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Microbial Spectrum and Antimicrobial Resistance in Burn Wound Infections after an Aviation Disaster in Bangladesh

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Abstract:

Background: Burn wound infections are a major cause of morbidity and mortality, particularly following mass casualty events where healthcare systems are rapidly overwhelmed. On 21 July 2025, an aviation disaster in Dhaka, Bangladesh resulted in a sudden influx of patients with severe burn injuries, creating significant challenges for infection control and antimicrobial management.

Objective: This study aimed to characterize the microbiological profile and antimicrobial resistance patterns of burn wound infections among victims of a mass casualty aviation disaster in Bangladesh.

Methods: This observational, cross-sectional study was conducted at the National Institute of Burn and Plastic Surgery and the Combined Military Hospital (CMH), Dhaka, from 22 July to 22 August 2025. A total of 40 burn wound samples from hospitalized patients with clinically suspected infections were analyzed. Microbial isolation and identification were performed using standard culture techniques. Antimicrobial susceptibility testing was carried out using the Kirby–Bauer disk diffusion method and the VITEK® 2 automated system, with interpretation according to CLSI M100 guidelines (2024).

Results: A total of 46 microbial isolates were recovered. Gram-negative bacteria predominated (78.3%), followed by Gram-positive bacteria (17.4%) and fungi (4.3%). Pseudomonas spp. were the most common pathogens (47.8%), followed by Staphylococcus aureus (17.4%), Klebsiella spp. (13.0%), and Acinetobacter spp. (8.7%). High resistance to fluoroquinolones and carbapenems was observed among Gram-negative isolates. Pseudomonas spp. showed preserved susceptibility to piperacillin–tazobactam (81.8%) and colistin (100%). Fifty percent of S. aureus isolates were methicillin-resistant, while all remained susceptible to vancomycin and linezolid.

Conclusion: Burn wound infections following this mass casualty aviation disaster were predominantly caused by multidrug-resistant Gram-negative bacteria, particularly Pseudomonas spp. The findings underscore the need for early microbiological surveillance, rational antimicrobial use, and strengthened infection prevention strategies to improve outcomes in disaster-related burn care.

Keywords: *Burn wound infection; Mass casualty incident; Antimicrobial resistance; Multidrug-resistant organisms; Methicillin-resistant Staphylococcus aureus.*

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Introduction

On 21 July 2025, a Bangladesh Air Force (BAF) training aircraft on a routine mission crashed into the campus of Milestone School and College in Diabari, Uttara, Dhaka, Bangladesh, shortly after take-off, resulting in a mass casualty incident. At least 35 individuals on the ground lost their lives and 171 others were injured, the majority of whom were students who sustained severe burn injuries and secondary trauma following the impact and subsequent fire. Many victims suffered extensive thermal burns and inhalational injuries and were rapidly transferred to specialized burn care facilities, including the National Institute of Burn and Plastic Surgery and the Combined Military Hospital, Dhaka. The sudden influx of critically injured burn patients placed substantial strain on healthcare services, posing significant challenges to clinical management, infection control practices and antimicrobial stewardship within an already resource-constrained healthcare system.

Patients with burn injuries are highly susceptible to infectious complications due to disruption of the skin barrier, burn-induced immune dysfunction and the frequent requirement for invasive procedures and prolonged hospitalization (Greenhalgh, 2019). Infection remains a leading cause of morbidity and mortality in patients with major burns, a risk that is further

amplified during large-scale disaster situations where optimal wound care, patient isolation and antimicrobial oversight are difficult to maintain (WHO, 2014).

The microbiological profile of burn wound infections evolves rapidly during hospitalization, with Gram-negative bacteria increasingly predominating in patients with extensive burns and prolonged hospital stays (Weber *et al.*, 2019). Pathogens such as *Pseudomonas aeruginosa*, *Acinetobacter baumannii* and carbapenem-resistant Enterobacterales are frequently implicated and are commonly associated with multidrug resistance, posing major therapeutic challenges (Ranjan *et al.*, 2021). In settings with a high prevalence of carbapenem resistance, infections caused by these organisms often necessitate the use of last-resort antimicrobial agents with limited efficacy and increased toxicity (WHO, 2017).

Mass casualty events involving fires or aviation-related disasters further increase the risk of emergence and transmission of resistant organisms due to empirical broad-spectrum antibiotic use, delayed microbiological diagnosis, overcrowding and compromised infection prevention and control measures (Sharma *et al*., 2019). Recent evidence from disaster-associated burn outbreaks has demonstrated a high burden of multidrug-resistant Gram-negative infections, which significantly complicate clinical management and prolong hospital stay (Nițescu *et al*., 2023).

Despite the substantial burden of burn injuries in South Asia, data describing antimicrobial resistance patterns in burn wound infections following sudden aviation-related mass casualty events remain limited. The present study aimed to characterize the etiological agents and antimicrobial resistance profiles of burn wound infections among victims of the July 2025 aviation disaster in Dhaka, with the objective of informing empirical therapy and strengthening preparedness for future disaster-related burn incidents.

Materials and Methods

Study setting

This observational, cross-sectional study was conducted at the National Institute of Burn and Plastic Surgery, Dhaka and the Combined Military Hospital (CMH), Dhaka, Bangladesh, from 22 July 2025 to 22 August 2025.

Study population

The study population comprised patients with clinically suspected burn wound infections following the aviation disaster. Only culture-positive burn wound samples were included in the final analysis, resulting in a total of 40 samples from hospitalized burn patients.

Study procedure

Burn wound samples were collected aseptically from the wound surface after gentle removal of necrotic debris and cleansing with sterile normal saline. Specimens were placed in sterile containers and transported promptly to the Microbiology Laboratory of the Armed Forces Institute of Pathology (AFIP), Bangladesh for further processing.

Isolation and identification of bacterial isolates

Samples were inoculated onto Blood agar and MacConkey agar plates and incubated aerobically at 37°C for 24–48 hours. Bacterial isolates were initially identified based on colony morphology, Gram staining and conventional biochemical tests using standard microbiological procedures.

Antimicrobial susceptibility testing

Antimicrobial susceptibility testing was carried out using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar, supplemented by testing with the VITEK® 2 automated system. Interpretation of results was performed according to the Clinical and Laboratory Standards Institute (CLSI) M100 guidelines (2024).

Statistical analysis

All relevant data were recorded in structured data collection sheets and analyzed using the Statistical Package for the Social Sciences (SPSS), version 27. Descriptive statistics were used to summarize the data and results were presented in tables and charts where appropriate.

Ethical clearance

Ethical approval for the study was obtained from the Ethical Review Committee of the Directorate General of Medical Services (DGMS). Permission for sample collection and laboratory analysis was granted by the respective hospital administrations.

Results

Out of 40 culture-positive burn wound samples, single-organism growth was observed in 34 cases (85%), while mixed microbial growth was detected in 6 cases (15%) (Table 1).

Table 1: Culture positivity pattern of burn wound samples (n=40)

Culture result	Number n (%)
Culture positive – single organism	34 (85)
Culture positive – mixed organisms	6 (15)
Total culture-positive samples	40 (100)

A total of 46 microbial isolates were recovered from the positive cultures.

Gram-negative bacteria predominated, accounting for 78.3% (36/46) of isolates, followed by Gram-positive bacteria (17.4%, 8/46) and fungal isolates (4.3%, 2/46). This distribution demonstrates the dominance of Gram-negative organisms in burn wound infections following major trauma.

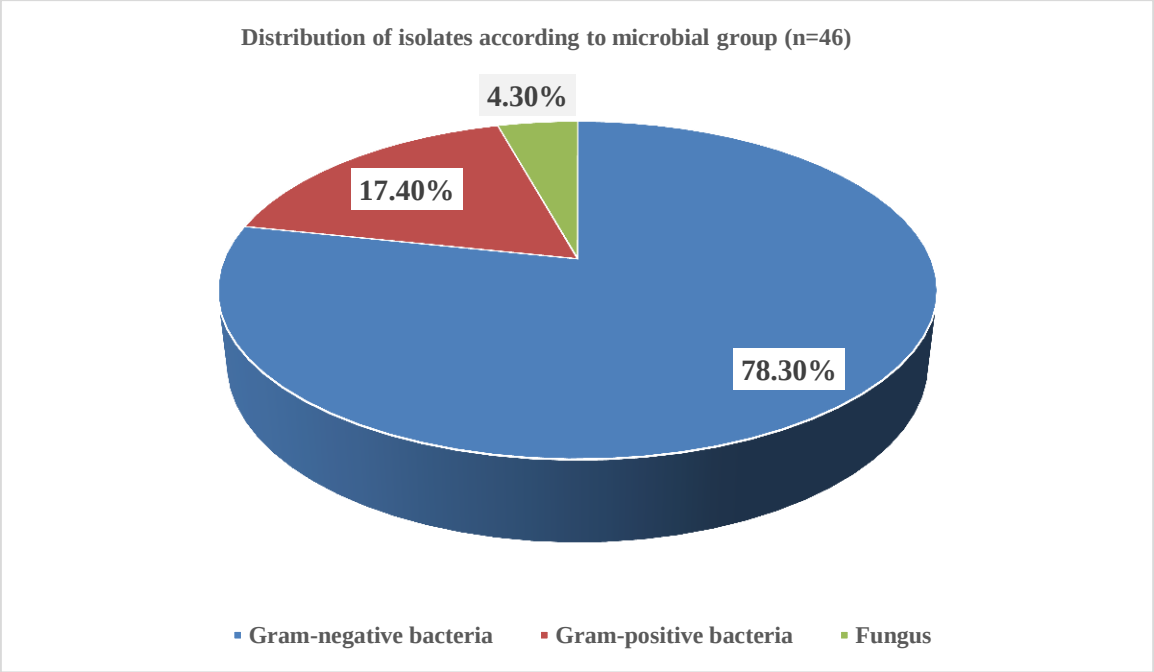

Fig-1: Distribution of isolates according to microbial group (n=46)

Organism-wise analysis revealed *Pseudomonas* spp. as the most frequently isolated pathogen (47.8%). This was followed by *Staphylococcus* spp. (17.4%), *Klebsiella* spp. (13%), and *Acinetobacter* spp. (8.7%). Two isolates each of *Burkholderia cepacia* complex, *Escherichia coli* and *Candida* spp. were also identified (Table 2).

Table-2: Organism-wise distribution of isolates from burn wound infections (n=46)

Organism	**Number n (%)**
Pseudomonas spp.	22 (47.8)
Staphylococcus spp.	8 (17.4)
Klebsiella spp.	6 (13)
Acinetobacter spp.	4 (8.7)
Burkholderia cepacia complex	2 (4.3)
Escherichia coli	2 (4.3)
Candida spp.	2 (4.3)
Total	46 (100)

Antimicrobial susceptibility testing of *Pseudomonas* spp. (n = 22) revealed high resistance to most antipseudomonal agents. Susceptibility was low to ciprofloxacin (27.3%), levofloxacin (18.2%), ceftazidime (18.2%), cefepime (9.1%), aminoglycosides (9.1–18.2%) and meropenem (18.2%). Moderate activity was observed with aztreonam (45.5%) and carbenicillin (36.4%). In contrast, piperacillin–tazobactam retained high activity (81.8%) and colistin showed 100% susceptibility.

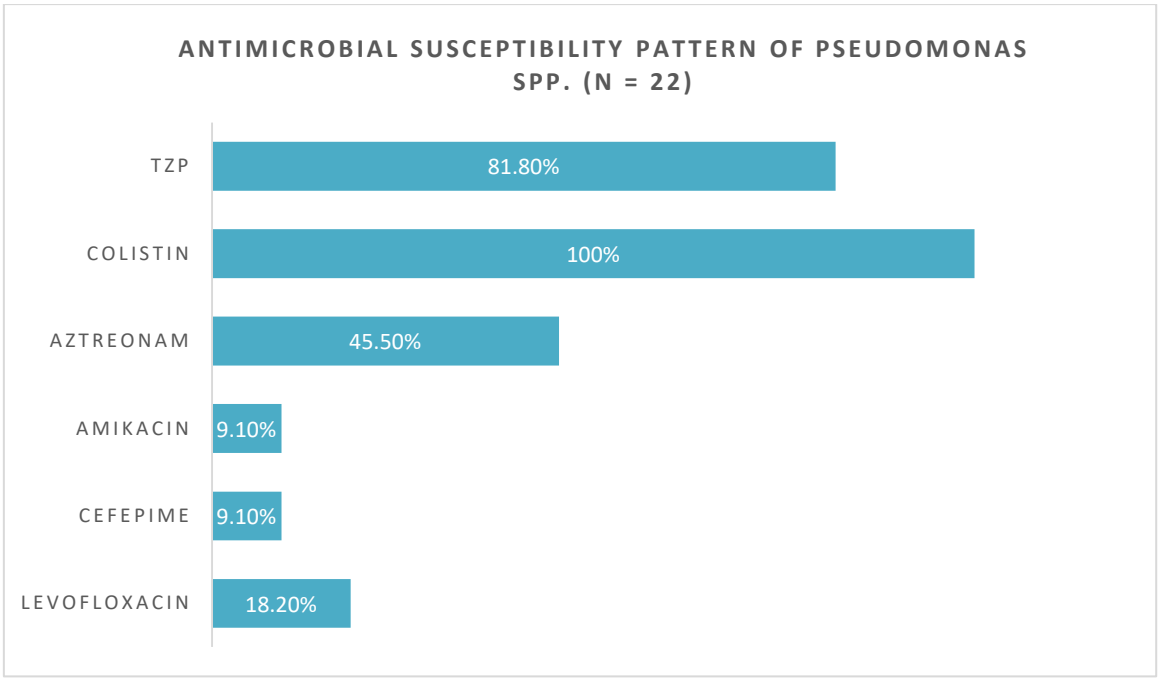

Figure-2: Antimicrobial susceptibility pattern of *Pseudomonas spp.* (n = 22)

Among the non-*Pseudomonas* Gram-negative bacilli (n = 14), which included *Klebsiella* spp., *Acinetobacter* spp., *Burkholderia cepacia* complex and *Escherichia coli*, susceptibility to most CLSI-recommended antimicrobial agents was markedly limited. Ciprofloxacin, ceftazidime, piperacillin–tazobactam, amikacin and gentamicin each demonstrated low susceptibility rates of 14.3%. Levofloxacin and meropenem showed slightly better activity, with susceptibility rates of 28.6% each, whereas cotrimoxazole exhibited moderate activity (42.9%). In contrast, colistin and tigecycline showed the highest in-vitro activity, with 85.7% of isolates remaining susceptible.

Table 3: Antimicrobial susceptibility pattern of non-Pseudomonas Gram-negative bacilli (n = 14)

Antibiotic	Sensitive n (%)	Resistant n (%)
Ciprofloxacin	2 (14.3)	12 (85.7)
Levofloxacin	4 (28.6)	10 (71.4)
Ceftazidime	2 (14.3)	12 (85.7)
Piperacillin–Tazobactam	2 (14.3)	12 (85.7)
Amikacin	2 (14.3)	12 (85.7)
Gentamicin	2 (14.3)	12 (85.7)
Meropenem	4 (28.6)	10 (71.4)
Cotrimoxazole	6 (42.9)	8 (57.1)

Among *Staphylococcus aureus* isolates (n = 8), 50% were identified as methicillin-resistant. Susceptibility to flucloxacillin, ciprofloxacin and levofloxacin was observed in 50% of isolates each, while all isolates were fully susceptible to vancomycin, linezolid, clindamycin and gentamicin.

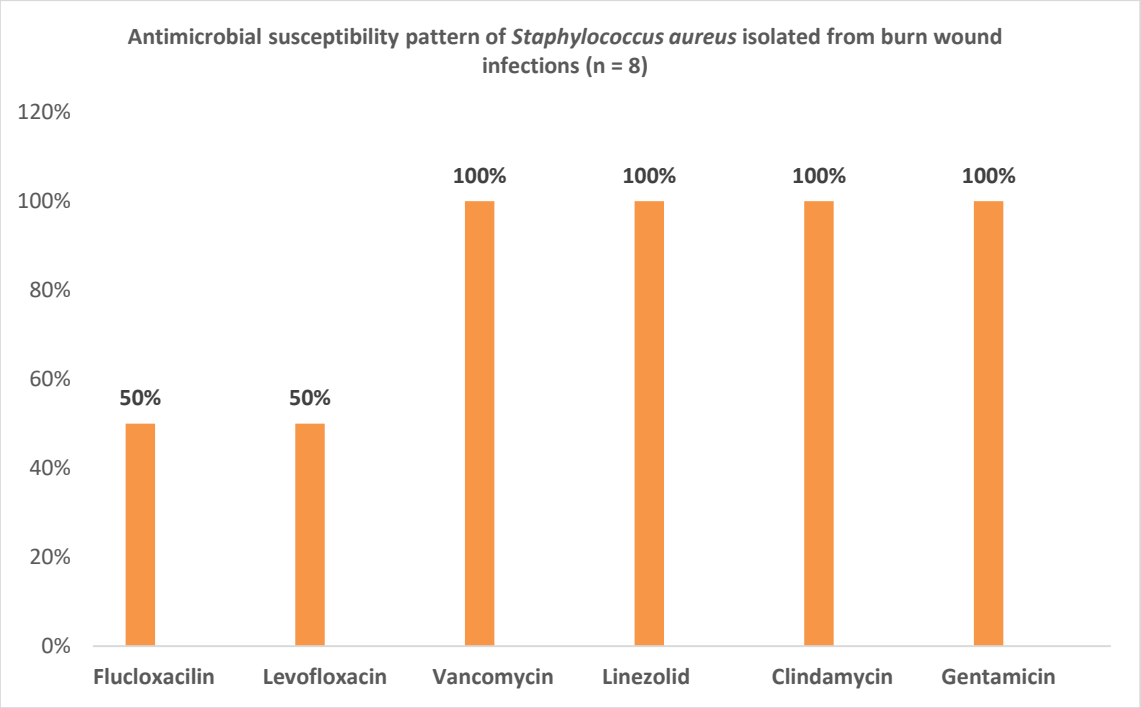

Figure-3: Antimicrobial susceptibility pattern of *Staphylococcus aureus* isolated from burn wound infections (n = 8)

Two isolates of *Candida albicans* were recovered, both of which were susceptible to fluconazole, amphotericin B, voriconazole and itraconazole.

Discussion

In this study, Gram-negative organisms accounted for 78.3% of all burn wound isolates, substantially exceeding the proportions of Gram-positive bacteria (17.4%) and fungi (4.3%). In a tertiary care study from India, Kumari *et al.* (2018) documented Gram-negative organisms in 74.6% of burn wound cultures, findings that closely parallel the results of the present investigation. Similarly, Tchakal-Mesbahi *et al.* (2021) reported that Gram-negative bacteria comprised 68.95% of burn wound isolates in a retrospective analysis, further corroborating the predominance of Gram-negative pathogens in burn infections.

Among the isolates recovered, Pseudomonas spp. constituted the largest proportion (47.8%), reaffirming its central role in burn wound infections. Comparable isolation rates have been reported in regional studies, with Sharma *et al.* (2019) identifying *Pseudomonas aeruginosa* in 45.2% of burn wound samples following major fire-related incidents. The predominance of this pathogen may be attributed to its ability to survive in moist environments, colonize damaged tissue and persist within healthcare settings, particularly during periods of increased patient load.

Staphylococcus aureus accounted for 17.4% of isolates in this study, with 50% identified as methicillin-resistant. This MRSA rate is comparable to reports from South Asia, where prevalence among S. aureus isolates ranges from 48.8% in Indian burn wound infections (Varaiya *et al*., 2010) to 52.8% in clinical samples from Bangladesh (Al-Mamun *et al.*, 2016). In contrast, surveillance data from the European Antimicrobial Resistance Surveillance Network (EARS-Net) indicate substantially lower MRSA rates, often below 15–20% in northern and western Europe (ECDC, 2023), likely reflecting stronger infection control and antimicrobial stewardship practices.

Klebsiella spp. accounted for 13.0% of isolates in this study, consistent with reports from regional burn centres. In a Pakistani burn unit, Klebsiella pneumoniae comprised 20.6% of burn wound isolates (Saaiq *et al*., 2015), underscoring its role as a common pathogen in burn infections across South Asia. In contrast, *Acinetobacter* spp. comprised 8.7% of isolates in the current study, which is lower than the 15–28% prevalence reported during endemic outbreaks in some burn units, possibly reflecting variations in environmental reservoirs and infection control practices (Peleg *et al*., 2012).

Antimicrobial susceptibility testing demonstrated substantial resistance among Pseudomonas spp., with low susceptibility rates to ciprofloxacin (27.3%), ceftazidime (18.2%) and meropenem (18.2%). Similar resistance trends have been reported in burn-related infections, where Ranjan *et al*. (2021) observed ciprofloxacin and carbapenem susceptibility rates of 22% and 20%, respectively. These findings highlight the escalating challenge of carbapenem-resistant *Pseudomonas* in burn units.

Conversely, piperacillin–tazobactam demonstrated relatively high activity (81.8%) against *Pseudomonas* isolates in the present study, exceeding susceptibility rates reported in several regional studies, which range from 55% to 70%. In the study by Kumari *et al*. (2018), susceptibility to piperacillin–tazobactam was reported at 63.4%, suggesting comparatively preserved effectiveness in the current setting. Colistin exhibited 100% in-vitro susceptibility, consistent with reports from European burn centers documenting activity exceeding 95%, although its clinical use remains constrained by concerns regarding nephrotoxicity (Falagas *et al*., 2010).

Among non-*Pseudomonas* Gram-negative bacilli, resistance to commonly used antimicrobial agents was pronounced, with ciprofloxacin, ceftazidime, aminoglycosides and piperacillin–

tazobactam each demonstrating susceptibility rates of only 14.3%. Similar resistance patterns have been described in burn units in Pakistan, where Saaiq *et al.* (2015) reported susceptibility below 20% for fluoroquinolones and aminoglycosides. In contrast, colistin and tigecycline remained effective against 85.7% of isolates, emphasizing their role as critical last-line options in multidrug-resistant burn wound infections.

Fungal pathogens were infrequently isolated, with Candida albicans accounting for only 4.3% of isolates. Both strains were susceptible to azoles and amphotericin B. This low frequency is consistent with previous reports indicating that fungi contribute to less than 10% of burn wound infections during the early post-burn period, with higher rates typically associated with prolonged hospitalization (Ballard *et al*., 2008).

Overall, the microbiological profile and resistance patterns observed in this study are consistent with those reported following disaster-related burn outbreaks in comparable healthcare environments.

Limitations

The sample size was small and the study duration was short due to the acute nature of the mass casualty event, which may limit generalizability. Inclusion of only culture-positive samples may have underestimated fastidious or non-culturable organisms and molecular characterization of resistance mechanisms was not performed. As the study was conducted in two centers following a single disaster, the findings may not be representative of burn wound infections in non-disaster or other healthcare settings.

Conclusion

Burn wound infections following a mass casualty aviation disaster in Bangladesh were predominantly caused by multidrug-resistant Gram-negative bacteria, particularly Pseudomonas spp., posing significant challenges to empirical therapy due to high resistance to fluoroquinolones and carbapenems, despite preserved susceptibility to piperacillin–tazobactam and colistin. These findings highlight the need for early microbiological surveillance, antimicrobial stewardship and strengthened infection control measures to optimize outcomes in mass casualty burn settings.

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