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Acute and long-term clinical, neuropsychological, and return-to-work sequelae following electrical injury: a retrospective cohort study

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Editor-in-Chief
Mr. Adrian Aldcroft
BMJ Open

Dear Mr. Aldcroft,

We are pleased to submit an original research article entitled "*Acute and long-term clinical, neuropsychological, and return-to-work sequelae following electrical injury: a retrospective cohort study*" for consideration for publication.

In this manuscript, we have characterized the multifaceted effects following electrical injury, that extend beyond the acute management period. Specifically, we have shown that both low- and high-voltage injuries are implicated in extensive, and adverse, neuropsychological and return-to-work sequelae. Currently, there is limited literature that has evaluated the social and mental health impacts of this type of burn injury. As such, our study is the first complete investigation of acute and long-term adverse effects in combination, within this complex patient population.

We believe that this manuscript would be an appropriate addition to BMJ Open because it aligns with several aims of this journal. Specifically, this study and its findings are of global relevance, as electrical injuries occur worldwide, across both developed and developing nations. By defining the clinical and psychosocial consequences of this injury, we aim to provide caregivers with a greater understanding of the barriers that these patients may face immediately following injury and throughout rehabilitation. Our hope is that these findings may contribute to enhanced monitoring, with subsequent diagnosis and earlier intervention.

We confirm that all authors have made substantial contributions to this article. This manuscript, including related data, figures and tables, has not been previously published and is not under consideration by any other journal.

Thank you for considering our manuscript.

Sincerely,

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Acute and long-term clinical, neuropsychological, and return-to-work sequelae following electrical injury: a retrospective cohort study

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ABSTRACT

Objective: To determine acute and long-term clinical, neuropsychological, and return-to-work (RTW) effects of electrical injuries (EIs). This study aims to further contrast sequelae between low- and high-voltage injuries (LVIs, HVIs). We hypothesize that all EIs will result in substantial adverse effects during both phases of management, with HVIs contributing to greater rates of sequelae.

Design: Retrospective cohort study evaluating EI admissions between 1998-2015.

Setting: Provincial burn centre and rehabilitation hospital specializing in EI management.

Participants: All EI admissions were reviewed for acute clinical outcomes (n=207). Rehabilitation patients, who were referred from the burn centre (n=63) or other burn units across the province (n=65), were screened for inclusion. Six patients were excluded due to pre-existing psychiatric conditions. This cohort (n=122) was assessed for long-term outcomes. Median time to first and last follow-up was 201(IQR 68-766) and 980(IQR 391-1409) days, respectively.

Outcome measures: Acute and long-term clinical, neuropsychological, and RTW sequelae.

Results: Acute clinical complications included infections (14%) and amputations (13%). HVIs resulted in greater rates of these complications, including compartment syndrome (16% vs. 4%, P=.007) and rhabdomyolysis (12% vs. 0%, P<.001). Rates of acute neuropsychological sequelae were similar between voltage groups. Long-term outcomes were dominated by insomnia (68%), anxiety (62%), PTSD (33%) and MDD (25%). Sleep difficulties (67%) were common following HVIs, while the LVI group most frequently experienced sleep difficulties (70%) and anxiety (70%). Ninety work-related EIs were available for RTW analysis. Sixty-one percent returned to their pre-injury employment and 19% were unable to return to any form of work. RTW outcomes were similar between voltage groups.

Conclusions: This is the first investigation to determine acute and long-term patient outcomes post-EI. Findings highlight substantial rates of neuropsychological and social sequelae, regardless of voltage. Therefore, specialized physical and psychosocial rehabilitation, both acutely and long-term, are indicated.

Keywords: Electrical Injuries, Burns, Rehabilitation

Word count: 300 (max. 300)

ARTICLE SUMMARY

Strengths and limitations of this study

- Our study evaluated broad sequelae, including clinical, neuropsychological and return-to-work parameters during acute and long-term intervals, which have not been collectively investigated for electrical injuries in prior studies.
- Outcome measures included a comprehensive list of neuropsychological symptoms and diagnoses that have not been contrasted between voltage groups in existing literature.
- Due to the longitudinal nature of our outcomes of interest, and the associated loss to follow-up, our findings may underrepresent the long-term neuropsychosocial sequelae within our study cohorts.

INTRODUCTION

Electrical injuries (EIs) account for approximately 5% of all annual burn admissions in North America, yet are a leading cause of occupational burns worldwide.[1] These injuries result in substantial limitations that impede return to work (RTW) and decrease quality of life.[2-5] Several studies globally have proposed that EIs result in persistent functional, cognitive and neuropsychological sequelae including flashbacks, depression, anxiety and post-traumatic stress disorder.[3,5,6-16] However, clinical evidence regarding such effects is limited, as the majority of reported findings are case reports or small clinical studies.

Additionally, uncertainty with EI classification remains. EIs can be classified in various ways and defined as either high or low voltage. Currently, an EI below 1000 volts is considered a low voltage injury (LVI), whereas one of 1000 volts or greater is considered a high voltage injury (HVI). Clear classification is necessary as LVIs and HVIs have been suggested to result in different clinical courses. For example, a recent review found that HVIs experience longer hospital stays and greater rates of complications relative to LVIs.[17] Differences between these EI subgroups during the acute and long-term phases of treatment are currently unknown. Within our provincial health care system, a large proportion of EI survivors are treated at a single acute care surgical site, the *Ross Tilley Burn Centre (RTBC)* at *Sunnybrook Health Sciences Centre (SHSC)*. Typically, patients requiring ongoing inpatient or outpatient rehabilitation services are managed at *St. John's Rehabilitation Hospital (SJRH)*, which additionally serves as a referral site for other acute care centres and the workplace injury insurance system. Fewer sites allow for the centralization of services and collection of information for an uncommon diagnosis across multiple phases of care.

There are two primary objectives to this study. First, we aim to determine the effects of EIs on the clinical course of acute hospitalization and long-term outcomes during rehabilitation. The second objective is to examine and contrast individual short- and long-term outcomes by voltage (HVI vs. LVI). We hypothesize that EIs result in substantial morbidity during acute hospitalization and are associated with significant impairments in rehabilitation, RTW and neuropsychology. Lastly, we expect HVIs to be implicated in more adverse clinical sequelae, longer rehabilitation phases and poorer long-term outcomes.

MATERIALS AND METHODS

Study design

We conducted a cohort study of all EI patients admitted to *RTBC* and *SJRH* between November 1998 and December 2015. This study was approved by the Research Ethics Board of *SHSC* (#075-2015). Patients were defined as HVI (≥1000 V) or LVI (<1000 V) group based on the voltage documented at the time of acute admission at *RTBC* or from existing records at the time of entering rehabilitation care at *SJRH*.

We defined EI sequelae during two phases of treatment: (1) acutely, defined as the initial hospital admission at *RTBC*, and (2) long-term, defined as the period of inpatient and outpatient rehabilitation at *SJRH*. The long-term cohort included both patients treated at *RTBC* and those referred from other acute care centres. Patients with pre-existing psychiatric diagnoses, as identified in the admissions note from *RTBC* or *SJRH* patient records, were excluded from analysis of neuropsychological and RTW sequelae. Substance misuse was not included in our exclusion criteria (online supplementary figure 1).

Acute period outcomes

Injury, demographic and clinical outcomes data were obtained through retrospective chart review of *RTBC* progress and summary notes. Variables collected included mean age, sex, mean percentage of the total body surface area (%TBSA), presence of inhalation injury, work-related nature of the injury, voltage (HVI vs. LVI) and EI type (flash, contact, both contact and flash, lightning or unspecified).

Clinical outcomes during the acute period that were collected included length of stay adjusted for %TBSA (LOS/%TBSA), number of amputations, amputation levels and number of operations. Incidence of mortality, rhabdomyolysis, compartment syndrome, one or more

infections, sepsis, multiple organ failure, and rehabilitation requirements (inpatient or outpatient) were additionally analyzed.

Patients transferred to *SJRH* for rehabilitation underwent neuropsychological screening prior to discharge, as part of the required referral documentation. This screen included: depressed mood, anxiety, flashbacks, avoidance, hypervigilance, hyperarousal, nightmares, sleep difficulties, social withdrawal, suicidal ideations, memory and concentration difficulties, dizziness, headaches and phantom limb pain.

Long-term period outcomes

Injury, demographic and neuropsychological outcomes data for patients in the long-term cohort were obtained through chart review of *SJRH* documentation. Variables collected included voltage (HVI vs. LVI), work-related nature of the EI and occupation. Long-term neuropsychological outcomes identified from rehabilitation records were rates of depressed mood, anxiety, flashbacks, avoidance, hypervigilance, hyperarousal, nightmares, sleep difficulties, social withdrawal, suicidal ideations, memory and concentration difficulties, dizziness, headaches, phantom limb pain and chronic pain. Treatment by a psychologist or psychiatrist and the need for medication to address these sequelae were also recorded. Additionally, we recorded formal diagnoses of post-traumatic stress disorder (PTSD), major depressive disorder (MDD), generalized anxiety disorder (GAD), adjustment disorder and panic disorder, as well as the time to diagnosis post-injury.

Patients with work-related EIs had information recorded regarding RTW goals: time required to return to pre-injury employment or alternative work in the labour market and the form of required workplace accommodations (i.e. modified scheduling or duties). Patients who did not have documented outcomes regarding their RTW status were excluded from this analysis.

Statistical analysis

Statistical analyses were performed using SPSS Statistics version 25.0 (IBM Corp.). Categorical variables are presented as percentages, with group comparisons made using Pearson's $\chi 2$ test and Fisher's exact test. Normally-distributed continuous variables are presented as mean and standard deviation (SD), and compared between groups using the student's t-test. Nonparametric data are presented as median and interquartile range (IQR), and compared using the Mann-Whitney U test. For all comparisons, $P \leq .05$ was considered statistically significant.

RESULTS

Acute period

We identified 207 acute EI admissions between 1998-2015 that were eligible for inclusion (online supplementary figure 2). Of these acute patients, 106 were discharged to either inpatient or outpatient rehabilitation at any rehabilitation facility and therefore had neuropsychiatric assessment data available for review. Four patients were excluded due to pre-existing psychiatric conditions that were documented on admission in their hospital records. *SJRH* records were obtained for 59 of these patients who were identified as having received inpatient or outpatient treatment at this facility without a pre-existing psychiatric condition. Health records for patients who were admitted to *SJRH* prior to the year 2003 were not accessible, therefore, these patients were not included in further analysis.

Demographics

Patients were predominantly male with a mean age of 41±13 years. Mean burn size was 8±12% TBSA and the incidence of inhalation injury was low. LVIs were more common than HVIs (59% vs. 37%). The most prevalent mechanism of EI was isolated flash injury, followed by direct contact with electrical current. The majority of injuries were work-related (83%; online supplementary table 1).

Clinical outcomes

The average LOS/%TBSA was 4.5±9.5 days/% burn, with 2% of patients not surviving to discharge (Table 1, online supplementary figure 3). The most common complications during acute management were infection, amputation and compartment syndrome. Multiple organ failure occurred in 1% of patients. While 13% of patients required at least one amputation, 6% required multiple. The most common amputation sites were the digits of the feet and the digits of

the hands (36% and 29%, respectively), while the least common was above the elbow (2%). Overall, half of all EI patients required rehabilitation on discharge; of these, 32% and 68% were referred to inpatient and outpatient rehabilitation, respectively (Table 1).

Table 1. Clinical outcomes during the acute phase of management.

	All Patients[a]	HVI	LVI	*P*
No. of patients	207	76	122	
LOS/TBSA, days/%, mean (SD)	4.5 (9.5)	8.0 (14.4)	2.6 (4.0)	.007
No. of ORs, median (IQR)	1 (0-2)	2 (0-3)	0 (0-1)	<.001
Complications, no. (%)				
Rhabdomyolysis	9 (4)	9 (12)	0 (0)	<.001
Compartment syndrome	17 (8)	12 (16)	5 (4)	.007
Infection	28 (14)	15 (20)	11 (9)	.05
Sepsis	11 (5)	8 (11)	3 (3)	.02
Multiple organ failure	1 (1)	1 (1)	0 (0)	.38
Amputation	26 (13)	21 (28)	3 (2)	<.001
Multiple amputations	13 (6)	10 (13)	2 (2)	.001
Requiring rehabilitation, no. (%)	106 (51)	49 (65)	54 (44)	.008
Discharged to inpatient rehabilitation, no. (%)	34 (32)	22 (45)	10 (19)	<.001
Discharged to outpatient rehabilitation, no. (%)	72 (68)	27 (55)	44 (82)	>.99
Mortality, no. (%)	4 (2)	3 (4)	1 (1)	.16

Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury; LOS, length of stay; TBSA, total body surface area.
[a] Includes patients whose voltage was not otherwise specified (n=9).

Neuropsychological outcomes

Of the 59 patients with neuropsychological screening, nearly one quarter experienced at least one neuropsychological symptom during the acute period (Table 2). The most common symptoms included flashbacks (15%), sleep difficulties (12%). Suicidal ideations, hyperarousal and social withdrawal did not occur during the acute phase of treatment (Figure 1).

Table 2. Neuropsychological sequelae and management.

	All Patients[a]	HVI	LVI	*P*
Acute Cohort				
No. of patients	59	26	31	
Neuropsychological sequelae, no. (%)	14 (24)	6 (23)	7 (23)	>.99
Long-Term Cohort				
No. of patients	122	51	69	
Days to first follow-up, median (IQR)	201 (68-766)	504 (179-1236)	124 (41-233)	<.001
Days to last follow-up, median (IQR)	980 (391-1409)	1099 (511-1651)	773 (315-1218)	.02
Neuropsychological sequelae, no. (%)				
<5 yrs. post-injury	99 (81)	42 (82)	56 (81)	>.99
>5 yrs. post-injury	20 (16)	13 (25)	7 (10)	.05
Psychological/ Psychiatric treatment, no. (%)	78 (64)	31 (61)	47 (68)	.44
Medication, no. (%)	78 (64)	30 (59)	47 (68)	.34

Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury.
Analysis excludes patients with documented pre-existing psychiatric conditions.
[a] Includes patients whose voltage was not otherwise specified (acute cohort, n=2; long-term cohort, n=2).

Acute period, high- vs low-voltage injuries

Demographics

The acute cohort was comprised of 76 HVI and 122 LVI patients, with both groups being predominantly male. Both voltage cohorts were similar in mean age, mean %TBSA and incidence of inhalation injury. LVIs were more likely of being occupational in nature (*P*=.03). HVIs were more frequently a result of combined flash and contact burn etiology, whereas LVIs were more commonly associated with isolated flash injuries (*P*<.001 for both; online supplementary table 1).

Clinical outcomes

The incidence and severity of clinical outcomes were overall worse in the HVI group. HVI patients experienced a longer LOS/%TBSA (*P*=.007) and greater incidences of

rhabdomyolysis (*P*<0.001), compartment syndrome (*P*=.007), infections (*P*=.05), and sepsis (*P*=.02; Table 1). However, there was no statistical difference in survival between HVIs and LVI (Table 1, online supplementary figure 3). Single and multiple amputations were more common among HVI patients (*P*<.001 and *P*=.001, respectively). The majority of HVI amputations involved digits (29% hands, 36% feet). Lastly, patients with HVIs were more likely of being discharged to inpatient rehabilitation than LVIs (*P*<.001; Table 1).

Neuropsychological outcomes

Of those screened, HVIs were equally as likely of experiencing neuropsychological sequelae during the acute treatment period (*P*>.99; Table 2). The incidence of symptoms was likewise similar between voltage groups. Marginally greater rates of the following symptoms were exhibited by the HVI group when contrasted with the LVI group: depressed mood (4% vs. 3%, *P*>.99), flashbacks (15% vs. 13%, *P*>.99), dizziness (4% vs. 3%, *P*>.99), nightmares (4% vs. 3%, *P*>.99), avoidance (4% vs. 0%, *P*=.46), memory and concentration impairments (8% vs. 3%, *P*=.59), headaches (4% vs. 0%, *P*=.46) and phantom limb pain (8% vs. 0%, *P*=.20). In contrast, LVIs were associated with slightly greater rates of sleep difficulties (13% vs. 8%, *P*=.68), anxiety (6% vs. 4%, *P*>.99) and hypervigilance (3% vs. 0%, *P*>.99; Figure 1).

Long-term period

Demographics

The long-term period cohort consisted of 128 patients, with a second screen identifying six patients meeting exclusion criteria due to pre-existing psychiatric conditions. Therefore, 122 patients were available for analysis. Half of these patients had been treated for their acute injury at *RTBC*. Acute data were available for those patients. The majority of patients in the long-term cohort suffered EIs that were occupational in nature (91%, online supplementary table 2).

Neuropsychological outcomes

More than half of all patients receiving rehabilitation were diagnosed with at least one psychiatric disorder after their injury, while one third of patients were diagnosed with two or more. The median time to a psychiatric diagnosis across all six conditions was 315 days (IQR 117-957) (online supplementary table 3). PTSD (33%), MDD (25%) and adjustment disorder (20%) were the psychiatric conditions that occurred most frequently (online supplementary figure 4). Of the vast majority of patients, 81% experienced at least one neuropsychological symptom between a median time to first and last follow-up of 201 (IQR 68-766) and 980 (IQR 391-1409) days post-injury, respectively (Table 2). The most common symptoms were sleep difficulties (68%), anxiety (62%), depressed mood (60%) and memory and concentration impairments (59%) (Figure 2). In more than 60% of patients, these were severe enough to require psychological/psychiatric treatment or medication. Patients with PTSD most commonly exhibited symptoms of anxiety, sleep difficulties and depressed mood (95%, 93% and 85%, respectively). MDD, GAD and adjustment disorder were frequently associated with symptoms of depressed mood, anxiety, sleep difficulties and memory and concentration impairments (online supplementary table 4).

Return-to-work outcomes

A total of 111 work-related EIs were reviewed; of these, data regarding RTW status were available for 90 patients. Electricians made up the predominant occupation group, followed by powerline technicians (online supplementary table 2). Sixty-one percent of patients were able to return to their pre-injury occupation, of which 60% required modified duties and 55% required modified scheduling. Furthermore, 19% of patients sustaining work-related EIs returned to alternative employment through labour market re-entry (LMR), with the median time for

returning to any work being 166 days (IQR 82-414). Overall, one fifth of EI patients were unable to return to any form of employment (Table 3).

Table 3. Return-to-work characteristics of occupational EIs within the long-term cohort.

	All Patients[a]	HVI	LVI	*P*
No. of patients	90	39	49	
Return to pre-injury occupation, no. (%)	55 (61)	23 (59)	30 (61)	>.99
Modified Duties, no. (%)	33 (60)	15 (65)	17 (57)	.58
Modified Schedule, no. (%)	30 (55)	11 (48)	17 (57)	.59
Labour Market Re-Entry, no. (%)	17 (19)	9 (23)	8 (16)	.80
Time to RTW, days, median (IQR)	166 (82-414)	207 (102-548)	124 (57-348)	.12
Unable to RTW, no. (%)	17 (19)	6 (15)	11 (22)	.43

Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury; RTW, return-to-work.
[a] Includes patients whose voltage was not otherwise specified (n=2).

Long-term period, high- vs low-voltage injuries

Neuropsychological outcomes

The distribution of formal diagnoses of individual psychiatric disorders was comparable between HVIs and LVIs (online supplementary figure 4). PTSD and MDD were the most common in both HVI and LVI groups (24% vs. 41%, *P*=.054 and 18% vs. 30%, *P*=.14, respectively), while panic disorder was the most infrequently diagnosed (0% and 1%, *P*>.99). HVIs were most commonly associated with sleep difficulties (67%), memory and concentration impairment (57%), and chronic pain (57%), while LVIs were most commonly associated with sleep difficulties (70%) and anxiety (70%) (Figure 2). HVIs were more likely of exhibiting neuropsychological sequelae beyond 5 years post-injury (*P*=.05; Table 2). Voltage groups did not differ in their rates of treatment and medication requirements for management of neuropsychological sequelae.

Return-to-work outcomes

LVIs and HVIs exhibited similar rates of return to pre-injury occupation. More than half of these patients required workplace accommodation. HVI patients more frequently required modified duties, while LVIs were more commonly associated with modified scheduling. The requirement for LMR for alternative employment was similar between voltage groups, along with the median time for RTW. A similar inability to return to any form of employment was observed between voltage groups (Table 3).

DISCUSSION

Our study identifies and delineates common sequelae that extend beyond acute management. When stratifying by voltage, the acute clinical findings indicate greater rates of complications and operative interventions in the HVI group. Conversely, rates of neuropsychological symptoms increase overtime. While overall neuropsychological sequelae are statistically comparable between voltage groups, LVIs result in marginally greater rates of depressed mood, anxiety, nightmares, headaches and hypervigilance. They have similarly been associated with greater rates of PTSD, MDD, GAD, adjustment disorder and panic disorder. Lastly, both voltage groups are comparably implicated in RTW challenges. HVIs result in more frequent job accommodations and retraining, while LVIs are more commonly associated with unsuccessful RTW. Therefore, while HVIs result in increased clinical morbidity, LVIs need to be recognized as significant burdens for their effects on neuropsychological and social well-being.

Acute clinical findings are consistent with other studies that have shown increased morbidity in patients who have sustained a HVI.[17-21] A recent systematic review evaluated the different injury patterns associated with HVIs and LVIs. Combined data indicate that HVIs experience longer hospital stays and greater complications rates.[17] Comparative data between voltage groups for other common complications implicated in EIs, such as compartment syndrome, rhabdomyolysis and amputations, are lacking in literature.[22-24] However, histological and gross structural modifications, along with subsequent muscle and vasculature destruction, have been observed with increasing voltage. This further suggests that HVIs may result in increased complication rates, morbidity and mortality.[24-28]

Hussmann et al. observed greater rates of neurological impairments in their EI patient cohort, over a mean follow-up time of 5 years.[6] This suggests that our findings may

underestimate the true severity of EIs, as continued care beyond 5 years was uncommon in our long-term cohort. Nevertheless, our findings are consistent with other studies that have evaluated the implications of EIs on behaviour, cognition and executive function.[5,6,8-10,14-16,29] Common difficulties identified during recovery include flashbacks, nightmares, MDD and PTSD. The findings of these studies highlight the need for further exploration of neuropsychological sequelae in this burn population. In doing so, we will improve the understanding of specific predispositions post-EI, facilitating symptom monitoring and management.

Current literature regarding neuropsychological sequelae suggests that burn survivors exhibit greater rates of psychiatric illnesses compared to the general population. Meyer et al. investigated the prevalence of diagnoses in young adults who had sustained a burn injury of any etiology prior to the age of 16.[30] Relative to our EI cohort, a lower rate of PTSD and greater incidences of MDD and GAD were reported. However, the mean follow-up time post-injury is greater than that of our study, which may result in underestimation of diagnosis rates within our cohort. Therefore, comparison of our findings to current evidence indicates that EI patients may be more predisposed to certain psychiatric conditions relative to the general burn population.

Lastly, our results demonstrate the challenges that EIs elicit with employment reintegration. Noble et al. found that a third of their EI cohort was unable to return to any employment.[5] In contrast, we observed a lower inability to RTW in both voltage groups. This may indicate improved strategies in EI management and more specialized rehabilitation programs that enhance work reintegration. However, workplace accommodations remain common amongst this burn population and should be an area of focus during rehabilitation.

This study provides a regional view into the truly global burden of this burn injury. A recent review of adult EIs identified a total of 41 publications globally in this area of research, with 58% of studies originating from outside of North America. Nearly half of all studies originated from outside of North American and did not independently evaluate HVI and LVI outcomes. These studies limited investigations to clinical-based outcomes without addressing rehabilitation and psychological impacts.[17] Therefore, to our knowledge, our study is the most comprehensive acute and long-term investigation of EIs to date, providing caregivers with an in-depth understanding of the acute and long-term barriers faced by this burn population. These findings additionally highlight the need for employee safety education and post-injury monitoring for common sequelae with any voltage. Lastly, the formulation of holistic EI teams (i.e. occupational therapists, physiotherapists, pain specialists, RTW coordinators) may facilitate reintegration to original employment.

Several limitations have been recognized. Data from the acute period was extracted from a single regional burn centre. Therefore, our cohorts consist of patients believed to be more injured than other EI patients, requiring specialized treatment. Long-term data is limited to patients who received rehabilitation services at *SJRH*. Patients may have sought treatment within their community, limiting identification of more long-term sequelae. Due to this loss to follow-up, our results may underrepresent the long-term neuropsychological and RTW effects of EIs.

In conclusion, EIs are implicated in multifaceted clinical, neuropsychological and social sequelae. Effects exist acutely and long-term, warranting monitoring that extends beyond initial treatment. LVIs are, at minimum, as likely as HVIs of exhibiting complications during recovery. Lastly, we have identified these effects as possible barriers for successful employment re-integration. Collectively, these findings indicate a need for focused training and rehabilitation.

Future investigations will involve implementing similar studies across broad geographic regions to inform region-specific management of this burn injury.

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COMPETING INTERESTS STATEMENT

None declared.

AUTHOR CONTRIBUTIONS

MGJ was responsible for the study design. NR was responsible for the literature search, data acquisition and drafting of the work. SR and NR conducted statistical analysis of data. NR, SAM, SR, MG and MGJ were responsible for revisions of the work. All authors gave approval for the final version of the manuscript.

DATA SHARING STATEMENT

No additional data from this study are available.

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Figure 1. Neuropsychological symptoms of EI patients during the acute phase of treatment. Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury.

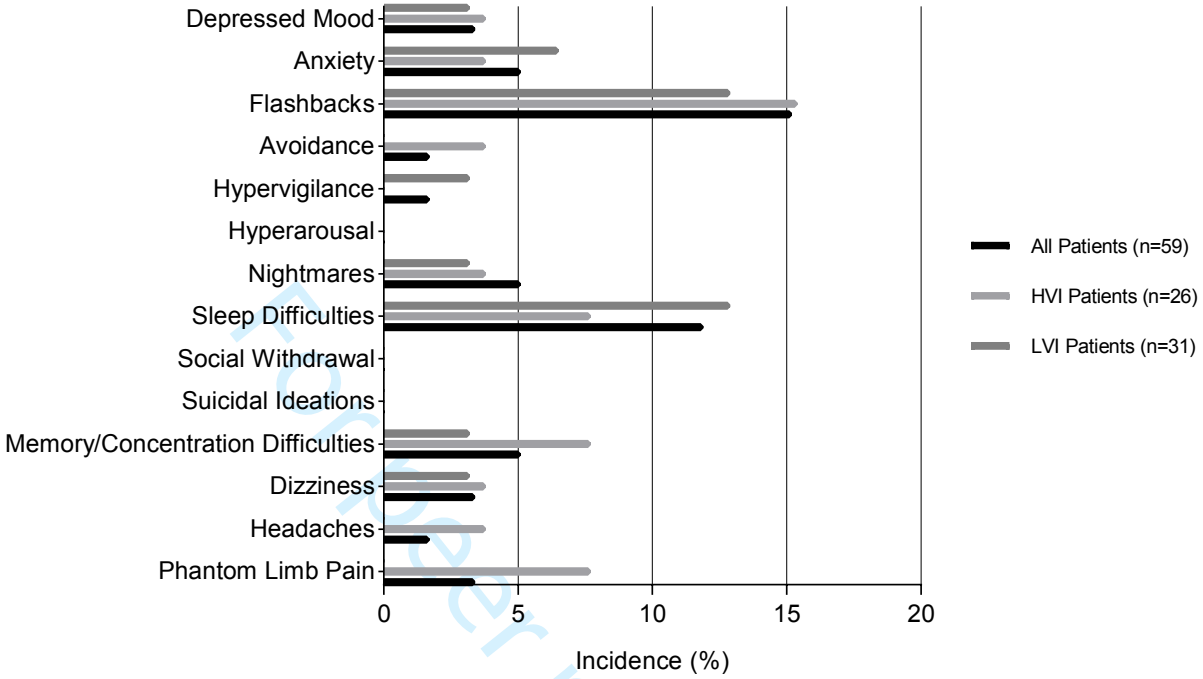
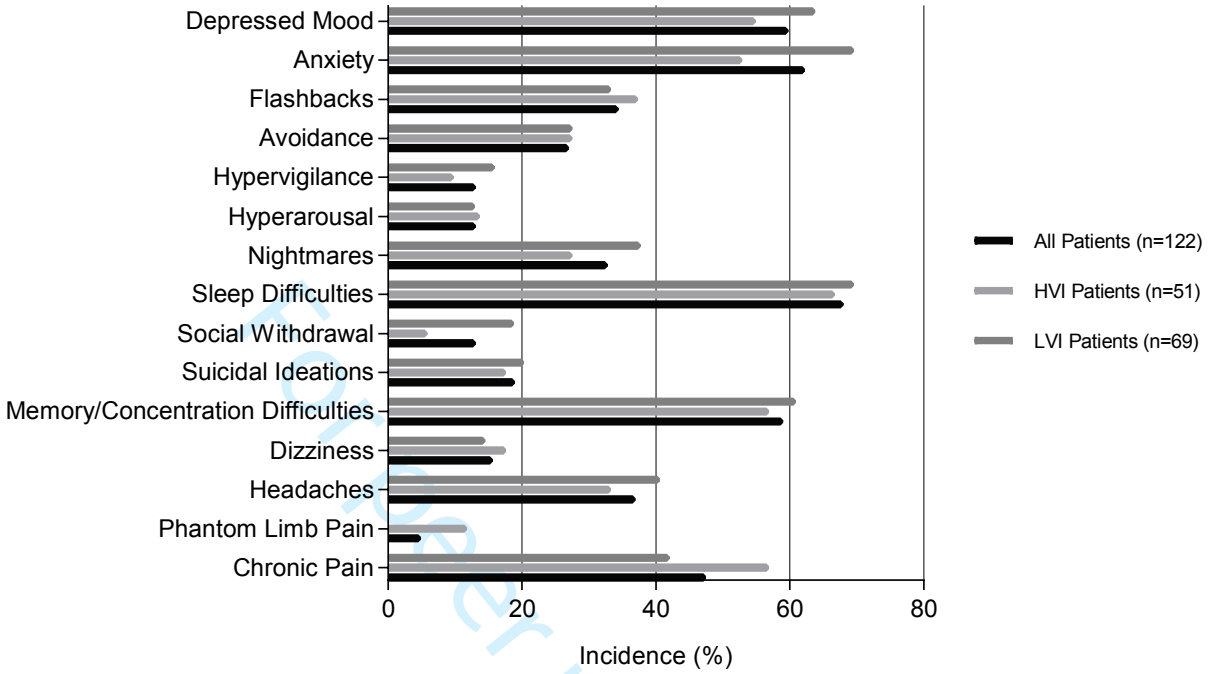
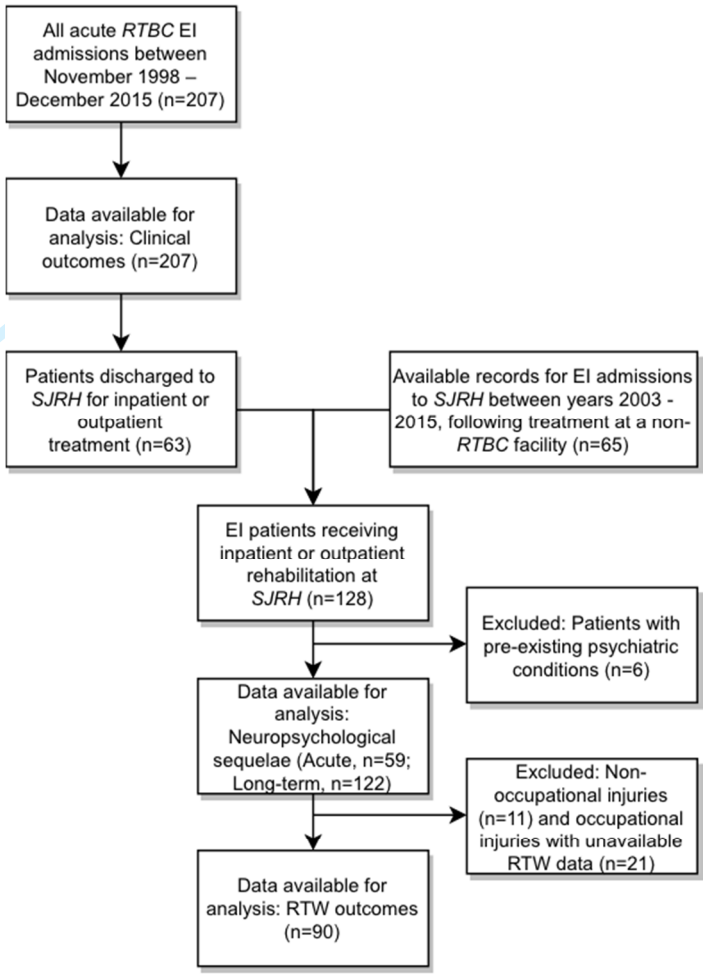


Figure 2. Neuropsychological symptoms of EI patients during the long-term phase of treatment. Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury.

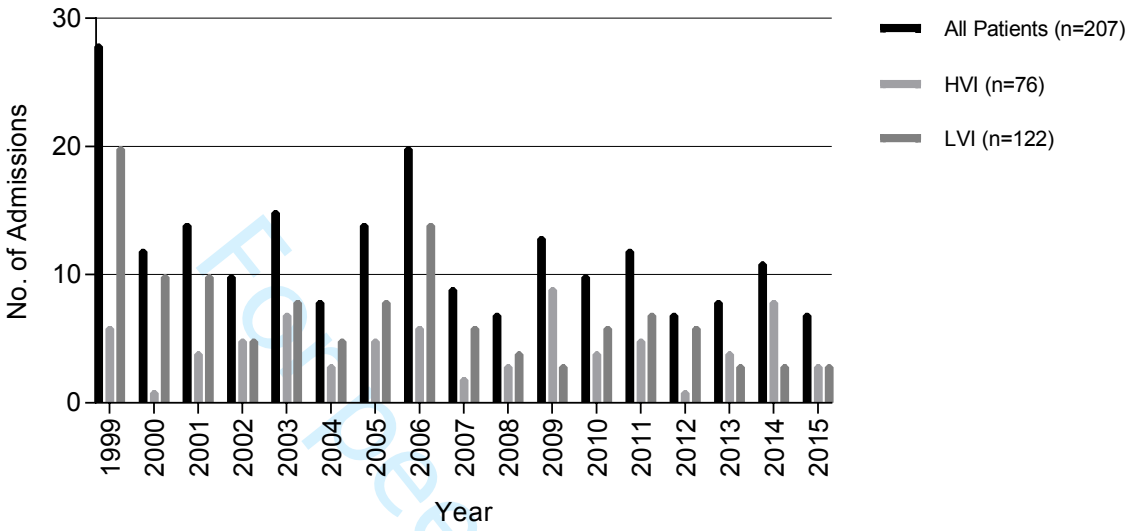


Supplementary Online Content

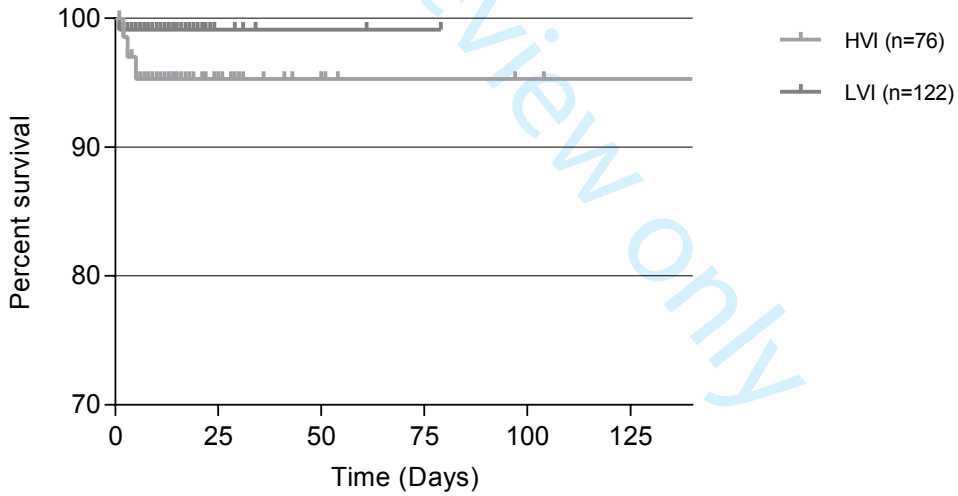
Supplementary Figure 1. Patient Flow Diagram. Abbreviations: RTBC, Ross Tilley Burn Centre; SJRH, St. John's Rehabilitation Hospital; RTW, return-to-work.



Supplementary Figure 2. Annual admissions of acute electrical injuries at the *Ross Tilley Burn Centre*, Toronto, Canada. A total of 9 admissions were of unknown voltage. Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury.

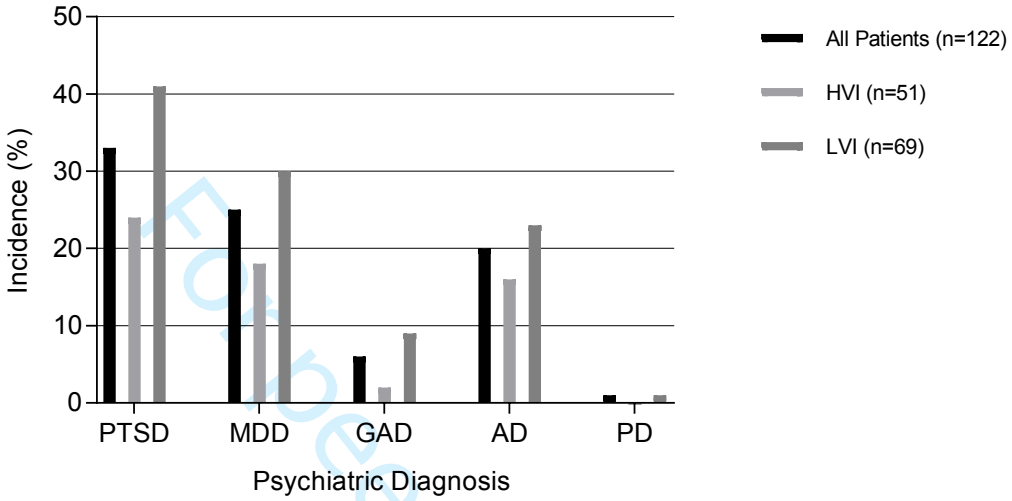


Supplementary Figure 3. Kaplan-Meier Survival Curve. Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury;



Supplementary Figure 4. Rates of psychiatric diagnoses among the long-term cohort.

Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury; PTSD, post-traumatic stress disorder; MDD, major depressive disorder; GAD, generalized anxiety disorder; AD, adjustment disorder; PD, panic disorder.



Supplementary Table 1. Demographics and injury characteristics of patients treated acutely at the burn centre.

	All Patients[a]	**HVI**	**LVI**	***P***
No. of patients	207	76	122	
Age, years, mean (SD)	41 (13)	40 (14)	41 (13)	0.64
Male, no. (%)	198 (96)	72 (95)	117 (96)	0.74
TBSA, %, mean (SD)	8 (12)	10 (13)	8 (11)	0.17
Inhalation injury, no. (%)	4 (2)	1 (1)	3 (3)	>.99
Work-Related, no. (%)	171 (83)	57 (75)	107 (88)	.03
Classification, no. (%)				
Contact	67 (33)	11 (15)	18 (15)	>.99
Flash	115 (56)	10 (13)	101 (83)	<.001
Contact and Flash	15 (7)	46 (61)	3 (3)	<.001
Lightning	4 (2)	4 (5)	0 (0)	.02
Unspecified	6 (3)	5 (7)	0 (0)	.008

Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury; TBSA, total body surface area.
[a] Includes patients whose voltage was not otherwise specified (n=9).

Supplementary Table 2. Demographics and injury characteristics of the long-term cohort.

	All Patients[a]	HVI	LVI	*P*
No. of patients	122	51	69	
Work-Related, no. (%)	111 (91)	47 (92)	62 (90)	>.99
Available RTW data, no. (%)	90 (81)	39 (83)	49 (79)	.54
Pre-Injury Occupation, no. (%)				
Electrician	26 (29)	6 (15)	19 (39)	.02
Mechanic	3 (3)	0 (0)	3 (6)	.25
Maintenance Worker	4 (4)	0 (0)	4 (8)	.13
Powerline Technician	13 (14)	13 (33)	0 (0)	<.001
Construction Worker	4 (4)	4 (10)	0 (0)	.04
Self-Employed	2 (2)	2 (5)	0 (0)	.19
Truck Driver	3 (3)	3 (8)	0 (0)	.08
Other	29 (32)	8 (21)	21 (43)	.04
Unknown	6 (7)	3 (8)	2 (4)	.65

Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury; RTW, return-to-work.
Analysis excludes patients with documented pre-existing psychiatric conditions.
[a] Includes patients whose voltage was not otherwise specified (n=2).

Supplementary Table 3. Time to diagnosis (from day of injury) of psychiatric conditions during the long-term period of treatment.

	All Patients	HVI	LVI	*P*
All Conditions (n=101), days, median (IQR)[a,b]	315 (117-957)	384 (161-1461)	272 (114-904)	.20
PTSD (n=40), days, median (IQR)	263 (78-937)	325 (153-1495)	253 (75-843)	.41
MDD (n=30), days, median (IQR)	531 (213-1061)	684 (265-1897)	402 (151-1013)	.33
GAD (n=7), days, median (IQR)	402 (261-1060)	-	374 (252-891)	-
Adjustment Disorder (n=23), days, median (IQR)[b]	177 (88-771)	177 (63-1042)	177 (99-358)	.82
Panic Disorder (n=1), days, median (IQR)	-	-	-	-

Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury; PTSD, post-traumatic stress disorder; MDD, major depressive disorder; GAD, generalized anxiety disorder.
Analysis excludes patients with documented pre-existing psychiatric conditions.
[a] Conditions include PTSD, MDD, GAD, adjustment disorder and panic disorder.
[b] Patients without documented diagnoses dates were excluded from analysis (n=1).

Supplementary Table 4. Rates of neuropsychological symptoms in patients formally diagnosed with a psychiatric condition in the long-term cohort.

	PTSD	MDD	GAD	Adjustment Disorder	Panic Disorder
No. of patients	40	30	7	24	1
Depressed Mood, no. (%)	34 (85)	29 (97)	7 (100)	24 (100)	1 (100)
Anxiety, no. (%)	38 (95)	28 (93)	7 (100)	21 (88)	1 (100)
Flashbacks, no. (%)	23 (58)	13 (43)	2 (29)	13 (54)	1 (100)
Avoidance, no. (%)	17 (43)	15 (50)	4 (57)	10 (42)	1 (100)
Hypervigilance, no. (%)	8 (20)	9 (30)	1 (14)	2 (8)	0 (0)
Hyperarousal, no. (%)	13 (33)	8 (27)	1 (14)	5 (21)	1 (100)
Nightmares, no. (%)	21 (53)	16 (53)	6 (86)	14 (58)	0 (0)
Sleep Difficulties, no. (%)	37 (93)	28 (93)	7 (100)	22 (92)	1 (100)
Social Withdrawal, no. (%)	10 (25)	8 (27)	2 (29)	4 (17)	0 (0)
Suicidal Ideations, no. (%)	18 (45)	15 (50)	4 (57)	9 (38)	1 (100)
Memory/Concentration Difficulties, no. (%)	33 (83)	29 (97)	7 (100)	21 (88)	1 (100)
Dizziness, no. (%)	7 (18)	7 (23)	2 (29)	7 (29)	0 (0)
Headaches, no. (%)	19 (48)	15 (50)	4 (57)	17 (71)	0 (0)
Phantom Limb Pain, no. (%)	2 (5)	2 (7)	1 (14)	1 (4)	0 (0)
Chronic Pain, no. (%)	24 (60)	23 (77)	3 (43)	16 (67)	0 (0)

Abbreviations: PTSD, post-traumatic stress disorder; MDD, major depressive disorder; GAD, generalized anxiety disorder.
Analysis excludes patients with documented pre-existing psychiatric conditions.

Reporting checklist for cohort study.

Based on the STROBE cohort guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cohort reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	3
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	4-5
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	7
Objectives	#3	State specific objectives, including any prespecified hypotheses	8
Study design	#4	Present key elements of study design early in the paper	9
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	9
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up.	9

	#6b	For matched studies, give matching criteria and number of exposed and unexposed	See note 1
Variables	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-10
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	9-10
Bias	#9	Describe any efforts to address potential sources of bias	See note 2
Study size	#10	Explain how the study size was arrived at	9
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	9
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	11
	#12b	Describe any methods used to examine subgroups and interactions	11
	#12c	Explain how missing data were addressed	12
	#12d	If applicable, explain how loss to follow-up was addressed	n/a
	#12e	Describe any sensitivity analyses	See note 3
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	12-15
	#13b	Give reasons for non-participation at each stage	12-15
	#13c	Consider use of a flow diagram	9

Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	12-15
	#14b	Indicate number of participants with missing data for each variable of interest	12-15
	#14c	Summarise follow-up time (eg, average and total amount)	16
Outcome data	#15	Report numbers of outcome events or summary measures over time. Give information separately for exposed and unexposed groups if applicable.	12-18
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-18
	#16b	Report category boundaries when continuous variables were categorized	12-18
	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	See note 4
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	12-18
Key results	#18	Summarise key results with reference to study objectives	19
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	21
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	21-22
Generalisability	#21	Discuss the generalisability (external validity) of the study results	21-22
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	23

Author notes

1. n/a - this was not a matched study
2. n/a - we were unable to account for two of the biases that affected our study (discussed on pg. 21)
3. n/a - our methods did not employ any sensitivity analyses
4. n/a - was not relevant to our study

BMJ Open

Acute and long-term clinical, neuropsychological, and return-to-work sequelae following electrical injury: a retrospective cohort study

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Primary Subject Heading:	Surgery
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Keywords:	Electrical Injuries, Burns, Rehabilitation

Acute and long-term clinical, neuropsychological, and return-to-work sequelae following electrical injury: a retrospective cohort study

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ABSTRACT

Objective: To determine acute and long-term clinical, neuropsychological, and return-to-work (RTW) effects of electrical injuries (EIs). This study aims to further contrast sequelae between low- and high-voltage injuries (LVIs, HVIs). We hypothesize that all EIs will result in substantial adverse effects during both phases of management, with HVIs contributing to greater rates of sequelae.

Design: Retrospective cohort study evaluating EI admissions between 1998-2015.

Setting: Provincial burn centre and rehabilitation hospital specializing in EI management.

Participants: All EI admissions were reviewed for acute clinical outcomes (n=207). For long-term outcomes, rehabilitation patients, who were referred from the burn centre (n=63) or other burn units across the province (n=65), were screened for inclusion. Six patients were excluded due to pre-existing psychiatric conditions. This cohort (n=122) was assessed for long-term outcomes. Median time to first and last follow-up was 201(IQR 68-766) and 980(IQR 391-1409) days, respectively.

Outcome measures: Acute and long-term clinical, neuropsychological, and RTW.

Results: Acute clinical complications included infections (14%) and amputations (13%). HVIs resulted in greater rates of these complications, including compartment syndrome (16% vs. 4%, P=.007) and rhabdomyolysis (12% vs. 0%, P<.001). Rates of acute neuropsychological sequelae were similar between voltage groups. Long-term outcomes were dominated by insomnia (68%), anxiety (62%), PTSD (33%) and MDD (25%). Sleep difficulties (67%) were common following HVIs, while the LVI group most frequently experienced sleep difficulties (70%) and anxiety (70%). Ninety work-related EIs were available for RTW analysis. Sixty-one percent returned to their pre-injury employment and 19% were unable to return to any form of work. RTW were similar when compared between voltage groups.

Conclusions: This is the first investigation to determine acute and long-term patient outcomes post-EI as a continuum. Findings highlight substantial rates of neuropsychological and social sequelae, regardless of voltage. Specialized and individualized early intervention including screening for mental health are imperative to improve outcomes of EI patients.

Keywords: Electrical Injuries, Burns, Rehabilitation

Word count: 300 (max. 300)

ARTICLE SUMMARY

Strengths and limitations of this study

- Our study evaluated broad sequelae, including clinical, neuropsychological and return-to-work parameters during acute and long-term intervals, which have not been collectively investigated for electrical injuries in prior studies.
- Outcome measures included a comprehensive list of neuropsychological symptoms and diagnoses that have not been contrasted between voltage groups in existing literature.
- Due to the longitudinal nature of our outcomes of interest, and the associated loss to follow-up, our findings may underrepresent the long-term neuropsychosocial sequelae within our study cohorts.

INTRODUCTION

Electrical injuries (EIs) account for approximately 5% of all annual burn admissions in North America, yet are a leading cause of occupational burns worldwide.[1] These injuries result in substantial limitations that impede return to work (RTW) and decrease quality of life.[2-5] Several studies globally have proposed that EIs are implicated in persistent functional, cognitive and neuropsychological sequelae including flashbacks, depression, anxiety and post-traumatic stress disorder.[3,5,6-16] However, clinical evidence regarding such effects is limited, as the majority of reported findings are based on case reports or small clinical studies.[17]

Additionally, uncertainty with EI classification remains. EIs can be classified in various ways and defined as either high or low voltage. Currently, an EI below 1000 volts is considered a low voltage injury (LVI), whereas one of 1000 volts or greater is considered a high voltage injury (HVI). These voltage categories have been defined based on arcing risk.[18] Clear classification is necessary as LVIs and HVIs have been suggested to result in different clinical courses. For example, two recent reviews found that HVIs experience longer hospital stays and greater rates of complications relative to LVIs.[19-21] Differences between these EI subgroups during the acute and long-term phases of treatment are currently unknown.

Within our provincial health care system, a large proportion of EI survivors are treated at a single acute care surgical site, the *Ross Tilley Burn Centre (RTBC)* at *Sunnybrook Health Sciences Centre (SHSC)*. Typically, patients requiring ongoing inpatient or outpatient rehabilitation services are managed at *St. John's Rehabilitation Hospital (SJRH)*, which additionally serves as a referral site for other acute care centres and the workplace injury insurance system. Fewer sites allow for the centralization of services and collection of information for an uncommon diagnosis across multiple phases of care.

There are two primary objectives to this study. First, we aim to determine the effects of EIs on the clinical course of acute hospitalization and long-term outcomes during rehabilitation. The second objective is to examine and contrast individual short- and long-term outcomes by voltage (HVI vs. LVI). We hypothesize that EIs result in substantial morbidity during acute hospitalization and are associated with significant impairments in rehabilitation, RTW and neuropsychology. Lastly, we expect HVIs to be implicated in more adverse clinical sequelae, longer rehabilitation phases and poorer long-term outcomes.

MATERIALS AND METHODS

Study design

We conducted a cohort study of all EI patients admitted to *RTBC* and *SJRH* between November 1998, the date of *RTBC* establishment at *SHSC*, and December 2015. This study was approved by the Research Ethics Board of *SHSC* (#075-2015). Patients were defined as HVI (≥1000 V) or LVI (<1000 V), based on the voltage documented at the time of acute admission at *RTBC* or from existing records at the time of entering rehabilitation at *SJRH*.

We defined EI sequelae during two phases of treatment: (1) acutely, defined as the initial hospital admission at *RTBC*, and (2) long-term, defined as the period of inpatient and outpatient rehabilitation at *SJRH*. The long-term cohort included both patients treated at *RTBC* and those referred from other acute care centres. Patients with pre-existing psychiatric diagnoses, as identified in the admissions note from *RTBC* or *SJRH* medical records, were excluded from analysis of neuropsychological and RTW sequelae. Substance misuse was not included in our exclusion criteria (online supplementary figure 1).

Acute period outcomes

Injury, demographic and clinical outcomes data were obtained through retrospective chart review of *RTBC* progress and summary notes. Variables collected included mean age, sex, median percentage of the total body surface area (%TBSA), presence of inhalation injury, work-related nature of the injury, voltage (HVI vs. LVI) and EI type (flash, contact, both contact and flash, lightning or unspecified).

Clinical outcomes during the acute period that were collected included length of stay (LOS) at *RTBC*, LOS adjusted for %TBSA (LOS/%TBSA), number of amputations, amputation levels and number of operations. Incidence of mortality, rhabdomyolysis, compartment

syndrome, one or more infections, sepsis, multiple organ failure, and rehabilitation requirements (inpatient or outpatient) were additionally analyzed.

Patients transferred to *SJRH* for rehabilitation underwent neuropsychological screening by the care team prior to discharge, as part of the required referral documentation. This screen was observational and included the following symptoms: depressed mood, anxiety, flashbacks, avoidance, hypervigilance, hyperarousal, nightmares, sleep difficulties, social withdrawal, suicidal ideations, memory and concentration difficulties, dizziness, headaches and phantom limb pain.

Long-term period outcomes

Injury, demographic and neuropsychological outcomes data for patients in the long-term cohort were obtained through chart review of *SJRH* documentation. Variables collected included voltage (HVI vs. LVI), work-related nature of the EI and occupation. Neuropsychological symptoms identified from rehabilitation records were rates of depressed mood, anxiety, flashbacks, avoidance, hypervigilance, hyperarousal, nightmares, sleep difficulties, social withdrawal, suicidal ideations, memory and concentration difficulties, dizziness, headaches, phantom limb pain and chronic pain. Additionally, we recorded formal diagnoses of post-traumatic stress disorder (PTSD), major depressive disorder (MDD), generalized anxiety disorder (GAD), adjustment disorder and panic disorder, as well as the time to diagnosis post-injury. Treatment by a psychologist or psychiatrist and the need for medications to address these sequelae were also recorded, with rates defined as the proportion of patients requiring these management modalities.

Patients with work-related EIs had information recorded regarding RTW goals: time required to return to pre-injury employment or alternative work in the labour market and the

form of workplace accommodations (i.e. modified scheduling or duties). Patients who did not have documented outcomes regarding their RTW status were excluded from this analysis.

Patient and Public Involvement

Active patient and public involvement was not incorporated into this study.

Statistical analysis

Statistical analyses were performed using SPSS Statistics version 25.0 (IBM Corp.). Categorical variables are presented as percentages, with group comparisons made using Fisher's exact test. Normally-distributed continuous variables are presented as mean and standard deviation (SD), and compared between groups using the student's t-test. Nonparametric data are presented as median and interquartile range (IQR), and compared using the Mann-Whitney U test. For all comparisons, $P \leq .05$ was considered statistically significant.

RESULTS

Acute period

We identified 207 acute EI admissions between 1998-2015 that were eligible for inclusion (online supplementary figure 2). Of these acute patients, 106 were discharged to either inpatient or outpatient rehabilitation at any rehabilitation facility and therefore had neuropsychological assessment data available for review. Four patients were excluded due to pre-existing psychiatric conditions that were documented on admission in their hospital records. *SJRH* records were obtained for 59 of these patients who were identified as having received inpatient or outpatient treatment at this facility without a pre-existing psychiatric condition. Health records for patients who were admitted to *SJRH* prior to the year 2003 were not accessible, therefore, these patients were not included in further analysis.

Demographics

Patients were predominantly male with a mean age of 41±13 years. Median burn size was 4 (1-10) %TBSA and the incidence of inhalation injury was 2%. LVIs were more common than HVIs (59% vs. 37%), and the voltage was unspecified for 9 patients. The most prevalent mechanism of EI was isolated flash injury, followed by direct contact with electrical current. The majority of injuries were work-related (83%; online supplementary table 1).

Clinical outcomes

The average LOS and LOS/%TBSA were 9 (3-18) days and 2 (1-4) days/% burn, respectively. Two percent of patients did not survive to discharge, with coroner reports identifying the following causes: anoxia, ARDS and SIRS, sepsis, and massive burns. (Table 1, online supplementary figure 3). The most common complications during acute management were infection, amputation and compartment syndrome. Multiple organ failure occurred in 1% of patients. While 13% of patients required at least one amputation, 6% required multiple. The most

common amputation sites were the digits of the feet and the digits of the hands (36% and 29%, respectively), while the least common was above the elbow (2%). Overall, half of all EI patients required rehabilitation on discharge; of these, 32% and 68% were referred to inpatient and outpatient rehabilitation, respectively (Table 1).

Table 1. Clinical outcomes during the acute phase of management.

	All Patients[a]	HVI	LVI	*P*
No. of patients	207	76	122	
LOS, days, median (IQR)	9 (3-18)	14 (4-24)	8 (3-15)	<0.001
LOS/TBSA, days/%, median (IQR)	2 (1-4)	3 (1-8)	2 (1-3)	<0.001
TBSA, %, median (IQR)	4 (1-10)	3 (1-15)	5 (2-9)	.44
No. of ORs, median (IQR)	1 (0-2)	2 (0-3)	0 (0-1)	<.001
Complications, no. (%)				
Rhabdomyolysis	9 (4)	9 (12)	0 (0)	<.001
Compartment syndrome	17 (8)	12 (16)	5 (4)	.007
Infection	28 (14)	15 (20)	11 (9)	.05
Sepsis	11 (5)	8 (11)	3 (3)	.02
Multiple organ failure	1 (1)	1 (1)	0 (0)	.38
Amputation	26 (13)	21 (28)	3 (2)	<.001
Multiple amputations	13 (6)	10 (13)	2 (2)	.001
Requiring rehabilitation, no. (%)	106 (51)	49 (65)	54 (44)	.008
Discharged to inpatient rehabilitation, no. (%)[b]	34 (32)	22 (45)	10 (19)	.005
Discharged to outpatient rehabilitation, no. (%)[b]	72 (68)	27 (55)	44 (81)	.005
Mortality, no. (%)	4 (2)	3 (4)	1 (1)	.16

Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury; LOS, length of stay; TBSA, total body surface area.
[a] Includes patients whose voltage was not otherwise specified (n=9).
[b] Percentages are calculated based on the total number of patients requiring any for of rehabilitation (All patients, n=106; HVI, n=49; LVI, n=54).

Neuropsychological outcomes

Of the 59 patients with neuropsychological screening, nearly one quarter experienced at least one neuropsychological symptom during the acute period (Table 2). The most common symptoms included flashbacks (15%) and sleep difficulties (12%). Suicidal ideations, hyperarousal and social withdrawal did not occur during the acute phase of treatment (Figure 1).

Table 2. Neuropsychological sequelae and management.

	All Patients[a]	HVI	LVI	*P*
Acute Cohort				
No. of patients	59	26	31	
Neuropsychological sequelae, no. (%)	14 (24)	6 (23)	7 (23)	>.99
Long-Term Cohort				
No. of patients	122	51	69	
Days to first follow-up, median (IQR)[b]	201 (68-766)	504 (179-1236)	124 (41-233)	<.001
Days to last follow-up, median (IQR)[b]	980 (391-1409)	1099 (511-1651)	773 (315-1218)	.02
Neuropsychological sequelae, no. (%)				
<5 yrs. post-injury	99 (81)	42 (82)	56 (81)	>.99
>5 yrs. post-injury[c]	20 (27)	13 (35)	7 (20)	.19
Psychological/ Psychiatric treatment, no. (%)	78 (64)	31 (61)	47 (68)	.44
Medication, no. (%)	78 (64)	30 (59)	47 (68)	.34

Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury.
Analysis excludes patients with documented pre-existing psychiatric conditions.
[a] Includes patients whose voltage was not otherwise specified (acute cohort, n=2; long-term cohort, n=2).
[b] Calculated from the date of injury.
[c] Percentages are calculated based on the total number of patients that were available for follow-up at >5 years post-injury (All patients, n= 74; HVI, n=37; LVI, n=35).

Acute period, high- vs low-voltage injuries

Demographics

The acute cohort was comprised of 76 HVI and 122 LVI patients, with both groups being predominantly male. Both voltage cohorts were similar in mean age, median %TBSA and incidence of inhalation injury. LVIs were more likely of being occupational in nature (*P*=.03). HVIs were more frequently a result of combined flash and contact burn etiology, whereas LVIs were more commonly associated with isolated flash injuries (*P*<.001 for both; online supplementary table 1).

Clinical outcomes

The incidence and severity of clinical outcomes were overall worse in the HVI group. HVI patients experienced a longer LOS (P<0.001) and LOS/%TBSA (P<.001), and greater incidences of rhabdomyolysis (P<0.001), compartment syndrome (P=.007), infections (P=.05), sepsis (P=.02; Table 1) and operations (P<0.001). However, there was no statistical difference in survival between HVIs and LVIs (Table 1, online supplementary figure 3). Single and multiple amputations were more common among HVI patients (P<.001 and P=.001, respectively). The majority of HVI amputations involved digits (29% hands, 36% feet). Lastly, patients with HVIs were more frequently discharged to inpatient rehabilitation relative to LVIs (P=.005), while initial outpatient rehabilitation was more common in the LVI group (P=.005; Table 1).

Neuropsychological outcomes

Of those screened, HVIs and LVIs were equally as likely of experiencing neuropsychological sequelae during the acute treatment period (P>.99; Table 2). Likewise, there was no significant difference in the incidence of symptoms between voltage groups. Marginally greater rates of the following symptoms were exhibited by the HVI group when contrasted with the LVI group: depressed mood (4% vs. 3%, P>.99), flashbacks (15% vs. 13%, P>.99), dizziness (4% vs. 3%, P>.99), nightmares (4% vs. 3%, P>.99), avoidance (4% vs. 0%, P=.46), memory and concentration impairments (8% vs. 3%, P=.59), headaches (4% vs. 0%, P=.46) and phantom limb pain (8% vs. 0%, P=.20). In contrast, LVIs were associated with slightly greater rates of sleep difficulties (13% vs. 8%, P=.68), anxiety (6% vs. 4%, P>.99) and hypervigilance (3% vs. 0%, P>.99; Figure 1).

Long-term period

Demographics

The long-term period cohort consisted of 128 patients, with a second screen identifying six patients meeting exclusion criteria due to pre-existing psychiatric conditions. Therefore, 122

patients were available for analysis. Half of these patients had been treated for their acute injury at *RTBC*, therefore, acute data were available for those patients. The majority of patients in the long-term cohort suffered EIs that were occupational in nature (91%, online supplementary table 2).

Neuropsychological outcomes

More than half of all patients receiving rehabilitation were diagnosed with at least one psychiatric disorder after their injury, while one third of patients were diagnosed with two or more. The median time to a psychiatric diagnosis from the date of injury across all six conditions was 315 days (IQR 117-957) (online supplementary table 3). PTSD (33%), MDD (25%) and adjustment disorder (20%) were the conditions that occurred most frequently (online supplementary figure 4). Additionally, 81% of the long-term cohort experienced at least one neuropsychological symptom between a median time to first and last follow-up of 201 (IQR 68-766) and 980 (IQR 391-1409) days post-injury, respectively (Table 2). The most common symptoms were sleep difficulties (68%), anxiety (62%), depressed mood (60%) and memory and concentration impairments (59%) (Figure 2). More than 60% of the long-term patient cohort exhibited symptoms that were severe enough to warrant psychological/psychiatric treatment or medication. Patients with PTSD most commonly exhibited symptoms of anxiety, sleep difficulties and depressed mood (95%, 93% and 85%, respectively). MDD, GAD and adjustment disorder were frequently associated with symptoms of depressed mood, anxiety, sleep difficulties and memory and concentration impairments (online supplementary table 4).

Return-to-work outcomes

A total of 111 work-related EIs were reviewed; of these, data regarding RTW status were recorded for 90 patients. Electricians made up the predominant occupation group, followed by powerline technicians (online supplementary table 2). Sixty-one percent of patients were able to

return to their pre-injury occupation, of which 60% required modified duties and 55% required modified scheduling. Furthermore, 19% of patients sustaining work-related EIs returned to alternative employment through labour market re-entry (LMR), with the median time for returning to any work being 166 days (IQR 82-414) from the time of injury. Overall, one fifth of EI patients were unable to return to any form of employment (Table 3).

Table 3. Return-to-work characteristics of occupational EIs within the long-term cohort.

	All Patients[a]	HVI	LVI	*P*
No. of patients	90	39	49	
Return to pre-injury occupation, no. (%)	55 (61)	23 (59)	30 (61)	>.99
Modified Duties, no. (%)[b]	33 (60)	15 (65)	17 (57)	.58
Modified Schedule, no. (%)[b]	30 (55)	11 (48)	17 (57)	.59
Labour Market Re-Entry, no. (%)	17 (19)	9 (23)	8 (16)	.80
Time to RTW, days, median (IQR)[c]	166 (82-414)	207 (102-548)	124 (57-348)	.12
Unable to RTW, no. (%)	17 (19)	6 (15)	11 (22)	.43

Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury; RTW, return-to-work.
[a] Includes patients whose voltage was not otherwise specified (n=2).
[b] Percentages are calculated based on the total number of patients that returned to their pre-injury occupation (All patients, n= 55; HVI, n=23; LVI, n=30).
[c] Calculated from the date of injury.

Long-term period, high- vs low-voltage injuries

Neuropsychological outcomes

The distribution of formal diagnoses of individual psychiatric disorders was comparable between HVIs and LVIs (online supplementary figure 4). PTSD and MDD were the most common in both voltage groups (24% vs. 41%, *P*=.054 and 18% vs. 30%, *P*=.14, respectively), while panic disorder was the most infrequently diagnosed (0% and 1%, *P>.99*). HVIs were most commonly associated with sleep difficulties (67%), memory and concentration impairment (57%), and chronic pain (57%), while LVIs were most commonly associated with sleep difficulties (70%) and anxiety (70%) (Figure 2). LVIs exhibited slightly greater rates of

depressed mood (64% vs. 55%, *P*=.35), anxiety (70% vs. 53%, *P*=.09), nightmares (38% vs. 27%, *P*=.33), headaches (41% vs. 33%, *P*=.45) and hypervigilance (16% vs. 10%, *P*=.42), however, these differences were not statistically significant. HVIs were more likely of exhibiting neuropsychological sequelae beyond 5 years post-injury (*P*=.05; Table 2). Additionally, our LVI cohort experienced greater requirements for management, including medications and psychological/psychiatric treatment, of these symptoms and conditions (P>.05).

Return-to-work outcomes

LVIs and HVIs had similar rates of return to pre-injury occupation. More than half of these patients required workplace accommodation. HVI patients more frequently required modified duties, while LVIs were more commonly associated with modified scheduling. The requirement for LMR for alternative employment was similar between voltage groups, along with the median time for RTW. A comparable inability to return to any form of employment was observed between voltage groups (Table 3).

DISCUSSION

Our study identifies and delineates common sequelae that extend beyond acute management. When stratifying by voltage, the acute clinical findings indicate greater rates of complications and operative interventions in the HVI group. Conversely, rates of neuropsychological symptoms in both groups increase overtime during the first five years post-injury, after which rates appear to decline. While overall neuropsychological sequelae are statistically comparable between voltage groups, LVIs result in marginally greater rates of depressed mood, anxiety, nightmares, headaches and hypervigilance. They have similarly been associated with greater rates of PTSD, MDD, GAD, adjustment disorder and panic disorder. Lastly, both voltage groups are implicated in RTW challenges. HVIs result in marginally more frequent job accommodations and retraining, while LVIs are associated with slightly greater rates of unsuccessful RTW. However, these results are not statistically significant. Therefore, while HVIs result in increased clinical morbidity, LVIs need to be recognized as significant burdens for their effects on neuropsychological and social well-being.

Acute clinical findings are consistent with other studies that have shown increased morbidity in patients who have sustained a HVI.[19-25] A recent systematic review evaluated the different injury patterns associated with HVIs and LVIs, with combined data identifying longer hospital stays and greater complication rates with higher voltage.[19-21] Comparative data between voltage groups for other common complications implicated in EIs, such as compartment syndrome, rhabdomyolysis and amputations, are lacking in literature.[26-28] However, histological and gross structural modifications, along with subsequent muscle and vasculature destruction, have been observed with increasing voltage.[29] This further suggests that HVIs may result in increased complication rates, morbidity and mortality.[28-33]

Hussmann et al. observed greater rates of neurological impairments in their EI patient cohort, over a mean follow-up time of 5 years.[6] This suggests that our findings may underestimate the true severity of EIs, as continued care beyond 5 years was uncommon in our long-term cohort. Nevertheless, our findings are consistent with other studies that have evaluated the implications of EIs on behaviour and cognitive function.[5,6,8-10,14-16,34] Common difficulties identified during recovery include flashbacks, nightmares, MDD and PTSD. The findings of these studies highlight the need for further exploration of neuropsychological sequelae in this burn population. In doing so, we will improve the understanding of specific predispositions post-EI, facilitating symptom monitoring and management.

Current literature regarding neuropsychological sequelae suggests that burn survivors exhibit greater rates of psychiatric illnesses compared to the general population. Meyer et al. investigated the prevalence of diagnoses in young adults who had sustained a burn injury of any etiology prior to the age of 16.[35] Relative to our EI cohort, a lower rate of PTSD and greater incidences of MDD and GAD were reported. However, the mean follow-up time post-injury is greater than that of our study, which may result in an underestimation of diagnosis rates within our cohort. Additionally, differences in cohort characteristics exist, with the mean age of our patient population being twice as high, with a significantly greater representation of males than females. Therefore, comparison of our findings to current evidence indicates that EI patients may be more predisposed to certain psychiatric conditions relative to the general burn population.

Lastly, our results demonstrate the challenges that EIs elicit with employment reintegration. Noble et al. found that a third of their EI cohort was unable to return to any employment.[5] In contrast, we observed a lower inability to RTW in both voltage groups. This may indicate improved strategies in EI management and more specialized rehabilitation

programs that enhance work reintegration. However, workplace accommodations remain common amongst this burn population and should be an area of focus during rehabilitation.

This study provides a regional view into the truly global burden of this burn injury. A recent review of adult EIs identified a total of 41 publications globally in this area of research. Nearly half of all studies originated from outside of North American and did not independently evaluate HVI and LVI outcomes. These studies limited investigations to clinical-based outcomes without addressing rehabilitation and psychological impacts.[19] Therefore, to our knowledge, our study is the most comprehensive acute and long-term investigation of EIs to date, providing caregivers with an in-depth understanding of the acute and long-term barriers faced by this burn population. These findings additionally highlight the need for employee safety education and post-injury monitoring for common sequelae with any voltage.[17] Additionally, specialized care centres should manage this patient population early on in treatment, with immediate involvement of mental health experts. Overall, the formulation of holistic EI teams (i.e. psychologists, occupational therapists, physiotherapists, pain specialists, RTW coordinators) may facilitate reintegration to original employment and improve patient outcomes.

Several limitations have been recognized. Data from the acute period was extracted from a single regional burn centre. Therefore, our cohorts consist of patients believed to be more injured than other EI patients, requiring specialized treatment. Long-term data is limited to patients who received rehabilitation services at *SJRH*. Patients may have sought treatment within their community, limiting identification of more long-term sequelae. Due to this loss to follow-up, our results may underrepresent the long-term neuropsychological and RTW effects of EIs. Furthermore, our study did not incorporate a control group, limiting our ability of identifying definitive causal relationships between EIs and neuropsychological sequelae. Lastly, LOS/%TBSA is a commonly used parameter in burns, however, it is not as reflective of EI-

associated damage, as the effects on underlying tissues are profound but not accounted for in %TBSA. Therefore, it has served as a minor outcome measure for this study.

In conclusion, EIs are implicated in multifaceted clinical, neuropsychological and social sequelae. Effects exist acutely and long-term, warranting monitoring that extends beyond initial treatment. LVIs are, at minimum, as likely as HVIs of exhibiting complications during recovery. Lastly, we have identified these effects as possible barriers for successful employment reintegration. Collectively, these findings indicate a need for focused training and rehabilitation. Future investigations will involve implementing similar studies across broad geographic regions to inform region-specific management of this burn injury.

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None.

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COMPETING INTERESTS STATEMENT

None declared.

AUTHOR CONTRIBUTIONS

MGJ was responsible for the study design. NR was responsible for the literature search, data acquisition and drafting of the work. SR and NR conducted statistical analysis of data. NR, SAM, SR, MG and MGJ were responsible for revisions of the work. All authors gave approval for the final version of the manuscript.

DATA SHARING STATEMENT

No additional data from this study are available.

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Figure Legends

- **Figure 1. Neuropsychological symptoms of EI patients during the acute phase of treatment.** Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury.
- **Figure 2. Neuropsychological symptoms of EI patients during the long-term phase of treatment.** Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury.

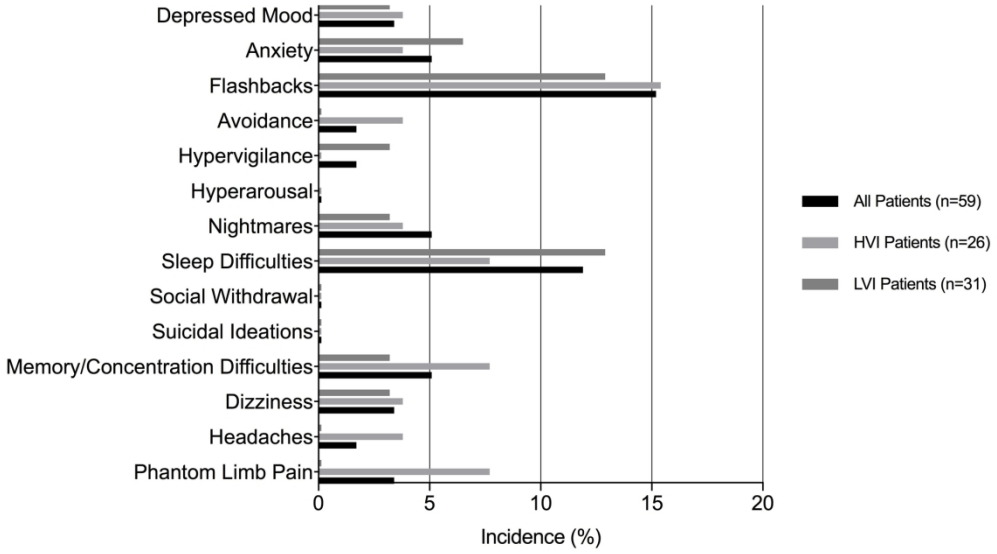

Figure 1. Neuropsychological symptoms of EI patients during the acute phase of treatment. Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury.

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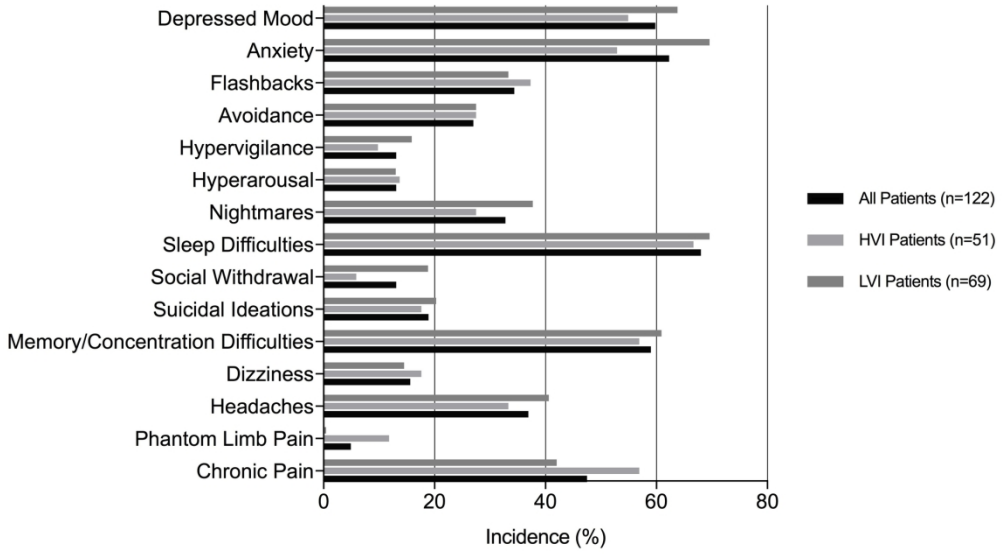
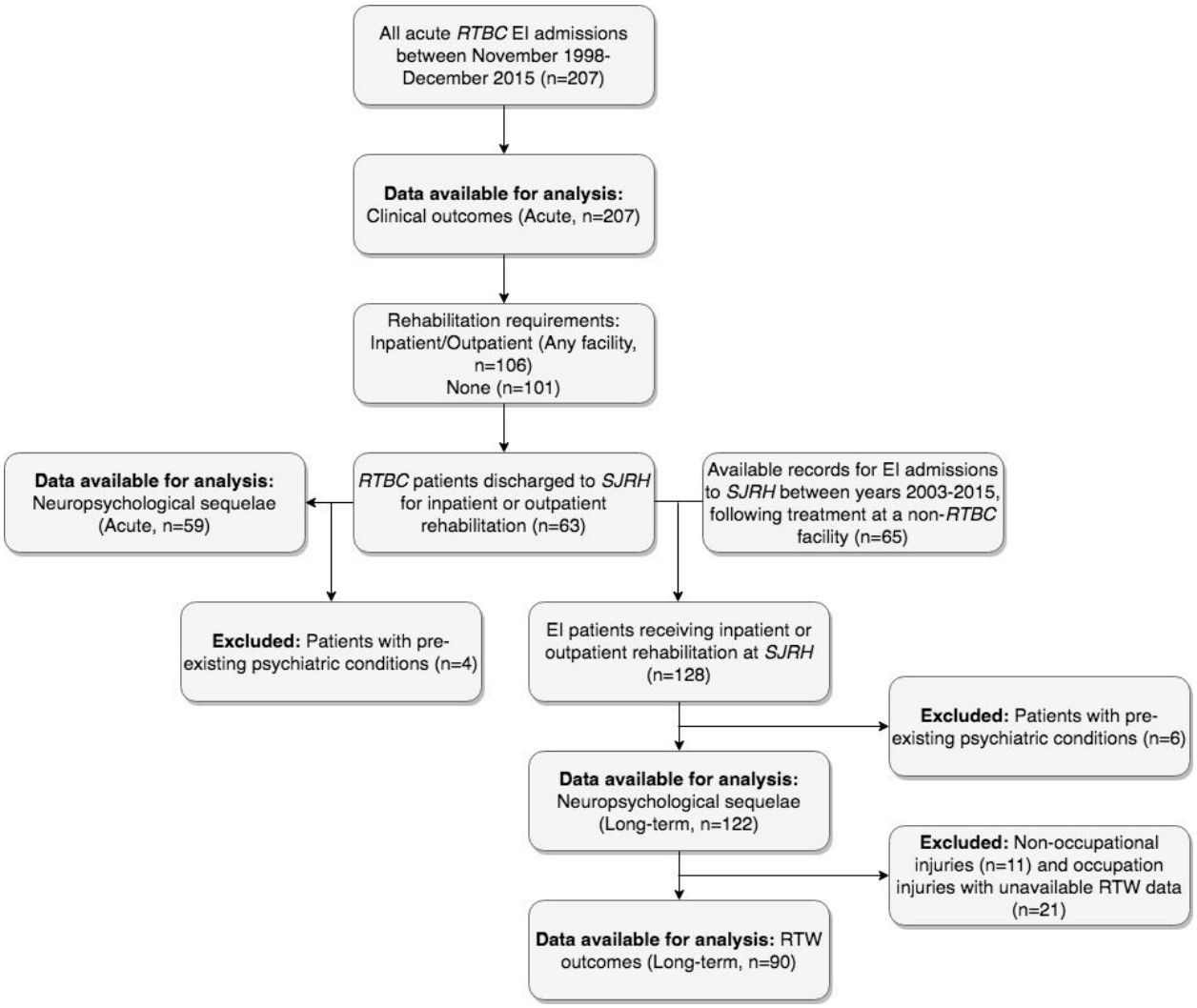


Figure 2. Neuropsychological symptoms of EI patients during the long-term phase of treatment. Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury.

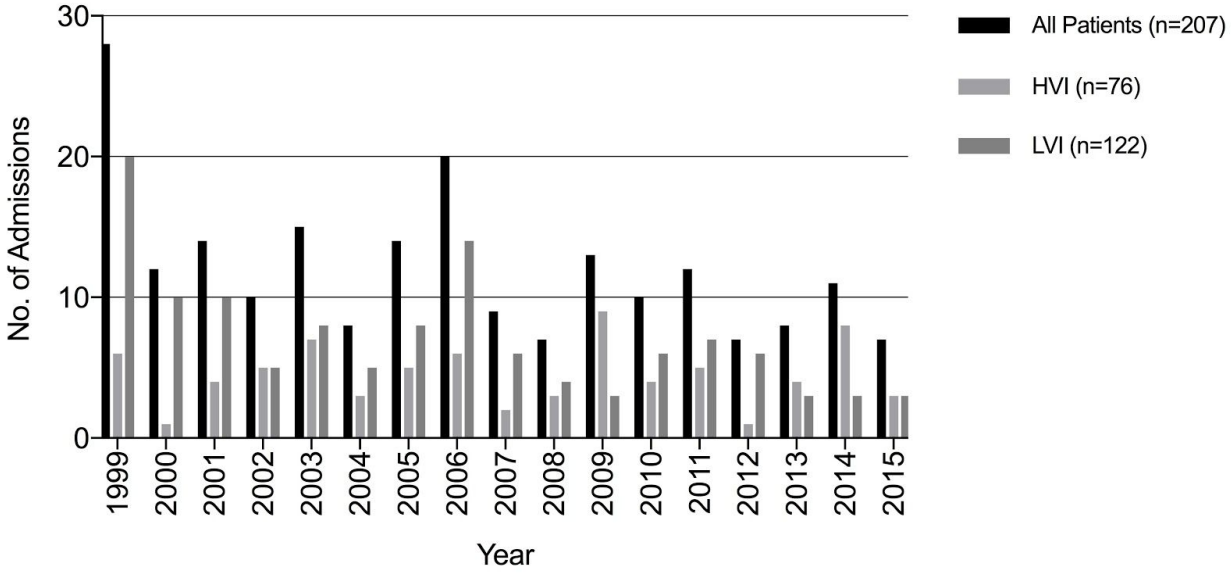
90x51mm (600 x 600 DPI)

Supplementary Online Content

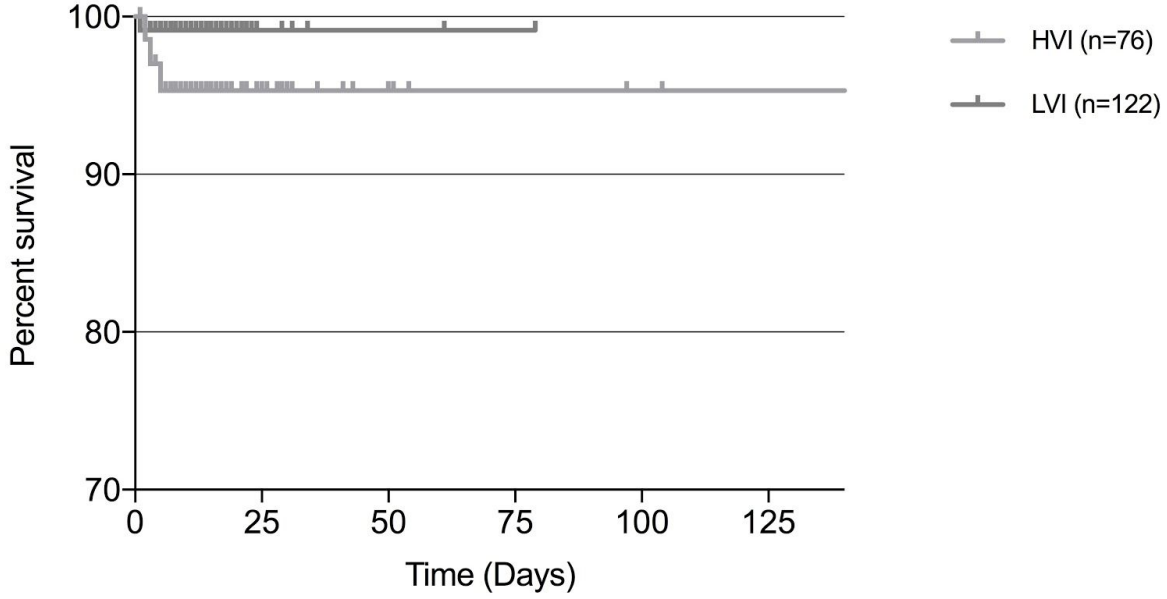
Supplementary Figure 1. Patient Flow Diagram. Abbreviations: RTBC, Ross Tilley Burn Centre; SJRH, St. John's Rehabilitation Hospital; RTW, return-to-work.



Supplementary Figure 2. Annual admissions of acute electrical injuries at the *Ross Tilley Burn Centre*, Toronto, Canada. A total of 9 admissions were of unknown voltage. Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury.

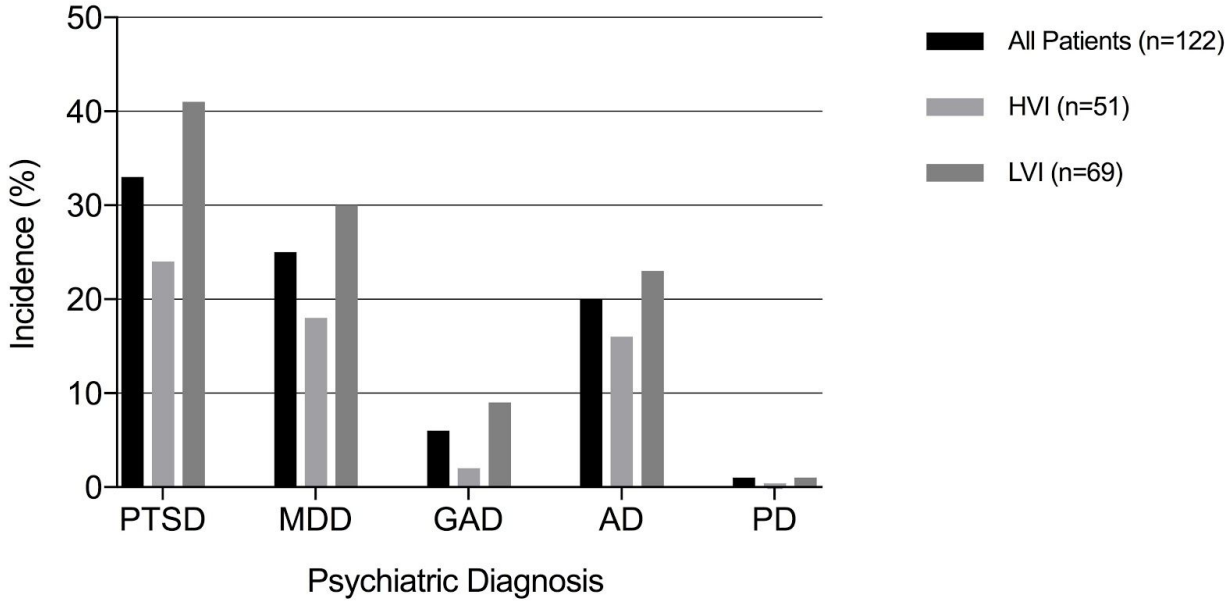


Supplementary Figure 3. Kaplan-Meier Survival Curve. Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury;



Supplementary Figure 4. Rates of psychiatric diagnoses among the long-term cohort.

Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury; PTSD, post-traumatic stress disorder; MDD, major depressive disorder; GAD, generalized anxiety disorder; AD, adjustment disorder; PD, panic disorder.



Supplementary Table 1. Demographics and injury characteristics of patients treated acutely at the burn centre.

	All Patients[a]	**HVI**	**LVI**	***P***
No. of patients	207	76	122	
Age, years, mean (SD)	41 (13)	40 (14)	41 (13)	0.64
Male, no. (%)	198 (96)	72 (95)	117 (96)	0.74
TBSA, %, mean (SD)	8 (12)	10 (13)	8 (11)	0.17
Inhalation injury, no. (%)	4 (2)	1 (1)	3 (3)	>.99
Work-Related, no. (%)	171 (83)	57 (75)	107 (88)	.03
Classification, no. (%)				
Contact	67 (33)	11 (15)	18 (15)	>.99
Flash	115 (56)	10 (13)	101 (83)	<.001
Contact and Flash	15 (7)	46 (61)	3 (3)	<.001
Lightning	4 (2)	4 (5)	0 (0)	.02
Unspecified	6 (3)	5 (7)	0 (0)	.008

Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury; TBSA, total body surface area.
[a] Includes patients whose voltage was not otherwise specified (n=9).

Supplementary Table 2. Demographics and injury characteristics of the long-term cohort.

	All Patients[a]	HVI	LVI	*P*
No. of patients	122	51	69	
Work-Related, no. (%)	111 (91)	47 (92)	62 (90)	>.99
Available RTW data, no. (%)	90 (81)	39 (83)	49 (79)	.54
Pre-Injury Occupation, no. (%)				
Electrician	26 (29)	6 (15)	19 (39)	.02
Mechanic	3 (3)	0 (0)	3 (6)	.25
Maintenance Worker	4 (4)	0 (0)	4 (8)	.13
Powerline Technician	13 (14)	13 (33)	0 (0)	<.001
Construction Worker	4 (4)	4 (10)	0 (0)	.04
Self-Employed	2 (2)	2 (5)	0 (0)	.19
Truck Driver	3 (3)	3 (8)	0 (0)	.08
Other	29 (32)	8 (21)	21 (43)	.04
Unknown	6 (7)	3 (8)	2 (4)	.65

Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury; RTW, return-to-work.
Analysis excludes patients with documented pre-existing psychiatric conditions.
[a] Includes patients whose voltage was not otherwise specified (n=2).

Supplementary Table 3. Time to diagnosis (from day of injury) of psychiatric conditions during the long-term period of treatment.

	All Patients	HVI	LVI	*P*
All Conditions (n=101), days, median (IQR)[a,b]	315 (117-957)	384 (161-1461)	272 (114-904)	.20
PTSD (n=40), days, median (IQR)	263 (78-937)	325 (153-1495)	253 (75-843)	.41
MDD (n=30), days, median (IQR)	531 (213-1061)	684 (265-1897)	402 (151-1013)	.33
GAD (n=7), days, median (IQR)	402 (261-1060)	-	374 (252-891)	-
Adjustment Disorder (n=23), days, median (IQR)[b]	177 (88-771)	177 (63-1042)	177 (99-358)	.82
Panic Disorder (n=1), days, median (IQR)	-	-	-	-

Abbreviations: HVI, high-voltage injury; LVI, low-voltage injury; PTSD, post-traumatic stress disorder; MDD, major depressive disorder; GAD, generalized anxiety disorder.
Analysis excludes patients with documented pre-existing psychiatric conditions.
[a] Conditions include PTSD, MDD, GAD, adjustment disorder and panic disorder.
[b] Patients without documented diagnoses dates were excluded from analysis (n=1).

Supplementary Table 4. Rates of neuropsychological symptoms in patients formally diagnosed with a psychiatric condition in the long-term cohort.

	PTSD	MDD	GAD	Adjustment Disorder	Panic Disorder
No. of patients	40	30	7	24	1
Depressed Mood, no. (%)	34 (85)	29 (97)	7 (100)	24 (100)	1 (100)
Anxiety, no. (%)	38 (95)	28 (93)	7 (100)	21 (88)	1 (100)
Flashbacks, no. (%)	23 (58)	13 (43)	2 (29)	13 (54)	1 (100)
Avoidance, no. (%)	17 (43)	15 (50)	4 (57)	10 (42)	1 (100)
Hypervigilance, no. (%)	8 (20)	9 (30)	1 (14)	2 (8)	0 (0)
Hyperarousal, no. (%)	13 (33)	8 (27)	1 (14)	5 (21)	1 (100)
Nightmares, no. (%)	21 (53)	16 (53)	6 (86)	14 (58)	0 (0)
Sleep Difficulties, no. (%)	37 (93)	28 (93)	7 (100)	22 (92)	1 (100)
Social Withdrawal, no. (%)	10 (25)	8 (27)	2 (29)	4 (17)	0 (0)
Suicidal Ideations, no. (%)	18 (45)	15 (50)	4 (57)	9 (38)	1 (100)
Memory/Concentration Difficulties, no. (%)	33 (83)	29 (97)	7 (100)	21 (88)	1 (100)
Dizziness, no. (%)	7 (18)	7 (23)	2 (29)	7 (29)	0 (0)
Headaches, no. (%)	19 (48)	15 (50)	4 (57)	17 (71)	0 (0)
Phantom Limb Pain, no. (%)	2 (5)	2 (7)	1 (14)	1 (4)	0 (0)
Chronic Pain, no. (%)	24 (60)	23 (77)	3 (43)	16 (67)	0 (0)

Abbreviations: PTSD, post-traumatic stress disorder; MDD, major depressive disorder; GAD, generalized anxiety disorder. Analysis excludes patients with documented pre-existing psychiatric conditions.

Reporting checklist for cohort study.

Based on the STROBE cohort guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cohort reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	3
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	4-5
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	7
Objectives	#3	State specific objectives, including any prespecified hypotheses	8
Study design	#4	Present key elements of study design early in the paper	9
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	9
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up.	9

	#6b	For matched studies, give matching criteria and number of exposed and unexposed	See note 1
Variables	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-10
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	9-10
Bias	#9	Describe any efforts to address potential sources of bias	See note 2
Study size	#10	Explain how the study size was arrived at	9
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	9
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	11
	#12b	Describe any methods used to examine subgroups and interactions	11
	#12c	Explain how missing data were addressed	12
	#12d	If applicable, explain how loss to follow-up was addressed	n/a
	#12e	Describe any sensitivity analyses	See note 3
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	12-15
	#13b	Give reasons for non-participation at each stage	12-15
	#13c	Consider use of a flow diagram	9

Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	12-15
	#14b	Indicate number of participants with missing data for each variable of interest	12-15
	#14c	Summarise follow-up time (eg, average and total amount)	16
Outcome data	#15	Report numbers of outcome events or summary measures over time. Give information separately for exposed and unexposed groups if applicable.	12-18
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-18
	#16b	Report category boundaries when continuous variables were categorized	12-18
	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	See note 4
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	12-18
Key results	#18	Summarise key results with reference to study objectives	19
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	21
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	21-22
Generalisability	#21	Discuss the generalisability (external validity) of the study results	21-22
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	23

Author notes

1. n/a - this was not a matched study
2. n/a - we were unable to account for two of the biases that affected our study (discussed on pg. 21)
3. n/a - our methods did not employ any sensitivity analyses
4. n/a - was not relevant to our study