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Published in:
International Archives of Occupational and Environmental Health

DOI:
10.1007/s00420-015-1069-3

2016

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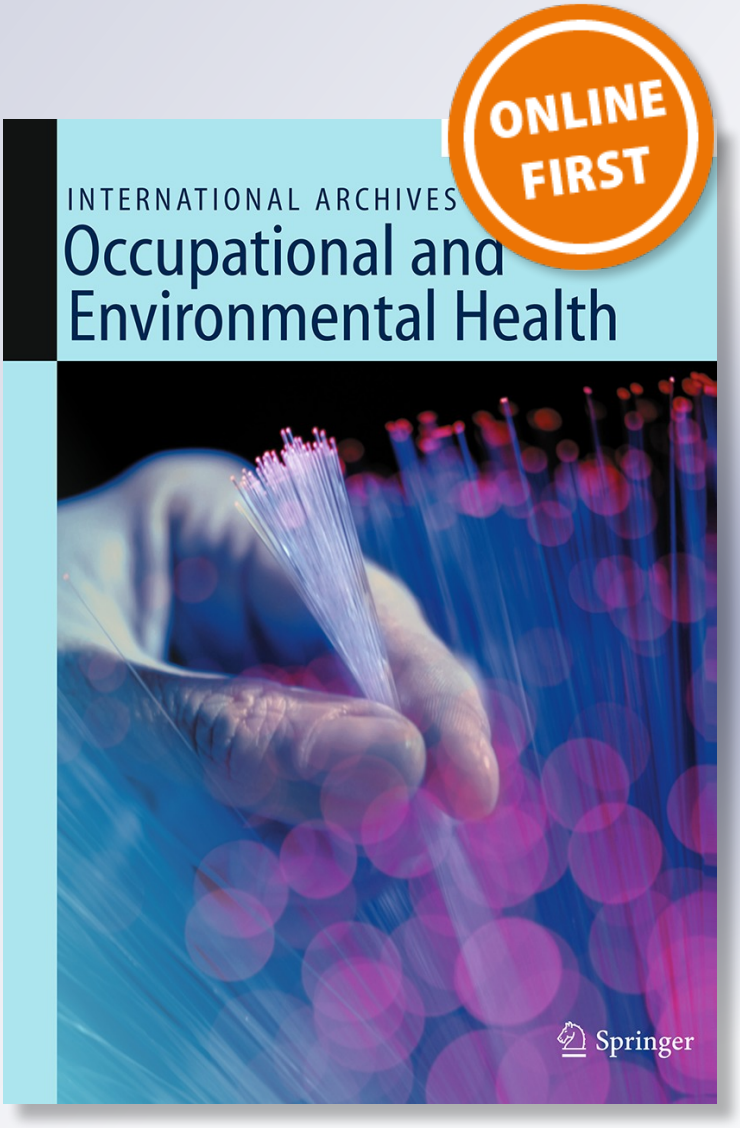
ISSN 0340-0131

Int Arch Occup Environ Health
DOI 10.1007/s00420-015-1069-3



Springer

Int Arch Occup Environ Health
DOI 10.1007/s00420-015-1069-3

ORIGINAL ARTICLE

Electrical injury in relation to voltage, "no-let-go" phenomenon, symptoms and perceived safety culture: a survey of Swedish male electricians

Lisa Rådman[1,2] · Ylva Nilsagård[3] · Kristina Jakobsson[4] · Åsa Ek[5] · Lars-Gunnar Gunnarsson[3]

Received: 19 December 2014 / Accepted: 24 June 2015

Abstract
Purpose Professional electricians are highly subjected to electrical injuries. Previous studies describing symptoms after electrical injury have not included people with less severe initial injuries. The purpose of the present study was to describe symptoms at different time points after electrical injury, the impact of "no-let-go" phenomenon and different electrical potential [high voltage (HV) vs. low voltage (LV)], and the safety culture at the workplace.
Methods A retrospective survey was conducted with 523 Swedish electricians. Two questionnaires were issued: the first to identify electricians who had experienced electrical injury and the second to gain information about symptoms and safety culture. Self-reported symptoms were described at different time points following injury. Symptoms for HV and LV accidents were compared. Occurrence or nonoccurrence of "no-let-go" phenomenon was analysed using two-tailed Chi-2. Safety culture was assessed with a validated questionnaire.
Results Nearly all reported having symptoms directly after the injury, mainly paraesthesia and pain. For the first weeks after injury, pain and muscle weakness dominated. The most frequently occurring symptoms at follow-up were pain, muscle weakness and loss of sensation. HV injuries and "no-let go" phenomenon were associated with more sustained symptoms. Deficiencies in the reporting routines were present, as well as shortage of preventive measures.
Conclusion The results indicate that symptoms are reported also long time after an electrical injury and that special attention should be paid to HV injuries and "no-let go" accidents. The workplace routines to reduce the number of work-related electrical injuries for Swedish electricians can be improved.

Keywords Electrical injury · Low-voltage injury · High-voltage injury · Safety management · Neurological symptoms · Pain

Introduction

Most electrical injuries are work-related, and electricians are at high risk for exposure (Butler and Gant 1977; Arnoldo et al. 2004; Fordyce et al. 2007). Around 100 electrical injuries entailing at least one-day sick leave are reported annually to the Swedish Work Environment Authority (SWEA) in Sweden (Arbetsskador 2008: Occupational accidents and work-related diseases 2009). Furthermore, in order to reduce the number of electrical injuries, all such injuries must be reported by the employer to SWEA (Arbetsmiljöförordningen 1997:1166).

In previous studies, electrical injuries have been divided into low-voltage (LV) (<1000 V) or high-voltage (HV) (>1000 V) injuries (Hussmann et al. 1995; Arnoldo et al.

✉ Lisa Rådman
lisa.radman@regionorebrolan.se

1 Department of Occupational and Environmental Medicine, Faculty of Medicine and Health, Örebro University, SE 701 82 Örebro, Sweden

2 Department of Physiotherapy, Faculty of Medicine and Health, Örebro University, SE 701 82 Örebro, Sweden

3 Department of Medicine, Faculty of Medicine and Health, Örebro University, SE 701 82 Örebro, Sweden

4 Division of Occupational and Environmental Medicine, Scania University Hospital, SE 221 85 Lund, Sweden

5 Ergonomics and Aerosol Technology, Department of Design Sciences, Faculty of Engineering, Lund University, SE 221 00 Lund, Sweden

Published online: 18 July 2015

2004; Chudasama et al. 2010). A study, covering 700 consecutive electrical burns in North America, revealed that HV caused more severe injuries compared to LV and also required longer hospital care (Arnoldo et al. 2004). Similar results were shown in another Northern American study where 129 patients sustained acute burns after an electrical injury. In comparison with LV injuries, HV injuries were, to a greater extent, associated with the need for more surgical procedures (Hussmann et al. 1995). Voltage is one risk factor for injury but the "no-let-go" phenomenon (involuntary muscle contraction that prevents the victim from breaking away) is also discussed in a Canadian review as possibly causing more severe injuries and higher mortality (Wesner and Hickie 2013). The frequency of "no-let-go" phenomenon was reported by 10 % out of 481 American electricians who experienced an electrical incident (Tkachenko et al. 1999). However, no study has previously investigated the consequences of "no-let-go" phenomenon regarding symptoms.

Only a few register studies describe the frequency of electrical injury (Fordyce et al. 2007; Huss et al. 2013; Piotrowski et al. 2014). Burn-related injuries among electric utility workers were studied by using the "Occupational Health and Safety Database" in the USA, in which 399 workers treated for electrical injuries were identified. The highest rate of injuries concerned hand/finger with a frequency of 1.93 per 10,000 employee-years (Fordyce et al. 2007). When exposures in different occupations in five European countries were assessed, electrical and electronic equipment mechanics and fitters were reported to have the highest risk for an electrical injury with 11.8 electrical injuries per 10,000 workers per year (Huss et al. 2013). In a French retrospective register study based on several national registers, 311 electrical injuries during the period 1996–2005 were reviewed. In 3 %, the outcome was fatal and almost 80 % of the survivors had burns on head/neck and hand/wrists. Ninety-eight out of 301 survivors had remaining sequelae after electrical burns. Neuropsychological symptoms (38 %) dominated, and the peripheral nervous system was affected in 12 % (Piotrowski et al. 2014).

Persistent neurological and neuropsychological sequelae after electrical injuries have been reported in several short-term follow-up reports of patients treated at burn clinics or emergency units (Hussmann et al. 1995; Arnoldo et al. 2004; Singerman et al. 2008; Chudasama et al. 2010). Peripheral neurological symptoms were reported from 60 % after HV injuries (38 patients) and 10 % after LV injuries (96 patients) (Hussmann et al. 1995). A review of medical records from 38 electrically injured patients at a Canadian burn clinic showed neurological symptoms in 12–16 % (numbness, weakness and memory problems) and psychological symptoms in 14–19 % (anxiety, nightmares and insomnia) (Singerman et al. 2008). A Canadian prospective observational study followed up on 114 patients with electrical injuries severe enough to require cardiac monitoring. Neurological or neuropsychological symptoms (most frequently muscle weakness and pain) were reported by a quarter of the patients 2 months after the injury (Bailey et al. 2008).

Studies reporting long-lasting symptoms after electric injury have only been reported in selected samples (Singerman et al. 2008; Bailey et al. 2008; Chudasama et al. 2010). On average, 29.5 months after the injury, eleven out of 38 patients were followed up by a telephone interview. There was a higher prevalence of almost all symptoms compared to what was reported at discharge. The most common neurological symptoms were numbness, paraesthesia, pain and weakness, and most common psychological symptoms were anxiety, depression, poor concentration and post-traumatic stress disorder (Singerman et al. 2008). In the study by Bailey, at 1-year follow-up, 24 out of 86 patients reported neurological or neuropsychological symptoms, and in 12 out of those, the symptoms had arisen between the two follow-ups. Voltage level or wet/humid extremity did not predict persisting symptoms (Bailey et al. 2008). Approximately 1 year after an electrical injury, 60 patients with HV injury and 25 patients with LV injury at a US burn centre were followed up. The HV group had greater initial physical injuries and longer length of hospital stay. However, the rate of neuropsychiatric symptoms between the groups was similar. Neuropathic pain was reported in approximately 40 %, irrespective of voltage group (Chudasama et al. 2010).

The safety culture at the electricians' workplaces can provide important information in order to prevent work-related electrical accidents. Few studies have examined the perceived safety culture among electricians. In a partially open-ended questionnaire answered by 481 members in an American electrical workers union about their awareness of occupational accidents, safety thoughts and experience with electrical injury, 97 % reported having experienced at least one electrical injury during their career. Only 11 % described their shock as an injury that required medical help. The majority of the electricians in the study agreed with the statement that if electricians are well trained and follow safety rules, accidents can be avoided (Tkachenko et al. 1999).

The literature regarding symptoms after electrical injury is scarce and mainly based on selected samples with patients treated at burn clinics. In summary, studies using an unselected sample, investigating symptoms at different time points after an electrical injury, also long-term symptoms, with respect to the impact of voltage and "no-let-go" phenomenon, will contribute to the base of knowledge regarding electrical injuries. The perceived safety culture at workplaces can provide additional information to act upon to reduce the frequency of electrical accidents.

The aims of the present study are to present results from a survey that was completed in the year 2012 and focusing on: (1) symptoms after an electrical injury at different time points, (2) the impact of voltage and the "no-let-go"

phenomenon, (3) the relationship with acute health care contacts and finally (4) electricians' perceptions of the safety culture at their workplaces.

Materials and methods

Design

A two-step retrospective survey was conducted among Swedish male electricians, including members from the Swedish Electricians Union (SEU), as well as electricians that had reported a work-related electrical injury to the Swedish Work Environment Authority (SWEA) during the period 2004–2011. Two packages of questionnaires were developed for the survey. The first package of questionnaire was a screening questionnaire including mainly questions in order to verify only electricians exposed to an electrical injury for both the SEU and SWEA groups. The second package of questionnaire explored symptoms in more detail after an electrical injury, the perceived work situation and the safety culture at the workplaces.

Procedure

Study group

The main study group included male members of the SEU, born between 1946 and 1993, living within the recruitment areas of five Occupational and Environmental departments (Gothenburg, Lund, Sundsvall, Umeå and Örebro) and employed as installation, maintenance or power-plant electricians. These criteria were fulfilled by 12,000 electricians. From this group, a random number generator was used to select a manageable sample of 4000 electricians.

The second study group comprised 343 persons living in the same recruitment area who, during the period 2004–2011, had reported an electrical injury to SWEA (data were only available for this period).

All subjects, in total 4343 persons, received a postal questionnaire designed to identify electricians that had been exposed to an electrical injury (Fig. 1). Two reminders were sent, and 2128 responded (response rate 50 %). Because of secrecy, the persons from the SWEA group were primarily anonymised for us and their questionnaires

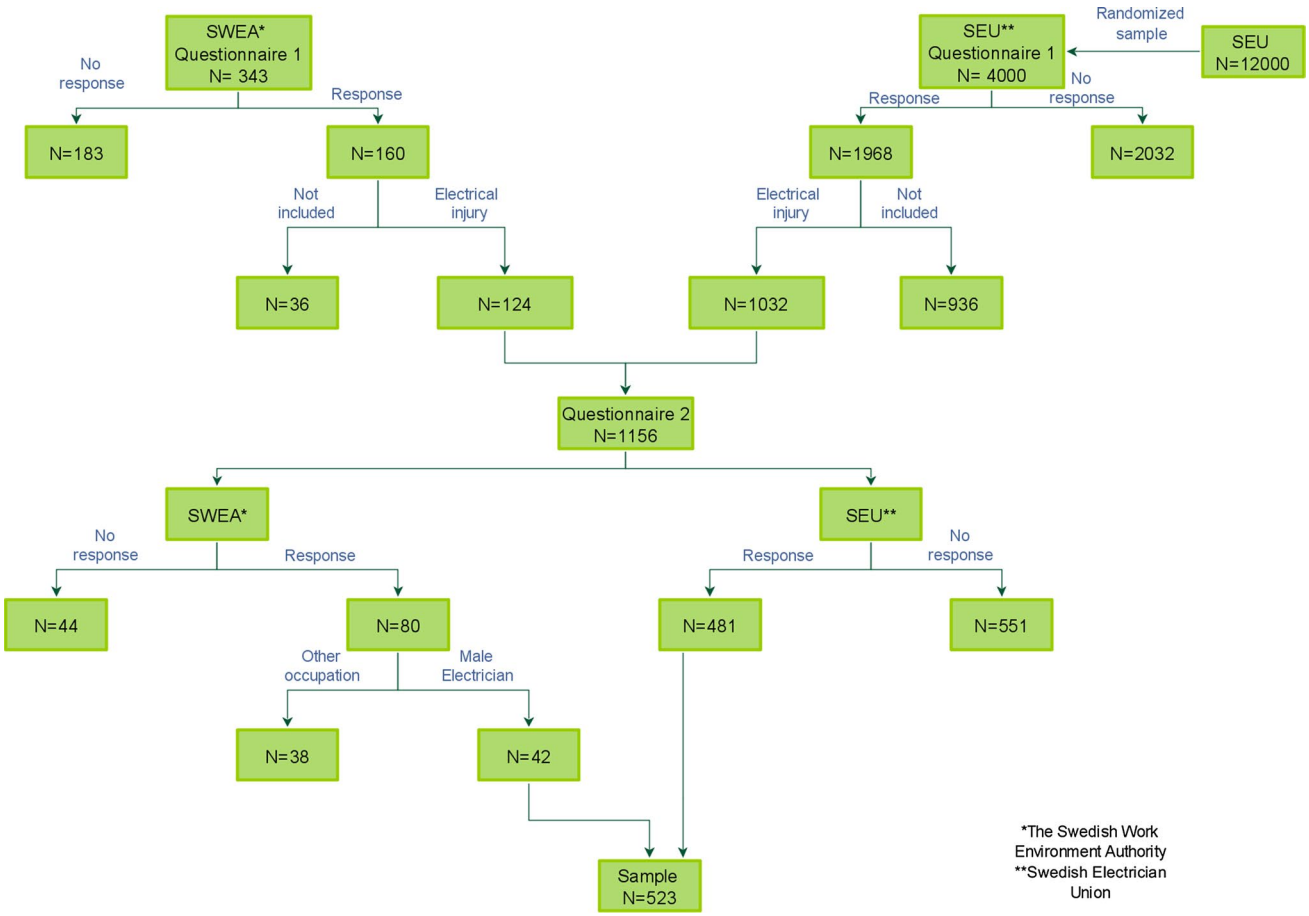


Fig. 1 The total study group and a flow chart of questionnaire responders

were distributed by the Swedish Work Environment Authority. Subsequently, 34 females who had received the questionnaire also replied but were excluded from the analysis. Two people died (unknown cause) before the second questionnaire was sent. The 936 electricians out of 1968 respondents from the SEU group who had never experienced an electrical injury were excluded from further analyses.

Altogether, 1156 men reported having experienced an electrical injury and were sent the second questionnaire. Two reminders were also sent for the second questionnaire (at 2 and 4 weeks). Out of 561 that responded to the second questionnaire, 523 were professional electricians. These 523 constituted the final study sample analysed.

The two questionnaires

The screening questionnaire package was developed to find electricians who had experienced a work-related electrical accident. The second questionnaire package aimed to explore detailed information of the circumstances for the most severe self-reported accident having occurred during the electrician's career, and the presence of symptoms related to this electrical injury at different time points thereafter. It comprised 45 main questions plus subqueries, mostly giving predefined response alternatives on demographic, occupational, educational and health items, and questions about health and symptoms. There were also 17 items aimed at gathering information on the electrical accident. These items had been used previously in a Norwegian study (Goffeng et al. 2006). In the original study, the response options were graded on a five alternative scale, but in the present study the response options were dichotomised (Yes or No).

The second questionnaire also contained questions on the perceived safety culture at the workplace at the time when this accident took place. Out of 24 questions with five-graded response options focusing on safety culture, 17 were based on a validated questionnaire developed at Lund University (Ek 2006). Another seven questions were developed in consultation with experts from the Swedish National Electrical Safety Board, the Swedish Electricians' Union, the Swedish Association of Electrical Contractors and the National Research Centre for the Working Environment in Denmark. Three of the seven questions had been used previously in surveys in the electrical industry (Swedish National Electrical Safety Board 2005; Swedish Electricians' Union 2010). The responses were graded on ordinal scales using five alternatives ranging from *not at all/never* to *very much/very often*.

For face validity, the second questionnaire was scrutinised by five experts and union representatives working in the field of electrical industry to verify the choice of words and questions. A pilot study was performed comprising 15 electricians working at Örebro University Hospital who were sent the second questionnaire by email in order to test the comprehensibility and feasibility of the questionnaire.

Statistical analyses

The Statistical Package for Social Science, version 22.0, was used for analysis. Descriptive statistics are given in frequencies and percentages, mean or median values. There was internal loss for single questions in the questionnaire, and, for each question, numbers of responses are presented and valid percentage calculated. Nonparametric tests were used as the response alternatives in the questionnaire were either nominal or ordinal. In some analysis, the participants were dichotomised with respect to number of reported electrical incidents. Comparison between those reporting more than ten accidents during their career and those with less than 10 accidents was tested using a Mann–Whitney *U* test. The Chi-square test (Fisher's exact test if less than five) was used both for analyses of the relationship between symptoms and exposure to low voltage ($\leq$1000 V) or high voltage (>1000 V), and for analyses of the relationship between symptoms and "no-let-go" phenomena. The significance level was set at 0.05 (two-tailed).

Ethical aspects

The study was approved by the regional ethics committee in Uppsala-Örebro (2011/252), and was conducted in accordance with the 1964 Declaration of Helsinki and its later amendments.

Results

Descriptive data for the study group (after completion of the second questionnaire) is given in Table 1. The mean age for the total group was 42.5 years. Six per cent reported that they were smokers, which is lower than an expected rate of about ten per cent in their social group (Danielsson et al. 2009). Most of the participants had received basic education as electricians (2 to 3-year upper secondary school/vocational training). Around 10 % of the participants reported that they had been exposed to more than ten electrical accidents. This more frequently exposed group was older and had worked longer as electricians. Comparing the SEU and the SWEA groups, the latter were, on average, 2 years older, but the professional experience of the participants as electricians was similar between groups.

Table 1 Characteristics and self-reported number of electrical accidents for the total study group and subgroups

Characteristics	Total group	<10 electrical accidents	≥10 electrical accidents
Age (years)			
Mean (SD)	42.5 (13.2)	41.4 (13.2)	46.1 (12.5)
Range	19–67	19–67	23–65
	$n = 523$	$n = 429$	$n = 53$
Work areas			
Installation	244 (53)	199 (52)	28 (60)
Service	128 (28)	110 (29)	11 (24)
Power field	32 (7)	27 (7)	2 (4)
Other tasks	50 (11)	43 (11)	4 (9)
Other (sick leave, parental leave)	9 (2)	6 (2)	2 (4)
	$n = 463$	$n = 385$	$n = 47$
Professional experience (years)			
Mean (SD)	21.6 (13.9)	20.6 (13.7)	26.4 (13.5)
Range	1–49	1–49	4–49
	$n = 499$	$n = 412$	$n = 51$
Specific electrical education			
Yes [*n* (%)]	458 (97)	409 (98)	20 (95)
No [*n* (%)]	12 (3)	8 (2)	1 (5)
	$n = 470$	$n = 417$	$n = 21$

For each question, numbers (*n*) of responders are presented

The internal falling off differed with regard to different questions, i.e. 41 participants did not answer the number of accidents and 60 participants did not answer about the work area, etc.

All 523 electricians included in this retrospective survey had experienced at least one electrical injury during their career, and 65 % reported at least two severe accidents during their working lives (range 1–90 accidents). Almost all accidents (95 %) occurred in the area of alternating current. Another 2 % occurred in the field of direct current and 3 % among participants working with induction current. Out of 441 answers to the question about levels of voltage, 96 % were exposed to LV power and 4 % to HV power. The most common level of voltage that the electricians worked with was 230 V, and the second most common was 231–400 V, reported by 52 and 36 %, respectively. Hand and finger together accounted for 96 % of the entry points and 77 % of the exit points, i.e. the path for the electricity.

Almost all participants reported acute symptoms occurring directly after the accident. In total, 94 % reported unspecific symptoms (nausea, stomach ache, sweating or chills), 85 % symptoms from the heart (palpitations, irregular heartbeat or chest pain) and 71 % sensory symptoms (pain, numbness or paraesthesia). The most common acute symptom was paraesthesia (65 %) followed by pain (54 %). For 30 %, the electrical injury caused immediate burns, mainly affecting hands or arms.

During the first 7 days after the electrical injury, pain and muscle weakness were the dominating symptoms (Table 2). Sensory and muscular symptoms were most commonly reported both during the first 7 days and after 1 week (Table 2). Fewer were affected by sleep disturbance, anxiety and fatigue and only a few reported to suffering from memory loss or concentration difficulties. When the questionnaire was answered, only a few per cent of the participants reported present symptoms; most frequently pain, loss of sensation and muscle weakness (Table 2).

A difference was seen where a lower proportion exposed to LV-reported symptoms, in particular sensory and muscular, lasting more than a week compared to those exposed to HV. The difference was statistically significant for seven out of nine symptoms (Table 3). Altogether, the symptoms were about ten times more frequent after HV accidents compared to LV accidents. "No-let-go" phenomenon (a current-induced involuntary grip) was reported by 26 % of the participants. Irrespective of voltage, participants reporting an accident with "no-let-go" phenomenon reported symptoms about three times more frequently compared to those who did not report an involuntary grip. The difference was statistically significant for six out of nine symptoms (Table 3).

The circumstances at the time of the most severe accident are presented in Table 4. Almost all had access to appropriate tools, but protective equipment was used by less than 40 %. Most participants were familiar with both the workplace and the task, but sometimes personal factors interfered with the work (e.g. tiredness and lack of concentration). Moreover, haste and tight deadlines hampered

Table 2 Symptoms remaining after the most serious self-reported accident for less than 1 week and for 1 week or more, respectively, and remaining symptoms (when the questionnaire was answered)

Symptom	*N*	<1 week		≥1 week		Remaining	
		n	%	*n*	%	*n*	%
Sensory symptom							
Pain	441	70	16	37	8	13	3
Loss of sensation	440	37	8	21	5	11	3
Muscular symptom							
Muscle weakness	442	62	14	20	5	12	3
Muscle twitching	440	34	8	15	3	6	1
Cognitive symptom							
Memory disturbance	439	6	1	8	2	3	<1
Concentration difficulties	439	22	5	6	1	3	<1
Sleep disturbance	438	14	3	14	3	7	2
Anxious	438	36	8	17	4	5	1
Fatigue	439	17	4	9	2	4	<1

For each question, numbers of responses (*N*) are presented and valid percentage calculated

Table 3 Statistically significant difference between symptoms after the most serious self-reported accident remaining more than 1 week in relation to exposure of voltage (V) and "no-let-go" (stuck to the source of current), calculated with Chi-2, $p \leq 0.05$ (two-tailed)

Symptoms	Voltage							No-let-go phenomenon						
	≤1000 V			>1000 V				Yes			No			
	N	*n*	%	*N*	*n*	%	*P* value	*N*	*n*	%	*N*	*n*	%	*P* value
Sensory symptom														
Pain	405	25	6	17	10	59	<0.001	115	17	15	312	20	6	0.011
Loss of sensation	405	13	3	17	7	41	<0.001	114	9	8	312	12	4	0.126
Muscular symptom														
Muscle weakness	406	11	3	17	7	41	<0.001	114	10	9	314	10	3	0.034
Muscle twitching	405	6	2	17	9	53	<0.001	114	9	8	312	6	2	0.006
Cognitive symptom														
Memory disturbance	405	7	2	16	1	6	0.268	113	3	3	312	5	2	0.443
Concentration difficulties	405	4	1	16	1	6	0.177	113	4	4	312	2	1	0.045
Sleep disturbance	404	9	2	16	4	25	0.001	112	8	7	312	6	2	0.013
Anxious	405	11	3	16	5	31	<0.001	112	9	8	312	8	3	0.021
Fatigue	405	5	1	16	4	25	<0.001	112	5	5	313	4	1	0.058

For each subgroup, the total numbers of responses (*N*) are presented and valid percentages are calculated

the job quite frequently (Table 4). Thirty-seven per cent out of 444 participants answering this question were not aware that the power line was energised at the time of the accident.

The perceived safety culture in the workplaces at the time of the most severe accident is presented in Table 5. The participants reported that there were deficiencies in the reporting cultures (*item 2–3*), especially for reporting near misses in writing. Even if deficiencies were discovered, their perception was that it did not lead to improve safety at the workplaces (*item 6*) and the participants experienced that actions taken by the employer to prevent further accidents was lacking (*item 21–22*). The participants reported good access to safety equipment at the workplaces (*item 8*) (Table 5). There were no statistically significant differences in reported safety culture between those reporting having experienced less than ten accidents and those reporting ten or more accidents.

Out of 443 participants answering this question, a quarter of the electricians sought medical care after the electrical injury. Inpatient care followed by primary care was the most common health care instance. Twenty-five per cent of those who received any kind of medical care felt that the caregiver lacked experience regarding symptoms after an

Table 4 Self-reported circumstances where the most serious self-reported accident occurred for the 523 electricians included in the study

	Yes	
	n	%
Protection and tools		
Used goggles $n = 449$	16	4
Used appropriate protective equipment $n = 445$	255	57
Used appropriate tools $n = 450$	372	83
Workplace and task		
Was		
Familiar with the workplace $n = 447$	320	71
Familiar with the task $n = 448$	409	91
Well prepared for the task $n = 445$	332	75
Found		
The task complicated $n = 443$	59	13
The workplace noisy $n = 449$	104	23
The workplace cold $n = 449$	62	14
Worked alone $n = 448$	265	59
Personal factors		
Experienced the tasks as risky $n = 447$	77	17
Was tired $n = 448$	58	13
Had trouble concentrating $n = 448$	45	10
Had other things on my mind $n = 446$	125	28
Worked more than usual $n = 443$	81	18
Time pressure		
Was in a hurry $n = 450$	160	36
Experienced tight deadline $n = 449$	125	28

For each question, numbers (*n*) of responders are presented

electrical injury. Medical care after the electrical accident was sought for by 89 % of the HV group compared to 21 % for the LV group ($p < 0.001$) and by 39 % of those reporting "no-let-go" phenomenon compared to 19 % not reporting this phenomenon ($p < 0.001$).

Discussion

The present study not only reports symptoms directly after an electrical injury, but also for a longer time period. The findings indicate that high-voltage injuries and "no-let-go" phenomenon were more frequently associated with long-term symptoms, mainly pain, sensory symptoms and muscle weakness. The study also provides information of deficiencies both in reporting accidents at the workplaces and in preventive actions after an electrical accident.

The percentage of electricians with persistent symptoms was considerably lower in the present study compared to previous case series from burn clinics (Hussmann et al. 1995; Arnoldo et al. 2004; Singerman et al. 2008; Chudasama et al. 2010). Our estimate is likely more representative of the general situation, since the questionnaire was sent to a large and random sample of Swedish electricians and, in addition, electricians reporting their accidents to the Swedish Work Environment Authority (SWEA). The study sample includes persons who had not necessarily been in contact with health care after an electrical injury and therefore also covers those with less severe initial injuries. Notably, even though all accidents should be reported in accordance with current Swedish health and safety rules, the results in the present study show that only a small percentage of all electrical injuries in the study were reported to SWEA.

The questions used in the present study to gather information about the electrical accident had previously been used and tested in another study (Goffeng et al. 2006). In their study, the items concerning the electrical accident had only been used for people with LV injuries; however, there is no reason why electricians exposed to HV injuries should differ in their response about their work situation (Goffeng et al. 2006).

The majority of the safety culture items in the questionnaire were an extract from a larger safety culture questionnaire used in the areas of sea and aviation transport in Sweden (Ek 2006). A few items from other questionnaire studies were also added (see "Materials and methods"). Face validity of the items was tested by both experts and union representatives in the electrical industry. Further studies on safety culture at electricians' workplaces are recommended in order to get appropriate standards for identifying different aspects of deficient safety culture.

A weakness with a retrospective study is the risk of recall bias, especially when the accident could have happened several years ago. Persons experiencing symptoms after an electrical accident might be more motivated to answer the questionnaires. The response rate is important for the credibility of a study. About 50 % participated in the present study which is a normal response rate in surveys today (Baruch and Holtom 2008; Wenemark 2010) and somewhat higher than in the study by Thachenko et al. (1999) (40 %). The conclusions in the present study are of course hampered by the fact that 50 % did not respond to the postal questionnaire.

In the present study, we asked for a date for the most *serious* accident. Seventy-three per cent answered this question, and the time lag ranged from one to 45 years. Although the specific date for the accidents was seldom reported (the response rate for this question had higher internal loss compared to other questions), the stated symptoms cannot be ascribed to a specific accident. Therefore, the duration of symptoms for persons who still had persistent symptoms when answering the questionnaire cannot be calculated. Furthermore, we did not specify what should be

Table 5 Self-reported safety culture at work where the most serious accident happened

Safety culture questionnaire	Median Mean	IQR 25–75 % SD
1. Did you receive the information you needed to be able to carry out your job in a safe manner?[a]	4	3–4
	3.49	1.22
2. If you experienced a near miss (i.e. an event which could have led to an accident), did you report this verbally?[a]	3	2–4
	2.94	1.37
3. If you experienced a near miss (i.e. an event which could have led to an accident), did you report this in writing?[a]	1	1–2
	1.74	1.07
4. Did you experience that the safety rules and routines for preventing problems in the work functioned in reality?[a]	3	2–4
	3.10	1.13
5. Did your supervisor intervene if safety rules/routines were not followed?[a]	3	2–4
	2.87	1.30
6. If you detected deficiencies on the job that could affect work safety, did you think improvements were then made?[a]	3	2–4
	3.29	1.17
7. Did you think the company management actively encouraged safe work?[a]	4	3–4
	3.51	1.23
8. Did you have access to the equipment needed in order to perform your work in a safe manner?[b]	4	4–5
	4.0	0.87
9. Did you feel that the knowledge and experiences of all employees were appreciated?[c]	4	3–4
	3.48	0.93
10. Did you feel that employees were encouraged to put forward ideas and suggestions for improvements concerning work?[c]	3	3–4
	3.20	1.07
11. Did you feel that you could say what you thought about safety at work?[c]	4	3–4
	3.74	1.04
12. Did you feel that you and your co-workers received praise for calling attention to deficiencies in safety?[c]	3	2–4
	2.86	1.14
13. Did you think the company called attention to and took seriously the problems regarding safety that arose on the job?[c]	3	2–4
	3.16	1.08
14. Did you feel that you talked in general about how the work could be improved in order to lead to increased safety?[c]	3	2–4
	2.98	1.11
15. Did your superiors encourage good order on the job?[c]	3	2–4
	3.28	1.13
16. Did you think that your supervisor believed safety was a part of daily work?	3	2–4
	3.24	1.16
17. Did your supervisor occasionally check the work to see if it was performed safely?[c]	2	2–3
	2.51	1.14
18. Did you feel you had an influence on safety in your work?[c]	4	3–4
	3.67	1.0
19. Did your own safety thinking change after the accident?[c]	4	3–4
	3,64	1.20
20. Did the focus on safety at the workplace increase after the accident?[c]	3	2–4
	2.95	1.20
21. Did you think the employer did anything to make the work safer?[c]	3	2–3
	2.64	1.14
22. Did the employer want to take on board your point of views and experiences from the accident in order to prevent other accidents?[c]	3	2–4
	2.68	1.24

Table 5 continued

Safety culture questionnaire	Median Mean	IQR 25–75 % SD
23. Was there a risk that your work could lead to others being injured?[c]	1	3–5
	1.88	1.15
24. Did you think there was a high risk for accidents in your work?[d]	3	2–4
	2.85	1.21

Median (quartiles) and mean (SD) are presented based on a 1 (low) to 5 (high) safety culture scale

Response alternatives for the items: [a] 1 = never 2 = seldom 3 = sometimes 4 = often 5 = always. [b] 1 = no access at all 2 = barely no access 3 = a little access 4 = much access 5 = very much access. [c] 1 = not at all 2 = barely 3 = a little 4 = much 5 = very much. [d] 1 = very high risk 2 = high risk 3 = medium risk 4 = low risk 5 = no risk at all. [e] 1 = yes, to high extent 2 = yes, to some extent 3 = neither yes or no 4 = barely no risk 5 = no, not at all

regarded as a severe electrical accident, and thus, the interpretations can vary between study subjects.

Another limitation in the present study is the 20 % internal loss of answers distributed over all questions. Since there was no systematic patterning found, this loss was nondifferential and does not falsify our results. Since fewer of the participants than expected were smokers, we considered possible biases. However, statistical analysis showed no relation between smoking habits and the frequency of reported accidents ($p = 0.67$).

Direct comparisons with other studies are problematic due to differences in selection of participants and actual time when reporting symptoms. Despite that, the results of the present study are in line with those reported by Bailey and co-workers. They reported fatigue (12 %), pain (10 %), muscular weakness (7 %) and memory loss (3 %) 2 months after an electrical injury in 114 patients, treated in hospital with cardiac monitoring upon arrival (Bailey et al. 2008). In addition, the profile of symptoms remaining 1 year after the injury is in line with our study. Their study supports the theory that electricians after electrical injury can develop symptoms with a delay of some months (Bailey et al. 2008).

In the present study, HV caused more sustained symptoms compared to LV. Chudasama et al. found no statistically significant difference ($p \leq 0.05$) in neuropsychiatric sequelae between HV and LV injuries (Chudasama et al. 2010). The differences in the results might be explained by the fact that the two study samples are not comparable. Most of the electricians with LV injuries in the present study were not treated in hospital, unlike the 25 LV patients with a mean stay in hospital for 4 days in the study made by Chudasama et al. (2010).

Moreover, our results confirm the hypothesis that longer duration of contact to the power, irrespective of voltage group, caused an increased number of long-lasting symptoms. A quarter of the electricians in the present study reported having experienced a "no-let-go" phenomenon; this is significantly higher compared to the 10 % reported previously among 481 American electricians (Tkachenko et al. 1999). It is, therefore, an important question for health care personnel to enquire whether the patient had suffered a "no-let-go" experience.

To our knowledge, there is a dearth of studies that describe perceived safety culture at workplaces for electricians. In the present study, we chose to study perceptions on a limited number of safety culture aspects and in relation to an occurred accident or injury. The present study indicates that improvements could be made in areas concerning the safety culture, especially apparent in the perceptions of insufficient improvement actions when an accident or injury had occurred. The reporting routines were not well established, and the electricians perceived that there were shortages of preventive actions to avoid a new accident.

Previous investigations among electricians stated that focus on personal factors was most relevant to avoid an accident (Tkachenko et al. 1999), but the present study highlights that structures and organisation in the workplaces are also of importance. Interestingly, no statistically significant differences were found in the self-rated safety culture among those experiencing ten or more electrical injuries during their career and those experiencing less. Only a fifth experienced the tasks as risky, but routines were lacking for checking whether the power line was energised or not. Nearly 60 % worked alone, and about one-third experienced time pressure when the accident happened which might imply increased risk of an electrical accident. Despite the fact that most of the electricians had access to appropriate tools, one in five of them chose not to use these tools. It might be speculated that if there is no risk of others being hurt, one's own safety might be ignored.

Despite the fact that all the electricians in the present study had experienced at least one electrical accident and many had symptoms directly related to the accident, only one quarter sought medical care after the accident. Those most likely to seek medical treatment were those exposed to HV and those who experienced "no-let-go", which is in concordance with the results of the study by Tkachenko

et al. (1999). Thus, according to the present study, there seems to be a lack of routine for seeking medical attention after an injury.

Conclusion

The findings in the present study confirm that symptoms can remain 1 week after an electrical accident and sometimes longer and that exposure to HV and "no-let-go" phenomenon was associated with more sustained symptoms. The findings also emphasise the need for more electricians seeking health care after an electrical injury, to follow up on persons exposed to electrical injury and the importance of using clinical measures to objectify the symptoms after electrical injuries. Verification of the results of the present study using prospective study designs with unselected samples is warranted. Further investigation on safety culture among electricians can guide preventive work.

Acknowledgments The present study was funded by the Swedish Research Council for Health, Working Life and Welfare (previously Swedish Council of Working life (FAS Number 2010-0561)) and by the Örebro Research Committee. We would like to express our gratitude to the Swedish Electricians Union, the Swedish Association of Electrical Contractors and the Swedish National Electrical Safety Board for contributions to knowledge in the field of electrical industry and to Lars Ole Goffeng PhD, psychologist and researcher, National Institute of Occupational Health, Norway, for his valuable contributions to the questionnaire. Thanks are also due to research assistant Ing-Liss Bryngelsson, Department of Occupational and Environmental Medicine, Örebro University Hospital for valuable help with the data analysis.

Conflict of interest The authors declare no conflict of interest.

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