Original Article

Bacteriological Profile and Antimicrobial Susceptibility Patterns of Burn Wound Infections in a Tertiary Care Hospital of Bangladesh: A Retrospective Cross-Sectional Study

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Abstract:

Background: Burn wound infections significantly increase morbidity, length of hospital stay, and mortality. Bangladesh carries a disproportionately high burden due to limited burn care facilities and rising antimicrobial resistance (AMR). **Objective:** To identify the bacteriological profile and antimicrobial susceptibility patterns among burn wound infections in a tertiary care hospital in Bangladesh. **Methods:** This retrospective cross-sectional study included 104 burn patients from January 2023 to December 2023 in the Burn and Plastic Surgery Department at Comilla Medical College Hospital. Wound swabs were cultured using standard microbiological techniques, and antimicrobial susceptibility testing was performed according to CLSI guidelines. **Results:** Among 104 samples, 96.16% yielded microbial growth. *Pseudomonas* spp. was the predominant isolate (43.04%), followed by *Staphylococcus aureus* (19.62%) and *Klebsiella* spp. (10.76%), *E. coli* (8.86%),*Proteus* spp. (6.96%), *Acinetobacter* spp. (6.33%), and *Candida* spp. (4.43%). Colistin exhibited the highest activity against Gram-negative bacteria, while Methicillin Resistant *Staphylococcus Aureus* (MRSA) and Methicillin Sensitive *Staphylococcus Aureus* (MSSA) showed 100% susceptibility to vancomycin and linezolid. **Conclusion:** Gram-negative bacteria dominate burn wound infections in Bangladesh, with total body surface area (TBSA), flame burns, and inhalation injury significantly increasing the risk of resistance. Targeted infection control, early microbiological surveillance, and antibiotic stewardship are critical to reducing the burden of resistant organisms and improving clinical outcomes.

Key words: Burn wound infection, Bangladesh, antimicrobial resistance, *Pseudomonas aeruginosa*, MRSA, MSSA.

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Introduction:

Burn injuries are a major global public health concern, particularly in lower and middle-income countries, contributing substantially to morbidity, prolonged hospitalization, and mortality[1]. Loss of skin integrity exposes patients to microbial colonization, biofilm formation, and secondary infection[2-4]. In Bangladesh, these challenges are exacerbated by limited burn care infrastructure, overcrowded hospitals, and insufficient infection-control practices[5].

Epidemiological data from tertiary hospitals of Bangladesh reveal a predominance of gram-negative bacteria in burn wounds. At Dhaka Medical College Hospital, *Pseudomonas aeruginosa* accounted for 46.4% of isolates, followed by *Proteus* spp. (21.4%) and *Klebsiella* spp. (19.6%)[6]. A Khulna Medical College study reported that 42% of burn patients developed nosocomial infections, including 33% wound infections and 9% septicemia[7]. A cross-sectional study in the National Institute of Burn and Plastic Surgery, Dhaka, found MDR *P. aeruginosa* is the most frequent isolates[8]. These studies highlight the shift from gram-positive to gram-negative dominance in burn wound infections in Bangladesh.

AMR in burn wounds is increasingly alarming. Local surveillance has documented high prevalence of ESBL-producing Enterobacteriaceae[9], carbapenem-resistant *Pseudomonas*[10], and plasmid-mediated colistin resistance[11]. Genomic analyses from the National Institute of Burn and Plastic Surgery (NIBPS) revealed the presence of widespread

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β-lactamase genes, integrons, and biofilm-associated gene clusters among MDR *P. aeruginosa* isolates[12]. These findings indicate the circulation of high-risk epidemic clones with extensive drug-resistance in most of the burn units of Bangladesh[13].

Globally, burn wounds are prone to colonization due to tissue devitalization, protein-rich exudates, immune impairment, and biofilm formation[4,14]. Early colonizers are usually gram-positive organisms such as *S. aureus*, but gram-negative bacteria like *Pseudomonas*, *Klebsiella*, *E. coli*, and *Acinetobacter* spp. increasingly dominate with prolonged hospitalization[15]. Emergence of MDR and XDR strains complicates management, and plasmid-mediated resistance genes threaten last-line therapy[11]. Therefore, continuous local surveillance of microbial spectrum and antimicrobial susceptibility is critical for guiding empirical therapy and informing infection prevention strategies in Bangladesh.

Methods:

Study design:

A retrospective cross-sectional study was conducted in the Department of Microbiology and Burn and Plastic Surgery Unit at Comilla Medical College and Hospital. Samples were collected from the Burn and Plastic Surgery Unit at Comilla Medical College and Hospital. Culture sensitivity tests were done at the Department of Microbiology of Comilla Medical College and some private diagnostic centers, Cumilla.

Study period: All burn wound samples over one year, from January 2023 to December 2023, were included in this study.

Sample size:

A total of 104 clinically diagnosed burn wound infection cases were included.

Inclusion criteria:

- Burn patients showing clinical signs of wound infection
- Adequate wound swab submitted for culture

Exclusion criteria:

- Contaminated samples
- Prior antibiotic use >72 hours

Sample collection:

Wound swabs were taken from deep viable tissue after cleansing with sterile saline.

Laboratory Processing

Specimens from burn wound infections were collected using sterile swabs after proper wound cleaning with normal saline to avoid contamination. Samples were immediately transported to the microbiology laboratory under appropriate conditions to ensure viability of the organisms.

Culture and Isolation

All samples were inoculated onto Blood Agar (BA) and MacConkey Agar (MAC) plates and incubated at 37°C for 24–48 hours under aerobic conditions. Blood agar was used to support the growth of fastidious organisms and to observe hemolytic patterns, while MacConkey agar facilitated the selective growth of Gram-negative bacteria and differentiation based on lactose fermentation.

Identification of Isolates

Bacterial isolates were initially characterized by colony morphology, Gram staining, and microscopic examination. Definitive identification was carried out using standard biochemical tests, including catalase, coagulase, oxidase, indole production, citrate utilization, urease test, triple sugar iron (TSI) test, motility, and others as appropriate, following conventional microbiological protocols.

Antimicrobial Susceptibility Testing (AST)

Antimicrobial susceptibility of all confirmed isolates was performed using the Kirby–Bauer disk diffusion method, adhering strictly to Clinical and Laboratory Standards Institute (CLSI) guidelines. Briefly, bacterial suspensions equivalent to 0.5 McFarland standard were prepared and inoculated uniformly on Mueller–Hinton agar plates. Antibiotic-impregnated disks were placed on the surface of the inoculated plates and incubated at 37°C for 16–18 hours. Zones of inhibition were measured in millimeters and interpreted as susceptible, intermediate, or resistant according to CLSI breakpoints**.**

Results:

This retrospective cross-sectional study involves 104 burn patients from January 2023 to December 2023 at Comilla Medical College Hospital.

Table-I: Demographic and burn injury characteristics of the study population (n=104)

Variable	Number (n)	Percentage (%)
Sex		
Male	63	60.6
Female	41	39.4
Source of burn		
Thermal	99	94.9
Chemical	4	2.8
Electrical	1	1.6
Total Burn Surface Area		
Minor (<10%)	64	63.3
Moderate (10–20 %)	32	29.6
Severe (>20 %)	8	7.2

Table I shows the majority were male (60.6%), while females accounted for 39.4% of cases. Thermal burns were the most common type of injury, comprising 94.9% of all cases, followed by chemical burns (2.8%) and electrical burns (1.6%).

Regarding the extent of burn injury, most patients (63.3%) sustained minor burns involving less than 10% of the total body surface area (TBSA). Moderate burns (10–20% TBSA) were observed in 29.6% of the cases, while severe burns involving more than 20% TBSA were reported in 7.2% of the study population. These findings indicate that the majority of patients presented with minor to moderate burn injuries.

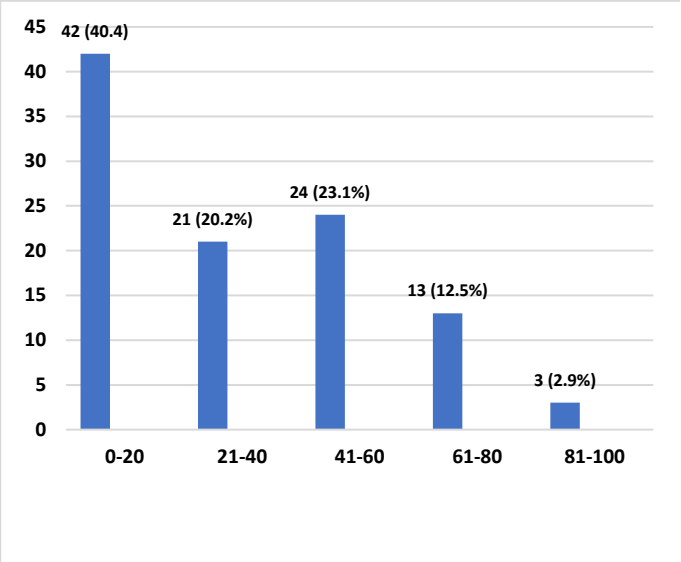

Figure-1: Distribution of study population by age group

The study population predominantly comprised younger patients, with 40.4% aged 0–20 years. Patients aged 41–60 years constituted 23.1%, followed by 21–40 years (20.2%) and 61–80 years (12.5%). Individuals aged 81–100 years were the least represented (2.9%). (Figure 1)

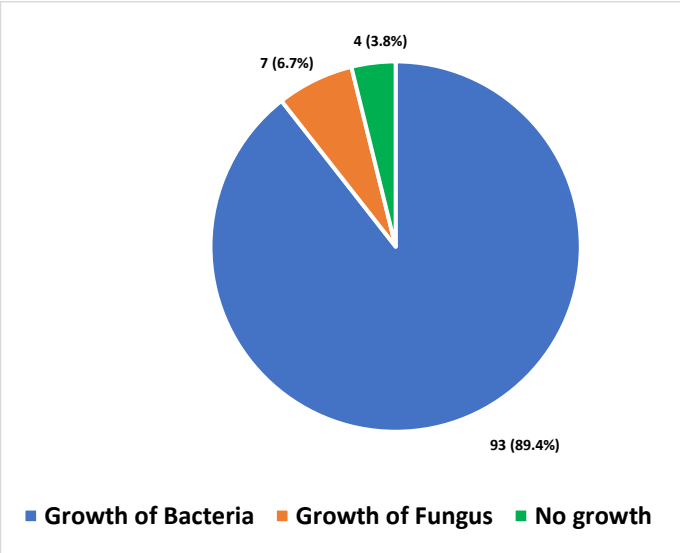

Figure-2: Results of wound swab culture among the study population (n=104)

Figure 2 shows that, out of all samples cultured, the majority showed microbial growth, while a smaller proportion yielded no growth. Specifically, growth was observed in 100 (96.16%) samples, whereas no growth was noted in 4 (3.85%) samples.

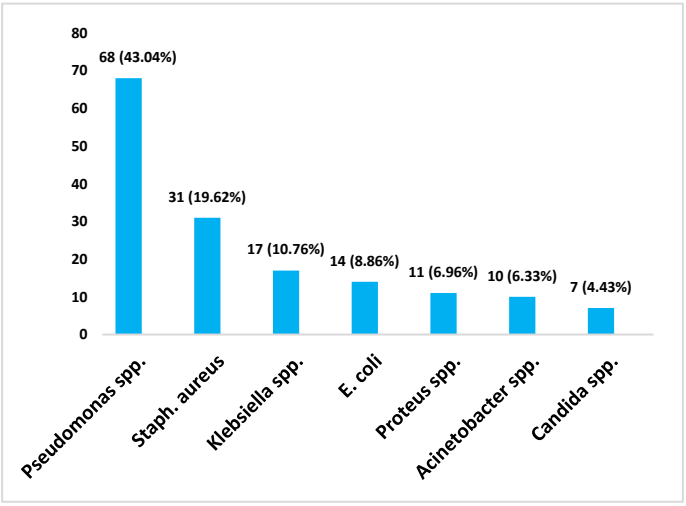

Figure 3: Distribution of organisms among the culture-positive cases

Note: The total number of organisms exceeded the number of samples because co-infections, resulting from the colonization of multiple species, have been detected.

Among the culture-positive cases, *Pseudomonas* spp. was the most frequently isolated organism, accounting for 68(43.04%) of all growth samples. *Staphylococcus aureus* was the second most common isolate, 31(19.62%), followed by *Klebsiella* spp. 17(10.76%), *Escherichia coli* 14(8.86%), and *Proteus* spp. 11(6.96%). *Acinetobacter* spp. and *Candida* spp. were isolated in 10(6.33%) and 7(4.43%) of the samples, respectively. (Figure 3)

Overall, *Pseudomonas* spp. and *Staphylococcus aureus* together constituted more than 60% of all isolates, indicating their predominance in the studied population.

Table-II: Antimicrobial susceptibility patterns of isolated pathogens

Antimicrobial agents	*Pseudomonas* spp. (n=68)	*Klebsiella* spp. (n=17)	*E. coli* (n=14)	*Proteus* spp. (n=11)	*Acinetobacter* spp. (n=10)	MRSA (n=21)	MSSA (n=10)
Amikacin	24.51%	11.77%	14.29%	18.19%	10.00%	0%	100%
Amoxicillin	-	0%	0%	0%	0%	0%	0%
Amoxicillin/ clavulanic acid	-	5.89%	7.13%	0%	10.00%	0%	0%
Aztreonam	-	5.89%	7.13%	9.09%	20.00%	-	-
Ceftriaxone	-	11.77%	14.29%	9.09%	30.00%	-	-
Ceftazidime	10.20%	11.77%	14.29%	18.19%	20.00%	-	-
Colistin	96.21%	94.12%	100%	0%	90.00%	-	-
Cloxacillin	-	-	-	-	-	0%	100%
Cefotaxime	-	5.89%	7.13%	9.09%	10.00%	0%	0%
Cefoxitin	-	-	-	-	-	0%	100%
Ciprofloxacin	11.20%	5.89%	0%	0%	10.00%	0%	0%
Co-trimoxazole	-	0%	7.13%	0%	20.00%	0%	0%
Doripenem	36.47%	41.17%	57.15%	27.28%	30.00%	-	-
Gentamicin	13.37%	0%	7.13%	0%	10.00%	0%	50.00%
Imipenem	31.34%	47.05%	64.29%	45.46%	40.00%	-	-
Levofloxacin	8.01%	-	-	-	-	-	-
Linezolid	-	-	-	-	-	100%	100%
Meropenem	42.24%	58.83%	71.43%	81.82%	60.00%	-	-

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Piperacillin/ Tazobactam	**58.83%**	**82.36%**	**85.72%**	**90.91%**	**80.00%**	-	-
Tigecycline	-	**88.23%**	**100%**	-	**90.00%**	-	-
Vancomycin	-	-	-	-	-	**100%**	**100%**

Table II shows Antimicrobial susceptibility patterns varied markedly among the isolated pathogens. *Pseudomonas spp.* showed the highest sensitivity to colistin (96.21%), and piperacillin–tazobactam (58.83%), while susceptibility to most other agents was low. *Klebsiella spp.* demonstrated high susceptibility to tigecycline (88.23%) and colistin (94.12%), with moderate sensitivity to carbapenems. *E. coli* isolates were fully susceptible to tigecycline and colistin (100%), and showed good sensitivity to meropenem (71.43%) and imipenem (64.29%).

Proteus spp. exhibited the highest susceptibility to meropenem (81.82%) and piperacillin–tazobactam (90.91%), with poor response to most other antibiotics. *Acinetobacter spp.* showed preserved activity only to tigecycline (90%) and colistin (90%), while carbapenem susceptibility remained limited.

Among Gram-positive pathogens, MRSA showed 100% susceptibility to vancomycin and linezolid, while MSSA was fully susceptible to cloxacillin, cefoxitin, vancomycin, and linezolid.

Table-III: Multivariable Logistic Regression Analysis for Predictors of MDR Infection

Predictor Variables	Adjusted β	Std. Error	Adjusted Odds Ratio (aOR)	95% Confidence Interval	p-value
TBSA Category (Minor → Moderate → Severe)	0.94	0.29	2.56	1.45 – 4.51	0.001
Age	0.015	0.009	1.02	0.99 – 1.04	0.080
Sex	0.41	0.33	1.50	0.79 – 2.85	0.210
Cause of Burn	0.78	0.34	2.19	1.11 – 4.33	0.023
Inhalation Injury	1.12	0.42	3.07	1.35 – 6.99	0.007
Hospital Stay	0.028	0.017	1.03	0.99 – 1.06	0.100

Table III shows presents the multivariable logistic regression analysis identifying independent predictors of drug-resistant infections among burn patients. After controlling for age, sex, cause of burn, inhalation injury, and hospital stay duration, TBSA percentage remained a significant predictor (aOR 2.56; p=0.001). Inhalation injury (aOR 3.07; p=0.007) and flame burns (aOR 2.19; p=0.023) were also independently associated with MDR infections.

Discussion:

In this study, we observed a high culture positivity rate (96.16%) and predominance of Gram-negative pathogens, consistent with prior Bangladeshi and international studies [12,15,16]. *Pseudomonas aeruginosa* was the most frequent isolate (43.04%), followed by *S. aureus* (19.62%), and *Klebsiella* spp. (10.76%), and *E. coli* (8.86%). These findings corroborate earlier studies in Dhaka and Khulna, where *Pseudomonas* spp. consistently dominate burn wound infections[6-8,12]. The predominance of *Pseudomonas*, *Klebsiella*, and *Acinetobacter* spp. aligns with regional patterns in South Asia[17,18]. *P. aeruginosa* harbors multiple virulence factors, biofilms, elastases, exotoxin A, quorum-sensing molecules, and resistance mechanisms, enabling persistence in hospital environments and resistance to disinfectants[19]. Genomic data from NIBPS demonstrated widespread NDM-1, VIM-2 and OXA-type carbapenemases, and integrons, confirming the presence of MDR and XDR clones in burn units[12,13]. These features limit treatment options and increase the risk of outbreaks.

Our study demonstrated that colistin, tigecycline, and carbapenems remain effective against the majority of gram-negative isolates. This is consistent with findings from Fatema et al., where imipenem and colistin were effective against MDR *Pseudomonas* and *Klebsiella* isolates in Dhaka burn units[14]. However, genomic and phenotypic data highlight the emergence of resistance mechanisms that threaten the long-term efficacy of these agents[12,16]. Globally, colistin resistance via mcr genes is increasingly reported, especially in South Asia[11]. The high usage of colistin in human and veterinary medicine in Bangladesh further accentuates this risk.

Tigecycline exhibited good activity against *Klebsiella*, *E. coli*, and *Acinetobacter*, consistent with previous regional studies[6,14]. However, its low serum concentrations limit systemic use, necessitating careful consideration for deep tissue infections. Carbapenems retained moderate activity; however,the spread of carbapenem-resistant Enterobacterales and NDM-producing organisms in Bangladesh has been documented[9,10]. Resistance mechanisms include AmpC overproduction, loss of OprD porin, and β-lactamase genes[16], which were reported in previous comparative studies from Chittagong and Dhaka[8,12].

MRSA and MSSA isolates in our study were fully susceptible to vancomycin and linezolid, in agreement with prior studies in Bangladesh[7,14]. Comparable microbial profiles were observed in a recent investigation conducted at Khulna Medical College Hospital, where both *Staphylococcus aureus* and *Pseudomonas* spp. were identified as major causative organisms, suggesting the need for empirical regimens that cover both Gram-positive and Gram-negative pathogens[7]. Evidence from Dhaka also aligns with our findings, particularly regarding the high rate of MDR Pseudomonas, which mirrors the resistance burden identified in the current analysis[8]. Broader regional studies from Pakistan and India further demonstrate that burn units

across South Asia consistently face Gram-negative predominance, especially *Pseudomonas, Acinetobacter*, and *Klebsiella* species, along with alarming MDR and XDR profiles, reinforcing the regional pattern observed here[17,18]. These comparative studies not only contextualize our microbiological findings but also underscore the growing threat of resistant pathogens in burn care settings.

The clinical implications of these findings are substantial. Empirical therapy in burn units must prioritize coverage against both *Pseudomonas* spp. and MRSA, and treatment decisions should be tailored based on updated local antibiograms to ensure optimal outcomes[6,14]. Routine microbiological surveillance, incorporating timely culture and susceptibility testing, is essential for detecting shifts in pathogen prevalence and resistance patterns. Strong infection-control measures, including rigorous hand hygiene compliance, patient cohorting, environmental decontamination, and continuous staff training, are crucial to limiting the spread of MDR and XDR organisms[12]. Furthermore, incorporating molecular monitoring tools such as PCR and whole-genome sequencing (WGS) can help detect high-risk clones and resistance genes, allowing clinicians and public health teams to intervene proactively.[13] These strategies collectively play a central role in mitigating morbidity and mortality in burn patients while improving antimicrobial stewardship.

The extent of burn injury or TBSA, flame burns, and inhalation injury were identified as significant independent predictors of resistant infections. While colistin, tigecycline, and carbapenems remain effective against most isolates, the rising prevalence of resistance highlights the urgent need for routine culture-based therapy. Similar observations have been reported in international and regional studies. Laupland et al (2007). found that patients with larger burns had significantly higher rates of MDR Acinetobacter baumannii infections, suggesting that increased tissue necrosis and prolonged hospitalization favor resistant pathogen colonization[19]. Waibel et al (2018). reported that higher TBSA and deeper burns were independent predictors of MDR bacterial infections in a tertiary burn center, highlighting the role of wound severity in infection dynamics[20]. Hettiaratchy and Papini also emphasized that extensive burns compromise the skin barrier and immune defense, facilitating colonization by resistant organisms[21]. In Bangladesh, Rashid et al (2019). observed that MDR Pseudomonas and *Acinetobacter* spp. were disproportionately isolated from patients with large or flame-related burns, supporting our findings[22].

This study has certain limitations that should be acknowledged. As a single-center investigation with a cross-sectional design, the findings may not fully represent the diversity of microbiological profiles across different burn units in Bangladesh. Additionally, the absence of molecular characterization restricts deeper insight into clonal relatedness, transmission pathways, and specific resistance determinants. Future studies should therefore incorporate molecular epidemiology, including genotyping and resistance gene profiling, to strengthen surveillance efforts. Longitudinal, multi-center research is also needed to capture temporal trends in antimicrobial resistance and to generate nationally representative data. Such initiatives will significantly contribute to improved infection control, optimized antimicrobial use, and enhancement of burn care outcomes across Bangladesh.

Conclusion:

Gram-negative bacteria, particularly *Pseudomonas* spp., remain the predominant pathogens in burn wound infections in tertiary care settings of Bangladesh. Key independent risk factors for drug-resistant infections identified in this study include higher burn percentage, flame burns, and inhalation injury. These factors significantly increase the likelihood of resistant bacteria colonization and complicate clinical management. Although colistin, tigecycline and carbapenems retain activity against most of these isolates, the rising prevalence of resistance underscores the urgent need for routine culture-based therapy, strict infection control, and robust antibiotic stewardship. Early recognition of high-risk patients and implementation of targeted preventive strategies are essential to reduce morbidity, hospital stay, and the spread of resistant pathogens in burn units.

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