

INVESTIGATION OF HIGH-RISK AREAS OF ELECTRICAL DAMAGE IN THE PROVINCE OF TEHRAN

CARTOGRAPHIE DES ZONES À HAUT RISQUE D'ÉLECTRISATION DANS LA PROVINCE DE TÉHÉRAN

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SUMMARY. Electrical burns are an uncommon type of burn that can cause serious disabilities and mortality. This study aims to provide preventive strategies to investigate high-risk areas of electrical damage in Tehran Province. This is a descriptive cross-sectional study performed on patients with electrical burns referred to Shahid Motahari Educational and Medical Center during 2015-2017. Patients' information was collected in a researcher-made information form. In this study, information of 133 patients with electrical injury was recorded. Electrical injuries occurred mainly in the workplace (63.1%). Nearly half of the population were construction workers. The results showed that most of the electrical burn accidents in Tehran province occurred in the surrounding counties of the city of Tehran (64%). According to the results, it is suggested that preventive strategies first be implemented in high-risk areas of the province of Tehran.

Keywords: electrocution, electrical injuries, burns

RÉSUMÉ. Les brûlures électriques sont rares mais peuvent être responsables d'une mortalité élevée et de séquelles majeures. Cette étude a pour but de repérer les zones particulièrement à risque dans la province de Téhéran, afin d'y adapter la prévention. Cette étude comparative descriptive a été réalisée dans le CHU Shahid Motahari entre 2015 et 2017, au moyen d'un dossier spécifique. Cent trente-trois patients ont été ainsi sélectionnés. L'électrification survenait le plus souvent au travail (63,1%), dans le BTP pour la moitié des cas, dans les villes-banlieues de Téhéran. C'est dans cette zone que devraient se concentrer les actions de prévention.

Mots-clés : électrification, brûlure, décès

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Introduction

According to the World Health Organization, more than 7.1 million people suffered accidental burns in 2004, with a total of 110 burns per 100,000 people per year. This number was 187 burns per 100,000 people per year in the Eastern Mediterranean area. The lowest rate was 19 burns per 100,000 people per year, which took place in the United States, and the highest incidence was reported in Southeast Asia at 243 burns per 100,000 people.¹ Over the past 20 years, mortality from burns has declined in developed countries, and most victims of burn injuries survive. A study of 84 centers (two burn centers and 82 non-burn centers) in Canada from 2003 to 2013 found that mortality rates declined when there were significant improvements in the centers.² Effective prevention strategies, the establishment of improved resuscitation facilities, specialized burn care centers, early skin excision and graft techniques, and intensive care and nutritional support have all led to significant reductions in disability and burn mortality in developed countries. However, comparatively higher burn rates are continuing in developing countries and are more devastating than in developed countries.³ Burns are one of the most expensive traumas in the world due to the high cost of wound healing, and long hospitalization and rehabilitation.⁴ Studies have shown that 90% of burns occur in low-income countries.⁵ Iran is one of the countries with a high rate of burn accidents, and devastating consequences, mortality, and disabilities resulting from burn accidents.⁶ Electrical injuries have the highest rate of disability and complications in burns and are the fourth most common cause of hospitalization in burn centers. They can also cause devastating complications and long-term socio-economic effects.⁷ While the number of burns caused by electrocution is small compared to other types of burns, they lead to significant disability and mortality rates.⁸ Electrical injuries damage tissues through three different energies: electrical, mechanical and thermal.⁹ High-voltage electrocutions are often associated with the jobs of industrial workers and people working with high-voltage power lines. Conversely, accidents related to low-voltage power lines often occur in the home environment.¹⁰ The

severity of tissue damage usually depends on the voltage of electric current (low-voltage versus high-voltage), the type of current (direct or indirect), the amount of electricity, the injured part of the body, the duration of contact, the difference in resistance and the associated trauma.¹¹ The passage of electricity through the tissue causes heat generation and cellular depolarization and often leads to skin burns, deep tissue necrosis leading to fasciotomy, skin grafts, amputations, and other surgical procedures. Typically, the bones suffer the most damage and the nerves suffer the least damage from the passage of electricity.¹⁰ Due to its high resistance, bone tissue retains heat and transmits it to the muscles and periosteum, causing severe damage.¹²

Burn accidents are mostly preventable. Construction workers and electricians are the main victims of electric burns.¹³ It is estimated that about 1,500 deaths from electrocutions occur annually in the United States, with an average of one death per day among workers. The main causes of death from electrocution are cardiac and respiratory arrests that occur at the scene.¹⁴ According to occupational accident statistics in the United States, 42% of electrocution-related deaths in work-related injuries were due to exposure to overhead power lines. Construction workers accounted for 47% of all electrocution-related deaths between 1992 and 2002. Work-related accidents are the most common cause of electrical injuries in developing countries as well as countries with high economic status.¹⁵ Improper use of electricity, poor quality control and safety standards, and a lack of public awareness are some of the main causes of electrical injuries. Identifying risk factors and demographic characteristics can be effective in setting a targeted prevention program.¹⁶ The management of electrical burns faces serious obstacles and there is no specific treatment for electrical burns. Despite advances in treatment, the tendency to implement preventive programs plays a major role in controlling electrical injuries.¹⁵ Therefore, prevention of electric burns should be a priority, and preventive measures should be implemented to reduce the incidence rates.¹⁶ Standardization of electrical appliances, continuous monitoring of workers, proper use of appliances, following precautions and safety measures by placing “hazard” labels on haz-

ardous electrical appliances, restriction of non-skilled access to hazardous electrical appliances, continuing education programs for construction workers and electricians, informing the population about the dangers of improper use of electrical devices, and explaining preventive measures can all play a role in the prevention of electric burns.¹⁷ Moreover, although the true origins of the accident are not always clear,¹⁸ given the limited results of the studies conducted in the field of electric burns, construction workers are the largest victims of electrocution in Iran. This epidemiological study is the first part of a larger study that was conducted with the aim of identifying areas and people who are at a higher risk of electrical injuries in the province of Tehran. The information obtained in this study will be used to provide effective and practical solutions for preventing electrical accidents to the relevant institutions.

Materials and methods

This study is a descriptive cross-sectional study that was performed on patients with electrocution referred to Shahid Motahari Educational and Medical Center over two years from September 2015 to September 2017.

Data collection

Patient information was collected by a researcher-made information registration form which consisted of two sections: demographic information and burn-related information. The demographic section included information about age, sex, marital status, education, and previous occupation. The burn-related section included information about the cause of burn, voltage, accompanying trauma, length of hospital stay, time of occurrence, location, number and type of surgeries, amputated limbs, death, and the total cost during hospitalization, and was completed through the patients' medical records. Furthermore, information about the status of patients, including their current job, duration of return to work, disability, and basic and supplementary insurance coverage was recorded during a telephone call with the patients. This form was designed based on similar articles and was approved by the Methodology, Burn

and Plastic Surgery Department. Data entry was done by a trained questioner through medical records and telephone contact with the patient.

Data analysis

Data were extracted and analyzed by SPSSv.20 software. Mean (standard deviation) and ratio (percentage) were used to describe quantitative and qualitative data, respectively.

Ethical considerations

The plan was approved by the ethics committee of XXX [Blinded by request from JOEM] and received the ethics code IR.IUMS.REC 1396.32353. Oral consent was obtained from the patients before the interview.

Results

During the study period, the information of 133 patients with electrical injuries was recorded through medical records and telephone calls with the patient. The mean age of the patients was 31.36 ± 13.25 , and most (94.7%) were male. Most of the patients (86.3%) had a diploma or lower education and 66.1% were married.

The study of the geographical distribution of electrical injuries showed that most of the electrocution incidents in Tehran province occurred in the surrounding counties of the city of Tehran (64%) and then in the city of Tehran (36%). Among the surrounding counties, Shahriar (19%), Islamshahr (18%) and Varamin (16%) had the highest rates, respectively. The results of this study also showed that among the 22 districts of the city of Tehran, the most common districts in terms of the incidence of electrocution were districts one and four (*Figs. 1 & 2*).

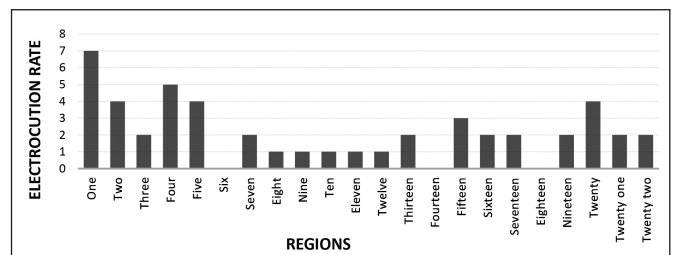


Fig. 1 - Geographical distribution of electrocutions in the 22 districts of the city of Tehran

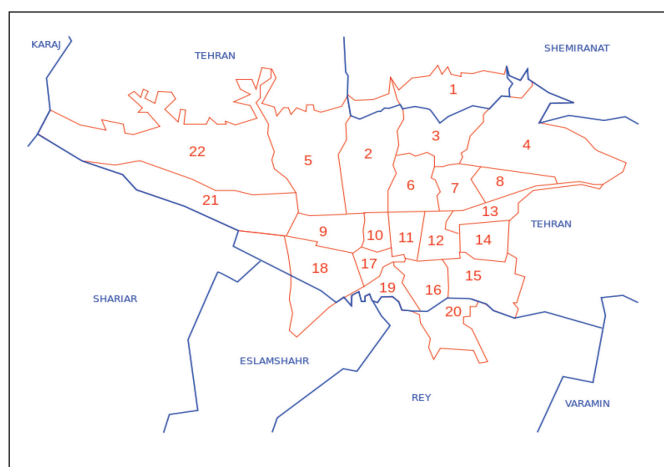


Fig. 2 - Geographical map of the counties of Tehran Province and the 22 regions of the city of Tehran

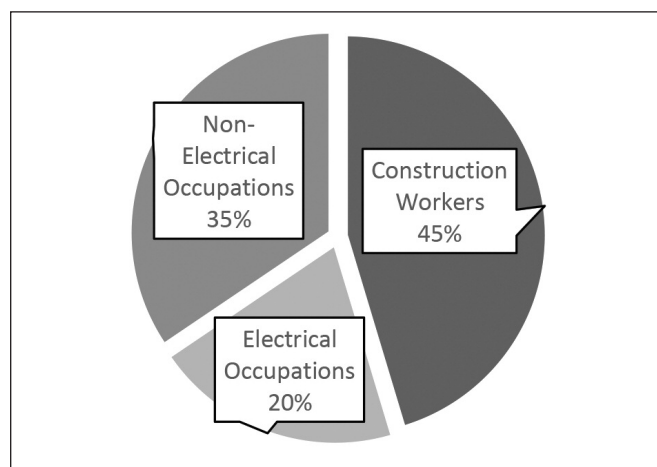


Fig. 3 - Occupational status of patients with electrical injury

The results of this study showed that electrical injuries occurred mainly in the workplace (63.1%). About half of the study population (45.4%) were construction workers and 20.2% had electricity-related jobs. Following the accident, 23.9% of the patients became disabled and only 58.1% returned to their previous job (Fig. 3).

The most common mechanism of injury was contact with overhead wires (67.9%), and the injuries were mainly caused by high-voltage electricity (73.7%). Among the patients under study, 10.5% had concomitant trauma and 21.1% had thermal burns. The average length of hospital stay was 14.59 days, and the mean cost of treatment was close to \$10,000 (USD). Furthermore, 10.5% of patients did not have

insurance coverage. Also, 3% of patients passed away and nearly 90% of patients underwent debridement at least four times and skin graft surgery twice. Moreover, about 9% of the study population needed fasciotomy. Lastly, 14.1% patients underwent amputation, which mainly involved the upper limbs (Table I). Our results showed that mortality was not associated with the age of the patients (p-value=0.501) and high-voltage electricity (p-value=0.228).

Discussion

Electrical injuries are one of the most devastating burn accidents, which, despite their low prevalence,

Table I - Quantitative variables related to electrocution and electric burns

Variables	Quantity (Percentage %)	
Cause of injury	Overhead wires	89 (67.9%)
	Underground wires	1 (0.8%)
	Home electrical appliance	4 (3.1%)
	Industrial electrical appliance	4 (3.1%)
	Wire/socket/outlet	12 (9.2%)
	Transformer/generator	1 (0.8%)
	Box/fuse/panel/electricity meter	8 (6.1%)
	Network/power post	8 (6.1%)
	Other	4 (3.1%)
	Voltage type	High-voltage
Low-voltage		35 (26.3%)
Concomitant trauma	14 (10.5%)	
Thermal burns	28 (21.1%)	
Insurance coverage	119 (89.5%)	
Death	4 (3.0%)	
Surgery type	Debridement	118 (88.7%)
	Skin grafts	59 (69.2%)
	Fasciotomy	12 (9.0%)
	Amputation	19 (14.3%)
Mean treatment cost	10,000± 2778 \$	
Mean length of hospitalization	14.59 ± 13.02 Days	

have high disability and mortality rates. This study showed that most of the patients with electrical burns were male and at a young age. These results were confirmed by other studies.^{4,11} This study, in line with studies by Elloso & Cruz and Saaiq, found that a small percentage of patients died after hospitalization, which could confirm the high mortality rates of electrocution at the scene.^{7,12}

In this study, most of the patients with electrical injuries were construction workers, followed by electrical workers, who often had an accident due to the contact of metal tools with overhead cables. Other studies in Iran reported similar results. In a retrospective study, Salehi and colleagues found that construction workers were the most common victims of electrocution. Furthermore, they also found that contact of metal devices with high-voltage wires was the most common mechanism of injury.¹⁵ In the Ghavami study, similarly, most electrical injuries occurred at work to workers and employees.¹⁷ Furthermore, based on the geographical distribution of the accident sites, the surrounding counties of the city of Tehran were the most common locations of injury. In the 22 districts of the city of Tehran, the northern and eastern regions had the highest prevalence of accidents, respectively. Due to the high activity of construction workshops in these areas and the high prevalence of electrocution among construction workers, these areas can be considered high-risk areas for electrical damage.

Electrocution injuries are associated with disability and high treatment expenses. 88% percent of the patients underwent surgery for debridement, about 70% for grafts, 9% for fasciotomy, and nearly 14% for amputation. Moreover, about 10% of them also had concomitant trauma. Patients were hospitalized for an average of 15 days and the mean cost of treatment was about 36,000,000 Toman. This is while 10% did not have insurance coverage. 23.9% of the patients became disabled following the accident and only half of the patients returned to their previous jobs. A study by Elloso & Cruz at a burn center in the Philippines found that patients were hospitalized

for 14 to 28 days, and only 2% of patients developed disabilities and needed amputations.⁷ In a study of electrocuted children in Canada between 2004 and 2009, Glatstein et al. found that out of 36 injured children, only two underwent fasciotomy and escharotomy, and none of the patients required amputation.¹⁴ These results can demonstrate the differences in the pattern and mechanism of injury in children compared to adults, and in developed countries compared to developing countries. In another study conducted from 2007 to 2011 at Shahid Motahari Hospital in Tehran, the length of hospital stay was reported to be 18.5 days.¹⁷ Comparison of the results shows that the average hospitalization length in Iran has decreased to some extent, which is probably due to the use of new methods in the treatment of burns. Due to the high cost of treatment and the irreparable disabilities caused by electrical accidents, which often occur in younger people and productive sections of society, the use of effective interventions to prevent injury seems very necessary and valuable.

Conclusion

Based on the above-mentioned results and determination of high-risk geographical areas, risk factors and identification of the target group, preventive strategies for insulation of overhead wires and cables before construction and the protection of residential areas to reduce the number of electrical injuries, in a one-year period, in high-risk areas, are proposed. The design and implementation of such programs will require the cooperation of relevant organizations, such as the Ministry of Energy, the Ministry of Urban Development, and the Ministry of Housing. After the implementation of intervention measures in high-risk areas, the epidemiological pattern of electrocution clients should be evaluated again, and the resulting changes should be determined during another study.

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