ORIGINAL ARTICLE

Electric shocks at work in Europe: development of a job exposure matrix

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ABSTRACT

Objectives Electric shocks have been suggested as a potential risk factor for neurological disease, in particular for amyotrophic lateral sclerosis. While actual exposure to shocks is difficult to measure, occurrence and variation of electric injuries could serve as an exposure proxy. We assessed risk of electric injury, using occupational accident registries across Europe to develop an electric shock job-exposure-matrix (JEM).

Materials and methods Injury data were obtained from five European countries, and the number of workers per occupation and country from EUROSTAT was compiled at a 3-digit International Standard Classification of Occupations 1988 level. We pooled accident rates across countries with a random effects model and categorised jobs into low, medium and high risk based on the 75th and 90th percentile. We next compared our JEM to a JEM that classified extremely low frequency magnetic field exposure of jobs into low, medium and high.

Results Of 116 job codes, occupations with high potential for electric injury exposure were electrical and electronic equipment mechanics and fitters, building frame workers and finishers, machinery mechanics and fitters, metal moulders and welders, assemblers, mining and construction labourers, metal-products machine operators, ships' decks crews and power production and related plant operators. Agreement between the electrical injury and magnetic field JEM was 67.2%.

Conclusions Our JEM classifies occupational titles according to risk of electric injury as a proxy for occurrence of electric shocks. In addition to assessing risk potentially arising from electric shocks, this JEM might contribute to disentangling risks from electric injury from those of extremely low frequency magnetic field exposure.

What this study adds

- Electric shocks have been suggested as a potential risk factor for some neurological diseases, but exposure cannot be directly measured.
- Based on five European national accident registries, we identified occupations with high, medium or low risks of electrical injury.
- Our job exposure matrix can contribute to assessing long-term health risks arising from electrical injury.

INTRODUCTION

Over the last three decades, job exposure matrices (JEM) have developed into a standard tool of occupational exposure assessment used in epidemiology when only information on job titles and/or industry are available.[1] A JEM allows assigning average exposures encountered in specific occupations to individual study subjects. In this way, titles of occupational groups have been used as a proxy for exposure to, for example, pesticides, solvents, metals or asbestos.[2–5] More recently, JEMs have been developed for physical exposures related to the generation, transmission, distribution and use of electricity (ie, especially to magnetic fields).[6–8]

Neurodegenerative diseases, especially Alzheimer's disease and amyotrophic lateral sclerosis (ALS), have been linked in some studies with exposure to extremely low-frequency magnetic fields (ELF-MF) as can be encountered in some occupational groups.[9] For ALS, exposure to electric shocks has been raised as a potential alternative explanation for these findings.[10–12] It has been difficult to disentangle the two exposure measures due to the lack of a valid exposure assessment method for electric shocks. Electric shock exposures occur inadvertently and therefore cannot be routinely measured with personal exposure measurement devices as are available, for example, ELF magnetic fields. Workplace injuries, however, are documented in national accident statistics as electric injuries, and could serve as an exposure proxy for electric shocks. In our study, we analysed the risk of occupational accidents due to electric injury, using occupational accident registries across several European countries to develop a general-population JEM for potential exposure to electrical shocks.

METHODS

Electrical injury data

Most European countries follow the definition of the European Statistics on Accidents at Work, which defined reportable accidents as those that result in incapacity for work for at least three consecutive days, excluding the day of the accident, or accidents resulting in death.[13] Accident data in our study were either obtained on 4-digit job codes of the International Standard Classification of Occupations 1988 (ISCO 88), or obtained in another classification scheme and translated into ISCO 88.

We obtained data from the German Social Accident Insurance on electrical injuries at work for the years 2005–2008, coded in 4-digit ISCO 88

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codes. The German Social Accident Insurance dataset is based on a 7–10% sample of all accidents.[14] It excludes accidents in the self-employed or farmers. Data from the United Kingdom (UK) were provided by the Health and Safety Executive and included data for the years 2007-2009. Accidents were coded in the British Standard Occupational Classification (SOC) 2000, which we transferred into ISCO 88 4-digit codes using a translation provided online,,[15] and by hand checking the assigned occupational codes (AH and HK). In the UK database, cells with less than three accidents were suppressed and were imputed by us as 1.5. The Austrian Workers' Compensation Board database included accidents for the years 2005–2009, coded in ISCO 08, which we translated into ISCO 88 using a correspondence table provided by the International Labour Organisation.[16] The Swiss Accident Insurance records accidents if workers cannot work for over 3 days, including the day of the accident, which constitutes a small difference compared with the International Labour Organisation definition used in the German, Austrian and UK dataset, where the day of the accident is excluded. In the Swiss dataset, of the accidents registered for the years 2003–2008, a random 5% sample of all accidents was entered into the database, including the ISCO 88 occupational code. Accidents do not include those from the self-employed. Data from The Netherlands were provided by the Dutch Labour Inspectorate. Accidents were reportable if they resulted in serious physical or mental injury or death. A physical injury is considered to be serious if the victim is hospitalised for at least one day within one day of the accident, or if the injury is permanent.[17] The dataset with accidents reported between January 1998 and February 2004 included both job titles and the industry where the accident had occurred. We coded these descriptions into ISCO 88 codes.

Denominator data

We retrieved the number of workers per ISCO 88 job category per country from European Statistics (EUROSTAT).[18] These data refer to the year 2001 and are detailed on a 3-digit level of the occupational codes. Since the number of workers per job code could not be obtained on a 4-digit level from all national statistical bureaus (ie, not available from Germany or The Netherlands), we therefore decided to summarise the electrical injury data on 3-digit resolution by collapsing the nominator data into these ISCO 88 codes. For Germany, we excluded the self-employed and family workers from the number of workers per ISCO88 code.

Data handling

In some cases, in the EUROSTAT database, we encountered zero workers for an occupational code in one country, but not in another. This might reflect differences in educational systems or coding conventions, but not necessarily in the corresponding occupational tasks. In these cases, we merged the number of electrical injuries and the number of workers with an occupational code of a similar job description. This concerned in particular occupations with separate codes for 'professionals' and 'associate professionals'. An example is nursing and midwifery professionals who were merged with nursing and midwifery associate professionals (ISCO 88 codes 223 and 323). Other merged codes were pre-primary and primary teachers, special education teachers and other teaching professionals (codes 233, 331 and 332; 234 and 333; 235 and 334, respectively). We also merged market-oriented gardeners, crop and animal producers (codes 611, 612 and 613) into one group, and wood-products machine operators with cabinet makers (codes 824 and 742) for the same reason.

Recoding ISCO 08 Austrian data into ISCO 88 led to 35 of 116 one-to-many codes, meaning that an occupational code in ISCO 08 may have more than one corresponding code in ISCO 88. In these cases, number of injuries was split over the respective codes, since the electric injury could have occurred in either of the occupations. The same procedure was applied to the SOC 2000 codes from the UK dataset, where four of 117 occupations with one-to-many ISCO 88 titles occurred.

Statistical analysis

We calculated the number of electrical injuries in a job code per year and calculated a 95% CI of the electrical injury rate using the number of workers in that specific ISCO 88 code per country as the denominator. For each job code, we then pooled the injury rates across countries with a random effects model using the METAN command in Stata. Given the distribution of the pooled electrical injury rates (figure 1), we categorised the rates at the 75th and 90th percentiles into low, medium and high risk, respectively. In addition, for an occupation to be in the 'medium' category, injuries had to be reported from at least two countries and for a 'high' category from at least three countries. Occupations not meeting these criteria were labelled as 'low' as were occupations without any reported injuries.

In order to evaluate whether risk of electric injury is correlated with ELF magnetic field exposure, we cross-referenced our electric injury JEM with an ELF magnetic field JEM and calculated the κ coefficient of the occupational ISCO 88 codes across groups of magnetic field exposure and the risk of electric injury. The magnetic field JEM is a modified version of the previously published ELF-MF-JEM based on geometric means of magnetic field exposures in US occupational classifications.[6] The original ELF-MF-JEM (on 4-digit ISCO 88), which reflected full-shift time-weighted-averages of the magnetic flux density in micro-Tesla (μT) by job, was first categorised into low, medium and high exposures based on distributional cut points at 0.15μT and 0.30μT, corresponding to the approximate 60th and 90th percentile, respectively. The resulting intensity-based ratings (low, medium, high) were subsequently upgraded or downgraded by two industrial hygienists (HK and RV) based on estimated probabilities of exposure, based on expert judgment. Jobs where the majority of workers were unexposed but a subgroup was highly exposed (and had been preferably measured in the past) were downgraded. Upgrading took place in jobs where

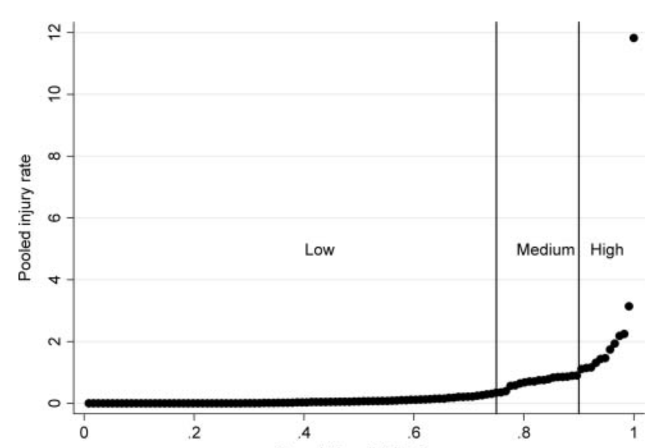

Figure 1 Cumulative distribution of the pooled injury rate Lines represent cut-offs at the 75th and 90th percentile, pooled injury rate is per year and 10 000 workers.

exposures were considered to be higher and more frequent than following from the measurement results. Less than 1% (31) of the 544 job codes were upgraded, 1% (52) was downgraded. Exposure ratings were performed separately, with conflicting scores settled by consensus. The assigned exposure score was ordinal (0=low exposure, 1=medium exposure and 2=high exposure). Inter-rater agreement for the two raters was 89%.

All analyses were performed in Stata V.10 (Stata Corp. College Station, Texas, USA).

RESULTS

All datasets except the one from The Netherlands had electrical injuries of workers who had been ill for at least 2 days (Switzerland), or 3 days (all other countries) following the injury. The largest dataset was obtained from Germany with 12 193 electrical injuries, and the smallest one came from The Netherlands with a total of 224 electrical injuries. An overview of all datasets is given in table 1, and an overview of the number of reported electrical injuries, ISCO 88 codes and number of electrical injuries with missing job codes is given in table 2.

We pooled and categorised electrical injury rates in a final dataset of 116 occupational codes on a 3-digit level of ISCO 88 codes (table 3). Pooled electrical injury rate per 10 000 workers and year varied between zero in 30 job titles and 11.8 in the group of the electrical and electronic equipment mechanics and fitters (code 724). In this latter group, the relatively high number of electrical injuries (eg, more than 300 electrical injuries per year in Germany) translated into a rate that was about four times higher than in the next highest group.

The cross-tabulation of the frequency of high, medium or low risk of electric injury and magnetic field density is given in table 4. The κ coefficient between the Shock JEM and ELF-MF JEM was 0.29 and agreement was 67.2%.

DISCUSSION

Our JEM classifies occupational titles according to risk of electric injury. Based on the ranking of electrical injuries, occupations with high potential for electric shock exposure include electrical and electronic equipment mechanics and fitters, building frame and finishers, machinery mechanics and fitters, metal moulders and welders, assemblers, mining and construction labourers, metal products machine operators, ships' decks crews and power production and related plant operators. Overall, risk of electric injury was low, with the highest risk occurring in the group of electrical and electronic equipment mechanics and fitters with about 11.8 electrical injuries per 10 000 workers per year.

In our analysis, some under-reporting of electrical injuries might be expected in the individual databases since registration of electric injury usually occurs from text reports of accidents. This means that if text entries do not include keywords such as 'electrical' or 'shock' or similar wording, electric injury might not be captured. Unfortunately, we cannot assess whether under-reporting might be differential across occupational groups leading to different rankings of the occupations in terms of their risk of electric injury.

Table 2 Number of electrical injuries reported from accident registries

	N electrical injuries	N (%) missing job codes or accidents in the general public*	N accidents precise on 3-digit resolution	Number of job codes with at least one accident	% of electrical injuries of all occupational accidents‡
The Netherlands	224	22 (9.8%)	201	35	0.03
Germany	12193	676 (5.1%)	11517	69	0.31
UK†	537	70.5 (13.1%)	495	60	0.08
Switzerland	3074	623 (20.3%)	2169	29	0.16
Austria	2150	36 (1.7%)	2114	75	1.0

*Students, pensioners, no occupation, etc; or coded as 9999.
†Cells with less than three accidents were suppressed and were imputed by us as 1.5, N of all accidents based on imputed number of accidents, therefore it differs from total number of accidents given in table 1.
‡Percentage of electrical injury data of all national accident data (as reported by EUROSTAT, 1998–2007).

Table 1 Overview of electrical injury datasets by country

Country	Data received from	N, time period	Job coding scheme	Type of accident	Comments
The Netherlands	Dutch labour inspectorate	224 electrical injuries, years 1998– Feb 2004	Jobs and industry given as titles, coded into ISCO 88	'Contact with electricity' recorded	Accidents that get investigated by the Labour Inspectorate
Germany	DGUV Deutsche Gesetzliche Unfallversicherung	12193 electrical injuries, years 2005–2008	ISCO 88	Only injury or deaths of 'electrical accidents at work' are recorded	Based on 6.7% of data of *Berufsgenossenschaften* and 10% of other accident insurance companies. Excludes self-employed and farmers
UK	HSE, Health and Safety Executive, Merseyside, UK	637 electrical injuries, years 2007–2009	Coded in SOC 2000, recoded into ISCO 88	'Fatal', 'major injury' or 'over 3 day illness' accidents, 'electric shock' in comment field	In cells of accidents with under three accidents, the number of accidents was not reported due to privacy regulation. 1.5 cases per cell were imputed. One-to-many codings from SOC 2000 to ISCO 88
Switzerland	SUVA, Schweizerische Unfallversicherungsanstalt	3074 electrical injuries, years 2003–2008	ISCO 88	Accident recorded as 'being electrified'	Based on 5% sample of all accidents. Excludes self-employed
Austria	Österreichische Unfallversicherung	2150 electrical injuries, years 2005–2009	ISCO 08, recoded into ISCO 88	'Electric disturbance', with subcategories of direct/ indirect contact, fire, explosion or other electric disturbance	One-to-many codings from ISCO08 to ISCO 88

All time periods refer to January to December of a given year, except for the Dutch dataset.

Table 3 Pooled accident rates of occupational accidents resulting in electric injury, per year and 10000 workers and across five countries (NL, DE, UK, AT, CH)

ISCO 88	ISCO 88 title	Number of countries reporting at least one accident	Pooled injury rate	Risk of electrical injury
11	Military	1	0	Low
111	Legislators	0	0	Low
112	Senior government officials	0	0	Low
113	Traditional chiefs and heads of villages	0	0	Low
114	Senior officials of special-interest organisations	0	0	Low
121	Directors and chief executives	2	0.07	Low
122	Production and operations department managers	3	0.041	Low
123	Other department managers	2	0.012	Low
131	general managers	4	0.075	Low
211	Physicists, chemists and related professionals	1	0.042	Low
212	Mathematicians, statisticians and related professionals	0	0	Low
213	Computing professionals	2	0.058	Low
214	Architects, engineers and related professionals	5	0.12	Low
221	Life science professionals	1	0.15	Low
222	Health professionals (except nursing)	3	0.11	Low
223	Nursing and midwifery professionals	4	0.21	Low
231	College, university and higher education teaching professionals	1	0.027	Low
232	Secondary education teaching professionals	1	0.0026	Low
233	Primary and pre-primary education teaching professionals	3	0.048	Low
234	Special education teaching professionals	0	0	Low
235	Other teaching professionals	2	0.042	Low
241	Business professionals	1	0.00039	Low
242	Legal professionals	0	0	Low
243	Archivists, librarians and related information professionals	1	0.088	Low
244	Social science and related professionals	2	0.0031	Low
245	Writers and creative or performing artists	2	0.099	Low
246	Religious professionals	0	0	Low
311	Physical and engineering science technicians	5	0.9	Medium
312	Computer associate professionals	3	0.35	Low
313	Optical and electronic equipment operators	3	0.39	Medium
314	Ship and aircraft controllers and technicians	2	0	Low
315	Safety and quality inspectors	3	0.21	Low
321	Life science technicians and related associate professionals	1	0.074	Low
322	Modern health associate professionals (except nursing)	3	0.17	Low
323	Nursing and midwifery professionals	4	0.21	Low
324	Traditional medicine practitioners and faith healers	0	0	Low
331	Primary and pre-primary education teaching professionals	3	0.048	Low
332	Primary and pre-primary education teaching professionals	3	0.048	Low
333	Special education teaching professionals	0	0	Low
334	Other teaching professionals	2	0.042	Low
341	Finance and sales associate professionals	3	0.017	Low
342	Business services agents and trade brokers	2	0.0034	Low
343	Administrative associate professionals	2	0.00018	Low
344	Customs, tax and related government associate professionals	1	0	Low
345	Police inspectors and detectives	1	0	Low
346	Social work associate professionals	3	0.12	Low
347	Artistic, entertainment and sports associate professionals	4	0.071	Low
348	Religious associate professionals	0	0	Low
411	Secretaries and keyboard-operating clerks	1	0	Low
412	Numerical clerks	3	0.03	Low
413	Material-recording and transport clerks	3	0.13	Low
414	Library, mail and related clerks	2	0.067	Low
419	Other office clerks	4	0.059	Low
421	Cashiers, tellers and related clerks	3	0.11	Low
422	Client information clerks	1	0.021	Low
511	Travel attendants and related workers	2	0.031	Low
512	Housekeeping and restaurant services workers	5	0.78	Medium

Continued

Table 3 Continued

ISCO 88	ISCO 88 title	Number of countries reporting at least one accident	Pooled injury rate	Risk of electrical injury
513	Personal care and related workers	2	0.01	Low
514	Other personal services workers	2	0.0031	Low
515	Astrologers, fortune-tellers and related workers	0	0	Low
516	Protective services workers	5	0.68	Medium
521	Fashion and other models	0	0	Low
522	Shop salespersons and demonstrators	5	0.15	Low
523	Stall and market salespersons	0	0	Low
611	Market gardeners and crop growers	3	0	Low
612	Market gardeners and crop growers	3	0	Low
613	Market gardeners and crop growers	3	0	Low
614	Forestry and related workers	2	0.85	Medium
615	Fishery workers, hunters and trappers	2	0	Low
621	Subsistence agricultural and fishery workers	0	0	Low
711	Miners, shot firers, stone cutters and carvers	2	0.29	Low
712	Building frame and related trades workers	5	1.5	High
713	Building finishers and related trades workers	4	3.1	High
714	Painters, building structure cleaners and related trades workers	5	0.86	Medium
721	Metal moulders, welders, sheet-metal workers,...	5	2.2	High
722	Blacksmiths, tool-makers and related trades workers	5	0.58	Medium
723	Machinery mechanics and fitters	5	1.9	High
724	Electrical and electronic equipment mechanics and fitters	5	11.83	High
731	Precision workers in metal and related materials	1	0.26	Low
732	Potters, glass-makers and related trades workers	1	0.016	Low
733	Handicraft workers in wood, textile, leather and related materials	1	0	Low
734	Printing and related trades workers	2	0.017	Low
741	Food processing and related trades workers	5	0.85	Medium
742	Wood treaters, cabinet-makers and related trades workers	4	0.71	Medium
743	Textile, garment and related trades workers	3	0.22	Low
744	Pelt, leather and shoemaking trades workers	0	0	Low
811	Mining- and mineral-processing-plant operators	1	0	Low
812	Metal-processing-plant operators	4	0.56	Medium
813	Glass, ceramics and related plant operators	1	0	Low
814	Wood-processing- and papermaking-plant operators	3	0.099	Low
815	Chemical-processing-plant operators	2	0.15	Low
816	Power-production and related plant operators	4	1.1	High
817	Automated-assembly-line and industrial-robot operators	0	0	Low
821	Metal- and mineral-products machine operators	5	1.1	High
822	Chemical-products machine operators	2	1.3	Medium
823	Rubber- and plastic-products machine operators	4	0.34	Medium
824	Wood treaters, cabinet-makers and related trades workers	4	0.71	Medium
825	Printing-, binding- and paper-products machine operators	2	1.4	Medium
826	Textile-, fur- and leather-products machine operators	2	0.045	Low
827	Food and related products machine operators	4	0.89	Medium
828	Assemblers	4	1.7	High
829	Other machine operators and assemblers	3	0.067	Low
831	Locomotive-engine drivers and related workers	3	0.64	Medium
832	Motor-vehicle drivers	3	0.18	Low
833	Agricultural and other mobile-plant operators	3	0.31	Low
834	Ships' deck crews and related workers	4	1.2	High
911	Street vendors and related workers	0	0	Low
912	Shoe cleaning and other street services elementary occupations	0	0	Low
913	Domestic and related helpers, cleaners and launderers	5	0.24	Low
914	Building caretakers, window and related cleaners	4	0.75	Medium
915	Messengers, porters, doorkeepers and related workers	3	0.013	Low
916	Garbage collectors and related labourers	2	0.83	Medium
921	Agricultural, fishery and related labourers	2	0.044	Low
931	Mining and construction labourers	5	2.2	High
932	Manufacturing labourers	5	0.75	Medium
933	Transport labourers and freight handlers	4	0.083	Low

Pooled injury rates in military based on Dutch data, and in codes 611, 612, 613 on data from The Netherlands, UK, Austria and Switzerland (farmers not included in German database).

Table 4 Frequency of occupations in groups of risk of electric injury and magnetic field exposure

Risk of electric injury	Magnetic field exposure		
	High	Medium	Low
High	3	3	4
Medium	3	7	9
Low	0	18	69

The κ coefficient between the two JEMs is 0.29 with an agreement of 67.2%.

We decided to group occupations without any reported electrical injuries together with the 'low' risk group as they may not constitute a different group: The installation or maintenance of electrical systems and equipment has been reported to be the most frequent cause of occupational electrical incidents.[19] Such tasks can be performed by personnel from very different backgrounds and are not necessarily restricted to a few occupations. Accordingly, in our analysis, we identified electric injury across a very wide range of occupations, with many occupations where only very few cases of electrical injury were reported. A job code without any reported electrical injury may therefore not necessarily reflect a true absence of risk.

A strength of our JEM is that it is based on data from several countries, which provides an opportunity to assess patterns in the data. We used random effects pooling[20] of our country-specific electrical injury rates, because we observed a high variation of the rates, as measured with the I^2–statistic[21] (data not shown). In random effects pooling, rates are more balanced between countries, otherwise our results would have been driven primarily by data from Germany, with a large number of reported electrical injuries and workers.

There are several reasons that might have caused this high heterogeneity. For example, variation in electrical injury rates across countries might reflect different safety standards in the respective countries. Another reason might be differing degrees of under-reporting of electric injury in the individual databases. For example, we observed that electrical injury rates from The Netherlands and the UK were frequently lower than those from the other countries. This is also reflected in the lower percentages of electrical injury of all accidents (table 2). The data set from The Netherlands was the only one with a more stringent definition of accidents, which is most likely an underlying reason for reporting fewer accidents. However, when we excluded this dataset, the relative ranking of the jobs, and thus the classification in low, medium, and high, remained essentially unchanged (data not shown). Our translation of ISCO 08 as well as SOC 2000 codes into ISCO 88 might also have contributed to heterogeneity. A high I^2 could therefore stand for true differences in risk of electrical injury across countries, in which case our pooled risk estimates might not be representative of the corresponding risk of the working population of a specific country. We therefore preferred to express risk of electrical injury in our JEM in groups of 'low', 'medium' or 'high' risk instead, thus assuming that the ranking of occupations with higher or lower risks is still captured correctly.

Accidents registered in the national databases usually represent serious accidents as workers were not able to work for at least 3 consecutive days. An advantage of these databases is that accidents are based on quite similar definitions. However, electric injury as captured in our JEM is a broad definition, including several types of injury and likely differing degrees of severity: Electrical injuries have been divided into direct contact to high-voltage (1000 V or above) or low-voltage (<1000 V) power sources, or indirect contacts resulting, for example, in flash, thermal, blunt or arc accidents.[22 23] The severity of the injury depends on a range of factors including current intensity and pathway through the body, voltage and duration of exposure.[23] Accordingly, injury characteristics have been reported to vary in a wide range, for example, from strains, fractures, burns, arrhythmia to cardiac arrest.[24 25] Types of accidents and types of injury are usually not specified in the available datasets, although this might be of importance when evaluating electrical injury as a potential risk factor: A systematic review identified severity of shocks to be associated with non-progressive spinal cord syndrome, but not with progressive ALS.[26]

In addition to the risk of electrical injury, workers can be exposed to a range of other exposures such as magnetic fields, electric fields, perceivable nuisance shocks or imperceptible contact currents.[7] We compared our electrical injury JEM to an ELF magnetic field JEM and found only a moderate agreement. This could be caused by true differences between occupations with a low risk of shocks but high magnetic field exposures, or vice versa. On a three digit ISCO-code level, we did not encounter jobs with high magnetic field exposure and low risk of electrical injury. In contrast, mining and construction labourers (ISCO 931) had relatively frequent electrical injuries reported in all countries' datasets, but were in the low ELF magnetic field exposure group. One might hypothesise that a high magnetic field—low injury type of exposure pattern could arise when a person's workstation is close to electric equipment (eg, sewing machine operators, ISCO 8263[27 28]), but who will not come into accidental contact with live circuits, because repair or maintenance of the equipment will be performed by other occupations (eg, electrical mechanics, fitters and services, ISCO 7241). The other way around, occupations could have a high risk of electrical injury and low magnetic field exposure if the work is seldom close to energised equipment emitting magnetic fields, but creates opportunities for accidental contact with power lines by metal objects, such as the ladders, cranes and scaffolds used in construction occupations.[29] Alternatively, the moderate correlation between our two exposure metrics could be at least partly due to random misclassification in both JEMs due to their small sample sizes in some occupations.

Our JEM is in line with a recent analysis of the risk of electrical injury or electrocution that used US occupational survey data in combination with expert judgement.[8] In this analysis, especially electricians, welders and cutters, construction labourers, mechanics and repairer helpers and electrical power installers were identified as high-risk occupations for electrical injury. Cooks, janitors and cleaners were also classified as high-risk in this analysis, but with a medium risk in ours. Such variation could be either based on the deviations in occupational coding systems used by Vergara *et al* (Bureau of Census 1990) and ISCO 88 applied by us, or on differences in methodology by implementing expert judgment into the classification. The common underlying pattern in both analyses, however, seems to be that occupations concerned with installation, repair or maintenance of electrical systems or equipment appear to be the occupations with higher risk of electrical injury.

In conclusion, registries of occupational accidents may provide a good way to assess patterns of electrical injuries. To our knowledge, we are the first to pool such accident data across several European countries in order to summarise and present them as a population-based JEM. Electric shocks have been discussed as potential cause for neurodegenerative diseases such as ALS. Our JEM might contribute to assessing long-term risks arising from electric shocks, as well as disentangling them from those of magnetic field exposure in community-based epidemiological studies.

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