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Wound culture patterns and clinical outcomes in burn patients; a six-month cross-sectional study at Taleghani hospital, Ahvaz

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Abstract

Introduction: Burn injuries represent a significant global health burden, with infection-related complications being a leading cause of morbidity and mortality in affected patients.
Objectives: This study aimed to characterize wound culture patterns, bacterial isolate distribution, and mortality-associated factors among burn patients admitted to Taleghani hospital in Ahvaz, Iran.
Materials and Methods: This retrospective cross-sectional study analyzed burn patients referred to Taleghani hospital in Ahvaz, Iran. Data were collected retrospectively from hospital clinical documents, focusing on demographic characteristics, clinical parameters, and microbiological findings from wound cultures.
Results: The study identified *Pseudomonas* species, particularly *Pseudomonas aeruginosa*, as the most prevalent pathogens in burn patients, alongside *Klebsiella pneumoniae*, *Escherichia coli*, and *Staphylococcus aureus* strains (methicillin-resistant *Staphylococcus aureus* [MRSA], methicillin-susceptible *Staphylococcus aureus* [MSSA], vancomycin-resistant *Staphylococcus aureus* [VRSA]). Polymicrobial infections involving *P. aeruginosa* with *E. coli* or *K. pneumoniae* were common, reflecting complex wound ecologies. Mortality analysis revealed a prevalence of 54.5% of deaths and significant associations with male gender, extensive burn surface area, and higher burn grades, while age showed no prognostic relevance. Pathogen-specific outcomes highlighted exclusive fatality linkages for *Acinetobacter* (particularly co-infections with Klebsiella or MRSA) and polymicrobial *P. aeruginosa* infections, whereas MSSA and *Proteus* correlated strongly with recovery.
Conclusion: This study highlights the critical relationship between microbial ecology, antimicrobial resistance, and clinical outcomes in burn care, identifying *P. aeruginosa* as the predominant pathogen, often coexisting with *K. pneumoniae* or *E. coli* in fatal polymicrobial infections. Mortality risks correlated strongly with male gender, extensive burn surface area, and higher burn grades, but not age. *Acinetobacter* species (particularly in co-infections with *Klebsiella* or MRSA) and polymicrobial *Pseudomonas aeruginosa* infections were exclusively linked to mortality, contrasting with favorable outcomes for MSSA and *Proteus* monoinfections.

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Introduction

Burn injuries represent a significant global health burden, with an estimated 180 000 deaths annually attributed to burn-related infections, predominantly occurring in low- and middle-income countries (1). Thermal burns produce extensive tissue damage that eliminates the protective role of the skin, creating an ideal environment for microbial colonization and proliferation (2). The disruption of the skin barrier, combined with the immune dysfunction that accompanies the inflammatory response to major burns, renders patients particularly susceptible to overwhelming infection (3,4). Infection has emerged as the most common complication and primary cause of death in burn patients, with the extensive tissue damage from severe burns triggering an overactive immune response that can progress to sepsis, where bacterial infection spreads systemically rather than remaining localized (2,3).

The bacteriological profile of burn wound infections exhibits distinct patterns that vary by geographic region, time since injury, and institutional factors. *Pseudomonas aeruginosa* and *Staphylococcus aureus* consistently emerge as the predominant pathogens in burn wound cultures globally, with studies demonstrating bacterial culture positivity rates of approximately 67% in burn wound swabs (3,5). The prevalence of specific organisms shows regional variation, with some studies identifying *P. aeruginosa* as the leading pathogen, followed by *S. aureus*, *Acinetobacter* species, and *Klebsiella*

Key point

In a cross-sectional study, we found that *Pseudomonas aeruginosa* is the most frequently isolated pathogen in burn patients' Wound culture. Fatal outcomes were strongly associated with polymicrobial infections involving *P. aeruginosa* paired with *Klebsiella pneumoniae* or *Escherichia coli*, alongside *Acinetobacter* co-infections with *Klebsiella* or methicillin-resistant *Staphylococcus aureus* (MRSA). Mortality predictors included male gender, extensive burn surface area, and higher burn grades, whereas age showed no significant impact. Conversely, infections caused by methicillin-susceptible *Staphylococcus aureus* (MSSA) or Proteus species correlated with recovery.

species (5). The antimicrobial susceptibility patterns of these isolates reveal concerning trends toward multidrug resistance, with enhanced resistance to common antimicrobial agents presenting ongoing challenges in burn wound management (6,7). Gram-negative bacteria predominate in burn wound infections, comprising up to 93.75% of isolates in some populations, with maximum susceptibility observed to carbapenems such as imipenem among gram-negative organisms (8).

The mortality outcomes in burn patients demonstrate a clear association with infectious complications, with infected burn patients exhibiting significantly higher mortality rates compared to non-infected individuals. Previous meta-analyses have revealed that the overall mortality rate is substantially elevated in infected burn patients, with odds ratios indicating a markedly increased risk of death when infection is present (9). Multiple factors contribute to increased mortality risk, including advanced age, extensive total body surface area involvement, delays in burn wound excision, presence of inhalation injury, and the development of multidrug-resistant infections (3,10,11). The mortality rates in European burn centers typically range between 1.4% and 18%, with organ failure and sepsis identified as the most frequently reported causes of death. In contrast, early mortality within 48 hours is primarily attributed to burn shock and inhalation injury (10). Despite improvements in burn care over the past decade, continued efforts in timely management and infection prevention remain essential for optimizing patient outcomes (3).

Objectives

The primary objective of this retrospective cross-sectional study was to analyze wound culture patterns and the distribution of bacterial isolates identified from wound specimens among burn patients referred to Taleghani hospital in Ahvaz, Iran, between September 23, 2023, and March 19, 2024. Additionally, the study aimed to evaluate the prevalence of burn-related mortality and to identify demographic and clinical factors associated with fatal outcomes, with the overarching goal of enhancing the understanding of both microbiological and clinical aspects of burn injury management in this patient population.

Materials and Methods

Study design and participants

This retrospective cross-sectional study was conducted on burn patients who were referred to Taleghani hospital in Ahvaz, Iran, over a six-month period spanning from September 23, 2023, to March 19, 2024. The study aimed to analyze relevant clinical and microbiological patterns within this patient population by systematically reviewing medical records and pertinent laboratory data collected during the specified timeframe.

Inclusion and exclusion criteria

Inclusion criteria for this study encompass all patients presenting with burn injuries who were referred to Taleghani hospital in Ahvaz, Iran, during the designated study period from September 23, 2023, to March 19, 2024; no exclusions based on age, gender, or severity of burns were applied at this initial stage of participant selection. However, patients with incomplete data were excluded.

Data collection

Data for this study were collected retrospectively from clinical documents archived at Taleghani hospital in Ahvaz. Key variables extracted included patients' demographic characteristics, specifically age and gender, as well as clinical parameters such as burn extent and severity, mortality outcomes, wound culture patterns, and the distribution of bacterial isolates identified from wound culture specimens.

Outcomes

The primary outcomes of this study were to assess the patterns of wound cultures and to determine the distribution of bacterial isolates identified from wound culture specimens among burn patients. Secondary outcomes included evaluating the prevalence of mortality associated with burn injuries and identifying key demographic and clinical factors that may contribute to these fatal outcomes, thereby providing a comprehensive understanding of both microbiological and clinical aspects of burn management.

Data analysis

Statistical analyses were performed using IBM SPSS (Statistical Package for Social Science [Version 27, IBM Corp, USA]). Descriptive statistics included frequencies and percentages for categorical variables (gender, burn extent, severity, mortality, wound culture pattern) and mean values with standard deviations (SD) for quantitative variables (age). The Kolmogorov-Smirnov test confirmed normal distribution of age data, validating parametric assumptions. Categorical variables were compared between survivors and non-survivor patients using the chi-square test and Fisher's exact test substitution for cells containing fewer than five expected observations. Age differences across mortality outcomes (recovery/death)

were assessed via the independent samples T-test. All analysis maintained a significance threshold of α = 0.05 for two-tailed hypotheses.

Results

The study population revealed that 319 (67.1% male and 32.9% female) burn patients, with a mean age of 32.73 + 9.55 years, were included. Burn extent analysis revealed that the majority of cases involved extensive burns (>60%), while smaller proportions presented with moderate or limited burn involvement. Burn severity was primarily characterized by third-degree injuries, with minimal cases classified as fourth-degree. Mortality outcomes demonstrated a prevalence of 54.5% of deaths (Table 1).

Wound culture analysis revealed a diverse array of bacterial pathogens isolated from burn patients, with *Pseudomonas* species, including *P. aeruginosa*, emerging as the most predominant isolates. *Klebsiella pneumoniae* and *Escherichia coli* were also frequently identified, alongside *S. aureus* strains encompassing methicillin-resistant (MRSA), methicillin-susceptible (MSSA), and vancomycin-resistant (VRSA) variants. *Acinetobacter* species, both independently and in co-infections with *Klebsiella*, were documented, as were Proteus infections. Notably, polymicrobial infections involving *P. aeruginosa* paired with *E. coli* or *K. pneumoniae* were observed, reflecting complex microbial interactions in burn wounds (Table 2).

Statistical analysis revealed significant associations between mortality outcomes and key demographic/clinical variables. Gender demonstrated a statistically significant relationship with mortality, with male patients exhibiting higher fatality rates compared to females. Burn extent (% total body surface area) showed a strong correlation with outcomes, as patients with more extensive burns had markedly elevated mortality risks. Similarly, burn severity (grade) was significantly linked to prognosis, with higher-degree burns (3 and 4) notably associated with fatal outcomes. In contrast, age did not reach statistical significance as a differentiating factor between survivors and non-survivors. These findings underscore the critical role of burn severity and extent in predicting mortality, while highlighting gender-specific disparities in clinical trajectories (Table 3).

Results revealed significant associations between specific bacterial pathogens and mortality outcomes. Infections involving *Acinetobacter* species, particularly when co-occurring with *Klebsiella* or MRSA, were exclusively linked to fatal outcomes, demonstrating a strong correlation with mortality. Similarly, polymicrobial infections combining *P. aeruginosa* with *E. coli* or *K. pneumoniae* were uniformly fatal. In contrast, MSSA and monomicrobial *S. aureus* infections were exclusively associated with recovery. While *P. aeruginosa* alone showed no mortality bias, *Pseudomonas* species infections were disproportionately linked to survival. Proteus infections also demonstrated a favorable prognosis, whereas *E. coli* and *K. pneumoniae* exhibited mixed outcomes (Table 4).

Discussion

Our research revealed that in the wound culture patterns of burn patients, *Pseudomonas* species, especially *P. aeruginosa*, were the predominant pathogens found in burn patients. Other frequently isolated bacteria included Klebsiella pneumoniae, *E. coli*, and various strains of *S. aureus*, such as MRSA, MSSA, and VRSA. Mixed infections involving *P. aeruginosa* together with *E. coli* or *K. pneumoniae* were commonly observed, highlighting the complexity of the wound microbiome. These findings align with previous studies. Multiple investigations have corroborated *P. aeruginosa* as the leading pathogen, with different prevalence rates across different geographical regions (5,12,13). A comprehensive study by Rehan et al from Pakistan reported *P. aeruginosa* in 68.60% of cases, followed by Klebsiella pneumoniae (32.55%) and MRSA (16.27%) (12), while another large-scale investigation by Azam et al documented *P. aeruginosa* positivity in 58.9%

Table 1. Frequency of demographic characteristics and clinical data in burn patients

Demographic/clinical data		Frequency	Percent
Gender	Female	105	32.9
	Male	214	67.1
Burn extent (%)	< 20	14	4.4
	20-40	76	23.8
	40-60	6	1.9
	> 60	223	69.9
Burn severity (grade)	< 3	63	19.7
	3	244	76.5
	4	12	3.8
Mortality outcomes	Recovery	145	45.5
	Death	174	54.5
Quantitative variables		**Mean**	**SD**
Age (year)		32.73	9.55

Table 2. Wound culture pattern and bacterial distribution in burn patients

Bacterial type	Frequency	Percent
Acinetobacter + Klebsiella	7	2.2
Acinetobacter	13	4.1
E. coli	17	5.3
Klebsiella pneumoniae	44	13.8
MRSA + Acinetobacter	9	2.8
MRSA	15	4.7
MSSA	10	3.1
Proteus	13	4.1
Pseudomonas aeruginosa	52	16.3
Pseudomonas aeruginosa + E. coli	14	4.4
Pseudomonas aeruginosa + Klebsiella	14	4.4
Pseudomonas species	95	29.8
Staphylococcus aureus	14	4.4
VRSA	2	.6

MRSA: Methicillin-resistant *Staphylococcus aureus*; MSSA: Methicillin-susceptible *Staphylococcus aureus*, VRSA: Vancomycin-resistant *Staphylococcus aureus*.

Table 3. Frequency distribution of demographic characteristics and clinical data based on mortality outcomes among burn patients

Demographic/clinical data		Mortality Outcomes		*P* value
		Recovery N (%) (n = 145)	Death N (%) (n = 174)	
Gender	Female (n = 105)	72 (68.6)	33 (31.4)	<0.001*
	Male (n = 214)	73 (34.1)	141 (65.9)	
Burn percent (%)	<20 (n = 14)	14 (100)	0 (0)	<0.001**
	20–40 (n = 76)	76 (100)	0 (0)	
	40–60 (n = 6)	6 (100)	0 (0)	
	>60 (n = 223)	49 (22)	174 (78)	
Burn severity (grade)	<3 (n = 63)	63 (100)	0 (0)	<0.001*
	3 (n = 244)	82 (33.6)	162 (66.4)	
	4 (n = 12)	0 (0)	12 (100)	
Quantitative variables		**Mean (SD)**	**Mean (SD)**	***P* value**
Age (year)		33.62 (13.12)	31.99 (4.82)	0.130***

N, Number; SD, Standard deviation; *Chi-square, **Fisher's Exact test, ***Independent T test.

Table 4. Frequency distribution of wound culture pattern and bacterial type based on mortality outcomes among burn patients

Wound culture pattern		Mortality Outcomes		*P* value
		Recovery N (%) (n = 145)	Death N (%) (n = 174)	
Type of bacteria	*Acinetobacter* + *Klebsiella* (n = 7)	0 (0)	7 (100)	<0.001*
	Acinetobacter (n = 13)	0 (0)	13 (100)	
	E. coli (n = 17)	5 (29.4)	12 (70.6)	
	Klebsiella pneumonia (n = 44)	15 (34.1)	29 (69.9)	
	MRSA + *Acinetobacter* (n = 9)	0 (0)	9 (100)	
	MRSA (n = 15)	0 (0)	15 (100)	
	MSSA (n = 10)	10 (100)	0 (0)	
	Proteus (n = 13)	10 (76.9)	3 (23.1)	
	Pseudomonas aeruginosa (n = 52)	26 (50)	26 (50)	
	Pseudomonas aeruginosa + *E. coli* (n = 14)	0 (0)	14(100)	
	Pseudomonas aeruginosa + *Klebsiella* (n = 14)	0 (0)	14(100)	
	Pseudomonas species (n = 95)	64 (67.4)	31 (32.6)	
	Staphylococcus aureus (n = 14)	14 (100)	0 (0)	
	VRSA (n = 2)	1 (50)	1 (50)	

MRSA: Methicillin-resistant *Staphylococcus aureus*; MSSA: Methicillin-susceptible *Staphylococcus aureus*, VRSA: Vancomycin-resistant *Staphylococcus aureus;* N, Number; SD, Standard deviation.
*Fisher's Exact test

of 720 burn wound samples (14). Similarly, studies by Shahi et al from Nepal (15) and Rathod et al (16) from India have confirmed *P. aeruginosa* as the predominant isolate at 55% and 34.93%, respectively, with consistent secondary patterns involving *S. aureus*, *Klebsiella* species, and *E. coli.* The occurrence of mixed infections, particularly those involving *P. aeruginosa* with other gram-negative organisms, has been consistently documented across multiple studies, with one investigation specifically noting *Klebsiella-Pseudomonas* combinations in 7.96% of cases (13). Interestingly, while most studies demonstrate *P. aeruginosa* predominance, regional variations exist, as evidenced by a Pakistani study where *S. aureus* was the most common isolate (46%) compared to *P. aeruginosa* (7%) (17), suggesting that local epidemiological factors and infection control practices may influence bacterial distribution patterns. The consistent identification of multidrug-resistant organisms, including MRSA-producing gram-negative bacteria across these studies (16), underscores the complexity of the burn wound microbiome and the critical need for targeted antimicrobial strategies. These collective findings confirm that burn wound infections represent a polymicrobial challenge dominated by opportunistic pathogens, with *P. aeruginosa* serving as the primary colonizer due to its adaptability to the compromised burn wound environment, while mixed infections reflect the disrupted cutaneous barrier and altered local immunity characteristic of severe burn injuries.

Our study also demonstrated that mortality analysis indicated a death rate of 54.5% in burn patients, with significant correlations identified for male gender, larger burn surface areas, and more severe burn grades, whereas age did not exhibit any prognostic significance. Our study's reported mortality rate of 54.5% substantially exceeds the mortality rates documented in recent systematic reviews and clinical studies, which typically range from 11.8% to 22% across diverse populations and burn severity classifications (18,19). While our findings regarding the

prognostic significance of male gender align with several contemporary investigations that have identified male sex as an independent risk factor for burn mortality (20), this association remains inconsistent across the literature, with some studies reporting mixed gender-related outcomes depending on regional and cultural factors. The identification of larger burn surface areas and more severe burn grades as significant mortality predictors strongly corroborates extensive evidence from multiple studies, where total body surface area and burn depth have consistently emerged as the most robust independent predictors of death across different populations and healthcare settings (18,21,22). However, our finding that age did not exhibit prognostic significance diverges markedly from the overwhelming consensus in burn literature, where advanced age has been repeatedly validated as one of the most reliable mortality predictors, with multiple large-scale studies demonstrating significant associations between increasing age and burn mortality through multivariate analyses (18,21-23). This discrepancy may reflect differences in patient demographics, sample size, burn severity distribution, or analytical methodologies, as meta-analyses of burn mortality prediction models have consistently incorporated age as a fundamental component of validated scoring systems such as the revised Baux score (23,24). The substantially elevated mortality rate observed in our cohort, combined with the absence of age-related prognostic significance, suggests either a particularly severe patient population or potential methodological considerations that warrant further investigation to ensure optimal burn care delivery and accurate risk stratification in clinical practice (19,24).

Moreover, our investigation of burn patients revealed that certain pathogens were uniquely associated with fatal outcomes, specifically, *Acinetobacter* infections (notably when co-occurring with Klebsiella or MRSA) and polymicrobial infections involving *P. aeruginosa*. In contrast, infections caused by MSSA and Proteus showed a strong correlation with patient recovery. The identification of *Acinetobacter* infections, particularly when co-occurring with Klebsiella or MRSA, as predictors of fatal outcomes aligns with extensive evidence demonstrating that *Acinetobacter baumannii* infections in burn patients are associated with significant morbidity and mortality, with studies reporting mortality rates ranging from 25.16% to 58.3% in burn intensive care units (25-27). Similarly, our finding that polymicrobial infections involving *P. aeruginosa* correlate with fatal outcomes is consistent with multiple investigations demonstrating that polymicrobial bacteremias are more prevalent among patients dying of sepsis, with gram-negative organisms, including *Pseudomonas*, being significantly associated with increased mortality rates (28,29). Conversely, our observation that MSSA infections correlate with patient recovery is supported by meta-analyses demonstrating significantly higher mortality risks associated with MRSA bacteremia compared to MSSA bacteremia (pooled OR: 2.35, RR: 2.01), although some studies report no significant mortality differences when confounding factors are controlled (30,31). However, our finding regarding Proteus infections and recovery presents a more complex picture, as while some studies identify Proteus mirabilis as a predominant burn wound pathogen (31.1% in one cohort), experimental models have demonstrated its potential for lethal burn surface infections and systemic migration (32,33). These collective findings underscore the critical importance of pathogen-specific risk stratification in burn patients, where multidrug-resistant organisms and polymicrobial infections, particularly those involving *Acinetobacter* and *Pseudomonas* species, serve as reliable predictors of adverse outcomes and warrant aggressive therapeutic intervention and infection control measures.

Conclusion

The findings of this study underscore the critical interplay between microbial ecology, antimicrobial resistance, and clinical outcomes in burn care. *P. aeruginosa* emerged as the predominant pathogen, frequently coexisting with Klebsiella pneumoniae or *E. coli* in polymicrobial infections, which were uniformly linked to fatal outcomes. Mortality risks were strongly associated with male gender, extensive burn surface area, and higher-grade burns, while age demonstrated no prognostic significance. Notably, *Acinetobacter* species, particularly in co-infections with Klebsiella or MRSA, and polymicrobial *P. aeruginosa* infections, exhibited exclusive mortality correlations, contrasting with the favorable prognosis observed in MSSA and Proteus monoinfections. These patterns highlight the urgent need for institution-specific antimicrobial stewardship programs, rigorous infection control measures targeting multidrug-resistant gram-negative pathogens, and tailored empirical therapies informed by local wound culture. Future efforts should prioritize longitudinal surveillance of resistance trends and deeper exploration of gender-specific pathophysiological disparities to optimize therapeutic strategies in high-risk burn populations.

Limitations of the study

This study has several limitations inherent to its retrospective cross-sectional design, including potential biases related to incomplete or inconsistent medical records and laboratory data. The single-center setting at Taleghani hospital limits the generalizability of the findings to other regions or healthcare facilities. Additionally, the exclusion of patients with incomplete data may have introduced selection bias. The study's reliance on existing documentation also restricted the ability to control for confounding variables or to collect more detailed clinical information, such as treatment protocols or long-term patient outcomes. Finally, the six-month study period may not capture seasonal variations in burn incidence or microbial patterns.

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Authors' contribution
Conceptualization: Ahmad Mohajerian and Alireza Rafati Navaei.
Data curation: Ahmad Mohajerian and Ali Zahmatkesh.
Formal analysis: Mandana Pouladzadeh.
Investigation: Alireza Rafati Navaei.
Methodology: Mandana Pouladzadeh and Ali Zahmatkesh.
Project management: Alireza Rafati Navaei.
Resources: All authors.
Supervision: Ahmad Mohajerian.
Validation: Ali Zahmatkesh.
Writing–original draft: All authors.
Writing–review and editing: All authors.

Conflicts of interest
The authors declare no conflict of interest.

Data availability statement
The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request

Declaration of generative artificial intelligence (AI) and AI-assisted technologies in the writing process
During the preparation of this work, the authors utilized AI (Perplexity.ai and Grammarly.com) to refine grammar points and language style in writing. Subsequently, the authors thoroughly reviewed and edited the content as necessary, assuming full responsibility for the publication's content.

Ethical issues
The research was conducted in accordance with the principles of the Declaration of Helsinki. This study resulted from the thesis of Ali Zahmatkesh (Thesis #330103837), with the ethical code (IR.AJUMS.HGOLESTAN.REC.1403.066; https://ethics.research.ac.ir/EthicsProposalView.php?id=493754), approved by the Medical Ethics Committee of Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. Patients provided informed consent upon hospital admission. Additionally, the authors have adhered to ethical standards, ensuring no issues related to plagiarism, data fabrication, or double publication.

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