonas* Isolates

Table 1: Total number of Non-MDR and MDR *Pseudomonas* aeruginosa Positive Patients Wise Distribution (n=85)

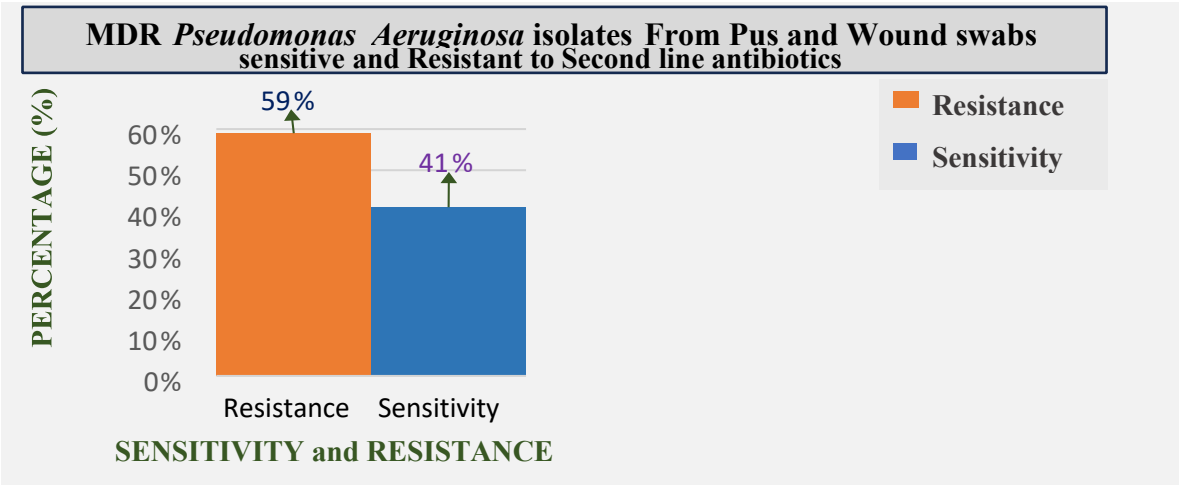
Total *Pseudomonas* aeruginosa	Number of Isolates	Percentage (%)
Total number of Non-MDR and MDR *Pseudomonas* aeruginosa Positive Patients	85	100%
Non-MDR Isolates	53	62%
MDR Isolates	32	38%



Graph 1- Non-MDR and MDR *Pseudomonas aeruginosa* Positive Patients Wise Distribution

TABLE 2. Total number of MDR *Pseudomonas aeruginosa* isolates Sensitive and Resistant to Second Line Antibiotics (n=32)

Sensitivity and resistance to Second line antibiotics	Number of isolates	Percentage isolates(%)of
Total number of MDR *Pseudomonas aeruginosa* isolates	32	100%
Sensitivity	13	41%
Resistance	19	59%

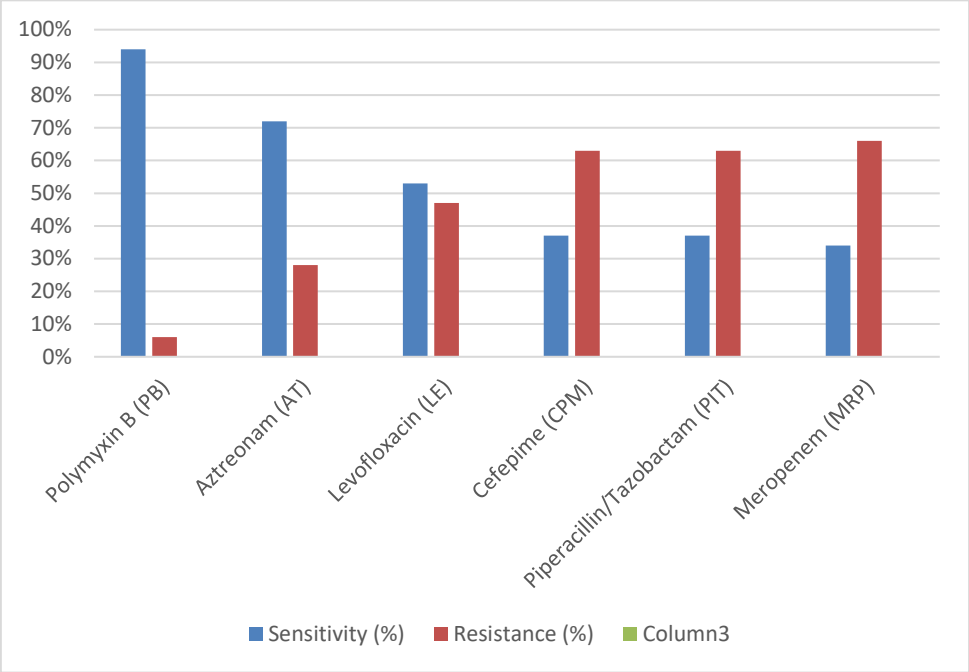


Graph 2- MDR Pseudomonas Aeruginosa isolates from pus and wound swabs sensitive and resistant to second line antibiotics

Table 3: Second Line Antibiotic Susceptibility Pattern of MDR *Pseudomonas aeruginosa* (n=32)

Antibiotic (Abbreviation)	Sensitivity (%)	Resistance (%)
Polymyxin B (PB)	94%	6%
Aztreonam (AT)	72%	28%
Levofloxacin (LE)	53%	47%
Cefepime (CPM)	37%	63%
Piperacillin/Tazobactam (PIT)	37%	63%
Meropenem (MRP)	34%	66%

Second line Antibiotic Susceptibility Pattern of MDR *P. aeruginosa* This graph illustrates the high resistance observed for most second-line antibiotics, with the notable exception of Polymyxin B.



Graph 3- Antibiotic Susceptibility of MDR *Pseudomonas aeruginosa*

Table 4: Antibiotic Susceptibility Pattern of MDR *Pseudomonas aeruginosa* to Colistin (Third Line Antibiotic) by E-test (n=19)

Antibiotic	Sensitivity (%)	Resistance (%)
Colistin (CL)	100%	0%

Colistin Susceptibility of MDR *P. aeruginosa* this graph highlights the complete sensitivity to the third-line drug Colistin among the tested isolates.

DISCUSSION

The analysis of Pseudomonas aeruginosa isolates obtained from pus and wound swabs demonstrates a notable burden of Multi-Drug Resistant (MDR) strains, underscoring an important concern for clinical management and infection prevention.

MDR Prevalence and Distribution

As shown in *Table 1* and *Graph 1*, our study represents, out of the of 85 isolates of Pseudomonas aeruginosa, 38% was MDR Pseudomonas aeruginosa and 62% was non MDR Pseudomonas aeruginosa. So, the incidence of MDR Pseudomonas aeruginosa was less than the incidence of non MDR Pseudomonas aeruginosa. This could be because of good infection control practices in our hospital. A similar study revealed a closer value of 34% of MDR Pseudomonas aeruginosa and a lower value of 15.1% of non MDR Pseudomonas aeruginosa by Lubna Farooq, et.al,[25] in Pakistan (Nazimabad). And, a closer value of 33.48% of multidrug-resistance (MDR) Pseudomonas aeruginosa was also revealed by Divya Banger, et.al [26] in India (Mangalore) from October 2012 to March 2014 in the department of Microbiology, Kasturba Medical College, Mangalore on pus, tissue, serous discharge, and slough from traumatic ulcers, burn and surgical wounds and diabetic ulcers.

Table 2 and graph 2 of our study represents, out of the total of 32 isolates of MDR *Pseudomonas aeruginosa* from Pus and Wound swabs, 13 (41%) isolates were sensitive and 19 (59%) isolates were resistant to second line antibiotics.

Second-Line Antibiotic Resistance in MDR *P. aeruginosa*

High Resistance:

A substantial proportion of MDR isolates exhibited high resistance to Meropenem (66%), Cefepime (63%), and Piperacillin/Tazobactam (63%). The pronounced resistance to Meropenem—a key carbapenem—raises concern as it likely indicates carbapenemase production or other potent resistance mechanisms. Such mechanisms markedly restrict both oral and parenteral therapeutic options.

Moderate Resistance:

Levofloxacin showed a moderate susceptibility profile, with 53% of isolates remaining sensitive while 47% were resistant.

Most Effective Second-Line Agent:

Polymyxin B emerged as the most effective second-line antibiotic, demonstrating 94% sensitivity and only 6% resistance. This finding reinforces its value as a reliable therapeutic option for MDR *P. aeruginosa*, especially in nosocomial infections.

Comparatively, a study by Lubna Farooq et al. [25] from Nazimabad, Pakistan reported even higher resistance patterns among MDR *P. aeruginosa*, with Imipenem resistance reaching 81.6%. In contrast, our study—using Meropenem as the representative carbapenem—documented a resistance rate of 66%. Their observed resistance rate of 62% to Piperacillin/Tazobactam closely aligns with the 63% resistance rate found in our isolates.

Similarly, findings from Nepal by Jaya Krishna Yakha et al. [27] involving 106 isolates, revealed resistance rates of 52.8% for Piperacillin/Tazobactam and 51.9% for Meropenem. This trend is comparable to our results, where Meropenem exhibited 66% resistance followed by Piperacillin/Tazobactam at 63%.

In contrast, a study conducted at MKCG Medical College, Berhampur, Odisha by Muktikesh Dash et al. [28] reported markedly lower resistance levels. Among 327 isolates, Meropenem and Piperacillin/Tazobactam showed minimal resistance (8% and 11.3%, respectively), indicating a higher susceptibility profile. Conversely, in our study, these antibiotics were among the least effective, with sensitivities of only 34% for Meropenem and 37% for Piperacillin/Tazobactam.

Colistin Efficacy (Third-Line Therapy)

For MDR *P. aeruginosa* isolates resistant to second-line agents (n = 19), Colistin demonstrated exceptional efficacy.

- **Complete Sensitivity:** All 19 isolates tested via E-test were 100% sensitive to Colistin (*Table 4*, *Graph 4*). This could be because Colistin (polymyxin) exhibits rapid bactericidal activity against gram negative bacteria. It acts by disrupting the structure and function of the outer cytoplasmic membrane of bacteria, ultimately causing its death which confirms its crucial role as a last-resort agent against highly resistant Pseudomonas strains.
- Although this complete susceptibility is reassuring, vigilant monitoring is essential, as the emergence of Colistin resistance would pose a serious therapeutic challenge.

Our study is similar to the study done in Pakistan (Nazimabad) by Lubna Farooq, et.al, [25] which revealed that all multi-drug-resistant Pseudomonas aeruginosa strains shown 100% susceptibility to Colistin. Our study is also similar to the study conducted by Divya Banger et.al, [26] in India (Mangalore) which revealed that all strains of P. aeruginosa showed 100% susceptibility to Colistin.

Implications

Overall, these findings highlight the critical need for:

- strengthening infection control measures
- judicious use of antibiotics
- routine antimicrobial resistance (AMR) surveillance
- robust antibiotic stewardship initiatives

CONCLUSION

The study findings highlight the importance of surveillance and adherence to antibiotic policy:

- **Antibiogram Monitoring:** The high prevalence of *P. aeruginosa* as an opportunistic nosocomial infection, along with the high frequency of antimicrobial resistance among clinical isolates, necessitates frequent antibiogram monitoring and effective antimicrobial policy implementation.
- **MDR Incidence:** Out of all *Pseudomonas* isolates, the incidence of MDR *Pseudomonas* (39%) was lower than Non-MDR *Pseudomonas* (61%).
- **MDR *P. aeruginosa*:** For *P. aeruginosa* specifically, 38% were MDR and 62% were non-MDR. This lower incidence of MDR was noted to be potentially due to good infection control practices at the hospital.
- **Second-Line Resistance:** Of the MDR *P. aeruginosa* isolates, 59% (19 out of 32) were resistant to second-line antibiotics.
- **Colistin Sensitivity:** The single MDR *Pseudomonas* species isolate that was resistant to second-line antibiotics was tested against Colistin (a third-line antibiotic) and showed 100% sensitivity by E-test. The sensitivity to Colistin (Polymyxin) is based on its rapid bactericidal activity, which disrupts the structure and function of the outer cytoplasmic membrane of Gram-negative bacteria.

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