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Journal homepage: <https://www.ejcmpr.com/>DOI: <https://zenodo.org/records/17195028>**Investigation of cases of amputation of upper and lower limbs in Shahid Motahari Medical Training Center of Tehran in 2022 and 2023**Maryam Nazari¹, Hamid reza Alizadeh Otaghvar^{2*}, Babak Nikoumaram³¹Medical student, Department of medicine, Islamic Azad University, Tehran medical sciences Branch, Tehran, Iran
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Keywords:Amputation, burn, electric shock,
upper limb, lower limb**ABSTRACT**

Background: Amputation remains a significant public health challenge in low and middle-income countries where specialized burn care is limited. Acute burns particularly electrical burns, cause irreversible tissue damage necessitating amputation. This study examined cases of upper and lower limb amputation following burns at Shahid Motahari Educational and Treatment Center in Tehran during the years 2022-2023.

Methods: After ethical approval a retrospective review was conducted on 150 burn patients who underwent amputation. The data included demographic information, hospitalization details, burn characteristics, amputation level, and additional surgical interventions (escharotomy, grafting, debridement). Burn severity was classified based on total body surface area percentage and burn degree. The data were analyzed using SPSS version 26.

Results: The mean age of patients was 38.8 ± 16.6 years with 84% being male. The average length of hospital stay was 19.7 days and 91.3% were discharged routinely. All mortalities occurred in males. The predominant occupations were freelancers (39.3%) and laborers (24.7%). Acute burns accounted for 59.3% of cases with 47.3% of known causes due to electric shock. Upper limb amputations mainly involved the fingers (50%) or forearm (39.5%) while lower limb amputations predominantly affected the toes (68.4%) or below the knee (23.7%). Diabetes was significantly associated with lower limb amputation ($P=0.003$). Acute burns were associated with a higher rate of upper limb amputation ($P=0.045$). Lower limb amputation correlated with longer hospital stays ($P=0.014$).

Conclusion: Burn related amputation primarily affected working age men in high-risk occupations with electrical injuries being the main cause. The findings emphasize the need for targeted occupational safety interventions, improved prevention of electrical hazards and enhanced diabetes care. Multicenter studies evaluating long term functional and psychosocial outcomes are essential to optimize rehabilitation strategies and community reintegration.

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Introduction

Amputation remains one of the most important and life-changing procedures in modern medicine, often accompanied by significant physical, psychological and socio-economic consequences. Severe burns are among the most destructive injuries and can lead to amputation, especially when early intervention and appropriate care are delayed or unavailable. In the United Kingdom the risk of amputation among hospitalized burn patients is 1.2% mostly occurring as minor amputations in the upper limbs(1). In the study by Sanober et al. (2025), electrical burns were associated with amputation in up to 54.8% of cases, with upper limbs more frequently affected than lower limbs(2).

Globally, trauma and burn injuries are leading causes of disability and mortality, especially in developing countries. Jacobs et al. (2021) demonstrated that low and middle-income countries experience higher mortality rates compared to high-income countries despite similar injury patterns and burn severities(3). In these regions, weak infrastructure, limited access to specialized care and inadequate prevention contribute to severe complications such as amputation. Burns caused by electricity or flames and high-energy traumas like accidents and crush injuries often result in irreversible tissue damage requiring amputation. Soni et al. (2022) reported that the economic burden of trauma is substantial, with over 90% of trauma-related deaths occurring in low and middle-income countries(4).

Amputation caused by burns is a complex process especially in electrical burns which are associated with deep necrosis and the need for upper limb amputation. Risk factors reported include electrical and flame burns, extent and full thickness burns, infection, male gender and age between 18 and 64 years(5). Understanding these pathways is essential for early diagnosis and intervention. The consequences of amputation are not limited to surgery, patients face prolonged hospitalization risk of infection, repeated surgeries, permanent disability and difficulty reintegrating into society. Additionally, they suffer significant psychological burdens including depression, anxiety, post-traumatic stress disorder, phantom limb pain, negative emotions and social isolation(6).

The study by Burns et al. (2020) in the United States demonstrated an increase in lower limb amputations in severe injuries(7) whereas the review by Behrendt et al. (2018) showed that internationally, except in Slovakia, major amputation rates vary but generally trend downward(8).

The applicability of these findings to Iran is limited due to socio cultural, occupational and systemic differences. Moreover, most global studies focus on long term rehabilitation or prosthetics rather than the

acute phase leading to amputation decision making. Additionally, there is insufficient understanding of how the type and severity of injury correlate with the location and level of limb loss.

In Iran especially in urban centers like Tehran, industrial and traffic related injuries are common, and electrical and flame burns are prevalent among workers in high risk occupations. However, there is no comprehensive national data documenting the causes and trends of amputation in burn patients. The aim of this study is to determine patient histories over a two-year period (2022-2023) and identify key variables such as demographics, type of injury, cause of burn, anatomical site of amputation, and trends over time. By doing so this research seeks to fill the existing knowledge gap and provide a clearer picture of the amputation landscape in one of the country's most important burn trauma hospitals.

Materials and Methods

Patient Enrollment:

This cross-sectional study was conducted as a retrospective case series and epidemiological review. The study population included patients who underwent upper or lower limb amputation. The sample consisted of patients who received upper or lower limb amputation at Shahid Motahari Hospital in Tehran during the years 2022 and 2023. Sampling was performed using a convenience method.

Inclusion criteria:

- 1) Patients who referred to Motahari Hospital in Tehran during the years 2022 and 2023.
- 2) Patients with a definitive diagnosis of the need for amputation based on the medical team's opinion (consent of three plastic surgeons to perform amputation).
- 3) Patients who have completed all necessary treatment stages before surgery and whose information is recorded in their medical records.
- 4) Patients who underwent upper or lower limb amputation.

Exclusion criteria:

- 1) Patients with incomplete information.
- 2) Patients who developed serious complications or died during the study period, making it impossible to continue reviewing their records.
- 3) Patients who presented with non-acquired (congenital) limb amputation.
- 4) Patients who underwent reconstructive or repair surgery (other than amputation).

Study Design

After obtaining ethical approval from the Ethics Committee of the Tehran Branch of Islamic Azad University of Medical Sciences, a retrospective study was designed and conducted. The aim of this research was to review the medical records of patients with various types of burns who underwent amputation surgery. For this purpose, 150 patients who met the inclusion criteria and underwent amputation were selected using convenience sampling.

In the first stage, the patient's initial information was reviewed, which included demographic data such as age, gender, marital status, and occupation. Additionally, information related to the patients' hospitalization status, including length of stay, discharge status or death, and the cause of hospital admission based on the type of burn injury was collected. For patients with burns, burn assessment was conducted based on the percentage or degree of the burn.

In the next stage the status of the amputated limb and the site of amputation in the upper and lower extremities were examined. Additionally, other treatment methods such as escharotomy, graft and debridement that may have been used in the patient's treatment process were analyzed.

Tools and Criteria Used in Data Collection

Data for this study were obtained through medical record review, and no specific tool was used for data collection. However, two criteria "percentage of burn" and "degree of burn" were considered as standard measures for burn assessment in the study.

Burn Percentage (Total Body Surface Area (TBSA)):

Burn percentage, often referred to as the TBSA burned is a clinical estimate of the extent of the patient's body affected by burns. This measurement is essential for guiding fluid resuscitation assessing burn severity, determining prognosis and making decisions about referral to specialized burn centers. Depending on the patient's age and clinical condition, different methods are used to calculate the burn area:

1) Rule of Nines (adults): The body is divided into anatomical sections, each representing 9% or multiples of 9% of the TBSA (for example, head and neck=9%, each arm=9%, each leg=18%, anterior trunk=18%, posterior trunk=18%, perineum=1%).

2) Lund and Browder Chart: A more precise method that adjusts the percentage based on the patient's age especially useful for children.

3) Palm Method: The patient's palm (including fingers) represents approximately 1% of the total body surface area and is used for small or scattered burns.

Interpretation of Results:

- ✓ **<10% of total body surface area:** Minor burns (in adults).
- ✓ **10-20% of total body surface area:** Moderate burns.
- ✓ **20-30% of total body surface area:** Severe burns (requiring hospitalization)
- ✓ **40-50% of total body surface area:** High risk of complications and mortality.
- ✓ **70% of total body surface area:** Often fatal without aggressive specialized care.

Burn Degree (Burn Depth Classification):

Burn degree refers to the depth of damage to the skin and tissue caused by thermal, chemical, electrical or radiation injury. Historically, the classification system divided burns into first, second, third and fourth degrees though modern clinical practice often prefers terms such as superficial burns, partial thickness, full thickness and deep full thickness burns.

Burn depth is determined by clinical examination, including assessment of color, moisture, capillary refill, sensation and blistering. When necessary, imaging methods such as laser Doppler, ultrasound, histopathology or investigations where the depth is unclear are used.

Burn degrees are as follows:

- 1) First degree (superficial):** Affects only the epidermis. Red, painful, dry (e.g., mild sunburn).
- 2) Second degree (partial thickness):** Superficial partial thickness: involves the epidermis and part of the dermis. Red, blistered, moist, painful. Deep partial thickness: deeper skin damage, less pain, slower healing, potential for scarring.
- 3) Third degree (full thickness):** involves the entire dermis. White or charred, dry, leathery, painless due to nerve damage.
- 4) Fourth degree:** extends to muscle, tendon, or bone. Life threatening, requires extensive surgery.

Interpretation of results is as follows:

- 1) Superficial and superficial partial-thickness burns usually heal spontaneously with minimal scarring.
- 2) Deep partial thickness and full thickness burns often require grafting and carry a higher risk of infection and scarring.
- 3) Fourth degree burns typically require amputation or complex reconstructive surgery and have a poor prognosis.

Therapeutic Techniques Used

Escharotomy:

A longitudinal incision made in tight, non-elastic scars caused by deep burns (usually third-degree burns) that act like a "tight cage" restricting blood flow and pulmonary ventilation. The patient should be closely monitored after this procedure.

Indications in Burn and Amputation:

- ✓ Circumferential burns of the limb causing burn compartment syndrome.
- ✓ Decreased or absent peripheral pulses due to swelling and pressure from the scar.
- ✓ Ventilatory disturbances in circumferential chest burns.

In patients who are candidates for amputation, escharotomy can preserve the limb and prevent the need for amputation. Benefits include rapid reduction of compartment pressure, restoration of tissue perfusion, prevention of secondary necrosis, avoidance of unnecessary amputation, and reduction of amputation level.

Graft or Skin Graft:

Skin grafting involves transferring skin from a donor site to the burned and epithelial-deficient area. It includes types such as split thickness skin grafts (STSG), which consist of the epidermis and part of the dermis, and full thickness skin grafts (FTSG) which include all layers of the epidermis and dermis. This method is used in deep, extensive third degree burns, areas showing muscle, bone or tendon exposure after debridement and coverage of amputation wounds to accelerate healing and prepare the limb for prosthesis. Its advantages include faster wound healing, reduced risk of infection, decreased loss of fluids and electrolytes, improved appearance and function of the limb and creating a smooth surface for better prosthesis fitting.

Debridement:

The removal of necrotic, dead or infected tissue from the wound to facilitate healing. Depending on the depth of the burn, this can be superficial or performed with a dermatome. This method reduces microbial load and the risk of systemic infection, increases blood flow to healthy tissue, prepares the wound for healing or skin grafting, prevents lesion spread and reduces the level of amputation.

Statistical Analysis

The collected data were systematically organized into an Excel file. During this process, data coding was performed followed by the necessary analyses using SPSS version 26. Initially descriptive statistics including measures of central tendency and dispersion were presented in tables and related charts. Subsequently, appropriate statistical tests were selected based on the type of variables to perform analytical analyses and examine relationships between variables. For example, the Chi Square test was used for associations between qualitative variables, and the independent ttest was utilized for comparing mean values. Throughout all analysis stages, statistical significance was set at a p value less than 0.05.

To determine the sample size, an alpha level of 0.05 was used with the assumption of $P=0.5$ (considering the lack of similar studies the largest sample size occurs when $p=q=0.5$) and $d=0.08$. Based on these assumptions, the sample size was estimated to be 150.

Results

Descriptive Results: Population and Clinical Characteristics

This study was conducted with the aim of determining the cases of amputation of the upper and lower extremities at Shahid Motahari Educational and Therapeutic Center in Tehran during the years 1401 and 1402. The study included 150 patients who underwent amputation surgery. The mean age of the patients was 38.8 ± 16.6 years (Table 1).

Table 1. Central Indicators of the Age Variable

Variable	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Age	150	71	1	72	38.80	16.666	277.772

The majority of patients were male, with a disparity exceeding fivefold. Males accounted for 126 patients (84%) and females accounted for 24 patients (16%) of the total patient population.

The mean hospital stay duration was 19.7 days (Table 2). The highest frequency of hospitalization

was up to 16 days, and as the number of days increased, the number of patients decreased (Chart 1).

Table 2. Central Indicators of the Variable "Number of Days Hospitalized"

Variable	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Length of Hospital Stay (days)	150	82	0	82	19.70	16.168	261.393

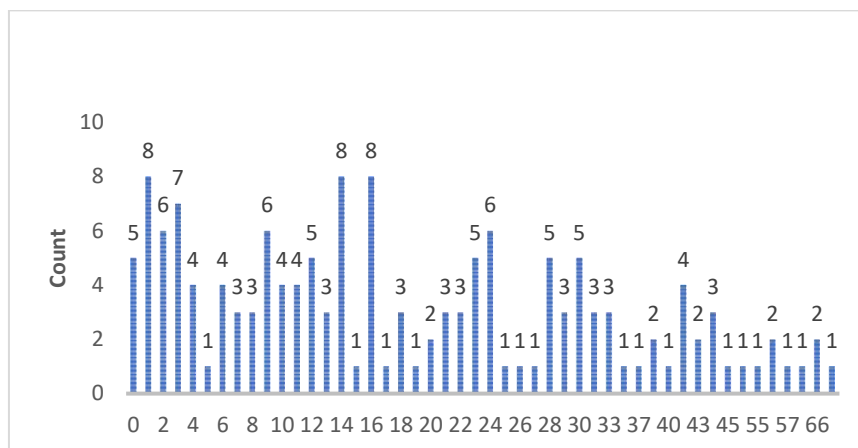


Chart 1. Frequency of Patients According to the Number of Hospitalization Days

After the specified hospitalization period, patients had three discharge statuses according to the physician's opinion, patient's consent or death. The

majority of patients (91.3%) were discharged through the normal procedure (Table 3) and all death cases were male (Chart 2).

Table 3. Frequency of Patient Discharge Status

Discharge Status	Frequency	Percentage
Recovered / Discharged	137	91.3%
Personal Satisfaction	9	6.0%
Death	4	2.7%
Total	150	100.0%

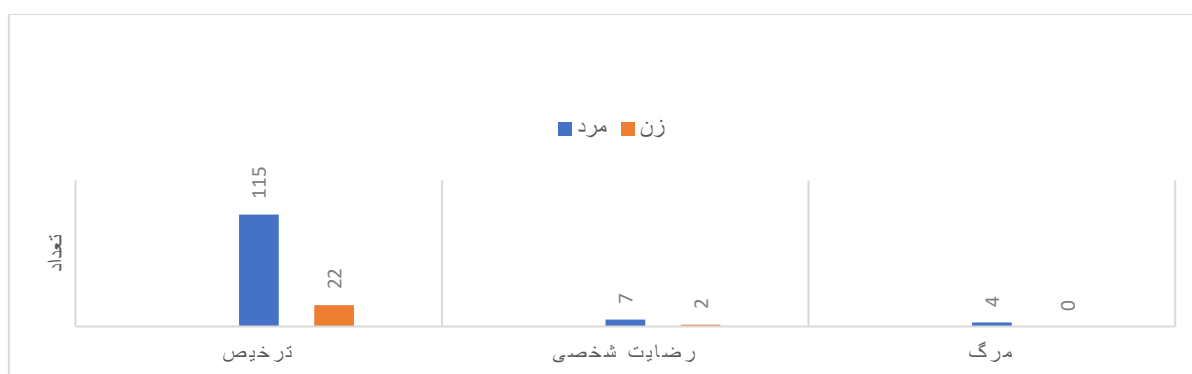


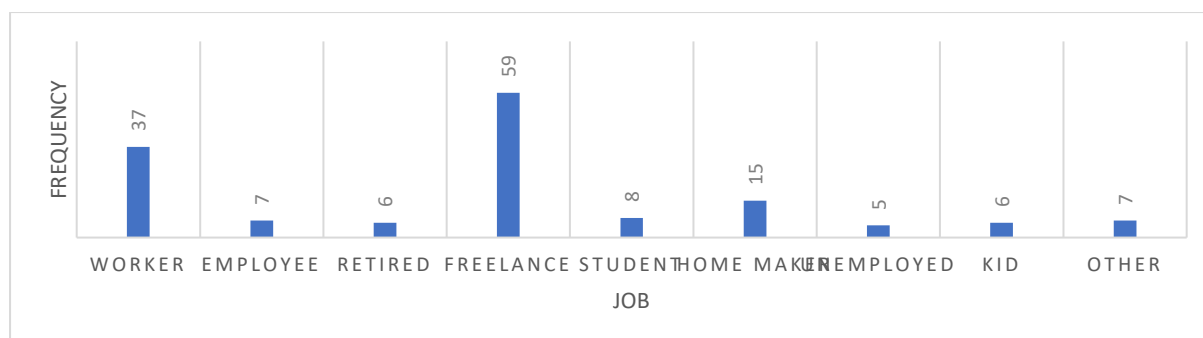
Chart 2. Frequency of Patients by Discharge Status According to Gender

The most frequent occupations among patients were self-employed (39.3%) and laborers (24.7%) while

other occupational groups each accounted for less than 10% (Table 4 and Chart 3).

Table 4. Frequency of Patients According to Occupation

Occupation	Frequency	Percentage
Worker	37	24.7%
Employee	7	4.7%
Retired	6	4.0%
Self-employed	59	39.3%
Student	8	5.3%
Housewife	15	10.0%
Unemployed	5	3.3%
Child	6	4.0%
Other	7	4.7%
Total	150	100.0%

**Chart 3.** Distribution of Patients Based on Occupation

In this study three aspects of patients' medical history and social background were examined: marital status which included 57 single patients (38%) and 93 married patients (62%); diabetes with 15 patients (10%) diagnosed; and drug addiction observed in 42 patients (28%).

In this study all patients suffered from some form of burn. Initially cases were divided into two categories: acute burns and previous complicated

burns. The majority of patients (59.3%) had acute burns. Compartment syndrome, an important complication following burns occurred in both groups. According to the center's statistics on average, one case of compartment syndrome was reported weekly (Table 5).

Table 5. Frequency Distribution of Patients Based on Burn Status

Burn Status	Frequency	Percentage
Acute Burn	89	59.3%
Previous Burn	61	40.7%
Total	150	100.0%

For cases with acute burns the percentage of burn surface area was measured. Approximately three-quarters of patients with acute burns (74.2%) had a

burn percentage of less than 20% (Table 6). The frequency trend of patients in each 10% burn

percentage group decreased as the extent of the burn increased (Chart 4).

Table 6. Frequency Distribution of Burn Percentage Among Patients with Acute Burns

Percentage of Burn in Acute Cases	Frequency	Percentage	Cumulative Percentage
0–9	44	29.3%	49.4%
10–19	22	14.7%	74.2%
20–29	11	7.3%	86.5%
30–39	7	4.7%	94.4%
40–49	5	3.3%	100.0%
Total	89	59.3%	—

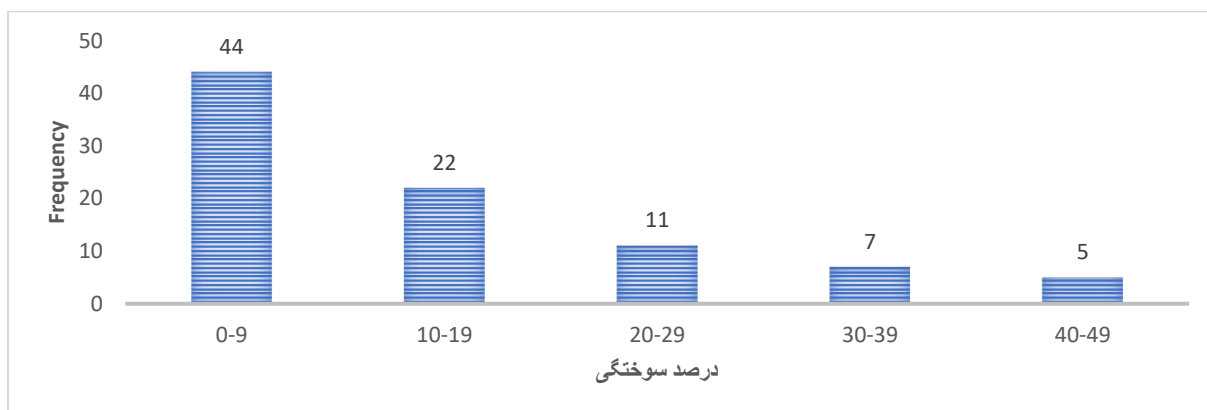


Chart 4. Frequency Distribution of Burn Percentage Among Patients with Acute Burns (in 10% Groups)

Burns were mainly comprised of second degree (1.3%) and third degree (53.3%) burns (Table 7). For only 3 patients with complicated burns, the burn

degree was determined all of whom had third degree burns (Chart 5).

Table 7. Frequency Distribution of Burn Degree

Burn Degree	Frequency	Percentage
Degree 2	2	1.3%
Degree 3	80	53.3%
Total Assessed	82	54.7%
Not Assessed	68	45.3%
Overall Total	150	100.0%

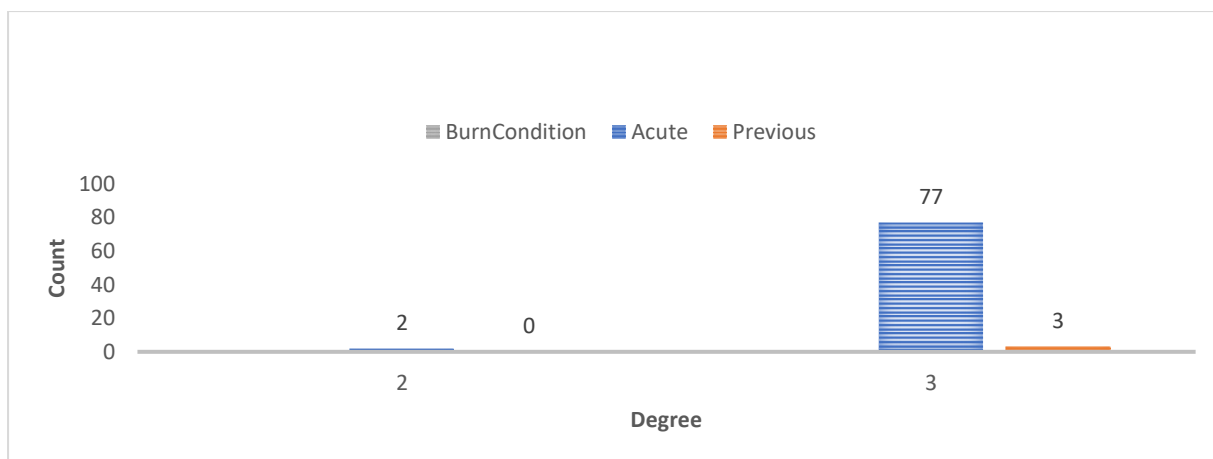


Chart 5. Distribution of Burn Degree by Initial Burn Status

In this study, 55.3% of patients had known causes of their burns of which 47.3% were due to electrical burns. Among the unknown or unspecified causes

burns caused by liquids, such as acid and boiling water were predominantly reported (Table 8).

Table 8. Frequency Distribution of Causes and Factors Leading to Burns

Cause of Burn	Frequency	Percentage	Cumulative Percentage
Electric Shock	71	47.3%	47.3%
Frostbite	1	0.7%	48.0%
Oven	5	3.3%	51.3%
Gas Cylinder	2	1.3%	52.7%
Boiling Water	1	0.7%	53.3%
Fire Flame	2	1.3%	54.7%
Natural Gas	1	0.7%	55.3%
Unknown	67	44.7%	100.0%
Total	150	100.0%	—

According to the anatomical site, burns were most commonly observed in the limbs with 52% of patients experiencing upper limb burns and 42% experiencing lower limb burns. Burns of the head

and neck were the least frequent at 8.7%. Patients had at least one limb affected by burns and some also had burns in other anatomical areas (Table 9).

Table 9. Frequency Distribution of Burn Sites Based on Anatomical Location

Burn Site	Frequency (n)	Percentage (%)
Head and Neck	13	8.7
Trunk	33	22
Upper Limbs	78	52
Lower Limbs	63	42

Amputation Information

In upper limb amputations finger level amputations accounted for the highest frequency (50%), and amputations at the finger and forearm levels together made up 89.5% of cases (Table 10). In lower limb amputations finger level amputations were also the most frequent (68.4%) and amputations at the finger

and below-knee levels together accounted for 92.1% of cases (Table 11).

In both upper and lower limbs, as the level of amputation moves proximally (closer to the body) the percentage of burn increases. Lower percentage burns below 10% showed a decreasing trend (Charts 6 and 7).

Table 10. Frequency distribution of upper limb amputation cases based on anatomical level

Level of Upper Extremity Amputation	Frequency (n)	Percentage of Total (%)	Percentage Among Upper Extremity Cases (%)	Cumulative Percentage (%)
Finger	43	28.7	50.0	50.0
Wrist	1	0.7	1.2	51.2
Forearm	34	22.7	39.5	90.7
Elbow	5	3.3	5.8	96.5
Arm	3	2.0	3.5	100.0
Total (Amputated Upper Extremity)	86	57.3	100.0	
No Upper Extremity Amputation	64	42.7		
Total	150	100.0		

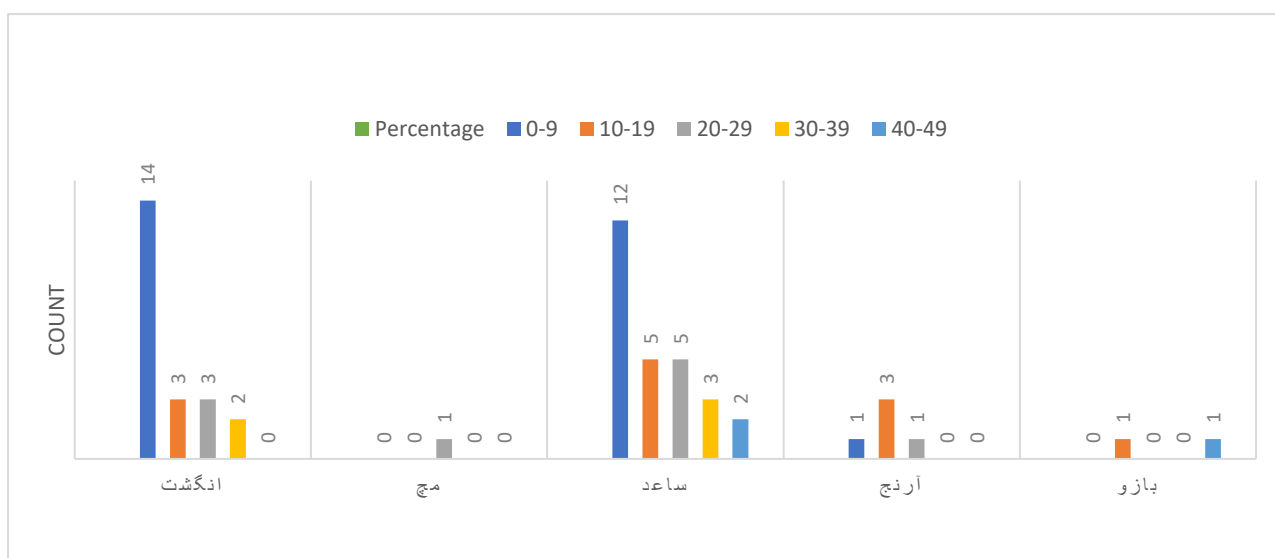


Chart 6. Distribution of Upper Limb Amputation Cases by Anatomical Level Based on Burn Percentage

Level of Lower Extremity Amputation	Frequency (n)	Percentage of Total (%)	Percentage Among Lower Extremity Cases (%)	Cumulative Percentage (%)
Toe	52	34.7	68.4	68.4
Sole	4	2.7	5.3	73.7
Heel	1	0.7	1.3	75.0
Below Knee	18	12.0	23.7	98.7
Above Knee	1	0.7	1.3	100.0

Total (Amputated Lower Extremity)	76	50.7	100.0	
No Lower Extremity Amputation	74	49.3		
Total	150	100.0		

Table 11. Frequency Distribution of Lower Limb

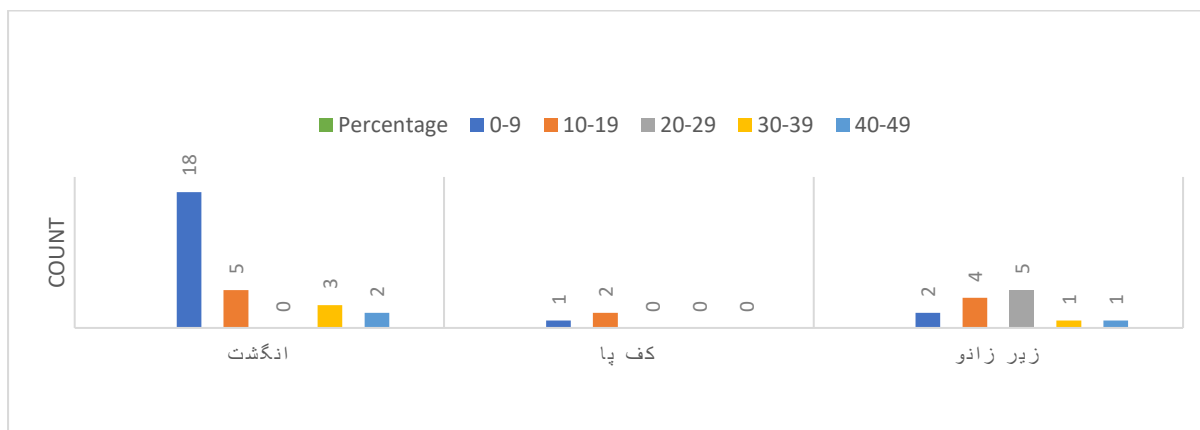


Chart 7. Distribution of Lower Limb Amputation Cases by Anatomical Level Based on Burn Percentage

Additional surgical procedures

In this study, three additional surgical procedures escharotomy, grafting and debridement may have been performed alongside amputation surgery for the patients. Each of these procedures was carried out in more than half of the patients (Table 12).

Table 12. Frequency of Additional Surgical Procedures

Frequency (%)	Frequency (n)	Intervention
56	84	Escharotomy
56.7	85	Grafting
54	81	Debridement

Analytical Analysis

The rate of amputation in men was clearly higher at 84% compared to 16% in women, indicating a greater overall risk and likelihood for this procedure in men. However, based on the chi square test results, performing amputation in upper and lower limbs did not have a statistically significant correlation with the patients' gender (P-value 0.126 and 0.159, respectively).

Regarding the relationship between amputation of the upper and lower limbs, only 12 patients (8%) underwent amputation surgery on both limbs and based on the chi square test, these two variables showed a statistically significant inverse correlation (Table 13).

Table 13. Results of Chi Square Test Between the Two Variables of Amputation in Upper and Lower Limbs

			Upper Extremity Amputation		Total	P-value	Statistic
			No	Yes			
Upper Extremity Amputation	No	Frequency (n)	0	64	64	0.00	108.69
		Percentage of Total (%)	0.0%	42.7%	42.7%		
	Yes	Frequency (n)	74	12	86		
		Percentage of Total (%)	49.3%	8.0%	57.3%		
Total	Frequency (n)	74	76	150			
	Percentage of Total (%)	49.3%	50.7%	100.0%			

Regarding the condition of burns and its relationship with amputation in limbs, amputation cases in the upper limb due to acute burns were almost twice as many as cases with complications and this association was statistically significant according to the chi square test with $P=0.045$ (Table 14).

However, in the lower limb, the situation was different; acute burn cases were 15.8% more than complicated cases, but based on $P=0.716$, this difference was not statistically significant (Table 15).

Table 14. Results of Chi Square Test Between the Two Variables of Amputation in the Upper Limb and Burn Status

			Burn Status		Total	P-value	Statistic
			Acute	Previously Complicated (Burn)			
Upper Extremity Amputation	No	Frequency (n)	32	32	64	0.045	4.03
		Percentage Within Non-Amputees	50.0%	50.0%	100.0%		
	Yes	Frequency (n)	57	29	86		
		Percentage Within Amputees	66.3%	33.7%	100.0%		
Total	Frequency (n)	89	61	150			
	Percentage of Total (%)	59.3%	40.7%	100.0%			

Table 15. Results of Chi Square Test Between the Two Variables of Amputation in the Lower Limb and Burn Status

		Burn Status			Total	P-value	Statistic
		Acute	Previously Complicated (Burn)				
Lower Extremity Amputation	No	Frequency (n)	45	29	74	0.716	0.132
		Percentage Within Non-Amputees	60.8%	39.2%	100.0%		
	Yes	Frequency (n)	44	32	76		
		Percentage Within Amputees	57.9%	42.1%	100.0%		
Total		Frequency (n)	89	61	150		
		Percentage of Total (%)	59.3%	40.7%	100.0%		

Based on the results of the independent t-test, there was no statistically significant relationship between undergoing amputation in the limbs and the percentage of burns, with P=0.311 reported for upper limb amputation and P=0.603 for lower limb amputation.

Also, regarding the relationship between amputation in the limbs and burn degree, no statistically significant association was observed. Although only 2 cases of second degree burns were evaluated, both in the lower limb resulting in amputation, and the rest of the graded cases were all third degree burns, the presence of third degree burn cases that did not

lead to amputation (30 cases in the upper limb and 40 cases in the lower limb) explains this statistic. The chi-square test results for upper limb amputation and burn degree was P=0.073 and for lower limb amputation and burn degree was P=0.162.

For diabetic patients, 86.6% underwent amputation in the lower limbs. This finding was statistically significant with P=0.003 whereas the situation was completely reversed for the upper limbs (Table 16).

Table 16. Results of Chi Square Test Between the Two Variables of Amputation in the Lower Limb and Diabetes Status

		Diabetes Mellitus		Total	P-value	Statistic	
		No	Yes				
Lower Extremity Amputation	No	Frequency (n)	72	2	74	0.003	8.642
		Percentage Within Non-Amputees	97.3%	2.7%	100.0%		
	Yes	Frequency (n)	63	13	76		
		Percentage Within Amputees	82.9%	17.1%	100.0%		
Total		Frequency (n)		15	150		

	Percentage of Total (%)		10.0%	100.0%		
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Based on the results of the chi square test, no statistically significant association was found between undergoing amputation in the limbs and having addiction, with $P=0.48$ for upper limb amputation and $P=0.642$ for lower limb amputation. In the hospital status evaluation, no statistical association was found between discharge status and any of the amputation surgeries. However, for the variable "number of days hospitalized" an independent t-test revealed a statistically significant association with undergoing lower limb amputation ($P=0.014$). Specifically, the average length of stay for patients who underwent lower limb amputation was 22.89 days compared to 16.42 days for those who did not undergo the surgery.

Discussion

This study aimed to determine cases of amputation in the upper and lower limbs at Shohada Motahari Educational and Therapeutic Center in Tehran during the years 1401 and 1402 (2022-2023). Analysis of 150 patients with a mean age of 38.8 years showed that amputation after burn injury mainly affected working age adults. This pattern aligns with burn statistics in middle-income environments. Amputation has significant socio economic consequences and is consistent with previous reports(3, 9). In patients with type 2 diabetes, lower limb amputation increases with age, particularly over 80 years(10).

In this study, 84% of the amputee patients were male and 16% were female, indicating a fivefold predominance of men. Other studies attribute this difference to men's greater exposure to occupational hazards, risky activities and differences in help seeking behavior. The importance of occupational safety and preventive programs focused on men has been emphasized(5, 11).

The average length of hospital stay in this group was 19.7 days with 91.3% discharged under routine procedures, and mortality occurred only in men. Prolonged hospitalization indicates the complexity of care and efforts to save the limb before amputation(1). According to Duan et al. (2023)(12) for extensive burns ($\geq 50\%$ TBSA), increased total burn surface area (TBSA) is associated with longer hospital stays. Abdelwahab et al. (2018)(13) identified infection rate, wound depth, TBSA percentage, and inhalation injury as factors contributing to increased hospitalization. Mortality limited to men may point to more severe mechanisms or the burden of comorbidities in this group, but the small number of deaths limits definitive conclusions.

The occupational distribution of patients mostly included free workers (39.3%) and laborers (24.7%) indicating high occupational exposure to burn risk factors, consistent with studies on electrical and thermal burns(2). The study by Başaran & Ozlu (2019)(14) identified risky behaviors, carelessness, and lack of protective equipment, especially among inexperienced workers, as factors influencing occupational burns. Additionally, Al Benna's study (2023)(15) showed that low-voltage occupational electrical burns can lead to serious complications such as finger loss and kidney failure. These findings underscore the importance of preventive measures in informal and poorly supervised workplaces.

Diabetes was observed in 15 patients (10%), with 86.6% of them having lower limb amputation ($P=0.003$). This association is attributed to neuropathy, peripheral arterial disease, and impaired wound healing, all of which increase the risk of amputation. Studies emphasize the importance of infection control and early assessment(7, 16). Drug addiction was present in 42 patients (28%), and substance use exacerbated burn severity delayed medical referral and complicated wound healing(3, 17). The high prevalence here indicates the need for burn prevention among substance users and integrated addiction services in burn care pathways. However, only 12.6% of patients with positive addiction screening receive addiction counseling(18).

Most burns (59.3%) were acute, and the majority (74.2%) involved less than 20% total body surface area (TBSA) with predominantly third-degree depth (53.3%). Deep electrical and contact burns cause localized muscle necrosis and neurovascular damage, which justifies the need for amputation even with limited cross-sectional involvement.

The incidence of compartment syndrome is notably concerning, with an average of one case per week as a serious complication in both types of burns. According to studies, new approaches such as negative pressure wound therapy combined with injection and immobilization, along with epidermal debridement and grafting, show promise in preserving limb function(19). Another study highlights that extensive burns are not always necessary for compartment syndrome to develop, it can even occur in small circumferential burns where flap surgery or amputation might be required(20).

In this study, 55.3% of patients had a known cause of burn, with 47.3% of these being electrical injuries, consistent with regional reports highlighting the primary role of electrical trauma in limb loss(21). These findings emphasize the importance of targeted interventions such as

electrical safety and protective equipment at workplaces. Burns mostly occurred in the limbs, with 52% in upper limbs and 42% in lower limbs, while the head and neck had the lowest prevalence (8.7%). Perez et al. (2021) showed a similar distribution of wounds in upper and lower limbs in war-related injuries(22). This limb distribution is associated with a higher risk of local tissue loss and the need for amputation.

Amputation of fingers in the upper extremity (50%) and toes/digits in the lower extremity (68.4%) were the most common with the majority of amputations occurring at distal levels (89.5% upper extremity, 92.1% lower extremity). This pattern is consistent with mechanisms of distal localized necrosis, which include electrical current entry points and crush or contact burns. The study by Dash et al. (2021)(23) confirmed these findings and identified localized necrosis at current entry points and electrical contact burns as the main cause of amputation. Similar patterns have also been reported in other tertiary care centers, with digit level loss following thermal and electrical injuries(11). Adjunctive procedures such as escharotomy, grafting and debridement were performed in over half of the patients undergoing amputation, indicating staged management of severe limb burns. Repeated debridement to control necrosis and infection, along with split thickness autologous skin grafting is the standard treatment during the acute phase. A repeated decision-making process balancing conservative limb salvage and definitive amputation has been emphasized. Various debridement methods, including tangential, hydro-surgical, enzymatic and shock wave techniques, have been studied, however, there is no definitive evidence supporting the superiority of any specific method(24, 25).

Although men accounted for 84% of amputations the chi square test showed no significant association between gender and amputation of the upper or lower extremity ($P = 0.126$ and 0.159 , respectively). This is likely due to greater exposure of men to injurious mechanisms rather than a specific biological susceptibility of gender to amputation, although sample size and clustering of injury causes may have limited the power to detect gender effects. Only 12 patients (8%) had amputations of both upper and lower extremities, and an inverse statistical relationship between amputations of both limbs was observed. This may be due to the rarity of mechanisms causing severe bilateral injury or the lower likelihood of survivors with multiple limb injuries undergoing surgery. Additionally, resource limitations and triage decisions in acute settings influence prioritization of limb salvage over amputation. Amputation of the upper extremity in acute burns was nearly twice as frequent as in previously complicated burns, and this difference

was statistically significant ($P=0.045$). This is likely attributable to high voltage electrical injuries and thermal contact trauma to the hands and forearms, causing rapid tissue necrosis. In contrast, there was no significant difference in lower extremity amputation between acute and complicated burns ($P = 0.716$) as the hands and upper extremities are more often the initial contact points in electrical or occupational injuries that increase the risk of severe damage. Neither TBSA burned nor burn depth (second degree versus third degree) showed a statistically significant association with amputation likely due to the small number of second degree burns and the presence of third-degree burns without amputation. Therefore, burn depth and extent alone are insufficient predictors, and injury mechanism, vascular compromise, infection, and comorbidities play important roles(5). The study by Bartley et al. (2019) similarly reported risk factors for amputation including total body surface area burned, electrical burns, Black race, and underlying comorbidities(26).

A strong association between diabetes and lower extremity amputation ($P = 0.003$) indicates the predisposition of diabetic foot ischemia to progress to non-salvageable lesions and underscores the importance of integrated diabetes care and early interventions(27). The length of hospital stay for patients with lower extremity amputation was significantly longer (mean 22.89 versus 16.42 days; $P = 0.014$) reflecting greater treatment complexity. Prolonged hospitalization increases the risk of infection and resource utilization, highlighting the need for streamlined, multidisciplinary pathways for decision making in limb salvage(28).

Conclusion

This review of upper and lower extremity amputations related to burns at Shahid Motahari Educational and Treatment Center in Tehran during 2022-2023 highlights a predominantly working-age male group with acute electrical burns as the primary cause, resulting in distal amputations often accompanied by debridement, grafting, and escharotomy. Significant associations include diabetes with lower extremity amputation, acute burns with upper extremity cases, and prolonged hospitalization for lower extremity surgeries, while gender and burn size/depth showed no statistical correlation. These findings align with global patterns in low- and middle-income settings and emphasize occupational hazards, electrical risks and comorbidities as key drivers. Preventive measures targeting high risk occupations early diabetes screening and improved electrical safety protocols are recommended to reduce amputation incidence. Future multicenter studies in Iran could examine psychological outcomes and long term quality of life

as suggested by literature on post amputation care to enhance support for community reintegration.

Study limitations

The limitations of this study should be acknowledged. Its retrospective design and single center scope restrict causal inference and generalizability. Key variables such as vascular studies, time from injury to first surgery, voltage details for electrical injuries and severity specifics of comorbidities were incompletely recorded for some patients, reducing data granularity. Small subgroup sizes (such as second degree burns, bilateral amputations) limited statistical power in these comparisons. Future prospective, multicenter studies with standardized data collection (including mechanism characteristics, vascular imaging, infection markers and timing of interventions) will improve risk modeling of amputation in burn patients.

Abbreviations

TBSA: Total Body Surface Area; STSG: Split Thickness Skin Grafts; FTSG: Full Thickness Skin Grafts.

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Ethical Approval and Consent to Participate

This study was conducted in full compliance with ethical considerations and received ethical approval from the research unit following the approval of the relevant proposal. Data were collected based on patient records, and direct consent was not required; however, the use of information adhered to ethical protocols, ensuring complete protection of patient's privacy and intellectual rights. The results are presented in aggregate form without any identifying information and all data were analyzed impartially to guarantee the validity and reliability of the findings.

Conflict of Interest

There were no financial, personal or professional conflicts of interest that could have influenced the conduct or outcomes of this study. This matter was also considered as one of the fundamental principles in conducting scientific research.

Disclosure Statement

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Authors' Contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

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