Occupational electrocutions in Jefferson County, Alabama

A. J. Taylor[*‡], G. McGwin, Jr[*†‡], G. G. Davis[§‖], R. M. Brissie[§‖] and L. W. Rue, III[*†]

[*]*Center for Injury Sciences;* [†]*Section of Trauma, Burns, and Surgical Critical Care, Department of Surgery, School of Medicine;* [‡]*Department of Epidemiology, School of Public Health, University of Alabama at Birmingham, Birmingham, AL;* [§]*Coroner/Medical Examiner Office, Jefferson County, AL; and* [‖]*Department of Pathology, Forensic Division, University of Alabama at Birmingham, Birmingham, AL, USA*

Few studies have presented the general epidemiology of electrocution deaths using local medical examiner data. Data were obtained from coroner/medical examiner's files for electrocution deaths occurring between 1981 and 1998. All 27 occupational electrocutions were among men; 92.6% were white and 7.4% were black, with a mean age of 33.1 years. The rates of high- and low-voltage electrocution were similar. Low-voltage deaths showed a seasonal pattern, with the largest numbers in July, August and October. Deaths occurred most frequently among electricians and electrical helpers. The level of detail available from medical examiner records permits more complete evaluation of injury patterns than is possible using death certificate data; however, even more detailed studies, exploring worker activity at the time of injury, education, experience and training, are needed.

Key words: Electrocution; epidemiology; occupation.

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Introduction

Electrocution is reported as the fifth leading cause of occupational injury death in the USA [1]. An average of 411 occupational electrocution fatalities per year (1980–1992) were recorded by the National Institute for Occupational Safety and Health (NIOSH) [2]. The rate of occupational electrocution death has reportedly been gradually decreasing [2], as has the overall rate of death from electrocution in the USA [3].

Few studies have presented the general epidemiology of electrocution fatalities using local data. Most studies have used large national data sets and/or are industry- or occupation-specific [4–10]. Among the national databases used are the National Traumatic Occupational Fatality (NTOF) and Integrated Management Information Systems (IMIS) [4,5,8,9,11,12]. NTOF is based upon death certificate data, which are often incomplete as to occupational classification and whether the injury occurred at work [13]. IMIS is based upon Occupational Safety and Health Administration (OSHA) fatality investigations, which selectively capture cases, as not all workers fall under OSHA jurisdiction (e.g. public-sector and self-employed workers) and some types of injury events, such as motor vehicle crashes and homicides, are not subject to OSHA investigation [14]. Also, OSHA investigations tend to be concentrated in the construction and manufacturing industries [4,12]. Studies specific to industry or occupation are helpful in directing interventions toward particular groups, but do not present a complete picture of electrocution fatalities. Two studies present state-wide data, one based solely on death certificate data [15] and one using death certificate and workers' compensation file data [16]. Mellen *et al.* [17] and DiVincenti *et al.* [18] used forensic data; however, the populations studied were largely military, thereby limiting the generalizability of the study results.

The present study uses local medical examiner data. Only original sources, coroner's files and death certificates can be used to identify all cases of death due to injury [14]. (Other sources contain cases identified via one of these sources.) Death certificate data are not always accurate and consistent with respect to whether an injury was sustained at work, as there is no uniform definition of work relatedness [14] and definitions and,

Correspondence to: Allison J. Taylor, 110 Kracke Building, 1922 7th Avenue South, Birmingham, AL 35294-0016, USA. Tel: +1 205 975 3037; fax: +1 205 975 3039; e-mail: allison.taylor@ccc.uab.edu

consequently, the data, are often inconsistent among jurisdictions. The present study relies upon data from one medical examiner's jurisdiction, which uses consistent criteria for assigning work relatedness and for assigning electrocution as a cause of death.

The purpose of this paper is to present the epidemiology of occupational electrocution deaths in Jefferson County, Alabama, USA, using medical examiner data.

Methods

A retrospective review was conducted of all decedents examined at the Jefferson County Coroner/Medical Examiner's Office between 1981 and 1998 with the primary or underlying cause of death recorded as 'electrocution'. During this time, the medical examiner's office was operating under a consistent medical examiner's statute and all deaths investigated by the office were certified by one of five forensic pathologists. The medical examiner's statute charges the office with the responsibility of investigating all sudden and unexpected deaths that have occurred in Jefferson County and that have been caused by events that transpired there. Information was abstracted from the files, including age, race, sex, educational level, cause of death, occupation, industry, blood alcohol level, other substances detected, work relatedness and circumstances surrounding death. The focus of the present study is those electrocution fatalities specified in the medical examiner's files as work related.

According to the classification scheme proposed by Rossignol and Pineault [19], fatal injuries were classified as having involved either an electrical or non-electrical task, having occurred indoors or outdoors, having involved direct electrical exposure versus exposure via a vector (e.g. metal ladder, crane cable) and having involved high voltage versus low voltage. Information about whether a decedent had been working alone or as part of a team was largely unavailable in the present study; therefore, this category of Rossignol's classification has been omitted.

Analyses consisted of calculation of the mean age and calculation of frequency distributions for age, sex, race, voltage (high versus low), location of incident (indoors versus outdoors), task being performed (electrical versus non-electrical), contact with the electrical source (direct versus indirect), month of injury, toxicological analyses, occupation and industry.

Mortality rates were calculated using data from the Current Population Survey (CPS) as denominators. The CPS provides information on the number of employed persons in the USA and specific geographic locales, including Jefferson County, Alabama.

Results

Between 1981 and 1998, 46 electrocution deaths occurred in Jefferson County, Alabama; of these, 27 (58.7%) were work related. The mortality rate per 100 000 persons per year was 0.44 for occupational electrocution deaths (Table 1). The mean age was 33.1 years. The highest rate of death was among the 20- to 24-year-old age group (0.81 per 100 000 persons per year), followed by those aged 65 and older (0.59 per 100 000 persons per year). All decedents were male and the majority (92.6%) were of white race.

The proportion of deaths involving high voltage (44.4%) was similar to that involving low voltage (48.2%), as were the rates for high- and low-voltage deaths (0.19 and 0.21 per 100 000 persons per year (Table 2). The majority of decedents were electrocuted outdoors and were performing non-electrical tasks at the time of electrocution. The rate of indirect contact with the electrical source via a vector was 0.27 per 100 000 persons per year. Nearly half of the occupational electrocution fatalities involved either direct or indirect contact with a power line (Table 3).

The highest numbers of electrocution deaths occurred in June, July and August (Figure 1). Low-voltage electrocution deaths showed a seasonal pattern, with the largest numbers in July, August and October. Deaths due to high-voltage electrical sources were more evenly distributed throughout the year.

One individual had a positive blood alcohol level (0.03 mg/dl) and two tested positive for drugs of abuse, one for cannabinoids and one for propoxyphene.

The largest number of deaths occurred among electricians and electrical helpers (n = 5, 18.5%), followed by laborers (n = 4, 14.8%). Among skilled construction trades overall, including electricians, there were eight

Table 1. Demographic characteristics of occupational electrocution deaths in Jefferson County, 1981–1998

	n (%)	*Rate per 100 000 employed persons*
Overall	27 (100.0)	0.44
Age (years)		
16–19	1 (3.7)	0.41
20–24	6 (22.2)	0.81
25–34	10 (37.0)	0.51
35–44	6 (22.2)	0.54
45–54	3 (11.1)	0.20
55–64	0 (0.0)	0.00
65+	1 (3.7)	0.59
Sex		
Male	27 (100.0)	0.85
Female	0 (0.00)	0.00
Race		
White	25 (92.6)	0.67
Black	2 (7.4)	0.08

Table 2. Event characteristics of occupational electrocution deaths in Jefferson County, 1981–1998

Characteristic	*n (%)*	*Rate per 100 000 employed persons*
Voltage		
High	12 (44.4)	0.19
Low	13 (48.2)	0.21
Unknown	2 (7.4)	
Location of event		
Indoors	9 (33.3)	0.14
Outdoors	15 (55.6)	0.24
Unknown	3 (11.1)	
Task being performed		
Electrical	5 (18.5)	0.08
Non-electrical	21 (77.8)	0.34
Unknown	1 (3.7)	
Contact with electrical source		
Direct	9 (33.3)	0.14
Indirect	17 (63.0)	0.27
Unknown	1 (3.7)	

Table 3. Source of electrical exposure for occupational electrocution deaths in Jefferson County, 1981–1998

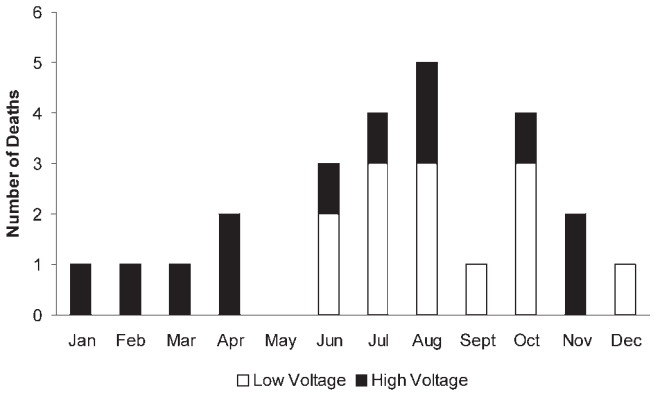
	n	*%*
Charged object	2	7.4
Charged water	1	3.7
Electrical wiring	6	22.2
Electrical wiring via a vector	1	3.7
Machine	2	7.4
Power line (direct contact)	2	7.4
Power line (contact via a vector)	10	37.0
Power tool	1	3.7
Lightning	1	3.7
Unknown	1	3.7
Total	27	100.0

deaths (29.6%). For five decedents, occupation at time of death was not noted. Occupational electrocution deaths were most common among those employed in industrial settings (n = 6, 22.0%), followed by construction (n = 4, 14.8%), electrical services (n = 3, 11.1%) and roofing (n = 2, 7.4%).

Discussion

All 27 of the occupational electrocution deaths during the study period were among men, 92.6% of white race and 7.4% of black race. This pattern is similar to that reported in NIOSH surveillance findings [2]; 99% of occupational electrocutions during 1998 occurred among men, 86% among whites and 7.1% among blacks. (Alabama's population is 26% black and Jefferson County's nearly 40%, whereas the population of the USA overall is 12.6% black.)

Figure 1. Numbers of low- and high-voltage electrocution deaths by month.



Deaths resulting from occupational electrocution appear to occur at a younger age than occupational injury deaths overall. We observed a mean age among occupational electrocution deaths of 33 years. Loomis *et al.* [20] found the mean age for all occupational fatalities in North Carolina to be 40 years and the Centers for Disease Control and Prevention reported a mean age of 37 years for occupational fatalities in Texas, with a mean age for occupational electrocution deaths of 32 years [15]. Two studies of workers <18 years of age have been conducted. Suruda *et al.* [11] found 16% of deaths investigated by OSHA in workers under 18 to have been caused by electrocution (22% of these electrocution deaths occurred during work performed in violation of the Fair Labor Standards Act). Castillo *et al.* [12] reported a higher rate of work-related electrocution deaths among 16- and 17-year-olds than among adults (0.61 per 100 000 full-time equivalents versus 0.43). They reported a rate ratio (16- and 17-year-olds to adults) of 1.42 for electrocution deaths, as opposed to a rate ratio of 0.84 for all causes of occupational injury death. Ore and Stout [9] reported fatality rates for electrocution death among construction laborers in the USA aged 16–24 years higher than that for laborers aged 25 years and older. They did not find a higher rate of death among younger laborers for other causes of death. Further study is needed to discover the reasons for the lower mean age among electrocution fatalities, which may be important to targeting prevention efforts. Safety training specific to electrical hazards may be warranted for younger workers and re-evaluation of types of work appropriate for younger, inexperienced workers may be needed. Youthful rashness and sense of invulnerability may be in part to blame; however, these factors are difficult to evaluate and to influence.

Electricians and laborers represented the largest categories of occupational electrocution deaths. Similarly, Fatovich [21] reported that 38% of workplace electrical

deaths were among electricians, apprentices and linemen, and 26% among laborers. With respect to industry, the highest numbers of occupational electrocution deaths in the present study were among manufacturing and construction workers. Jones *et al.* [16] reported that the most electrocution deaths by industry occurred among construction, utility and manufacturing workers. Ore and Casini [8] reported electrocution as the second leading cause of death in the construction industry.

The ratio of high- to low-voltage electrocution deaths was ~1:1, consistent with that found by Wright and Davis [22]. An Australian study found the ratio of low- to high-voltage electrocution deaths (occupational and non-occupational) to be 7:1 [21]. The differences in the proportion of high-voltage deaths and the proportion of occupational electrocution deaths among studies may in part be due to variations in the mix of industries represented among catchment areas.

Wright and Davis [22] found that 86% of high-voltage deaths occurred on the job, more than half of which were among workers employed by the power company or one of its subcontractors. Other studies have also noted a high rate of electrocution death among utility workers [16,23]; unlike these studies, none of the electrocution deaths in this study was recorded as having involved utility workers.

Nearly half of the fatalities examined in this study resulted from contact with power lines. The Census of Fatal Occupational Injuries (CFOI) has reported that ~50% of occupational electrocution fatalities result from contact with overhead power lines [1] and most published studies addressing electrocution deaths have found the highest proportion to involve power line contact [5,8, 18,24]. Contact with overhead power lines by cranes is a common mechanism responsible for electrocution death [10,22]. NIOSH recommends that arrangements be made with power companies for power lines to be de-energized or covered with insulating materials when work is being performed in close proximity [7,25]. There were two electrocution deaths in Jefferson County attributable to contact between cranes and power lines. In Jefferson County, the suspension of power to electrical lines in the vicinity of a crane during its operation is routine [26]. Davis and Brissie reported that the expected number of deaths in Jefferson County between 1981 and 1996 would have been seven, suggesting that five lives may have been saved by this practice. OSHA requires 10 ft of separation between equipment and high-voltage power lines [24]; however, an analysis by the Consumer Product Safety Commission on contact between metal ladders and power lines found that this clearance is often misjudged [7]. Contact between metal ladders and power lines is another common source of electrical injury [6] and OSHA regulations prohibit their use by those engaged in electrical work [4,7]. Non-electrical trades employing ladders, such as construction painting [5] and roofers [16], are also at risk. NIOSH recommends use of non-conductive headgear and gloves and prohibition of conductive tools or materials where the possibility of power line contact exists. In rural areas, contact between irrigation apparatus and power lines is a common cause of electrocution [27].

In the present study, among those deaths for which it was known whether the source was high or low voltage, approximately half were caused by low-voltage electrical sources. Jones *et al.* [16] found 22.4% of occupational electrocution deaths in Virginia to result from machine or tool usage or repair. Suruda and Smith [4] reported that 9% of occupational electrocution deaths recorded in NIOSH databases resulted from portable power tools and appliances. Electrocutions via these sources are often preventable by proper equipment maintenance and use of ground fault circuit interrupters [4].

The seasonal pattern seen among electrocution deaths is similar to that reported in other studies [2,8,16]. Low-voltage deaths in the present study showed a pattern similar to that reported by Wright and Davis [22], with the highest numbers occurring between June and October and few deaths occurring November through May. The lack of a seasonal pattern among high-voltage electrocution deaths was also consistent with Wright's findings. Other studies presenting data by month did not separate deaths into those resulting from high- versus low-voltage sources. The seasonal pattern among low-voltage electrocutions may be related to the seasonal nature of some types of work, particularly in the construction trades. Analysis of the data for the present study did not demonstrate a seasonal pattern of electrocution deaths among the construction trades; however, this may be due to the small sample size of this study. Such a pattern among US construction workers was described by Ore and Casini [8]. It is also possible that the seasonal pattern of low-voltage deaths is due to variations in work tasks by season, which we were unable to measure. Hot and humid weather contributes to electrocution, because skin is more likely to be moist and thereby offer less resistance to electric current [28]. Also, in summer workers are less likely to employ heavy boots and clothing, which have insulating properties. Alabama's hot, humid summers would therefore appear to increase the risk of electrocution.

A strength of this study is its reliance on medical examiner's data, which are more complete than data derived from death certificates. Medical examiner's files include a greater level of detail on circumstances of death than is generally available from death certificate data, allowing more complete analysis of injury patterns. However, the results of this study must be considered in light of two limitations. The number of cases studied is small. As all cases occurred in a single county in Alabama, the results may not be generalizable to the US overall.

Electrocution deaths are preventable. Efforts have been made to reduce the number of occupational electrocution fatalities; however, further study is needed of non-fatal as well as fatal electrocutions. Future studies should attempt to explore worker activities at the time of injury, as well as levels of education, experience and safety training among the injured.

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