



Original Paper

Characterization and Resistance Patterns of *Pseudomonas aeruginosa* Isolated from Burn Patients in Al-Diwaniyah City, Iraq

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ABSTRACT

Pseudomonas aeruginosa is a major cause of burn wound infection. This study investigated the frequency, antibiotic resistance patterns and virulence traits of *P. aeruginosa* isolated from burn patients. In this cross-sectional study, 44 burn swabs were collected from patients attending the Burn Specialty Center in Al-Diwaniyah City, Iraq, between December 2025 and February 2026. Patients of both sexes, aged 1.5–85 years, were included. Isolates were identified by culture and the Vitek 2 compact system, and antibiotic susceptibility testing, biofilm formation and motility assays were performed. Twenty-four isolates (54.55%) were confirmed as *P. aeruginosa*. Antibiotic susceptibility testing revealed 50.00% resistance to piperacillin/tazobactam, ceftazidime, ceftazidime/avibactam, ceftolozane/tazobactam and gentamicin, whereas imipenem, amikacin and ciprofloxacin each showed 45.83% resistance; multidrug-resistant (MDR) isolates constituted 41.67%. Moderate biofilm formation was the predominant category (66.67%). In motility assays, strong swarming motility was observed in 54.17% of the isolates, and strong swimming and intermediate twitching motility were frequent (58.33% and 91.67%, respectively). Biofilm formation was significantly associated with the resistance patterns and with the susceptibility status to most of the studied antibiotics, and all strong biofilm-producing isolates were classified as MDR/XDR. These findings demonstrate a significant correlation between biofilm formation and the antimicrobial resistance profile of *P. aeruginosa* isolated from burn patients.

KEYWORDS: *Pseudomonas aeruginosa*, Resistance patterns, Biofilm, Motility, Burn patients.

1-INTRODUCTION

Pseudomonas aeruginosa is an aerobic, non-fermentative, Gram-negative bacillus belonging to the family *Pseudomonadaceae*. It is one of the most feared causes of severe infection in clinical settings, particularly in immunocompromised patients and in patients with severe burns [1].

P. aeruginosa causes serious infections and complications in burn patients and accounts for about 45% of mortality among them [2]. The presence of devitalised tissue, a moist environment, impaired immunity and prolonged hospital stay render the burn wound vulnerable to *P. aeruginosa* infection. These infections are difficult to treat because the organism is naturally susceptible to only a limited number of antimicrobial agents, and the high rates of resistance associated with *P. aeruginosa* strains frequently necessitate combination therapy [2].

The pathogenesis of *P. aeruginosa* depends strongly on motility, which enables the bacterium to colonise diverse environments, attach to surfaces and form biofilms. *P. aeruginosa* is capable of twitching, swimming and swarming motility. Type IV pili mediate twitching motility on solid surfaces or interfaces, whereas a single polar flagellum enables the bacterium to swim in aqueous environments and, together with type IV pili and rhamnolipids, to swarm on semi-solid agar [3]. Biofilm formation is the most effective mechanism used by *P. aeruginosa* to improve its survival [4]. A biofilm is a complex aggregate of bacteria enclosed in alginate polysaccharide, whose synthesis is

determined by the *algD* gene. The biofilm forms a barrier between the bacterial cells and antibiotics and is therefore regarded as one of the main strategies of antibiotic resistance; it also increases horizontal gene transfer between susceptible and resistant strains [5].

P. aeruginosa displays resistance to a wide range of antibiotics, including β -lactams, aminoglycosides and quinolones. The main mechanisms by which *P. aeruginosa* evades the action of antibiotics can be categorised as intrinsic, acquired and adaptive resistance [6]. Antibiotic resistance rates in *P. aeruginosa* are increasing worldwide, and some strains exhibit resistance to multiple antibiotics through several mechanisms, including the production of hydrolysing enzymes, loss of outer-membrane proteins, efflux systems and target mutations [7]. *P. aeruginosa* strains are classified as multidrug-resistant (MDR) when they are non-susceptible to at least one agent in three or more antimicrobial categories, extensively drug-resistant (XDR) when they are non-susceptible to at least one agent in all but two or fewer categories, and pandrug-resistant (PDR) when they are non-susceptible to all antimicrobial agents [8].

In recent years, the emergence of MDR and XDR strains of *Pseudomonas* spp. has become a global threat to human health and is associated with high morbidity and mortality worldwide, highlighting the need for novel, antibiotic-independent treatment strategies [9].

In Al-Diwaniyah City, data on burn-associated *P. aeruginosa* are limited. The present study was therefore conducted to provide updated local evidence on the pathogenic characteristics of burn-related *P. aeruginosa* isolates. Specifically, it aimed to investigate the frequency, antimicrobial susceptibility profile and virulence phenotypes of *P. aeruginosa* isolates obtained from patients attending the Burn Specialty Center in Al-Diwaniyah City, Iraq.

2-MATERIALS AND METHODS

2.1. Clinical specimens and culture characteristics

A cross-sectional study was conducted on 44 burn swab samples collected from patients attending the Burn Specialty Center in Al-Diwaniyah City, Iraq, over a period of three months, from December 2025 to February 2026. No prior sample-size calculation was performed; the sample size reflected the specimens collected during the study period. Samples were taken from patients of either sex and of all age groups with suspected or proven burn infection and a hospitalisation period of 48 hours or more. Each sample was streaked on MacConkey agar and blood agar (HiMedia, India) and incubated aerobically at 37 °C for 24 hours. Colonies with different morphologies were isolated, tested for oxidase production and subcultured on cetrimide agar (Liofilchem, Italy), then incubated for 24 hours at 37 °C. The growth and colour of the bacterial colonies were recorded, and the identity of *P. aeruginosa* was confirmed using the Vitek 2 compact system with the GN identification card (bioMérieux, France) according to the manufacturer's instructions.

2.2. Antibiotic susceptibility testing

Antibiotic susceptibility testing was performed using the Vitek 2 system with the AST-N419 card (bioMérieux, France) according to the manufacturer's instructions. The tested antibiotics were piperacillin/tazobactam, ceftazidime, ceftazidime/avibactam, ceftolozane/tazobactam, cefepime, imipenem, meropenem, amikacin, gentamicin, ciprofloxacin and colistin. The results, except for colistin, were interpreted according to the CLSI guidelines (CLSI M100, 35th edition, 2025) [10]. Colistin MIC values generated by the Vitek 2 system were reported descriptively, as they were not confirmed by the broth microdilution method.

2.3. Biofilm formation assay

The microtiter plate method was used to quantify biofilm formation as previously described [11]. Briefly, 200 μ L of an overnight culture in Luria–Bertani (LB) broth (Oxoid, England) supplemented with 1% glucose, adjusted to a turbidity equivalent to McFarland standard no. 0.5, was transferred to the wells of sterile 96-well flat-bottomed polystyrene microplates and incubated aerobically at 37 °C for 24 h. After incubation, the contents of the wells

were aspirated and the wells were washed three times with 200 μ L of sterile phosphate-buffered saline (PBS) to remove loosely adherent cells. The attached bacteria were fixed with 200 μ L of absolute methanol for 15 minutes and stained with 200 μ L of 0.1% crystal violet solution for 15 minutes at room temperature. Excess stain was removed under running tap water, and the plates were dried in a 37 °C incubator for approximately 30 minutes. The bound dye was resolubilised with 200 μ L of 33% glacial acetic acid for 15 minutes, and the optical density (OD) of each well was measured at 600 nm with a microplate reader [12].

The results were interpreted according to Atshan et al. [13]: the cut-off value (OD_c) was calculated as the mean OD of the control wells plus three standard deviations, and the isolates were classified as non-producers (OD $\leq$ OD_c), weak (OD_c < OD $\leq$ 2 $\times$ OD_c), moderate (2 $\times$ OD_c < OD $\leq$ 4 $\times$ OD_c) or strong (OD > 4 $\times$ OD_c) biofilm producers.

2.4. Motility tests (swarming, swimming and twitching motility)

Motility assays were carried out according to O'May and Tufenkji [14] with minor modifications. Petri dishes containing nutrient broth (HiMedia, India) with different agar concentrations were used: 0.5% (w/v) agar supplemented with D-glucose (5 g/L, filter-sterilised and added separately) for swarming motility, 0.3% (w/v) agar for swimming motility and 1.0% (w/v) agar for twitching motility.

Swim and swarm plates were inoculated with 5 μ L of an overnight bacterial broth culture. The inoculum was placed on the agar surface (centre) for swarm plates and directly into the centre of the agar for swim plates. The diameters of the swarming and swimming zones were measured after incubation at 37 °C for 24 hours. For twitching motility, a bacterial colony was stab-inoculated deeply into the agar with a sterile wooden stick so that it touched the agar–dish interface. After incubation for 24 hours at 37 °C, the agar was carefully removed, and the plates were stained with 0.1% (w/v) crystal violet for 1 minute and rinsed before the diameter of the twitching zone was measured.

Isolates were described as non-motile when the zone diameter was < 5 mm, intermediate when it was 5–20 mm and strong when it was > 20 mm [15].

2.5. Statistical analysis

Data were collected, summarised, analysed and presented using the Statistical Package for the Social Sciences (SPSS) version 26 and Microsoft Excel 2021. Fisher's exact test was used to examine the association between variables. A P-value of less than 0.05 was considered significant and a P-value of 0.01 or less highly significant [16].

2.6. Ethical approval

Ethical approval for this study was obtained as part of the main master's research project approved by the Medical Ethics Committee of Middle Technical University (No. 168, dated 31/12/2025). In addition, official permission for sample collection and laboratory work was obtained from the Burn Specialty Center and Al-Diwaniyah Teaching Hospital (No. 509, dated 8/12/2025).

3-RESULTS

3.1. Isolation and identification of *P. aeruginosa*

This study included 44 burn swab samples obtained from burn patients aged 1.5–85 years of both sexes. Of the cultured samples, 54.55% (24 of 44) yielded *Pseudomonas* species, whereas the remaining 45.45% (20 of 44) were negative for *Pseudomonas* species. Presumptive identification was based on the shape, size, colour and surface structure of the colonies on the different culture media (Figure 1). The final identification by the Vitek 2 compact system confirmed that all 24 isolates were *P. aeruginosa*.

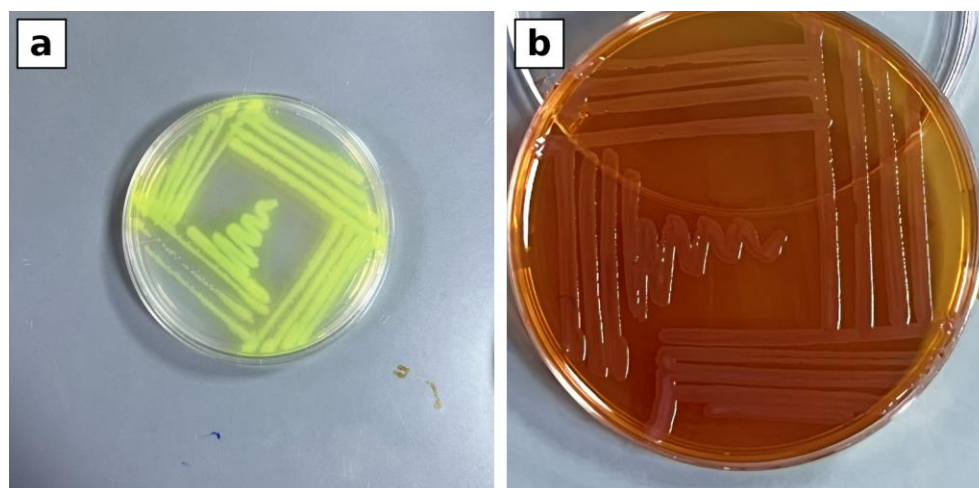


Figure (1): Culture characteristics of *P. aeruginosa* isolates: (a) on cetrimide agar; (b) on MacConkey agar.

3.2. Demographic characteristics of patients from whom *P. aeruginosa* was isolated

Most patients with *P. aeruginosa* isolates were in the 20–39-year age group (13/24, 54.17%), compared with the other age groups. Males constituted 83.33% (20/24) and females 16.67% (4/24) of the patients (Table 1).

Table (1) Demographic characteristics of patients with *P. aeruginosa* isolates

Characteristic	Patients with <i>P. aeruginosa</i> infection (n = 24)
Age (years), mean $\pm$ SD	24.9 $\pm$ 20.05
Age (years), median	20.5
Age (years), range	1.5–85
Age < 20 years, n (%)	8 (33.33)
Age 20–39 years, n (%)	13 (54.17)
Age $\geq$ 40 years, n (%)	3 (12.50)
Male, n (%)	20 (83.33)
Female, n (%)	4 (16.67)

n: number of cases; SD: standard deviation.

3.3. Antibiotic susceptibility testing

The Vitek 2 AST system was used to assess the antibiotic susceptibility of the isolates. *P. aeruginosa* isolates showed varying levels of resistance to the antimicrobial agents: piperacillin/tazobactam, ceftazidime, ceftazidime/avibactam, ceftolozane/tazobactam and gentamicin each showed 50.00% resistance, whereas imipenem, amikacin and ciprofloxacin each showed 45.83% resistance. Colistin was excluded from the categorical susceptibility interpretation because the Vitek-derived results were not confirmed by broth microdilution. The remaining percentages are shown in Table 2.

Table (2) Antimicrobial susceptibility profile of *P. aeruginosa* isolates (n = 24)

Antimicrobial agent	Sensitive n (%)	Intermediate n (%)	Resistant n (%)
Piperacillin/tazobactam	12 (50.00)	0 (0.00)	12 (50.00)
Ceftazidime	12 (50.00)	0 (0.00)	12 (50.00)
Ceftazidime/avibactam	12 (50.00)	0 (0.00)	12 (50.00)
Ceftolozane/tazobactam	12 (50.00)	0 (0.00)	12 (50.00)
Cefepime	12 (50.00)	2 (8.33)	10 (41.67)
Imipenem	13 (54.17)	0 (0.00)	11 (45.83)
Meropenem	13 (54.17)	1 (4.17)	10 (41.67)
Amikacin	12 (50.00)	1 (4.17)	11 (45.83)
Gentamicin	12 (50.00)	0 (0.00)	12 (50.00)
Ciprofloxacin	13 (54.17)	0 (0.00)	11 (45.83)

Interpretation according to CLSI M100, 35th edition (2025). Colistin is not included because the Vitek 2 MIC values were not confirmed by broth microdilution.

3.4. Distribution of the studied characteristics in *P. aeruginosa* isolates

Table 3 shows the frequency distribution of biofilm formation, motility phenotypes and resistance patterns among the *P. aeruginosa* isolates. Moderate biofilm formation (66.67%), strong swarming motility (54.17%), strong swimming motility (58.33%) and intermediate twitching motility (91.67%) were the predominant phenotypes, and susceptible isolates (50.00%) were the most frequent resistance pattern. Representative motility phenotypes of the isolates are shown in Figure 2.

Table (3) Frequency distribution of the studied characteristics in *P. aeruginosa* isolates (n = 24)

Characteristic	Category	No.	%
Biofilm formation	Strong	8	33.33
	Moderate	16	66.67
	Weak	0	0.00
	Non-producer	0	0.00
Swarming motility	Strong	13	54.17
	Intermediate	11	45.83
	Non-motile	0	0.00
Swimming motility	Strong	14	58.33
	Intermediate	10	41.67
	Non-motile	0	0.00
Twitching motility	Strong	2	8.33
	Intermediate	22	91.67
	Non-motile	0	0.00
Resistance pattern	Susceptible	12	50.00
	Resistant (non-MDR)	0	0.00
	MDR	10	41.67
	XDR	2	8.33

MDR: multidrug-resistant; XDR: extensively drug-resistant; Resistant (non-MDR): resistant isolates not meeting the MDR definition.

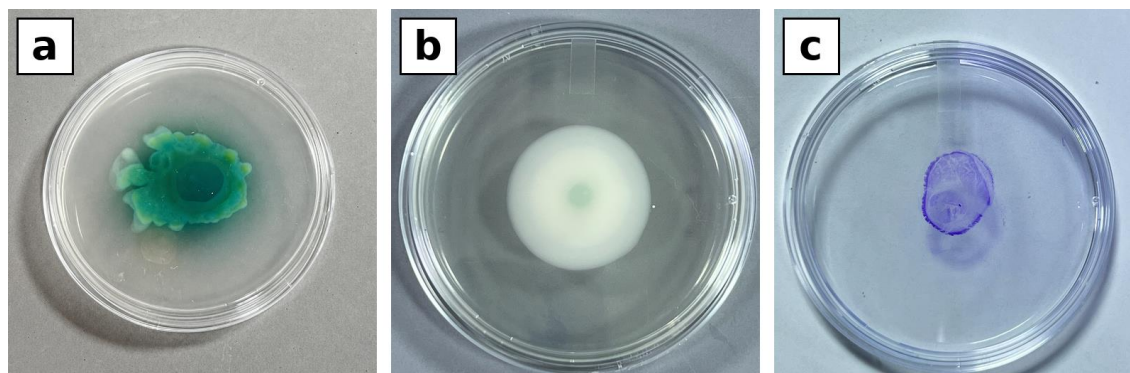


Figure (2): Motility phenotypes of the *P. aeruginosa* isolates: (a) swarming motility (nutrient broth + 0.5% agar); (b) swimming motility (nutrient broth + 0.3% agar); (c) twitching motility (nutrient broth + 1.0% agar, crystal violet stained).

3.5. Association of biofilm formation with antimicrobial resistance patterns

Tables 4 and 5 show the association of biofilm formation with the resistance patterns and with the antibiotic susceptibility status of the studied isolates. The frequency distribution of biofilm-producing *P. aeruginosa* isolates differed significantly according to the antimicrobial resistance pattern: all isolates with strong biofilm formation were MDR/XDR (8/8, 100.00%), compared with 4 of 16 (25.00%) moderate biofilm producers ($P = 0.001$). In

addition, biofilm formation was significantly associated with the susceptibility status for each of the tested antibiotics ($P < 0.005$ after Bonferroni correction).

Table (4) Relationship between biofilm formation and antimicrobial resistance (AMR) patterns in *P. aeruginosa* isolates (n = 24)

Biofilm pattern	MDR/XDR n (%)	Non-MDR n (%)	Total	P-value
Moderate	4 (25.00)	12 (75.00)	16	0.001 S
Strong	8 (100.00)	0 (0.00)	8	
Total	12 (50.00)	12 (50.00)	24	

n: number of cases; MDR: multidrug-resistant; XDR: extensively drug-resistant; Non-MDR: susceptible + resistant (non-MDR) group. P-value by Fisher's exact test; S: significant at $P < 0.05$.

Table (5) Distribution of *P. aeruginosa* isolates according to susceptibility status and biofilm category for each antibiotic (n = 24)

Antibiotic	Biofilm category	R n (%)	S n (%)	I n (%)	Total n (%)	P-value
Piperacillin/tazobactam	Moderate	4 (16.67)	12 (50.00)	0	16 (66.67)	0.0013*
	Strong	8 (33.33)	0	0	8 (33.33)	
Ceftazidime	Moderate	4 (16.67)	12 (50.00)	0	16 (66.67)	0.0013*
	Strong	8 (33.33)	0	0	8 (33.33)	
Ceftazidime/avibactam	Moderate	4 (16.67)	12 (50.00)	0	16 (66.67)	0.0013*
	Strong	8 (33.33)	0	0	8 (33.33)	
Ceftolozane/tazobactam	Moderate	4 (16.67)	12 (50.00)	0	16 (66.67)	0.0013*
	Strong	8 (33.33)	0	0	8 (33.33)	
Cefepime	Moderate	2 (8.33)	12 (50.00)	2 (8.33)	16 (66.67)	0.0001*
	Strong	8 (33.33)	0	0	8 (33.33)	
Imipenem	Moderate	3 (12.50)	13 (54.17)	0	16 (66.67)	0.0002*
	Strong	8 (33.33)	0	0	8 (33.33)	
Meropenem	Moderate	2 (8.33)	13 (54.17)	1 (4.17)	16 (66.67)	0.0001*
	Strong	8 (33.33)	0	0	8 (33.33)	
Amikacin	Moderate	3 (12.50)	12 (50.00)	1 (4.17)	16 (66.67)	0.0002*
	Strong	8 (33.33)	0	0	8 (33.33)	
Gentamicin	Moderate	4 (16.67)	12 (50.00)	0	16 (66.67)	0.0013*
	Strong	8 (33.33)	0	0	8 (33.33)	
Ciprofloxacin	Moderate	3 (12.50)	13 (54.17)	0	16 (66.67)	0.0002*
	Strong	8 (33.33)	0	0	8 (33.33)	

R: resistant; S: sensitive; I: intermediate; n: number of isolates; percentages are of the total 24 isolates. P-values were calculated using Fisher's exact test and adjusted by Bonferroni correction; *significant at $P < 0.005$.

3.6. Association of motility phenotypes with biofilm formation and antimicrobial resistance patterns

Tables 6 and 7 show the association of the motility phenotypes (swarming, swimming and twitching) with biofilm formation and with the antimicrobial resistance patterns of the *P. aeruginosa* isolates. Most isolates with moderate biofilm formation and most MDR/XDR isolates showed strong swarming motility, intermediate swimming motility and intermediate twitching motility. However, no statistically significant association was found between any of the three types of motility and either biofilm formation or the antimicrobial resistance pattern ($P > 0.05$).

Table (6) Association between biofilm formation and motility phenotypes in *P. aeruginosa* isolates (n = 24)

Motility phenotype	Category	Strong biofilm n (%)	Moderate biofilm n (%)	Weak biofilm n (%)	P-value
Swarming motility	Strong	5 (62.50)	8 (50.00)	0	0.693
	Intermediate	3 (37.50)	8 (50.00)	0	
Swimming motility	Strong	3 (37.50)	11 (68.75)	0	0.203
	Intermediate	5 (62.50)	5 (31.25)	0	
Twitching motility	Strong	1 (12.50)	1 (6.25)	0	1.000

Intermediate	7 (87.50)	15 (93.75)	0
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Percentages are calculated within each biofilm category (strong, n = 8; moderate, n = 16). P-value by Fisher's exact test.

Table (7) Association between antimicrobial resistance (AMR) patterns and motility phenotypes in *P. aeruginosa* isolates (n = 24)

Motility phenotype	Category	Non-MDR n (%)	MDR/XDR n (%)	P-value
Swarming motility	Strong	6 (50.00)	7 (58.33)	1.000
	Intermediate	6 (50.00)	5 (41.67)	
Swimming motility	Strong	9 (75.00)	5 (41.67)	0.213
	Intermediate	3 (25.00)	7 (58.33)	
Twitching motility	Strong	1 (8.33)	1 (8.33)	1.000
	Intermediate	11 (91.67)	11 (91.67)	

MDR: multidrug-resistant; XDR: extensively drug-resistant; Non-MDR: susceptible + resistant (non-MDR) group. Percentages are calculated within each resistance group (n = 12 each). P-value by Fisher's exact test.

4-DISCUSSION

In this study, *P. aeruginosa* recovered from burn swabs displayed a combination of virulence-associated traits, including antibiotic resistance, motility phenotypes and, most importantly, the ability to form biofilm. These findings are consistent with the behaviour of *P. aeruginosa* in burn wound infections, where it is described as a highly adaptable pathogen known for colonisation, persistence through biofilm formation and the expression of multiple virulence traits [5,17].

The antibiotic susceptibility results highlight the clinical importance of antimicrobial resistance among *P. aeruginosa* isolates. Resistance was most frequent to piperacillin/tazobactam, ceftazidime, ceftazidime/avibactam, ceftolozane/tazobactam and gentamicin (50.00% each), followed by imipenem, amikacin and ciprofloxacin (45.83% each). These results are in partial agreement with a study from Erbil, Iraq, which reported high resistance to ceftolozane/tazobactam (84.2%), ceftazidime/avibactam (81.6%) and ceftazidime (73.5%) [18]. In contrast, a study in Baghdad, Iraq, found that *P. aeruginosa* isolates recovered from burn wound swabs were highly susceptible to piperacillin/tazobactam, amikacin and ciprofloxacin [19]. Although the Vitek 2 system generated low colistin MIC values for the tested isolates, these results should be interpreted with caution, because broth microdilution is the reference method for colistin susceptibility testing and the current CLSI criteria do not provide a susceptible category for colistin against *P. aeruginosa* [10]. Overall, the observed diversity of resistance may be explained by several factors. Burn wounds provide a favourable environment for bacterial colonisation and persistence owing to tissue damage, moisture and impaired immunity; moreover, prolonged antibiotic exposure, biofilm-forming ability and inducible resistance mechanisms together contribute to the variation in resistance profiles among isolates [6,20,21].

Regarding the overall resistance patterns, MDR and XDR isolates had frequencies of 41.67% and 8.33%, respectively. These findings reflect the ability of *P. aeruginosa* to develop resistance to multiple antimicrobial classes [2,22] and are supported by local studies that reported a high burden of resistance among burn-related isolates [23,24].

Biofilm formation was the most prominent virulence feature among the isolates, with 66.67% classified as moderate biofilm producers. This agrees with Kunwar et al. [25], who confirmed that *P. aeruginosa* is a typical biofilm-forming organism and that this trait contributes to antibiotic resistance and is an important determinant of pathogenicity.

More importantly, the present study demonstrated a highly significant association between biofilm formation and the AMR pattern: all strong biofilm-producing isolates belonged to the MDR/XDR category (100.0%, n = 8). This finding should nevertheless be interpreted cautiously because of the small number of isolates. Similar observations have been reported in previous studies [26,27], in which strong biofilm-producing strains showed higher rates of

multidrug resistance. This relationship may be explained by the role of the biofilm in limiting antibiotic penetration and creating a protected microenvironment, while efflux systems reduce intracellular antimicrobial concentrations; furthermore, the high cell density within the biofilm increases the potential for horizontal transfer of resistance determinants [28,29]. Not all studies, however, support this concept, and the relationship appears to vary among isolates [30].

Biofilm formation was also significantly associated with the susceptibility status for most of the tested antibiotics, and the association varied with the degree of biofilm formation. A comparable result was reported by Saud et al., who noted that the impact of biofilm on antimicrobial status may vary depending on the parameter tested [30].

Motility phenotypes were highly prevalent among the burn isolates, with strong swarming motility (54.17%), strong swimming motility (58.33%) and intermediate twitching motility (91.67%) predominating. These findings agree with a previous study showing that *P. aeruginosa* depends on motility for the pathogenesis of burn wound infection [31].

No statistically significant association was found between the motility phenotypes and either biofilm formation or the antibiotic resistance pattern. These results are consistent with those of Gajdács et al. [32], although other studies have shown that the relationship may vary among isolates [33]. This inconsistency may be attributable to the complex regulation of these phenotypes in *P. aeruginosa* [34].

The limited number of directly comparable local studies from Al-Diwaniyah City should be considered when interpreting the findings. Most of the available data are derived from other regions and may not necessarily reflect the local microbial and resistance profile of isolates, owing to geographical and hospital-specific variation. This also indicates that Al-Diwaniyah City remains an understudied area, and the current study may help to add region-specific data on antimicrobial resistance and virulence phenotypes.

This study has several limitations that should be considered when interpreting and generalising the findings, including the single-centre design, the small sample size, the short three-month collection period and the absence of molecular characterisation of resistance and biofilm genes (e.g. *algD*, *mexAB-oprM* and carbapenemase genes). In addition, the colistin MIC results obtained by the Vitek 2 system were not confirmed by the broth microdilution method.

CONCLUSION

P. aeruginosa isolated from burn patients possesses important resistance- and virulence-associated characteristics. Biofilm formation is an important virulence factor that supports the persistence of the pathogen in burn wound infections. MDR isolates accounted for 41.67% of the isolates, and strong biofilm formation was significantly associated with the MDR/XDR resistance pattern. Although the Vitek 2 system showed low colistin MIC values with no resistant isolates, these findings should be interpreted carefully because they were not confirmed by the broth microdilution method. Further local studies with larger sample sizes and molecular analysis are recommended.

DECLARATIONS

Conflicts of interest: The authors declare no conflicts of interest.

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