ORIGINAL ARTICLE

ปัจจัยที่ส่งผลต่อการเสียชีวิตจากการบาดเจ็บทางไฟฟ้าในพื้นที่ชนบทของประเทศไทย

Factors Affecting Mortality From Electrical Injuries in Rural Areas of Thailand

สุพจน์ ฉัตรทินกร พ.บ., ว.ว. ศัลยศาสตร์ตกแต่งและเสริมสร้าง

Suphot Chattinnakorn, M.D., Dip. Thai Board of Plastic and Reconstructive Surgery

กลุ่มงานศัลยกรรม โรงพยาบาลพระปกเกล้า จังหวัดจันทบุรี

Department of Surgery, Phrapokklao Hospital, Chanthaburi Province

Received: *September 29, 2025* **Revised:** *October 10, 2025* **Accepted:** *October 24, 2025*

บทคัดย่อ

ที่มาของปัญหา: การบาดเจ็บจากไฟฟ้าเป็นปัญหาที่สำคัญในพื้นที่ชนบทของประเทศไทย ปัญหาดังกล่าวส่งผลให้เกิดการสูญเสียทั้งต่อชีวิตและงบประมาณในการรักษาพยาบาล การทราบถึงอุบัติการณ์ ค่าใช้จ่ายทางการแพทย์และปัจจัยที่สัมพันธ์กับอัตราการเสียชีวิตจากการบาดเจ็บจากไฟฟ้าจะช่วยในการกำหนดมาตรการป้องกันในอนาคต

วัตถุประสงค์: เพื่อศึกษาปัจจัยที่ส่งผลต่อการเสียชีวิตจากการบาดเจ็บทางไฟฟ้า อุบัติการณ์ และค่าใช้จ่ายทางการแพทย์ที่เกิดขึ้นในผู้ป่วยจังหวัดจันทบุรี

วิธีการศึกษา: การศึกษานี้เป็นแบบย้อนหลัง (Retrospective cohort study) โดยเก็บข้อมูลจากเวชระเบียนผู้ป่วยที่ได้รับการวินิจฉัยการบาดเจ็บจากไฟฟ้า (ICD-10: T75.0, T75.4) และรับการรักษาตัวในโรงพยาบาลพระปกเกล้า ตั้งแต่วันที่ 1 มกราคม 2558 ถึงวันที่ 31 ธันวาคม 2567 วิเคราะห์ปัจจัยที่สัมพันธ์กับอัตราการเสียชีวิตด้วยวิธี Multivariable logistic regression

ผลการศึกษา: ผู้ป่วยที่ได้รับการวินิจฉัยการบาดเจ็บจากไฟฟ้ามีทั้งสิ้น 300 ราย เป็นเพศชาย 250 ราย (ร้อยละ 83.30) และเพศหญิง 50 ราย (ร้อยละ 16.70) อายุเฉลี่ย 31.80 ปี โดยส่วนใหญ่เกิดจากอุบัติเหตุจากการทำงาน 159 ราย (ร้อยละ 53.00) ค่ารักษาพยาบาลเฉลี่ยต่อราย 71,932.10 บาท ผู้ป่วยที่เสียชีวิต 19 ราย (ร้อยละ 6.30) ปัจจัยที่สัมพันธ์กับการเสียชีวิตอย่างมีนัยสำคัญทางสถิติ คือ พื้นที่ผิวหนังที่บาดเจ็บมากกว่าร้อยละ 40 ของพื้นที่ผิวร่างกาย (adjOR=44.74, p=0.017) ระดับ serum CPK ที่มากกว่า 1,527 U/L (adjOR=12.77, p=0.031) การรักษาตัวในหอผู้ป่วยวิกฤต (adjOR=25.71, p=0.001) การได้รับสารละลาย albumin ทางหลอดเลือด (adjOR=0.02, p=0.047) และภาวะ shock ใน 24 ชั่วโมงแรกหลังการบาดเจ็บ (adjOR=20.14, p=0.012)

สรุป: การบาดเจ็บจากไฟฟ้าในจังหวัดจันทบุรีส่วนใหญ่มีสาเหตุจากการทำงาน โดยเฉพาะเพศชายวัยกลางคนซึ่งมีอัตราการเสียชีวิตที่ร้อยละ 6.30 ค่ารักษาพยาบาลเฉลี่ยต่อราย คือ 71,932.10 บาท มีปัจจัยที่สัมพันธ์กับอัตราการเสียชีวิตอย่างมีนัยสำคัญทางสถิติคือ พื้นที่ผิวหนังที่บาดเจ็บมากกว่าร้อยละ 40 ของพื้นที่ผิวร่างกาย ระดับ serum CPK ที่มากกว่า 1,527 U/L การรักษาตัวในหอผู้ป่วยวิกฤต การได้รับสารละลาย albumin ทางหลอดเลือดและภาวะ shock ใน 24 ชั่วโมงแรกหลังการบาดเจ็บ

คำสำคัญ: การบาดเจ็บจากไฟฟ้า, ไฟฟ้าช็อต, ระบาดวิทยา อุบัติการณ์, อัตราการเสียชีวิต

Thaiclinicaltrials.org number, TCTR20250801003

ABSTRACT

BACKGROUND: Electrical injuries are a significant problem in rural areas of Thailand. These problems result in losses of both lives and medical treatment budgets. Knowledge of the incidence, medical costs, and factors associated with mortality from electrical injuries will help in determining future preventive measures.

OBJECTIVE: To study factors affecting mortality from electrical injuries, incidence, and medical costs incurred in patients in Chanthaburi Province.

METHODS: This was a Retrospective cohort study collecting data from medical records of patients diagnosed with electrical injuries (ICD-10: T75.0, T75.4) and treated at Prapokklao Hospital from 1 January 2015 to 31 December 2024. Factors associated with mortality were analysed using Multivariable logistic regression.

RESULTS: A total of 300 patients were diagnosed with electrical injuries, comprising 250 males (83.30%) and 50 females (16.70%), with a mean age of 31.80 years. The majority resulted from occupational accidents, 159 cases (53.00%). The average medical cost per case was 71,932.10 baht. Nineteen patients died (6.30%). Factors statistically significantly associated with mortality were: burn area greater than 40%TBSA (adjOR=44.74, *p*=0.017), serum CPK level greater than 1,527 U/L (Adjusted Odds Ratio 12.77, *p*=0.031), intensive care unit admission (adjOR=25.71, *p*=0.001), intravenous albumin infusion (adjOR=0.02, *p*=0.047), and shock within the first 24 hours post-injury (adjOR=20.14, *p*=0.012).

CONCLUSION: Electrical injuries in Chanthaburi Province predominantly caused by occupational accidents, particularly amongst middle-aged males, with a mortality of 6.30%. The average medical cost per case was 71,932.10 baht. Factors statistically significantly associated with mortality were: burn area greater than 40%TBSA, serum CPK level greater than 1,527 U/L, intensive care unit admission, intravenous albumin infusion, and shock within the first 24 hours post-injury.

KEYWORDS: electrical injury, electrocution, epidemiology, incidence, mortality

Thaiclinicaltrials.org number, TCTR20250801003

INTRODUCTION

Electrical injuries are a considerable public health problem particularly in rural areas with limitations of access to infrastructure and suitable security measures.[1] These injuries do not only affect victims' health, but also result in high medical costs and economic impacts on families as well as communities.[2,3]

Based on the literature review, it was found that the major causes of electrical injuries in rural areas result from several factors, i.e., occupational hazards, contact with cables with electric current, worn-out electrical equipment[4,5] and no awareness of safety.[6] Nevertheless, thus far there have been no in-depth studies providing data about current situations in the context of Thailand, particularly in rural areas. Therefore, it is urgently necessary to develop efficient prevention measures and suitable medical resource planning.

For these reasons, the objective of this study was to examine the causes of electrical injuries in Thailand, their impacts on health, the mortality, and the amount of medical costs, as well as the factors associated with the mortality of patients with electrical injury. All data obtained will be used to develop prevention guidelines and to set up efficient medical treatment systems in the near future.

METHODS

This is a Retrospective cohort study, of which the target population consisted of patients diagnosed with electrical injuries (ICD-10: T75.0, T75.4) in Chanthaburi and nearby provinces that sent those patients to Phrapokklao Hospital, Chanthaburi. Most parts of this province are the rural areas of Thailand. For the inclusion criteria, the patients must have been diagnosed with electrical injuries and admitted at Phrapokklao Hospital from 1 January 2015 to 31 December 2024. Patients whose medical records were incomplete or missing were excluded. The sample size was obtained from a pilot study through medical record review. Considering the variable "Type of electric current", it was found that 31.67 percent of patients who sustained high voltage electrical injuries survived, whilst 68.42 percent of patients who sustained high voltage electrical injuries died. A two-sided test was specified with a significance level of 0.05 and power of 0.80, with a ratio set at 14.79. The calculated sample size comprised 252 patients who sustained high voltage electrical injuries and survived, and 17 patients who sustained high voltage electrical injuries and died. Therefore, the total minimum sample size required for the study was 269 cases. Categorical data were presented as number and percentage, and differences were analysed using Chi-square test. Continuous data were presented as mean±SD, and differences were analysed using independent t-test. Factors associated with mortality were analysed using univariable logistic regression, presented as Crude Odds Ratio and 95%CI, and multivariable logistic regression, presented as Adjusted Odds Ratio and 95%CI, with $p<0.05$ considered statistically significant. All data were analysed with STATA version 18. This research was approved by the Chanthaburi Research Ethics Committee/Region 6, in compliance with Document no. (CTIREC 055/68)

RESULTS

From 1 January 2015 to 31 December 2024, there were a total of 300 patients diagnosed with electrical injuries and admitted to Phrapokklao Hospital, divided into 250 male (83.30%) and 50 female (16.70%). Their average age was 31.80 years.

Most of the patients (n=230) were Thai (76.70%), 52 were Cambodian (17.30%), 14 were Laotian (4.70%), and the remaining four were Myanmar (1.30%). The causes of injuries were divided into 141 patients from electrical appliance accidents (47.00%), 159 from occupational accidents (53.00%), and 102 from high voltage accidents (34.00%). The average burn area was 3.70% total body surface area (TBSA) (ranging from 0 to 56.00%). Length of stay was 9.5 days on average, deaths of patients were 19 (6.30%), and complications were reported by 11 patients (3.70%). A total of 53 patients were admitted to the Intensive Care Unit (ICU) (17.70%). Average medical cost per patient was 71,932.10 baht, and 98 patients underwent operations (32.70%), divided into fasciotomy 23 times, skin grafting 55 times, flap coverage 14 times, and amputation 21 times. Average level of serum creatine phosphokinase (CPK) was 5,962.50 U/L. (Table 1)

Table 1 Baseline Characteristics of the Target Population.

Baseline characteristics	Mortality (n=19)		Survival (n=281)		*p*-value
	n	(%)	n	(%)	
Gender					
Male	18.00	94.74	232.00	82.56	0.22
Female	1.00	5.26	49.00	17.44	
Age (year), mean±SD	33.42	±17.88	21.67	±16.81	0.67
Cause					
Occupational accidents	14.00	73.68	145.00	51.60	0.09
Electrical appliances	5.00	26.32	136.00	48.40	
Type of electric current					
Low voltage	6.00	31.58	192.00	68.33	0.002
High voltage	13.00	68.42	89.00	31.67	
Burn area (%TBSA) , mean±SD	11.48	±23.46	3.18	±7.59	<0.001
Level of serum CPK (U/L), mean±SD	34,345.68	±52,722.48	4,043.32	±9,742.04	<0.001
Underwent operations	3.00	15.80	95.00	33.80	0.11
Length of stay (days), mean±SD	18.79	±35.85	8.91	±16.52	0.023
Admission to ICU					
Yes	17.00	89.47	36.00	12.81	<0.001
No	2.00	10.53	245.00	87.19	
Albumin infusion					
Yes	2.00	10.53	6.00	2.14	0.09
No	17.00	89.47	275.00	97.86	
Complications					
Yes	4.00	21.05	7.00	2.49	0.003
No	15.00	78.95	274.00	97.51	
Sepsis					
Yes	3.00	15.79	2.00	0.71	0.002
No	16.00	84.21	279.00	99.29	

Table 1 Baseline Characteristics of the Target Population. (continue)

Baseline characteristics	Mortality (n=19)		Survival (n=281)		*p*-value
	n	(%)	n	(%)	
Respiratory failure					
Yes	10.00	52.63	20.00	7.12	<0.001
No	9.00	47.37	261.00	92.88	
Shock within 24 hrs after injury					
Yes	6.00	31.58	2.00	0.71	<0.001
No	13.00	68.42	279.00	99.29	
Cardiac arrest within 24 hrs after injury					
Yes	18.00	94.74	16.00	5.69	<0.001
No	1.00	5.26	265.00	94.31	

Table 2 Association between the Factors and Mortality of Patients with Electrical Injury using Univariable Logistic Regression and Multivariable Logistic Regression. (n=300)

Factors	Univariable analysis			Multivariable analysis		
	Crude OR	95%CI	*p*-value	Adjusted OR	95%CI	*p*-value
Type of electric current						
Low voltage	Reference					
High voltage	4.67	1.72-12.70	0.002	0.37	0.07-1.92	0.24
Burn area (%TBSA)						
< 40	Reference					
≥ 40	17.38	3.26-93.02	0.001	44.74	1.98-1007.49	0.017
Serum CPK more than 1,527 U/L						
No	Reference					
Yes	35.81	4.71-272.34	0.001	12.77	1.27-128.80	0.031
Length of stay(days)						
< 68	Reference					
≥ 68	8.14	1.39-47.66	0.020	1.78	0.15-21.57	0.65
Admission to ICU						
No	Reference					
Yes	57.85	12.82-260.90	<0.001	25.71	3.98-166.14	0.001
Albumin infusion						
No	Reference					
Yes	5.39	1.01-28.75	0.048	0.02	0.00-0.95	0.047
Complications						
No	Reference					
Yes	10.44	2.75-39.62	0.001	2.02	0.25-16.05	0.51

Table 2 Association between the Factors and Mortality of Patients with Electrical Injury using Univariable Logistic Regression and Multivariable Logistic Regression. (n=300) (continue)

Factors	Univariable analysis			Multivariable analysis		
	Crude OR	95%CI	*p*-value	Adjusted OR	95%CI	*p*-value
Sepsis						
No	Reference					
Yes	3.26	1.41-5.12	0.001	4.42	0.34-57.92	0.26
Respiratory failure						
No	Reference					
Yes	14.50	5.29-39.77	<0.001	0.69	0.14-3.55	0.66
Shock within 24 hrs after injury						
No	Reference					
Yes	64.38	11.83-350.39	<0.001	20.14	1.91-212.37	0.012

As seen in Table 2, it was found that the factors significantly associated with the mortality included type of electric current, burn area greater than 40%TBSA, serum CPK greater than 1,527 U/L, length of stay greater than 68 days, admission to ICU, albumin infusion, complications, sepsis, respiratory failure and shock within 24 hrs after injury

When factors associated with mortality from univariable logistic regression analysis were analysed using multivariable logistic regression, it was found that factors associated with mortality comprised burn area greater than 40%TBSA, serum CPK level greater than 1,527 U/L, intensive care unit admission, intravenous albumin infusion, and shock within the first 24 hours post-injury.

DISCUSSION

The aim of this research was to study factors affecting mortality, incidence and impact of electrical injuries in rural areas of Thailand. The target subject was the population in Chanthaburi, an eastern province with orcharding as the primary occupation. According to the results of the study, it was found that there were 300 patients with electrical injuries and admission to Phrapokklao Hospital over the last 10 years. Most of them were male, age 31.20 years on average. This conforms to previous studies, which found that most heat/electrical injuries that occurred involved middle-aged men.[7–9] Among all injured patients, the proportion of foreigners was high (23.30%) due to the large number of migrant workers. Moreover, because the territory of the province adjoins Cambodia, the proportion of Cambodian patients was also significant (17.30%). These workers might lack knowledge about self-prevention regarding electrical hazards, which could be a factor that contributed to the high proportion of incidence of electrical injuries among migrant workers. Electrical injuries were mostly caused by occupational accidents (53.00%), conforming to the studies conducted overseas, in both developed[8] and developing countries.[10–12] Regarding the type of electric current, most incidents were low voltage (66.00%). This differs from the studies from overseas, possibly because most of these studies were usually conducted at medical schools or hospitals with burn units that could treat seriously injured patients, resulting in proportions of patients with electrical injuries that were higher than those in this

study.[2,8] The average burn area was 3.70% (ranging from 0 to 56.00%), indicating that there were few severe electrical injuries. Nonetheless, the average serum CPK was 5,962.50 U/L and went up to 112 patients with serum CPK more than 1,527 U/L (37.30%), supporting the theory stating that electrical injuries frequently cause damage to deep tissues rather than the outer skin.[13]

As for the 98 patients who underwent operations, all of them received debridement at least one time. The average length of stay was 9.5 days. The number of patients requiring admission to the ICU was 53, less than those reported in previous studies.[2,8] Because of the lower number of severe injuries in this study, there were only eight patients who received albumin infusion (2.70%), and because this treatment approach at Phrapokklao Hospital requires payment, a number of patients who had financial problems could not be treated by this approach. Average medical cost per patient was 71,932.10 baht. Previously, there have been no studies conducted in Thailand that specified the medical costs of patients with electrical injuries. However, the results of this study might not be accurate due to the retrospective data collection over the last 10 years. The reported medical costs were not adjusted based on the higher inflation rates occurring each year. The deaths of 19 patients with electrical injuries were reported (6.30%), which is higher than the total mortality overseas.[10,14] This might be due to a lack of resources at Phrapokklao Hospital for treatment of these types of patients, e.g., a burn unit, advanced dressing materials, and free albumin solution for treatment. A total of 11 patients had complications (3.70%), the most common of which included pneumonia (9 patients), wound complications (5 patients), and urinary tract infection (2 patients). Five patients had sepsis (1.70%) caused by pneumonia while three patients had burn wound infection as a co-occurring symptom, conforming to the previous study stating that sepsis is a major cause of mortality in patients with burn and electrical injuries.[15]

Based on the analysis of the factors associated with mortality resulting from electrical injuries using multivariable logistic regression, it was found that the factors associated with mortality included burn area greater than 40%TBSA, serum CPK level greater than 1,527 U/L, intensive care unit admission, intravenous albumin infusion, and shock within the first 24 hours post-injury. This conforms to the previous studies which found that the burn area and levels of serum CPK were associated with severity and the mortality in patients with electrical injuries.[7,16,17] Even so, the previous study did not specify the exact level at which serum CPK started to be significantly associated with the mortality;[17] as presented in the results of this research. This study selected a serum CPK level of 1,527 U/L as the cut-off point for analysing the association with mortality at 94.70% sensitivity (95%CI 74.00-99.90), 66.50% specificity (95%CI 60.70-72.00), and a ROC area of 0.81. To clarify, the mortality of the patients with serum CPK more than 1,527 U/L was 12.77 times higher than those with serum CPK less than 1,527 U/L.

Most electrical injuries in rural areas of Eastern Thailand were caused by occupational accidents, particularly among middle-aged men, with the mortality at 6.30%. Average medical cost per patient was 71,932.10 baht. Furthermore, the factor significantly associated with the mortality were burn area greater than 40%TBSA, serum CPK level greater than 1,527 U/L, intensive care unit admission, intravenous albumin infusion, and shock within the first 24 hours post-injury.

ACKNOWLEDGEMENTS

I would like to express my gratitude to Dr Kriengsak Sirirak (MD), Dr Krit Jongjamfa (MD), and Dr Sawet Wangthammang (MD) for their permission to study the data of the patients. My sincere thanks also go to the residents of the Division of Plastic and Reconstructive Surgery at Siriraj Hospital as well as the residents of the Department of General Surgery and the interns at Phrapokklao Hospital for their extensive cooperation in the medical treatment of electrical as well as heat injuries.

FUNDING

The research received funding from the Medical Education Center, Phrapokklao Hospital.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

REFERENCES

1. Sarbazi E, Yousefi M, Khami B, Ettekal-Nafs R, Babazadeh T, Gaffari-Fam S. Epidemiology and the survival rate of burn-related injuries in Iran: a registry-based study. Ann Burns Fire Disasters 2019;32:3-9.
2. Başaran A, Gürbüz K, Özlü Ö, Demir M, Eroğlu O, Daş K. Electrical burns and complications: data of a tertiary burn center intensive care unit. Ulus Travma Acil Cerrahi Derg 2020;26:222-6.
3. Tróchez-Sanchez JP, Garcia-Perdomo HA. Electrical burn and associated factors that prolong in-patient stay in a level three burn unit. J Burn Care Res 2023;44:1241-8.
4. Chen J, Wang Y. Characteristics and risk factors for electrical burn injuries: a study based on world health organization global burn registry. Burns 2024;50:1116-21.
5. Salehi SH, Sadat Azad Y, Bagheri T, Ghadimi T, Rahbar A, Ehyaei P, et al. Epidemiology of occupational electrical injuries. J Burn Care Res 2022;43:399-402.
6. Gurbuz K, Demir M. Patterns and outcomes of high-voltage vs low-voltage pediatric electrical injuries: an 8-year retrospective analysis of a tertiary-level burn center. J Burn Care Res 2022;43:704-9.
7. Mongkornwong A, Sangthong R, Tunthanathip T, Sangkhathat S. Factors associated with in-hospital mortality in severe burn patients in Songklanagarind hospital: a retrospective study. Journal of Health Science and Medical Research 2021;39(3):191-200.
8. Schweizer R, Pedrazzi N, Klein HJ, Gentzsch T, Kim BS, Giovanoli P, et al. Risk factors for mortality and prolonged hospitalization in electric burn injuries. J Burn Care Res 2021;42:505-12.
9. Teherán AA, Ayala KP, Camero-Ramos G, Pombo LM, Mejía MC, Piñeros LG. Electrical injuries in occupational and non-occupational settings over a decade in Colombia: cross-sectional study. Clinical Epidemiology and Global Health [Internet]. 2025 [cited 2025 May 10];33:101980. Available from: https://www.sciencedirect.com/science/article/pii/S2213398425000697/pdfft?md5=3fef86168fb397a980b6fa8d69bf9f38&pid=1-s2.0-S2213398425000697-main.pdf
10. Islam MT, M Rahman, SMZ Nayeem, MF Uddin. Magnitude of electric burns at a burn center in tertiary level hospital. Bang Med J Khulna 2018;51:29-34
11. Gandhi G, Parashar A, Sharma RK. Epidemiology of electrical burns and its impact on quality of life - the developing world scenario. World J Crit Care Med 2022;11:58-69.
12. Keshavarzi A, Rahgozar Z, Mortazavi M, Dehghani A. Epidemiology, geographical distribution, and outcome analysis of patients with electrical burns referred to Shiraz Burn center, Shiraz, Iran during 2008-2019. World J Plast Surg 2022;11:102-9.
13. Gentges J, Schieche C. Electrical injuries in the emergency department: an evidence-based review. Emerg Med Pract 2018;20:1-20.
14. Mobayen M, Sadeghi M. Prevalence and related factors of electrical burns in patients referred to Iranian medical centers: a systematic review and meta-analysis. World J Plast Surg 2022;11:3-11.
15. Zhang P, Zou B, Liou YC, Huang C. The pathogenesis and diagnosis of sepsis post burn injury. Burns Trauma [Internet] 2021 [cited 2025 Sep 13];9:tkaa047. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC7901709/pdf/tkaa047.pdf
16. Tien NG, Chi LD, Lam NN. Assessment of creatine phosphokinase (CPK) changes in patients with high-voltage burns. Ann Burns Fire Disasters 2021;34:140-4.
17. Sachkov AV, Spiridonova TG, Zhirkova EA, Medvedev AV, Rogal ML. [Serum creatine phosphokinase as a predictor of upper limb amputation in electrical trauma]. Khirurgiia (Mosk) 2023;(5):47-52.