



Hospital-acquired sepsis in burn patients: epidemiology, bacterial profiles, and risk factors in a tertiary burn center in Iran

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ABSTRACT

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Sepsis is a significant cause of morbidity and mortality in burn patients due to compromised skin integrity and immune dysfunction. Despite advancements in burn care, hospital-acquired infections continue to be a significant challenge, particularly in low-resource settings. This cross-sectional observational study was conducted over a 12-month period at Mousavi Hospital, a tertiary referral burn center in Zanzan, Iran. All patients admitted with burn injuries who remained hospitalized for more than 72 hours were evaluated for hospital-acquired sepsis. Sepsis was diagnosed based on the combination of clinical signs and relevant laboratory and imaging findings. Demographic, clinical, and microbiological data were collected from medical records. Multivariate logistic regression was used to identify independent risk factors. Among 453 burn patients, 176 (38.8%) developed hospital-acquired sepsis. Sepsis was significantly associated with advanced age ($p = 0.007$), rural residence ($p < 0.001$), lower educational level ($p = 0.004$), higher burn severity ($p < 0.001$), and prolonged hospitalization ($p < 0.001$). The most commonly isolated microorganism was *Pseudomonas aeruginosa* (32.1%), followed by *Citrobacter spp.* (22.6%) and *Staphylococcus aureus* (15.1%). Multivariate logistic regression identified burn percentage (OR = 1.184, $p = 0.001$), length of hospital stay (OR = 1.585, $p < 0.001$), and lower educational level (OR = 0.501, $p = 0.005$) as independent predictors of sepsis. Hospital-acquired sepsis remains highly prevalent in burn patients. The key independent predictors were Total Body Surface Area (TBSA), duration of hospitalization, and education level. Regular microbial surveillance, timely diagnosis using burn-specific criteria, and targeted infection control measures are essential to reducing sepsis-related complications in this vulnerable population.

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1. Introduction

Burn injuries represent one of the most severe forms of physical trauma, often resulting in the destruction of skin integrity, immune system dysregulation, and the creation of an optimal environment for microbial invasion [1,2]. The loss of the protective skin barrier and the profound immune response that follows make burn patients particularly vulnerable to infections, which are among the most frequent complications and leading causes of mortality in this population [2]. Despite advances in critical care such as fluid resuscitation, early debridement, and skin grafting, infections and sepsis remain leading causes of in-hospital mortality in burn patients [3,4], with rates ranging from 50% to 75% and potentially rising to 86% due to emergence of multidrug-resistant organism (MDROs) [5–9]. The early diagnosis of sepsis in burn patients is particularly challenging due to post-burn physiological conditions such as intense inflammation and a hypermetabolic state, which can obscure typical signs of infection [2]. Wound infections, pneumonia, and catheter-related infections are among the most common complications [7,10,11].

A study from a regional burn center reported that 43.8% of patients developed infections by day 28, with skin and soft tissue infections (32%), hospital-acquired pneumonia (19.5%), and catheter-related bloodstream infections being the most prevalent. Multidrug-resistant pathogens—especially *Acinetobacter baumannii* (27%), *P. aeruginosa* (25%), and Methicillin-resistant *S. aureus* (MRSA) (26%)—play a significant role in these infections [1]. These organisms, if untreated, can invade deeper tissues and the bloodstream, leading to sepsis [11]. An Iranian study found that 38.54% of hospitalized burn patients had positive wound cultures, with *Staphylococcus spp.* (55.1%) and *P. aeruginosa* (14.29%) being the most frequently isolated bacteria [11].

Major risk factors for infection in burn patients include advanced age, extensive total body surface area (TBSA) involvement, use of central venous catheters (CVCs), and mechanical ventilation. The presence of CVCs alone increases the risk of infection more than sevenfold [1]. Early diagnosis of sepsis is particularly challenging, as the immune response following burn injury can mimic classic sepsis symptoms, making criteria such as the Sequential Organ Failure Assessment (SOFA) score or Sepsis-3 unreliable when used in isolation [2]. To address the limitations of standard diagnostic tools in burn patients, the American Burn Association (ABA) introduced burn-specific criteria for sepsis in 2007 based on changes in clinical status and signs such as fever, tachycardia, hyperglycemia, thrombocytopenia, and intolerance to enteral feeding [12].

In recent years, studies have increasingly focused on the early detection of infection and sepsis using biomarkers such as procalcitonin (PCT) and C-reactive

protein (CRP), as well as molecular diagnostic methods [2,13]. Although no single gold-standard diagnostic approach currently exists, combining clinical judgment with these novel tools appears more effective for managing burn-related infections. Prevention efforts also play a key role and include early wound debridement, appropriate dressing selection, close clinical monitoring, and timely antibiotic administration guided by culture results. Moreover, identifying local bacterial patterns, selecting targeted antibiotics, and tracking antimicrobial resistance are essential strategies to reduce infection-related complications. Given these challenges, this study aimed to investigate the prevalence, risk factors, and clinical outcomes of infections in burn patients, as well as to assess the bacterial profile and antibiotic susceptibility patterns in a selected burn care center.

2. Materials and Methods

2.1 Study Design

This cross-sectional, observational study was conducted to determine the frequency and associated risk factors of hospital-acquired sepsis in patients with burn injuries. The study was conducted at the Burn Unit and Intensive Care Unit (ICU) of Mousavi Hospital, a tertiary referral center located in Zanjan, Iran. Data were collected over 12 months, from June 2016 to May 2017. All patients admitted due to burn injuries were considered eligible for inclusion. Patients were evaluated for sepsis if they remained hospitalized for more than 72 hours.

The diagnosis of hospital-acquired sepsis was based on a predefined institutional protocol. Patients hospitalized for more than 72 hours were diagnosed with sepsis if they presented with clinical evidence of infection (e.g., fever $>38^{\circ}\text{C}$ or signs of wound infection) and at least two of the following signs of systemic inflammatory response: heart rate >90 bpm, respiratory rate $>24/\text{min}$, leukocytosis ($>12,000/\text{mm}^3$) or leukopenia ($<4,000/\text{mm}^3$), hypotension, oliguria, or altered mental status. Additionally, at least one confirmatory paraclinical finding was required, such as an abnormal chest X-ray, abnormal urinalysis, or a positive urine or blood culture.

The primary outcome was the diagnosis of hospital-acquired sepsis. Independent variables included demographic characteristics (age, sex, education level, residential location), clinical parameters (TBSA burned, burn depth, anatomical site of burn, duration of hospitalization), underlying comorbidities, use of a urinary catheter, and microbiological findings. Data were extracted from electronic medical records using a structured data collection form developed explicitly for the study. All clinical, laboratory, and imaging assessments were conducted as part of routine care. To minimize information bias, data collection was performed by trained medical personnel blinded to the study objectives. Patients with incomplete or ambiguous

medical records were excluded from the analysis. As this was a census-based study including all eligible patients within the defined time frame, no formal sample size calculation was performed.

2.2 Statistical Analysis

Data were analyzed using SPSS software, version 18. Descriptive statistics were used to summarize patient characteristics. Continuous variables were presented as mean and standard deviation (SD) and were compared between the sepsis and non-sepsis groups using the independent samples t-test. Categorical variables were expressed as frequencies and percentages. The association between categorical variables was examined using the Chi-square test, or Fisher's exact test when the expected count in any cell of a contingency table was less than five. Multivariate logistic regression analysis was conducted to identify independent predictors of hospital-acquired sepsis.

To build the multivariate logistic regression model, all variables considered clinically relevant, along with those showing significant associations in the univariate analysis, were included simultaneously using the 'Enter' method to assess their independent predictive value. A two-tailed P value <0.05 was considered statistically significant.

3. Results

A total of 453 burn patients were included in the study, as detailed in the patient flow diagram (Figure 1). Of these, 176 patients (38.8%) developed hospital-acquired sepsis during their hospitalization. The analysis revealed significant associations between several demographic and clinical variables and the development of sepsis (Table 1).

The mean age of patients with sepsis was higher than that of those without sepsis, and the prevalence of sepsis increased significantly with age ($p=0.007$). Notably, 60% of patients older than 60 years developed sepsis, compared to 32.8% in the under-18 age group. Gender was not significantly associated with sepsis ($p=0.414$). However, patients from rural areas had a significantly

higher prevalence of sepsis (47.3%) compared to urban residents (27.5%) ($p < 0.001$). Educational level was also a significant factor; patients with higher education had the lowest rate of sepsis (18.3%), whereas those with only elementary education or less had significantly higher rates ($p = 0.004$). Burn characteristics were strongly correlated with the occurrence of sepsis. Patients with third- and fourth-degree burns had notably higher rates of sepsis (87.7% and 100%, respectively) compared to those with second-degree burns (27.8%) ($p<0.001$).

The incidence of sepsis was significantly correlated with the TBSA affected. Notably, sepsis occurred in 100% of patients with TBSA involvement $\geq 40\%$, compared to only 22.3% among those with burns affecting less than 10% of TBSA ($p<0.001$) (Figure 2). Similarly, prolonged hospitalization emerged as a strong predictor of sepsis, with 70.6% of patients who remained hospitalized for more than four weeks developing sepsis ($p<0.001$).

Additional variables that demonstrated statistically significant associations with the development of sepsis included the presence of underlying comorbidities ($p < 0.001$), positive blood cultures ($p = 0.012$), and positive urine cultures ($p < 0.001$). Furthermore, abnormal findings on urinalysis ($p < 0.001$), evidence of pulmonary involvement ($p < 0.001$), and the use of urinary catheterization ($p < 0.001$) were all significantly correlated with an increased risk of sepsis. Among patients with sepsis, the most frequently isolated microorganism was *P. aeruginosa* (32.1%), followed by *Citrobacter spp.* (22.6%), *S. aureus* (15.1%), *Staphylococcus epidermidis* (13.2%), and *Escherichia coli* (13.2%) (Table 2). Multivariate logistic regression analysis identified length of hospital stay (OR=1.585; 95% CI: 1.404–1.790; $p<0.001$), burn percentage (OR=1.184; 95% CI: 1.075–1.305; $p=0.001$), and educational level (OR=0.501; 95% CI: 0.308–0.813; $p=0.005$) as independent predictors of sepsis (Table 3 and Figure 3). Other variables, including age, gender, comorbidities, burn degree, pulmonary involvement, and urinary catheter use, did not reach statistical significance in the multivariate model.

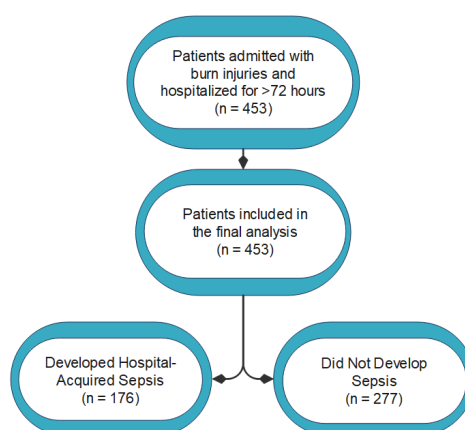


Figure 1. Flow diagram of patient inclusion in the study

Table 1. Comparison of baseline characteristics between patients with and without sepsis

Variable	Category	Non-sepsis (n, %)	Sepsis (n, %)	P value
Age	<18 years	125 (67.2%)	61 (32.8%)	0.007
	18-40 years	101 (62.7%)	60 (37.3%)	
	41-60 years	37 (52.1%)	34 (47.9%)	
	>60 years	14 (40.0%)	21 (60.0%)	
Gender	Male	182 (62.5%)	109 (37.5%)	0.414
	Female	95 (58.6%)	67 (41.4%)	
Residence	Urban	140 (72.5%)	53 (27.5%)	<0.001
	Rural	137 (52.7%)	123 (47.3%)	
Educational Level	Illiterate	99 (60.4%)	65 (39.6%)	0.004
	Cycle	70 (54.3%)	59 (45.7%)	
	Diploma	59 (59%)	41 (41%)	
	Higher education	49 (81.7%)	11 (18.3%)	
Burn Degree	Second-degree	269 (72.1%)	105 (27.8%)	<0.001
	Third-degree	8 (12.3%)	57 (87.7%)	
	Fourth-degree	0	14 (100%)	
Burn Percentage (TBSA)	<10%	262 (77.7%)	75 (22.3%)	<0.001
	10 – 19%	14 (23.7%)	45 (76.3%)	
	20 – 29%	1 (4.2%)	23 (95.8%)	
	≥40	0	33 (100%)	
Length Of Hospital Stay	<1 week	148 (92.5%)	12 (7.5%)	<0.001
	1 – 2 weeks	22 (84.6%)	4 (15.2%)	
	2 – 4 weeks	42 (91.3%)	4 (8.7%)	
	>4 weeks	65 (29.4%)	156 (70.6%)	
Underlying Disease	Yes	12 (30.8%)	27 (69.2%)	<0.001
	No	265 (64%)	149 (36%)	
Blood Culture	Negative	277 (61.7%)	172 (38.3%)	0.012
	Positive	0	4 (100%)	
Urine Culture	Negative	275 (62.5%)	165 (37.5%)	<0.001
	Positive	2 (15.4%)	11 (84.6%)	
Urinalysis	Normal	274 (65.2%)	146 (34.8%)	<0.001
	Active	3 (9.1%)	30 (90.9%)	
Pulmonary Involvement	No	277 (68.1%)	130 (31.9%)	<0.001
	Yes	0	46 (100%)	
Urinary Catheterization	No	276 (65.1%)	148 (34.9%)	<0.001
	Yes	1 (3.4%)	28 (96.6%)	

Table 2. Distribution of Causative Microorganisms in Sepsis Patients

Microorganism	Frequency (%)
<i>P. aeruginosa</i>	17 (32.1%)
<i>Citrobacter spp.</i>	12 (22.6%)
<i>S. aureus</i>	8 (15.1%)
<i>S. epidermis</i>	7 (13.2%)
<i>E. coli</i>	7 (13.2%)
Other bacterial species	2 (3.8%)

Table 3. Results of Multivariate Logistic Regression

Variable	OR (95% CI)	Wald Statistic	P value
Gender	1.613 (0.633 – 4.113)	1.002	0.317
Age	1.011 (0.984 - 1.039)	0.627	0.428
Education Level	0.501 (0.308 – 0.813)	7.811	0.005
Place of Residence	1.918 (0.867 – 4.244)	2.582	0.108
Underlying Disease	1.823 (0.260 – 12.790)	0.365	0.546
Length of Hospital Stay	1.585 (1.404 – 1.790)	55.499	<0.001
Burn Location	1.515 (0.827 – 2.777)	1.809	0.179
Burn Degree	1.482 (0.322 – 6.824)	0.255	0.614
Burn Percentage	1.184 (1.075 – 1.305)	11.699	<0.001
Urine Culture	0.315 (0.012 – 8.189)	0.483	0.487
Urine Analysis	2.557 (0.337 – 19.392)	0.824	0.364
Urine Catheter	0.218 (0.008 – 5.861)	0.822	0.364
Pulmonary Involvement	1.534 (0.634 – 2.434)	0.000	0.734

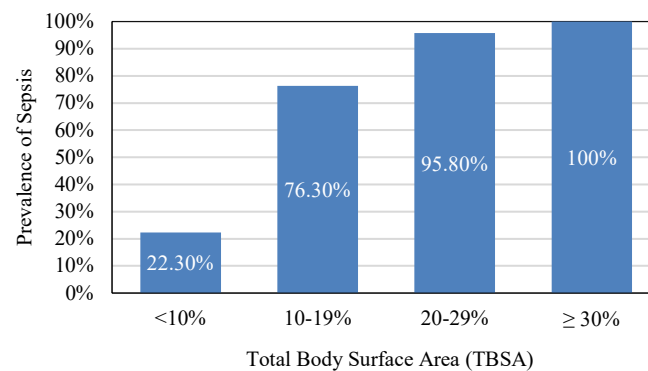


Figure 2. Prevalence of hospital-acquired sepsis according to the percentage of TBSA burned



Figure 3. Forest plot of the multivariate logistic regression analysis showing odds ratios (OR) and 95% confidence intervals (CI) for independent predictors of hospital-acquired sepsis

4. Discussion

This study demonstrated a 38.8% prevalence of hospital-acquired sepsis among burn patients, aligning with previous reports from similar settings [5,11]. The most important independent predictors of sepsis were a higher TBSA and prolonged hospitalization, while a higher educational level was identified as a significant protective factor. *P. aeruginosa* was the most commonly isolated pathogen, followed by *Citrobacter spp.* and *S. aureus*. The observed sepsis rate is comparable to those reported by Latifi et al. [11] in Iran (38.5%) and Alp et al. [5] in Turkey (40%), but lower than the 43.8% reported by Corcione et al. [1] in an Italian burn center. Differences in diagnostic criteria likely account for this variability. The diagnostic criteria used in our study were based on established principles of Systemic Inflammatory Response Syndrome (SIRS) combined with evidence of infection, an approach commonly utilized in many clinical settings. While not strictly adhering to the 2007 ABA consensus criteria, which include other metabolic markers like hyperglycemia or feeding intolerance, our approach aimed for high specificity by requiring confirmatory laboratory or

imaging evidence. This difference in diagnostic methodology should be considered when comparing our 38.8% sepsis prevalence with findings from other studies, particularly those that use the ABA criteria or the more recent Sepsis-3 definitions [2]. Moreover, the lower prevalence in our sample compared to high-income nations is potentially due to limited access to high-technology diagnostics, which may result in the missed detection of early sepsis cases [7]. The routine use of biomarkers, such as PCT, alongside ABA criteria can enhance the early detection of conditions. Standardizing diagnostic protocols across burn centers could facilitate more accurate comparisons of findings and, ultimately, lead to improved patient care. Consistent with global burn literature, gram-negative bacilli predominated. In our data, *P. aeruginosa* was the most common isolate (32.1%), a finding supported by numerous studies [1,5,7,9]. For example, Alp et al. [5] and Corcione et al. [1] found *P. aeruginosa* in roughly one-quarter of infections. Its prominence in burns is well known, owing to its affinity for moist wound beds and intrinsic resistance profile. *S. aureus* (15.1%) was less frequent than *Pseudomonas*; it is usually the top gram-positive in burn wounds, often around 25–35% of

isolates in other reports [1,14]. For instance, Corcione [1] reported MRSA in 25% of infections. Our relatively lower *S. aureus* rate may reflect our study's focus on definite sepsis episodes rather than all instances of wound colonization. The notably high prevalence of *Citrobacter spp.* (22.6%) in our series is unusual. *Citrobacter* is generally a rare burn pathogen, occurring in fewer than 1% of cases in some series [14].

However, it is recognized as a cause of urinary and bloodstream infections, particularly in catheterized patients. Its prominence here may reflect our high rate of catheter-associated sepsis and specific local ecology. This hypothesis is strongly reinforced by our data presented in Table 1. We found a dramatic and statistically significant association between sepsis and urinary tract-related factors. Specifically, 96.6% of patients with a urinary catheter and 84.6% of those with a positive urine culture developed sepsis ($p < 0.001$ for both). This robust correlation suggests that catheter-associated urinary tract infections (CAUTI) likely served as a primary source for sepsis in our cohort, providing a fertile ground for opportunistic pathogens like *Citrobacter* to thrive. This finding highlights a critical target for local infection control policies, underscoring the need for stringent protocols regarding catheter use. We did not detect *Acinetobacter* as a dominant agent, unlike Corcione (*Acinetobacter* 28%) or Alp (increasing MDR *Acinetobacter*) [1,5]. These differences likely stem from regional flora, antibiotic policies, and infection control practices. Overall, our findings reinforce that empirical therapy in burn sepsis must cover *Pseudomonas* and other hospital-acquired Gram-negative bacteria, and also address Gram-positive cocci where relevant. Continuous local surveillance of pathogen patterns and resistance profiles is essential. Burn percentage (OR = 1.184) and length of hospital stay (OR = 1.585) were the strongest independent predictors of sepsis, corroborating Strassle et al. [6], who associated greater TBSA with increased susceptibility to infection, and Alp et al. [5], who found prolonged hospitalization to be a key risk factor. Prolonged hospitalization was a significant predictor, with an odds ratio of 1.585, indicating a substantial increase in sepsis risk for patients with more extended stays. This is likely due to prolonged exposure to nosocomial pathogens and invasive devices, such as urinary catheters, which carry a 96.6% sepsis rate in catheterized patients ($p < 0.001$). In contrast, our observations differ from those of Williams et al. [3], who highlighted burn depth over TBSA. This difference may arise because severe burns (third/fourth-degree) in our study were closely correlated with higher TBSA, confounding the effect of depth in multivariate analysis. Early surgical care, including debridement and skin grafting, along with strict catheter removal regimens, can reduce hospital stays and promote effective care. Rapid discharge programs for valid cases could limit exposure to nosocomial infection. A lower education level (OR = 0.501) was an independent predictor, with

18.3% of sepsis cases among more educated patients compared with 39.6% among illiterate patients. This finding is consistent with indirect evidence from Norbury et al. [10], who attributed socioeconomic factors to poor burn outcomes; however, it differs from most burn studies, which do not typically measure education. Lower education could be related to delayed seeking of medical attention, knowledge about wound care, or greater TBSA upon arrival (mean TBSA: 8.03% among illiterate vs. 3.56% among more educated patients). Rural residence, which retained significance in univariate analysis ($p < 0.001$), became nonsignificant upon multivariate analysis, implying that education mediates its impact. Community programs teaching burn prevention and first aid, specifically targeting low-literacy individuals and those residing in rural areas, could help improve safety. Wound care teaching upon discharge helps prevent infection.

Age, comorbidity, and pulmonary involvement were significant factors in univariate analysis but did not remain so in multivariate models, as they were confounded by hospital stay length and TBSA. For example, increasing age (a 60% sepsis rate for individuals over 60 years, $p = 0.007$) and the presence of comorbidity (a 69.2% sepsis rate, $p < 0.001$) were typically associated with greater burn severity, resulting in prolonged hospital stays. This result is supported by Bloemsma et al. [4], who cited age effects mediated by burn severity. The finding that all patients with lung involvement developed sepsis ($p < 0.001$) was expected, given the high incidence of inhalation injuries in severe burn cases, as reported by Mosier and Pham [12]. The lack of correlation with gender ($p = 0.414$) concurs with the majority of burn infection studies [5].

Early multidisciplinary plan development, emphasizing respiratory support and infection monitoring, maximizes benefits for survivors. Collaborative, supportive care focused on managing comorbidities can improve outcomes for elderly survivors. This study has several limitations. First, its retrospective design is subject to information bias. We acknowledge that data for some variables were incomplete in the existing medical records; however, a formal quantification of the extent of missing data was not feasible at the time of revision. This missing information could introduce bias into the observed associations. Second, while our census-based sampling of all eligible patients minimizes selection bias, the absolute sample size may have limited our statistical power to detect significant associations for less prevalent risk factors. Third, as a single-center study, the generalizability of our findings may be limited. Future multicenter prospective studies are essential not only to validate our risk factors across different regions but also to explore the influence of varying socioeconomic contexts and local infection control protocols. Fourth, our microbiological data were limited to culture-based methods. Future studies should incorporate

comprehensive antimicrobial resistance profiling and molecular typing to provide a more complete epidemiological picture. Finally, we did not assess several key potential confounders, such as nutritional status, the timing of initial wound debridement, and prior antibiotic exposure.

The absence of these data may have influenced the observed associations and limited our ability to fully control for confounding. This study highlights a substantial burden of hospital-acquired sepsis among burn patients, with a prevalence of 38.8%.

The analysis identified larger burn surface area, prolonged hospitalization, and lower educational attainment as independent predictors of sepsis. *P. aeruginosa* emerged as the most frequently isolated pathogen, reflecting a persistent challenge in infection control within burn units. Targeted interventions, such as early wound care, minimizing the use of invasive devices, and patient education, may reduce the risk of sepsis. The strong link between social determinants and infection highlights the importance of health literacy and community outreach in burn care strategies. Future studies should focus on implementing and evaluating standardized diagnostic tools and prevention protocols to improve outcomes in this vulnerable population.

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Authors' contributions

MJ and AM: designed the study, supervised the project, and critically revised the manuscript. NM and AK: were involved in data collection and statistical analysis. ES: contributed to the study design and drafting of the manuscript. All authors read and approved the final version of the manuscript.

Conflict of interest

No potential conflict of interest was reported by the authors.

Ethical declarations

Patient confidentiality was strictly maintained throughout the study. Due to the retrospective design and the use of de-identified data from medical records, informed consent was waived. The study protocol was approved by the Institutional Ethics Committee of Zanjan University of Medical Sciences (approved code: ZUMS.REC.1395.91).

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