



# The etiology of hospital-acquired infections and environmental contamination in a subspecialty burn center

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## ABSTRACT

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Hospital-acquired infections contribute significantly to global morbidity and mortality. This study investigated the etiology of hospital-acquired infections and environmental contamination in a burn center. A cross-sectional study was conducted using 212 environmental samples and 673 clinical samples collected from burn patients admitted to Velayat Hospital, Rasht, Iran, between 2018 and 2021. Demographic data and clinical characteristics of the burn patients were recorded and analyzed. Of the 212 environmental samples, 94.8% were obtained from hospital surfaces, with the ICU being the most frequently sampled area (36.8%). Fungal infections were the most prevalent (65.5%), followed by *Staphylococcus* spp. (19.8%). Among the 673 burn patients, the majority were male (74.5%), with a mean age of 39.5 years and an average burn severity of 39.57%. Infections typically developed 3.91 days after admission, and the average hospital stay was 12.07 days. Among clinical samples, *P. aeruginosa* was the most commonly isolated pathogen (34.9%), followed by *Klebsiella* spp. (12.3%). The findings underscore the urgent need for improved infection control measures, enhanced environmental monitoring, and better diagnostic capabilities to reduce the incidence of nosocomial infections and improve outcomes for burn patients.

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## 1. Introduction

Nosocomial infections, also known as healthcare-associated infections (HAIs), pose a significant global health challenge, particularly in burn centers where patients are exceptionally vulnerable due to compromised skin barriers and immune systems. These infections complicate patient recovery and contribute to morbidity, mortality, and healthcare costs [1,2].

Burn patients are at an elevated risk of acquiring nosocomial infections due to factors such as prolonged hospital stays, invasive procedures, and the immunosuppressive effects of severe burns [3,4]. The prevalence of healthcare-associated infections (HAIs) ranges from 5–15% in developed countries and 5.7–25% in developing countries, with rates as high as 16% in the Eastern Mediterranean Region, reflecting higher risks in low-income settings due to inadequate facilities and poor hospital conditions [5–9].

The prevalence of nosocomial infections in burn centers varies globally, ranging from 19% to 84%, depending on the geographical location, healthcare infrastructure, and infection control practices [10,11]. Developing countries often face higher infection rates, sometimes exceeding due to resource limitations and challenges in implementing comprehensive infection control measures [12]. In Iran, studies have reported nosocomial infection rates in burn centers ranging from 44% to 73%, highlighting the magnitude of the problem in the region [3,13].

Environmental contamination plays a crucial role in transmitting nosocomial infections in burn units. The hospital environment, including surfaces, equipment, and air, can serve as reservoirs for pathogenic microorganisms [13,14].

Common nosocomial pathogens in burn units include *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, methicillin-resistant *Staphylococcus aureus* (MRSA), and various fungal species, all of which have been isolated from environmental samples in burn centers [14–16].

Despite these strategies, burn centers face numerous challenges in infection control. The critical condition of burn patients often necessitates frequent contact with healthcare workers and medical devices, increasing the risk of pathogen transmission [17,18].

The emergence of multidrug-resistant organisms complicates treatment options and underscores the importance of prevention. Resource limitations, especially in developing countries, can hinder the implementation of advanced infection control measures [19].

Therefore, in the current study, we investigated the etiology of hospital-acquired infections and environmental contamination in a burn center, which can help develop effective prevention and control strategies.

## 2. Materials and Methods

### 2.1 Study design

This cross-sectional study was conducted using data from 673 hospitalized patients with nosocomial infections and 212 environmental samples collected from various hospital units at the Velayat Burn Center, Rasht, the North of Iran, between 2018 and 2021. The study design was approved by the Ethics Committee of Guilan University of Medical Sciences (IR.GUMS.REC.1401.467). Data collected included patients' age, gender, time of admission, duration of hospitalization, time from admission to infection diagnosis, burn severity, and types of infection in both clinical samples and environmental samples. For environmental samples, sampling areas (ICU, operating room, emergency room, and non-clinical areas such as equipment rooms and rest areas) was also recorded.

### 2.2 Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics version 22.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the results. Continuous variables were expressed as mean  $\pm$  standard deviation (SD). Categorical variables were presented as frequencies and percentages.

## 3. Results

The study results showed that out of 212 hospital environmental samples, the majority were collected from hospital surfaces (94.8%), while only 5.2% came from hospital personnel. The ICU was the most frequently sampled area, accounting for 36.8% of all samples, followed by the clinical area (26.4%) and operating room (21.2%). Regarding the types of infections detected in the environmental samples, fungal infections were the most prevalent, found in 65.5% of samples. *Staphylococcus* spp. was the second most common in 19.8% of samples, followed by *Streptococcus* spp. (16.0%) and *Klebsiella* spp. (8.9%). *E. coli* was found in only 3.0% of samples (Table 1).

The study also analyzed data from 673 burn patients infected during the same period. The patient population was predominantly male (74.5%), with a mean age of  $39.50 \pm 20.21$  years. The average burn severity was  $39.57 \pm 23.73\%$ , and patients typically developed infections  $3.91 \pm 4.40$  days after admission. The mean length of hospital stay was  $12.07 \pm 8.94$  days. Patients were almost equally distributed between the burns surgery department (49.7%) and the ICU (50.3%) (Table 2). Analysis of bacterial infections in burn patients revealed that *P. aeruginosa* was the most prevalent pathogen, found in 34.9% of cases, followed by *Klebsiella* spp. (12.3%) (Table 3).

**Table 1.** Infection patterns in hospital environmental samples (N = 212). Results are presented as number (%).

Years	Origin of samples						
	ICU	Operating room	Emergency room	Clinical area	None- clinical area	Hospital surfaces	Hospital personnel
2018	10 (15.2)	10 (15.2)	13 (19.7)	23 (34.7)	10 (15.2)	59 (89.4)	7 (10.6)
2019	24 (54.5)	20 (45.5)	0 (0.0)	0 (0.0)	0 (0.0)	44 (100)	0 (0.0)
2020	14 (27.5)	15 (29.4)	0 (0.0)	12 (23.5)	10 (19.6)	47 (92.2)	4 (7.8)
2021	30 (58.8)	0 (0.0)	0 (0.0)	21 (41.2)	0 (0.0)	51 (100)	0 (0.0)
Total	78 (36.8)	45 (21.2)	13 (6.2)	56 (26.4)	20 (9.4)	201 (94.8)	11 (5.2)
Years	Types of infection						
	<i>Escherichia coli</i>	<i>Klebsiella</i>	<i>Staphylococcus</i>	<i>Streptococcus</i>	Fungal		
2018	2 (3.0)	1 (1.5)	9 (13.6)	0 (0.0)	30 (45.5)		
2019	1 (2.3)	2 (4.5)	8 (18.2)	2 (4.5)	21 (47.7)		
2020	0 (0.0)	0 (0.0)	5 (9.8)	0 (0.0)	14 (27.5)		
2021	0 (0.0)	0 (0.0)	21 (41.2)	0 (0.0)	23 (45.1)		
Total	139 (65.5)	42 (19.8)	34 (16.0)	19 (8.9)	44 (20.7)		

**Table 2.** Burn patients' demographical and clinical data (N=673). Results are presented as number (%).

Years	Gender n (%)		Admission department		Age Mean±SD	Burn severity Mean±SD	Time from admission to infection (day) Mean±SD	Length of hospital stay (day) Mean±SD
	Male	Female	Burns surgery	ICU				
2018	120 (70.6)	50 (29.4)	75 (44.6)	93 (55.4)	42.66±20.91	44.43±23.12	3.79±4.48	12.19±9.60
2019	129 (69.0)	58 (31.0)	81 (44.5)	101 (55.5)	38.57±21.070	38.43±23.78	3.63±4.55	11.38±8.49
2020	109 (77.3)	32 (22.7)	69 (48.9)	72 (51.1)	38.84±19.67	41.16±25.28	3.35±3.52	10.94±8.59
2021	144 (82.3)	31 (17.7)	106 (60.6)	69 (39.4)	37.96±17.99	35.01±22.11	4.76±4.70	13.60±8.86
Total	502 (74.5)	171 (25.4)	331 (49.7)	335 (50.3)	39.50±20.21	39.57±23.73	3.91±4.40	12.07±8.94

**Table 3.** The most prevalent bacterial infection in burn patients (N=673). Results are presented as number (%).

Years	<i>Staphylococcus coagulase+</i>	<i>Staphylococcus coagulase-</i>	<i>P. aeruginosa</i>	<i>Klebsiella</i>	<i>E. coli</i>	<i>Proteus</i>	Other <i>Enterobacteriaceae</i>	Unknown isolates
2018	1 (0.6)	3 (1.8)	71 (41.7)	23 (13.5)	4 (2.4)	7 (4.1)	1 (0.6)	60 (35.3)
2019	1 (0.5)	2 (1.1)	37 (19.8)	20 (10.7)	4 (2.1)	5 (2.7)	0 (0.0)	118 (963.1)
2020	0 (0.0)	2 (1.4)	59 (41.8)	12 (8.5)	3 (2.1)	1 (0.7)	0 (0.0)	64 (45.5)
2021	1 (0.6)	1 (0.6)	67 (38.3)	28 (16.0)	2 (1.1)	2 (1.1)	0 (0.0)	74 (42.3)
Total	3 (0.4)	8 (1.2)	234 (34.9)	83 (12.3)	13 (1.9)	15 (2.3)	1 (0.1)	316 (46.9)

### 4. Discussion

Nosocomial infections are a major concern in burn centers, where patients are highly vulnerable due to compromised skin barriers and prolonged hospital stays. The hospital environment can also become a source of infection, particularly in critical care areas [20]. This study investigated the prevalence of infections and environmental contamination in burn center from 2018 to 2021, highlighting the need for stronger infection control measures to protect patient safety. Evidence indicated that environmental contamination significantly contributes to HAIs, facilitating both cognized and unrecognized pathogen transmission, as many pathogens can persist in the hospital environment for extended periods, serving as vehicles for transmission [21].

Our findings demonstrated that the most prevalent

hospital environmental infections were fungi and *Staphylococcus* spp. Moreover, the most prevalent bacteria from clinical samples of burn patients were *P. aeruginosa* and *Klebsiella* spp. *P. aeruginosa* remained the predominant bacteria, although its prevalence fluctuated from 2018 to 2021. *Klebsiella* spp. showed a slight increase, while other bacterial infections generally decreased. A study by Nimer et al. reported that the most frequent detected nosocomial infections in Middle Eastern countries were related to *E. coli*, *Klebsiella* spp., and *S. aureus*, and also fungal infections such as *Candida* [22]. The high fungal prevalence in our study suggested a need for enhanced antifungal strategies in the burn center's infection control protocols.

A study by Vinaik et al. demonstrated that infection and sepsis were the leading cause of mortality in burn patients, with early colonization by *Staphylococcus* spp. and *Streptococcus* spp. followed by *P. aeruginosa* [23].

Another study by Weber et al. illustrated that contaminated hospital surfaces play a key role in the transmission of pathogens such as MRSA, *Enterococcus* spp, *Clostridium difficile*, *Acinetobacter* spp., as patient-to-patient transmission often occurs through contact with contaminated environments [24]. A previous study on hospitalized burn patients in Rasht, Iran, demonstrated a concerning high prevalence of multidrug-resistant (MDR) infections among hospitalized burn patients with a significant rate of mortality among burn patients [3].

In the current study, most patients were admitted to the ICU, and the mean length of hospital stay was 12 days. Vincent et al. found a high prevalence of infections among ICU patients [25]. The infection rate in burn patients in the ICU is higher due to several factors unique to their condition. Burn injuries compromise the skin, making patients more susceptible to bacterial, fungal, and viral pathogens. Additionally, these patients often require prolonged ICU stays, frequent invasive procedures, and the use of devices such as ventilators and catheters, all of which increase the risk of infection [26,27]. Moreover, the ICU environment, with a high prevalence of MDR organisms, further elevates the risk. On the other hand, burn patients also experience immune system dysfunction, which impairs their ability to fight off infections, leading to higher infection rates [28,29].

We observed a predominance of men among burn patients, indicating a higher proportion of male burn victims. We found an increasing proportion of male patients and a slight decrease in the mean age of the patients. Mehta et al. found that men were admitted to hospitals due to burn injuries more than women, while the disparity in distribution of females with burn injuries was reported [30]. The mean age of patients in our study was about 39.5 years, which was correlated with the findings of the other studies [31,32].

In the current study, the average time to infection development was about four days, and the mean length of hospital stay was 12 days. Patients admitted to the hospital with significant burn injuries face a high risk of developing HAIs, which become the leading cause of death if they survive the critical first three days, with ventilator-associated pneumonia being the most prevalent infection in this group. They reported that the severity of the patient's condition increased with prolonged duration of hospitalization [33].

The current study's time trends suggested improvements in patient care and outcomes but also highlighted ongoing challenges in infection control and the need for enhanced diagnostic capabilities to identify unknown pathogens. Still, the current study has some limitations, including its cross-sectional design, lack of complete clinical data of patients about the origin of the burn wounds, single-center study, and the immunogenic condition of the patients, which might limit the generalization of the results to other populations. By considering these issues, future research should focus on

identifying effective interventions to mitigate the risk of nosocomial infections in burn centers and developing better methods for rapid pathogen identification to guide treatment decisions. The current study demonstrated a high prevalence of fungal and *Staphylococcus* spp. in environmental samples, particularly in critical areas like the ICU, indicating a need for enhanced cleaning and disinfection protocols. Patient data identified *P. aeruginosa* as the predominant pathogen, commonly associated with MDR. These findings underscored the critical importance of implementing comprehensive infection control strategies, including regular environmental monitoring, stringent hygiene practices, and targeted antimicrobial therapies.

### Authors' contributions

Supervision, Conceptualization and Methodology: MHC, MM; Data collection, Analysis and Interpretation: PH, MS, MH; Writing draft and Editing: PH, MS, MH, MHC, MM. All authors have read and approved the final manuscript.

### Conflict of interest

No potential conflict of interest was reported by the authors.

### Ethical declarations

The study design was confirmed by the ethical committee of the Guilan University of Medical Sciences, Rasht, Iran [IR.GUMS.REC.1401.467]. Given the retrospective and descriptive nature of the study, the requirement for obtaining informed consent was waived by the Ethics Committee in accordance with national regulations and institutional guidelines.

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