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Severity of electrical accidents in the construction industry in Spain

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ABSTRACT

Problem: This paper analyzes the severity of workplace accidents involving electricity in the Spanish construction sector comprising 2,776 accidents from 2003 to 2008. *Method*: The investigation considered the impact of 13 variables, classified into 5 categories: *Personal*, *Business*, *Temporal*, *Material*, and *Spatial*. *Results*: The findings showed that electrical accidents are almost five times more likely to have serious consequences than the average accident in the sector and it also showed how the variables of age, occupation, company size, length of service, preventive measures, time of day, days of absence, physical activity, material agent, type of injury, body part injured, accident location, and type of location are related to the severity of the electrical accidents under consideration. *Summary*: The present situation makes it clear that greater effort needs to be made in training, monitoring, and signage to guarantee a safe working environment in relation to electrical hazards. *Practical applications*: This research enables safety technicians, companies, and government officials to identify priorities and to design training strategies to minimize the serious consequences of electrical accidents for construction workers.

1. Introduction

Workplace accidents are a serious problem and a significant challenge for companies, administrations, workers, and society in general (Haslam et al., 2005). Among occupational sectors, the construction industry has always had a high rate of workplace accidents (Dufort, Kotch, Marshall, Waller, & Langley, 1997; Koh & Jeyaratnam, 1998; Ore & Stout, 1996; Salminen, 2004). Despite the gradual improvement in statistics during recent years (Cawley & Brenner, 2012; Haslam et al., 2005; Xiuwen & Platner, 2004), construction still has a disappointing incidence rate (Chen & Fosbroke, 1998) with enormous consequential costs (Waehrer, Dong, Miller, Haile, & Men, 2007).

A number of studies attribute this situation to the natural complexity and continuous changes peculiar to the work environment in the construction industry (Pollack & Chowdhury, 2001; Pollack, Griffin, Ringen, & Weeks, 1996; Ringen, Englund, Welch, Weeks, & Seegal, 1995). The "*special*" circumstances of this work environment require a detailed analysis of the different risks to which construction workers are exposed. This analysis provides useful information that could lead to a reduction in workplace accidents (Chau et al., 2008; Dong, Vaughan, Sullivan, & Fletcher, 1995; Hatipkarasulu, Saginor, & Tibrewala, 2009).

Workplace accidents involving electrical contact stand out because of the severity of the injuries (Chen & Fosbroke, 1998) and the disproportionate number of fatalities (Cawley & Homce, 2003). The seriousness of these accidents is made evident in OSHA's estimation that about 350 deaths caused by electrical contact take place annually in the construction sector in the United States (OSHA, 2010).

Studies from several countries reveal the importance of the incidence of electrical accidents in construction compared to other kinds of accidents. Some studies indicate that electrical accidents, after falls, occupy the second and sixth places (Cawley & Homce, 2003; Chen & Fosbroke, 1998; Chi, Yang, & Chen, 2009; Janicak, 2008; Loomis, Dufort, Kleckner, & Savitz, 1999; McCann, Hunting, Murawski, Chowdhury, & Welch, 2003; Wang, 1999). However, many investigations found that electrical accidents are the major cause of injury and death in the construction industry (Bureau of Labor Statistics, 1997; Janicak, 2008; Jenkins et al., 1993; Kisner & Casini, 1998; Kisner & Fosbroke, 1994; Loomis et al., 1999; McVittie, 1995; Ore & Casini, 1996; Robinson, Petersen, & Palu, 1999; Rossignol & Pineault, 1994).

A study in the United States revealed that between 1992 and 1998 there were 2,287 fatal accidents in the workplace due to electrical causes, which equates to one death per day (Cawley & Homce, 2003). Another study conducted in the United States between 2003 and 2006 drew attention to the number of electrical accidents in the construction industry (Janicak, 2008). Janicak's study showed that 49% of a total of 997 fatal accidents caused by electrical contacts took place in the construction industry. Janicak highlighted a potential for improvement that could lead to the prevention of 125 deaths a year with the aid of efficient programs and correct isolation of electrical circuits and systems.

In an analysis of the proximal causes of an occupational accident, there is no doubt that working conditions and work environment are important (Cheng, Leu, Lin, & Fan, 2010; Melamed, Yekutieli, Froom, Kristal-Boneh, & Ribak, 1999). However, a series of worker-related factors can also increase the risk of accidents: age (Bastide, 1994; Chau

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Table 1
Economic activities related to the construction industry.

Code	Description
451	Preparation of construction sites (Demolitions, earth moving, land survey, excavations, etc.)
452	Construction of buildings and civil construction (Buildings, civil works, electrical nets, etc.)
453	Fit out of construction work (Partitions, acoustic, electrical, plumbing, etc.)
454	Completion of construction works (Painting, glazing, wood, etc.)

et al., 2008; Kingma, 1994; McCaig, Burt, & Stussman, 1998), training (Wong, 1994), experience (Chau et al., 2008; Salminen, 2004), risk perception, mindset, behavior (Chau et al., 2004; Maiti & Bhattacherjee, 1999), and so forth. For example, some studies on this subject show interesting results in relation to the occupation of the workers who had electrical accidents in the construction industry. The study conducted by Cawley in the United States (Cawley & Brenner, 2012) reveals that about 32% of fatal electrical accidents are related to five occupations: "electricians," "construction laborers," "roofers," "painters," and "carpenters." Another study also from the United States (Chen & Fosbroke, 1998) reveals that the highest electrocution rate is that of electricians, four times higher than the average for all construction workers; followed by steel frame workers and bricklayers.

These studies show the gravity of electrical accidents in construction and make evident the need to obtain relevant information on the causative factors in order to prevent and control possible risks (Cawley & Brenner, 2012; McCann et al., 2003; Williamson & Feyer, 1998). The specific aim of this paper is to characterize construction workplace accidents caused by electrical contact. First, the influence of the variables involved in this kind of accident is identified. This information would help workers, technicians, and safety officials responsible for assessment, prevention, and protection to significantly reduce this type of accident and the serious consequences.

2. Methodology

2.1. Data

The European Directive 89/391 dealing with the application of measures aimed at improving health and safety in the workplace, transposed to Spanish legislation through the *Ley 31/1995 de Prevención de Riesgos Laborales*, called for harmonization of the data related to workplace accidents. As a result, the *Orden* TAS/2926/2002 created the *Sistema de Declaración Electrónica de Accidentes de Trabajo* [System of Electronic Notification of Occupational Accidents] (Delt@) in Spain. This has been the compulsory mechanism for the notification of workplace accident reports since 2003. Thus, all accidents that result in an absence from work of one or more days must be notified through this system, filling an Official Workplace Incident Notification Form.

For this investigation the *Ministerio de Empleo y Seguridad Social* provided data from the 1,162,598 registered workplace accidents in construction from 2003 to 2008. As seen in Table 1, these data refer to activities in the construction industry, as coded in the *Clasificación Nacional de Actividades Económicas* (CNAE-93).

From this only the data relating to direct and indirect electrical contact as expressed in the deviation codes associated with the accidents were taken (Table 2). The selection produced a total of 2,776 accidents.

Table 2
Type of deviation.

Code	Deviation
11	Electrical indirect contact
12	Electrical direct contact

Table 3
Classification of accidents by severity of the injury.

Severity of the injury	Accidents
Light	2,583
Serious	139
Very serious	10
Fatal	44
Total	2,776

The occupational health authorities in Spain have to diagnose the severity of each accident according to medical criteria based on the severity of the injuries. Table 3 gives an itemized overview of the cases divided into the corresponding groups of severity.

2.2. Design of the analysis

As in other methodological research on the subject (Cameron, Hare, & Davies, 2008; Camino, Ritzel, Fontaneda, & González, 2008; Cawley & Homce, 2003; Chi et al., 2009; Haslam et al., 2005), the analysis focused on the characterization of electrical accidents in the construction industry.

The analysis of the accident variables aimed at identifying any possible co-relation between variables and accident severity. In a preliminary approach we analyzed all variables included in the accident notification form (57 variables) elaborating contingency tables. In some variables the contingency tables did not reach a statistical significance of 95% in order to reject the hypothesis of independence of variables, and we could not confirm the existence of more than a random influence for severity-variable. Accordingly, only 13 variables with a statistical significance < 0.05 were selected for this paper to answer questions as: *Who is most exposed to hazards?*, *What were the work conditions?*, *When did the accident take place?*, *What caused the accident?*, *Where did the accident take place?* For this, the classification suggested by Camino et al. (2008), which groups the different variables, was used (as shown in Table 4).

2.3. Statistical analysis

In order to identify the correlation between accident severity and each of the variables described above, contingency tables for the statistical Chi-square test were used. The aim was to reject with a statistical significance of 95% (sig. < 0.05) the null hypothesis of independence of the accident severity from the associated variables.

Different factors associated with each variable and the classification of the injuries that indicates the severity of the accident were used in the contingency tables. For a better description of the samples, information in the form of rates obtained from percentage frequencies was incorporated. These rates are: TAR (Total Accident Rate), LAR (Light

Table 4
Variables under consideration.

N	Question	Group	Variables
1	Who?	Personal	Age
2			Occupation
3	Which?	Business	Company staff
4			Length of service
5			Preventive organization
6	When?	Temporal	Time of accident
7			Days of absence
8	What?	Material	Physical activity
9			Material agent
10			Injuries
11			Body part
12	Where?	Spatial	Accident location
13			Place of accident