The Comparative and Comprehensive Analysis of Electrocution-Related Deaths in İzmir (2010-2012)

İzmir'de (2010-2012) Meydana Gelen Elektrik Çarpmasına Bağlı Ölümlerin Karşılaştırmalı ve Kapsamlı Analizi

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ABSTRACT Objective: Electrocution continues to be a serious health and medico-legal problem in Turkey and other developing countries. We have aimed to define regional data and preventive measures for electrocution-related deaths (ERDs), and to review international and national literature. **Material and Methods:** We retrospectively reviewed autopsy reports, the crime scene investigation data and knowledge obtained from eyewitnesses for ERDs between 1 January 2010 and 31 December 2012 of the Izmir Morgue Department. **Results:** 83 cases were evaluated. 95.2% of them were males. The manner of death was accident in 98.8% of cases, and suicide in one case. Majority of accidents were occupational (65.1%). Of all ERDs, 79.9% were dead on arrival at hospital. 43.9% of deaths occurred in the summer. Low-voltage current was involved in 74.7% and high-voltage in 25.3% of the cases. Electrical lesions were seen in 81% of cases and majority of them (59.3%) was located on the upper limbs. **Conclusion:** Many of the accidental ERDs in this study were readily preventable with improve of workplace safety inspections and installation of home security inspection in addition to training activities. We think that the efforts for preventing of occupational and domestic accidents will be prevent many fatal electrocutions at the same time.

Key Words: Electric injuries; autopsy; burns, electric; death; prevention&control

ÖZET Amaç: Elektrik çarpmaları Türkiye'de ve diğer gelişmekte olan ülkelerde ciddi bir sağlık sorunu ve adli tıbbi problem olmaya devam etmektedir. Bu çalışmada, elektrik çarpmasına bağlı ölümler (EÇBÖ) için bölgesel verileri ve önleyici tedbirleri tanımlamayı ve uluslararası ve ulusal literatürü gözden geçirmeyi amaçladık. **Gereç ve Yöntemler:** Bu çalışmada, 1 Ocak 2010 ve 31 Aralık 2012 tarihleri arasında İzmir Morg İhtisas Dairesi'nde otopsi uygulanmış olgulara ait otopsi raporlarını, olay yeri inceleme verilerini ve görgü şahitlerinden elde edilmiş bilgileri retrospektif olarak gözden geçirdik. **Bulgular:** 83 olgu değerlendirildi. Onların %95,2'si erkekti. Olayın orijini olguların %98,8'inde kaza ve bir olguda intihar idi. Kazaların büyük çoğu (%65,1), iş kazalarına bağlı idi. Tüm EÇBÖ'lerin, %79,9'u hastaneye ölü duhul etmişti. EÇBÖ'lerin %43,9'u yaz aylarında meydana gelmişti. Olguların %74,7'i düşük voltajlı akımlara, %25,3'ü yüksek voltajlı akımlara maruz kalmıştı. Elektrik akımı lezyonları olguların %81'inde görülmüştü ve onların çoğu (%59,3) üst ekstremitelere yerleşmişti. **Sonuç:** Bu çalışmada yer alan kaza ile ilişkili EÇBÖ'lerin çoğu, eğitim faaliyetlerine ek olarak, iş yeri güvenlik denetimlerinin arttırılması ve ev güvenlik denetimlerinin kurulması ile kolayca önlenebilirdi. Biz, iş ve ev kazalarının önlenmesine yönelik çabaların, aynı zamanda pek çok elektrik çarpması olayına engel olacağını düşünüyoruz.

Anahtar Kelimeler: Elektrik yaralanmaları; otopsi; yanıklar, elektrik; ölüm; önleme ve kontrol

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Electricity is an essential part of the daily life of modern society.[1] Despite the widespread use of electricity, electrocution-related deaths (ERDs) are not as common as expected, in relation to extensive legislation to

ensure electrical safety, in developed countries.[2,3] On the other hand, electrocution has been a problem in terms of health and socio- economics with devastating complications and long-term socioeconomic impact, and the rate of morbidity and mortality is still high in the developing countries.[1,4-6]

It is reported that injuries due to electrocutions are 4-7% of all admissions to burn centers; people more than 5000 visit annually the emergency departments in the United States.[7,8] In Canada, the annually incidence of electrocution-related injuries was reported to be 0.24 per 100 000 population, whilst the average incidence rate of non-fatal childhood electrocution was reported to be 53.2 per 100 000 population-year in Bangladesh.[4,9]

In various studies which reported from several countries and Turkey, various indicators about mortality rates of ERDs are still observed very high as much as cannot be ignored. These indicators are considered in detail in the discussion section of this study.[1-3,5-7,10-22]

In the ERDs, diagnosis of cause and manner of death is very important in criminal and compensation cases. Additionally, these provide extremely important clues for preventive measures in the occupational, environmental and domestic accidents.

In this study we aimed: to define regional data and preventive measures for ERDs, and to review international and national literature.

MATERIAL AND METHODS

This retrospective study includes the reports of medico-legal deaths which were autopsied according to public prosecutor request at Morgue Department of the Council of Forensic Medicine, Izmir, Turkey. The causes of death of 83 cases (1.34%), among 6,175 medico-legal autopsies performed during the period of 1 January 2010 and 31 December 2012 (three years), were defined to be ERDs. These 83 cases were accepted to be subjects of this study.

The population of Izmir was 4.005.459 according to Turkish Population Statistics-2012 *(http://www.tuik.gov.tr/PreIstatistikTablo.do?istab_id=1590)*.

In this study, retrospective data were collected from the autopsy reports, and hospital records, crime scene investigation data and knowledge obtained from eyewitnesses were reviewed for type of voltage and additional information.

The cases were evaluated according to age, gender, the duration of hospitalization before death, the manner of death, place and season of electrocution, voltage type of electric current responsible for the deaths, rate of electrical burns and/or current marks, body region distribution, existence of associate traumas, and potential risk factors for fatal injury.

Most of electricity supplies in Turkey use 110–380 volts (usually, 220 V, 50 Hz) so that this is classified as low voltage (50-1000 V) and high voltage (>1000 V).[18] In this article, these criteria were used to determine the type of voltage.

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All statistical analysis was performed with the use of the SPSS-15 computer program. The Mann-Whitney test was used for comparison of continuous data, and the χ^2 test was used for comparison of noncontinuous data. A "p" value less than 0.05 was considered statistically significant.

RESULTS

3-year study period between 1 January 2010 and 31 December 2012, there were 83 ERDs. The cases represented approximately 1.34% of all medico-legal autopsy cases performed in the Morgue Department of the Council of Forensic Medicine, Izmir. In this series, the average annual number of ERDs was 27.67 and average annual incidence of ERDs per 100,000 populations was 0.69.

The evaluation of 83 ERDs, with ages ranging from 1 to 80 years with a mean age of 33.4±15.2 years, showed that the vast majority (n=79; 95.2%) were male (p=0.000). Most of victims (n=20; 24.1%)

were aged 31-40 years (p=0.000) and almost half of them were aged between 21 and 40 years (n=39; 47%) (Figure 1).

Of all ERDs, 66 (79.9%) were dead on arrival at hospital, 11 (13.3%) died during treatment within 24 hours, 6 (7.2%) died during treatment after 24 hours (p=0.000). In this series, the longest period of hospitalization after the electrocution was 38 hours.

Out of ERDs, 54 (65.1%) were occupational accidents, 19 (22.9%) were home accidents and 9 (10.8%) were environmental accidents. Suicide was responsible for only one death (1.2%) and no homicide was identified (p=0.000).

Occupational electrocutions were the most common among the employees in electrical services (n=15; 27.8%) (p>0.1), followed by industrial settings (n=13; 24.1%), construction (n=10; 18.5%), agricultural or horticultural activities (n=8; 14.8%), cleaning services (n=4; 7.4%), navigation (n=2; 3.8%), roofing (n=1; 1.8%) and mining (n=1; 1.8%)(p=0.000).

Majority of the home accidents (n=13; 68.4%) occurred in the indoor areas of home (p=0.108), including two cases during repairs and thirteen cases during daily activities. Out of 6 ERDs occurred in the outdoor areas, 3 were injured during repairs on the roofs of homes; 3 were injured during the activities in the gardens.

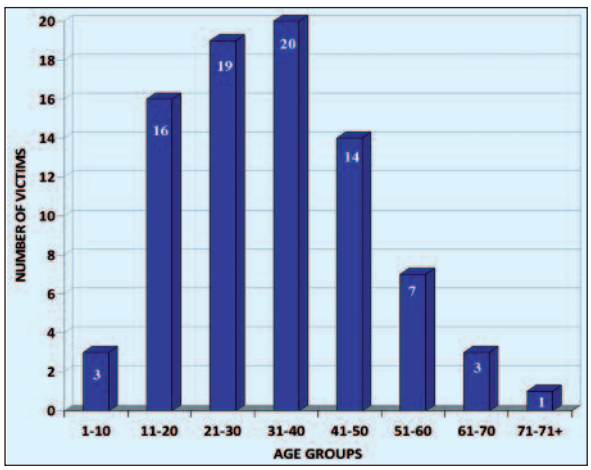

FIGURE 1: The distribution of victims according to age groups.

Among environmental accidents, four deaths (44.5%) were due to the lightning shock. Two victims (22.2%) exposed to the electrical shock from power line fell down the ground in the street. Two victims (22.2%) were injured while stealing power lines. One case (11.1%) was injured due to electrocution from electrical pole (p=0.550).

Considering the contact details of 79 ERDs except for lightning strikes, deaths were caused most frequently by touching electrical wires (n=45, 57.0%), followed by touching electrical cables (n=7; 8.9%), electrical poles (n=6; 7.6%), transformers (n=2; 2.5%), dynamo at workplace (n=2; 2.5%), electrical outlets (n=2; 2.5%), when replacing bulbs (n=2; 2.5%). Thirteen cases (16.5%) injured by touching electrical devices (2 electrical washing machines, 2 power saws, 2 hair-dryers, 2 refrigerators, 1 electrical water heater, 1 elevator, 1 vacuum cleaner, 1 ventilator, 1 milking machine) (p=0.000).

The majority of all ERDs occurred in the summer (n=36; 43.9%) (p=0.000), especially in June (n=14; 17.1%) (p=0.002) (Figure 2).

Voltage of electrical current could not be defined in four cases due to deficiency of the crime scene investigation data. Four cases had died due to the lightning shock. The rest 75 cases were evaluated according to voltage of electrical current. It was observed that low-voltage current (50–1000 V) was involved in 74.7% (n=56) and high-voltage current (>1000 V) in 25.3% (n=19) of the cases (p=0.000).

The electrocution lesions were verified in 68 cases (81.0%). The classification of them according to voltage of electrical current and type of electrocution lesions are presented at Table 1. Fifteen victims lacking electrical burns in the low-voltage group were found in a wet environment or had had wet extremities.

There were more than one electrocution lesion in some victims, and more than one body parts were involved in some cases. When body parts were divided into six areas as head and neck, chest, abdomen and gluteus, upper limbs, lower limbs, genitals; it was observed that 59.3% of electrical lesions were located on the upper limbs (in espe-

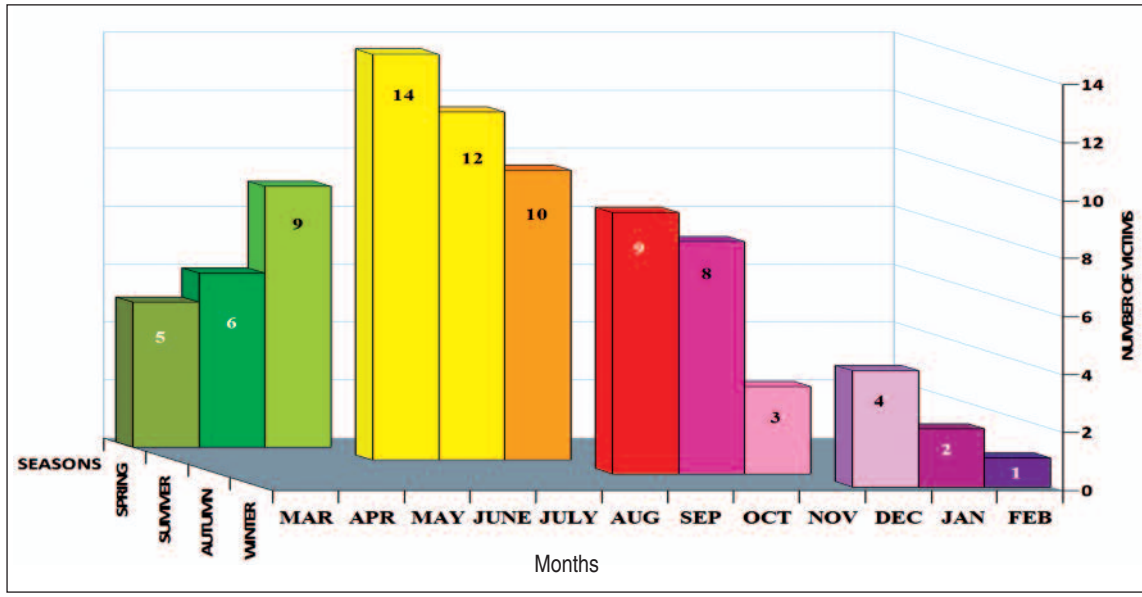

FIGURE 2: The distribution of victims according to seasons and months.

TABLE 1: The classification of electrocution lesions according to voltage of electrical current and their types.

Lesion	Low n (%)	High n (%)	Undetermined n (%)	Lightning n (%)	Total n (%)
Contact Lesions	38* (67.9)	7* (36.8)	0	0	45 (54.2)
Arching Burns	0	2*(10.6)	0	0	2 (2.4)
Non-Specific Burns	7 (12.5)	10 (52.6)	2 (50.0)	2** (50.0)	21 (25.3)
No Electrical Lesions	11 (19.6)	0	2 (50.0)	2 (50.0)	15 (18.1)
Total	56 (100.0)	19 (100.0)	4 (100.0)	4 (100.0)	83 (100.0)

p=0.000.

*Non-specific burns in the some of these cases were ignored in this table; ** One of lightning-shock cases showed the characteristic fern pattern at the skin of the chest and abdomen).

cially, on hands (43.5%)), 26.1% on the lower limbs (in especially, on feet (13.2%)), 7.1% on the chest, and 4.4% on the abdomen and gluteus and 3.1% on head and neck. No genital lesion was identified (p=0.000) (Figure 3). Nineteen (42.2%) of contact lesions which were macroscopically determined were confirmed histomorphologically. External and/or visceral petechial hemorrhages were defined in 23 (27.7%) of the cases.

In 9 cases (10.8%), there were the findings of the multiple traumas due to falls during the electrocution. Traces of hesitation which were formed with a cutting tool were observed in the forepart of the left wrist in the suicidal case.

In toxicological analysis, ethyl alcohol was determined in 3 cases (3.6%) (range: 44-54 mg/dL);

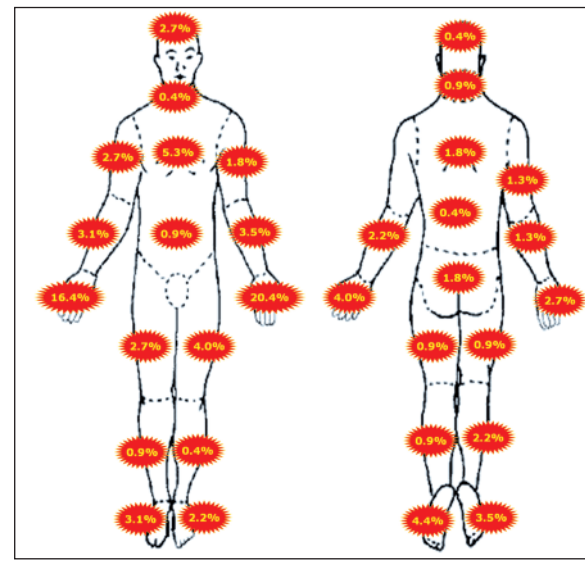

FIGURE 3: The distribution of electrical burns and/or current marks according to body regions.

delta9-tetrahydrocannabinol (THC) in blood of one victim (104 ng/mL) and in urine of one another victim.

DISCUSSION

Electrocution continues to be a serious health and medico-legal problem in our ceuntry and other developing countries.[1,4,5,18] In this study, the average annual number of ERDs (27.67) was found as higher than almost all of previous studies (ranged from 0.46 to 25.5), except for study in Tehran (59.0).[1-3,5-7,10-22] The average annual incidence of ERDs per 100 000 populations was 0.69 and the average annual rate of ERDs among all autopsy cases was 1.34%. In previous studies, the average annual incidence per 100 000 population ranged from 0.17 to 4.4 and average annual rate ranged from 0.1% to 2.02% (Table 2).[1,2,7,11,13-15,18,19,21,22] In another study performed in Izmir between 1983-1992, the average annual rate of ERDs among all autopsy cases was reported as 1.84.[23] This proportional change can be considered as a sign of the trend of a decline in ERDs in Izmir. Nonetheless, the rate of ERDs is higher than many cities in Turkey. We think that, the diversity and sheer number of workspaces of industrial, agricultural and transport sectors (Izmir port etc.) in Izmir are causes of high rate of work-related accidents, such as electrocutions, at the same time.

Our study has demonstrated a significantly higher rate of ERDs in males (n=79; 95.2%) compared with females (n=4; 4.8%) (p=0.000). In previous studies which were performed in several countries and several cities of Turkey, the rate of male electrocutions ranged from 62.5% to 100% (more than 90% in 10 of 24 studies).[1-7,9-25] The reason for such a marked male predominance in a variety of studies from different communities was explained with the fact that males were more likely to use a variety of electrical equipment in the work and domestic environment.[3,14]

According to several studies, the mean ages of the victims ranged from 20.7 to 49.2, and most of the victims accumulated between the age of 20 and 50 years.[1-3,5-7,9-16,19-22] In the present study, the mean age of victims was found 33.4. The majority of victims were aged between 31 and 40 years (p=0.000) and almost half of the victims accumulated between the age of 21 and 40 years (n=39; 47%). People in this age group are active in workplaces and in social life, and they are susceptible to exposure to electrical shock.

In the present study, 79.5% of cases were dead on arrival at hospital (p=0.000). This rate was defined as 67.5% in study of Akcan et al., 82.1% in study of Tirasci et al., 88% in study of Shaha et al., 91.9% in study of Bailey et al., 92.6% in study of Sheikhazadi et al., 96.07% in study of Gupta et al., and 98% in study of Rautji et al.[1,7,13,15,16,18,20] This was accepted as an indicator of mortality in the electrical shocks.[14] Electrocution causes death as a result of asystole, ventricular fibrillation or respiratory arrest secondary to titanic contraction of respiratory muscles, or damage to central respiratory control due to one or combination of electric shock, burn injuries caused by arc light and injuries caused by falls from a height due to electric shock.[17,18,26,27] As a consequence, death usually occurs instantly at the crime scene or in ambulances during transport.[18]

In the majority of ERDs, the manner of death is reported as accident; suicides are rare (from 0 to 29.2%) and homicides are extremely rare (from 0 to 5.4%) in the literature (Table 2).[1-3,5-7,10-22] Additionally, there were few case reports about suicidal electrocution and few case reports about accidental fatal electrocutions during autoerotic practice in the literature.[28-38] In the present study, the rates were found as 98.8% for accidents and 1.2% for suicides (p=0.000). No homicide and accidental autoerotic death were identified.

It was reported that, majority of accidental electrocutions occur in the homes and workplaces[19] (Table 2). Additionally, the rates of electrocution were reported 1.5% among all occupational accidents, 1.1% among all domestic accidents, from 5.2% to 14.6% among work-related deaths, and 4.8% among home-related deaths.[39-43] In the present study, the rates were found as 65.1% for occupational accidents, 22.9%

TABLE 2: Averages for elekctrocution-related deaths (ERDs), manner of electrocutions, type of accidental electrocutions and type of voltage in electrocutions from various countries (white region) and Turkey (gray region).

				Averages			Manner of electrocution				Type of accidental electrocutions				Type of voltage in electrocutions		
Reference Number	City or District/ Country	Study Period	Number of Cases	Average Annual Number of ERDs	Average Annual Incidence of ERDs per 100,000 Population	Average Annual Rate of ERDs Among all Autopsy Cases (%)	The rate of accidents n (%)	The rate of suicides n (%)	The rate of homicides n (%)	No identified	Occupa-tional Accidents n (%)	Domestic Accidents n (%)	Environ-mental Accidents n (%)	No identified	Low Voltage n (%)	High Voltage n (%)	No identified
1	Tehran/ Iran	2002-2006 (5 years)	295	59.00	0.70	0.60	285 (96.6%)	10 (3.4%)	0	0	188 (66.0%)	75 (26.3%)	22 (7.7%)	0	295 (100.0%)	0	0
2	Northern Ireland	1982-2003 (22 years)	59	2.68	0.17	Undefined	50 (84.7%)	9 (15.3%)	0	0	29 (58.0%)	19 (39.0%)	2 (4.0%)	0	26 (54.2%)	22 (45.8%)	11*
3	Adelaide/ Australia	1973-2002 (30 years)	96 Adults	3.20	Undefined	Undefined	66 (68.8%)	28 (29.2%)	2 (2.0%)	0	Undefined	Undefined	Undefined	Undefined	80 (84.2%)	15 (15.8%)	1
5	8 districts of the Republic of Bulgaria	1965-2006 (41 years)	291**	7.10	Undefined	Undefined	256 (88.0%)	17 (5.8%)	0	18 (6.2%)	113 (44.2%)	114 (44.5%)	29 (11.3%)	0	0	291** (100.0%)	0
6	8 districts of the Republic of Bulgaria	1965-2006 (41 years)	351***	8.56	Undefined	Undefined	322 (91.7%)	26 (7.4%)	0	3 (0.9%)	47 (14.6%)	274 (85.1%)	1 (0.3%)	0	351*** (100.0%)	0	0
7	Quebec/ Canada	1987-1992 (6 years)	124	20.70	Undefined	0.10 - 0.40	113 (91.1%)	11 (8.9.0%)	0	0	61 (54.0%)	25 (22.1%)	27 (23.9%)	0	Undefined	Undefined	Undefined
10	Munster/ Germany	1972-1997 (27 years)	37	1.37	Undefined	Undefined	25 (67.6%)	10 (27.0%)	2 (5.4%)	0	11 (44.0%)	10 (40.0%)	4 (16.0%)	0	12 (33.3%)	24 (66.7%)	1*
11	Zagreb County/ Croatia	1991-2010 (20 years)	89	4.45	0.36	Undefined	74 (83.1%)	12 (13.5%)	0	3 (3.4%)	22 (25.0%)	66 (75.0%)	0	1*	67 (78.8%)	18 (21.2%)	4*
12	Gauteng/ South Africa	2001-2004 (5 years)	126	25.20	Undefined	Undefined	123 (97.6%)	3 (2.4%)	0	0	Undefined	Undefined	Undefined	Undefined	91 (72.2%)	35 (27.8%)	0
13	Gujarat/ India	2004-2008 (5 years)	102	20.40	4.40	2.02	101 (99.0%)	1 (1.0%)	0	0	7 (6.9%)	75 (73.5%)	19 (19.6%)	0	Undefined	Undefined	Undefined
14	Lucknow/ India	2008-2012 (5 years)	83	16.60	0.40	0.40	71 (85.6%)	12 (14.4%)	0	0	49 (69.0%)	19 (26.8%)	3 (4.2%)	0	Undefined	Undefined	Undefined
15	South Delhi/India	1996-2001 (6 years)	153	25.50	Undefined	1.98	152 (99.3%)	1 (0.7%)	0	0	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined

continued→

TABLE 2: *Continued.*

				Averages			Manner of electrocution				Type of accidental electrocutions				Type of voltage in electrocutions		
Reference Number	City or District/ Country	Study Period	Number of Cases	Average Annual Number of ERDs	Average Annual Incidence of ERDs per 100,000 Population	Average Annual Rate of ERDs Among all Autopsy Cases (%)	The rate of accidents n (%)	The rate of suicides n (%)	The rate of homicides n (%)	No identified	Occupational Accidents n (%)	Domestic Accidents n (%)	Environmental Accidents n (%)	No identified	Low Voltage n (%)	High Voltage n (%)	No identified
16	Coimbatore/ India	2002-2006 (5 years)	118	23.60	Undefined	Undefined	118 (100.0%)	0	0	0	16 (13.6%)	73 (61.9%)	29 (24.5%)	0	98 (83.1%)	20 (16.9%)	0
17	Adelaide/ Australia	1967-2001 (35 years)	16 Children	0.46	Undefined	Undefined	15 (93.8%)	1 (6.2%)	0	0	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined
18	Adana/ Turkey	1999-2004 (6 years)	37 Children	6.17	Undefined	0.80	37 (100.0%)	0	0	0	8 (22.9%)	19 (54.2%)	8 (22.9%)	1*	34 (91.9%)	3 (8.1%)	0
19	Ankara/ Turkey	2002-2006 (5 years)	39	7.80	Undefined	0.86	38 (97.4%)	1 (2.6%)	0	0	20 (51.3%)	13 (33.3%)	6 (15.4%)	0	34 (87.2%)	5 (12.8%)	0
20	Diyarbakır/ Turkey	1996-2002 (7 years)	123	17.57	Undefined	Undefined	123 (100.0%)	0	0	0	30 (24.4%)	56 (45.5%)	37 (30.1%)	0	Undefined	Undefined	Undefined
21	Bursa/ Turkey	1996-2003 (8 years)	63	7.88	Undefined	1.49	63 (100.0%)	0	0	0	40** (76.9%)	10** (19.2%)	2** (3.9%)	11*	46 (73.0%)	17 (27.0%)	0
22	Sivas/ Turkey (Serie-1)	1996-2000 (5 years)	15	3.00	Undefined	1.98	15 (100.0%)	0	0	0	8 (53.3%)	4 (26.7%)	3 (20.0%)	0	Undefined	Undefined	Undefined
22	Sivas/ Turkey (Serie-2)	1996-2000 (5 years)	27	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	13 (48.2%)	4 (14.8%)	10 (37.0%)	0	11 (40.8%)	16 (59.2%)	0

* Unidentified cases were not included in percentage calculations,
** This series was related only high voltage electrocutions,
*** This series was related only low voltage electrocutions.

for domestic accidents and 10.8% for environmental accidents (p=0.000).

When assessed of occurrence of all electrocutions, we saw that majority of ERDs could be preventable. However it was reported that mostly electrocutions caused by carelessness, misuse or improper maintenance of equipment, and majority of workers and their employers did not recognize the importance of safety training and implementing safe practices.[1,7,18,44] Cawley and Homce reported that most fatal electrical incidents in the workplaces fall into one of five categories: (a) installation and maintenance not involving power lines; (b) incidental contact of an overhead power line with a handheld object; (c) incidental contact of an overhead power line through mobile equipment; (d) incidental contact with energized circuits other than overhead or buried power lines; and (e) power line installation and maintenance work.[41] Chi et al. reported that, inexperienced workers working smaller companies were more exposed fatal electrocutions due to improperly installed or damaged equipments.[42] They stated that, 1) welding workers should be provided with protective shields, protective barriers, or insulating materials to prevent inadvertent contacts with exposed energized parts for preventing improperly installed and damaged equipment injuries; 2) efficient but risky procedures such as moving on top of metal ladders and improper installations of equipment groundings should be discouraged and forbidden; 3) daily inspections of power tools and equipments, electrical maintenance programs, and GFCIs must be implemented by the company and applied by the workers. It is attractive that ¼ of victims who exposed to occupational electrocutions in the present study were employees in the electrical services. In Asirdizer et al.[43] reported that, unprotected electrical outlets and electrical wires are important risk factors for home accidents.[43] Also, in our study, majority of the home accidents (n=13; 68.4%) occurred in the indoor areas of home (p=0.108) and majority of electrocutions were caused by touching electrical wires (n=45, 57.0%) (p=0.000).

Sometimes, authors encounter with the different types of accidents. However, two cases in our series, eight cases in Iran, 29 cases and one case in Bulgaria, and eight cases in United States were exposed to electrocution during theft from electric utilities.[1,5,6,45]

In the literature, it was defined that most of electrocutions occurred in summer months (from 32.6% to 66.1%) (Table 3).[1-3,5,6,9,11-16,19-22] Also, the majority of ERDs occurred in the summer (n=36; 43.9%) (p=0.000), especially in June (n=14; 17.1%) in the present study (p=0.002). The reason for the increase of ERDs in summer was explained with the increase in construction activities and other activities, the decrease of skin resistance in parallel of the increase in sweating, heavy boots and clothing in relation to the temperature rise.[21,22,44]

In the present study, the voltage of electrical current could not be defined in four cases due to deficiency of the crime scene investigation data. Additionally lightning occurred in the four cases. Seventy-four point seven percent of the rest cases were low voltage (p=0.000). This data is compatible with other studies where low voltage electrocutions ranged from 33.3 to 100% (Table 2).[1-3,5,6,10-12,16,18,19,21,22]

In electrocution related injuries and deaths, cause of death and tissue damage on the body are affected from several factors: 1) whether electrical circuit is completed or not, 2) electrical current voltage 3) type of electrical current [alternative current (AC), direct current (DR)], 4) the electrical current intensity (amperage), 5) the route of passing the electrical current from the tissues, 6) the period of passing the electrical current from the tissues, 7) the electrical current resistance of tissues.[45] The external appearance of the electrical wound is associated with the localization of the wound, the width of the body region in contact with electrical current and the amount of electrical current which transmitted to the tissues. The most important obstacle for electric current in the body is the skin that it is more resistant than the internal tissues. Keratin-rich regions of the skin such as foot sole are more resistant to electricity.[11,46] Exposure to electric current may cause a variety of skin injuries ranging from local erythema to severe burns;

TABLE 3: Distribution of electrocutions according to seasons.

Reference Number	City or District/Country	Number of Accidental Cases	Spring n= (%)	Summer * n= (%)	Autumn n= (%)	Winter n= (%)
1	Tehran/Iran	295	56 (19.0%)	119 (40.3%)	72 (24.4%)	48 (16.3%)
2	Northern Ireland	51	11 (21.6%)	20 (39.2%)	11 (21.6%)	9 (17.6%)
3	Adelaide/Australia	96 Adults	27 (28.1%)	32 (33.3%)	24 (25.0%)	13 (13.6%)
5	8 districts of the Republic of Bulgaria	256	Undefined	175 (60.1%)	Undefined	Undefined
6	8 districts of the Republic of Bulgaria	322	Undefined	232 (66.1%)	Undefined	Undefined
9	Calgary/Canada	10	Undefined	5 (50.0%)	Undefined	Undefined
11	Zagreb County/Croatia	89	21 (23.6%)	29 (32.6%)	23 (25.8%)	16 (18.0%)
12	Gauteng/South Africa	91	25 (27.5%)	31 (34.1%)	18 (19.8%)	17 (18.6%)
13	Gujarat/India	102	Undefined	52 (51.0%)	Undefined	Undefined
14	Lucknow/India	83	Undefined	32 (38.6%)	Undefined	Undefined
15	South Delhi/India	153	Undefined	96 (62.7%)	Undefined	Undefined
16	Coimbatore/India	118	25 (21.2%)	50 (42.4%)	31 (26.3%)	12 (10.1%)
19	Ankara/Turkey	39	4 (10.3%)	21 (53.8%)	8 (20.5%)	6 (15.4%)
20	Diyarbakir/Turkey	123	25 (20.3%)	47 (38.2%)	38 (30.9%)	13(10.6%)
21	Bursa/Turkey	52	10 (15.9%)	34 (53.9%)	16(25.4%)	3 (4.8%)
22	Sivas/Turkey	27	6 (22.2%)	11 (40.8%)	8 (29.6%)	2 (7.4%)

* In this study, June, July and August in the north countries, December, January and February in the south countries, and June, July, August and September (Monsoon) in India was recorded as "Summer".

characteristically, contact lesions that have a central area of blistering surrounded by a blanched area with a rim of hyperemic tissue, producing a 'target' appearance; sparking may also be found when the electrical current passes through the air between the skin and another object. This produces a nodule of burnt keratin that is raised above the surrounding skin surface. These contact lesions are more common in low voltage injuries, whereas severe, non-specific burns are more common in high voltage or lightning accidents.[3,17,47] If a high-voltage electrocution occurs, or if the current flows for some time, there may be extensive burning or even charring of the body.[17] It was reported that high voltage more often caused the appearance of electrical lesions than low voltage.[10,11]

Electrical lesions were found in 81% (n=68) in the all ERDs, which is in accordance with results of the previous studies (ranged from 64.1% to 94.6%).[1-3,10,11,19,21] Typical contact lesions were seen in mostly of low voltage cases whereas non-specific burns were seen in high voltage cases in our study (p=0.000) in accordance with the literature.[3,10,11,47]

In presence of large surface area, such as in water, the electrical current mark may not be found at autopsy for water lowers skin resistance and current density.[17] The resistance of wet skin is only 200-300 ohms whereas the resistance of dry skin is around 1000 ohms.[15] Wet extremity was defined as one of primary risk factors for electrocution.[7-10,12,13] Also, 15 victims lacking electrical burns in the low-voltage group were found in a wet environment or had had wet extremities.

In the present study, majority of electrical lesions located on the upper limbs (59.3%), especially in the hands (43.5%) (p=0.000) in accordance with previous studies (range: from 59% to 74% for upper limbs).[1,11,18,19,21]

The existence of the multiple trauma due to a fall from a height or other causes and submersions were defined from 1% to 21.6% cases in the previous studies.[1,11,18,19,21] There were the findings of the multiple traumas due to falls during the electrocution in 10.8% of cases and no submersion in this series.

Alcohol consumption was defined as a preparative factor for electrocution, especially in occupa-

tional accidents.[19,21] In the several studies, the range of cases under the influence of ethyl alcohol during electrocution was reported between 11.1% and 62.5%.[3,11,19,21] In our study, this rate was quite low (3.6%), but there were two cases used THC, which was not notified in other studies.

CONCLUSION

In this study, it appears that ERDs are in the trend of a decline in Izmir. Nonetheless, the rate of ERDs in Izmir is higher than many cities in Turkey. Occupational and domestic accidents were major causes of ERDs, particularly, in males between the age of 21 and 40 years. The mortality rate is increasing, especially in the summer. In order to reduce accidents due to electrocution, infrastructure problems should be resolved, serious control should be supplied, quality standards should be developed, and training and security measures should be increased.[21] In addition to training activities, the improve of workplace safety inspections and installation of home security inspection will be an important step for the prevention of home and work-related accidents.[39,40,43] We think that the efforts for preventing of occupational and domestic accidents will be prevent many fatal electrocutions at the same time.

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