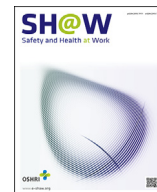




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Original Article

Analysis of Workplace Accidents in Automotive Repair Workshops in Spain



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ABSTRACT

Background: To analyze the effects of the factors associated with different types of injury (superficial wounds, dislocations and sprains, bone fractures, concussion and internal injuries, burns scalding and freezing) caused by occupational accidents in automotive repair workshops.

Methods: Study of a sample consisting of 89,954 industry accidents reported from 2003 to 2008. Odds ratios were calculated with a 95% confidence interval.

Results: Belonging to a small company is a risk factor for suffering three of the five types of injury studied. Women are less likely to suffer burns and superficial wounds, and more likely to suffer dislocations or sprains. Foreign workers are more likely to suffer concussion and internal injuries.

Conclusion: Health and safety strategies and accident prevention measures should be individualized and adapted to the type of worker most likely to be injured in each type of accident. Occupational health and safety training courses designed according to worker profile, and improving the participation of the workers in small firms creating regional or roving safety representatives would improve working conditions.

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1. Introduction

Prevention of injuries from occupational accidents is a public priority [1], and accordingly several studies on this issue have been conducted in Spain. These studies have focused on different aspects, such as trends over time for fatal injuries caused by occupational accidents across all sectors [2], or the risk of foreign workers suffering occupational accidents [3].

Much research has been done into occupational accidents in hazardous and economically important sectors such as the construction industry [4–6], but, although vehicle repair is an important global economic activity, this sector has been the target of far fewer studies on workplace health and safety than the aforementioned construction industry.

In the United States, 3.9 out of every 100 full-time workers employed in the automotive repair and maintenance sector in 2011 suffered some kind of nonfatal occupational accident or illness, according to data from the Bureau of Labor and Statistics [7]. The

accident rate for this industry was higher than that reported by other, apparently more hazardous, sectors such as support activities for mining or the chemical industry, which had rates of 2.3 and 2.4 per 100 workers, respectively [7].

The sector's high accident rate is associated with several different variables, and in their day-to-day activity workers from the sector are exposed to many different risk factors such as high noise levels [8–10], asbestos [11–13], or ergonomic conditions [14,15]. Although some of these risks are classified as hygienic risks and they are associated with occupational diseases, previous research [16] demonstrated that there were strong relationships between hygiene conditions and occupational accidents. They showed that poor hygienic conditions duplicate the probability of accident [16]. Majority of the previous scientific researches found about occupational health and Safety in the automotive repair and maintenance sector were located in the United States. In Europe, there is a lack of scientific publications about the topic; however, there are some professional guides about cited risks as the guide

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proposed by the Health and Safety Executive [17], and the training guide for assessing the risk in cars repair workshops [18] proposed in the TRIA project, coordinated by Cyprus Workers' Confederation. In Spain, there are more examples of risk assessment guides, such as that edited by the Centro de Experimentación y Seguridad Vial MAPFRE (CESVIMAP) [19], or the manual proposed by the Instituto Nacional de Seguridad e Higiene en el Trabajo (INSHT) [20].

It is remarkable that the Spanish Ministry of Employment registered 89,954 occupational accidents in the sector over the 2003 to 2008 period, leading to varying degrees of injury. Therefore, accidents in the sector are not a minor problem. Although it was not possible to obtain the disaggregate data of accidents the sector in order to calculate specific incidence rates, only the total number of accidents should be a reason to study and address the problem of the accidents in this sector more deeply.

The aim of this study is to analyze the effects of the factors associated with different types of injury (superficial wounds; dislocations and sprains; bone fractures; concussion and internal injuries; burns, scalding, and freezing) caused by occupational accidents in automotive repair workshops.

2. Materials and methods

2.1. Data collection of accident reports

Since 2003, it has been mandatory in Spain to register online all occupational accidents resulting in sick leave lasting 1 day or more (ORDER TAS/2926/2002, of November 19, establishing the new models for notifying occupational accidents and enabling these to be transmitted electronically). Accidents must be reported over the Delt@ electronic system by filling in an Official Occupational Accident Report. For the purpose of this study, the Ministry of Employment and Social Security provided us with 89,954 occupational accident reports corresponding to all the accidents reported from the automotive repair and maintenance sector (Classification of Economic Activities) between 2003 and 2008. This number represents the total amount of accidents reported in Spain in the cited period. Before 2003, not all accidents were reported digitally using the electronic system Delt@, because it was possible to report the accident alternatively using the official hard copy form. After 2008, Spanish Classification of Economic Activities codes were modified. Although cited codes changed, the majority of maintenance activities are similar in current times, and mechanical configuration of automobiles have not changed substantially. Cars with emergent technologies only represent a small percentage of the total vehicle population in Spain. A proof of that is that only 2% of new cars sold in 2015 in the country were hybrid or electric [21]. Also, emergent technologies do not affect maintenance of common elements as tires or bodywork. These are the main reasons for the period studied being limited to between 2003 and 2008.

The Ministry removed all personal data from the accident reports. Despite the statutory obligation to report accidents, some might not have been notified as required by prevailing regulations, leaving them with no official record.

2.2. Study variables

We used the *injury description code* variable, based on the first two digits of the main injury groups listed in accident reports, in order to measure the effect of different variables on different types of injury. The percentages of workers injured based on the description of the injury was as follows: superficial wounds and injuries (41.2%); dislocations, sprains, and strains (38.8%); bone fractures (6.2%); concussion and internal injuries (5.3%); and burns,

scalding, and freezing (2.0%). Injuries accounting for less than 2% of the total number of accidents were not analyzed. Overall, the percentage of injury descriptions studied encompassed 93.5% of all accidents.

Once the accidents had been grouped by injury description, different variables were chosen to determine how they affected different types of accident. The selection of the variables was based on the research conducted by Camino López et al [6]. In a preliminary approach we analyzed all variables ($n = 57$) included in the accidents records elaborating their contingency tables. Variables for which the majority of values in their contingency tables did not reach a statistical significance were rejected for current research. Finally, we chose the 11 variables which were statistically superior.

The variables studied were subdivided into three groups, according to whether they were worker, company, or accident description variables.

- Worker variables: Describe the profile of the injured worker. This group includes the variables sex, nationality, and employment situation (employed by a company vs. others, such as self-employment, or other special regimes).
- Company variables: Describe organizational aspects of the company. This group includes the size of the company (workforce), whether it conducts compulsory general risks assessments, its health and safety organization (outsourced prevention service or other prevention management system), and whether it worker who suffered the accident was recruited through temporary employment agencies.
- Accident description variables: Include variables related to the circumstances under which the accident occurred, such as whether it occurred in the worker's usual workplace, if more than one worker was affected, if accident occurred on Monday or not, or whether the worker was performing their usual job at the time of the accident.

2.3. Statistical analysis

Logistic regression model is a methodology used frequently in cohort studies and clinical trials. The model provides the odds ratios (ORs) for the disease or injury in those individuals who have suffered exposure to some specific variable with respect to those individuals who have not been exposed [22]. In the current research, the strength of relationship between the variables and the type of injury was measured using adjusted ORs and their 95% confidence intervals (CI). Independency of each variable was tested using Chi-square test. The data were analyzed statistically using SPSS version 19 (SPSS, Chicago, IL, USA).

3. Results

Results obtained are shown in Tables 1 and 2. In the following subsections the most remarkable results are highlighted.

3.1. Superficial wounds

Superficial wounds were significantly and independently associated with male sex (OR = 2.206; 95% CI, 2.02–2.409), with workers employed by companies (OR = 1.306; 95% CI, 1.143–1.491), with companies that used temporary employment agencies (OR = 1.885; 95% CI, 1.113–3.192), with the usual workplace (OR = 2.055; 95% CI, 1.965–2.149), and with the usual job (OR = 1.55; 95% CI, 1.472–1.633). It is also remarkable that accidents with more than one worker affected were significantly and

Table 1
Odds ratio (OR) values obtained in each injury

Variable	Variable value	Superficial wounds OR	Dislocations and sprains OR	Bone fractures OR	Concussion and internal injuries OR	Burns, scalding and freezing OR
Sex	Male	2.206	0.493	0.996	0.905	2.627
	Female	1	1	1	1	1
Nationality	Spanish	0.805	1.175	1.074	1.122	0.853
	Foreign	1	1	1	1	1
Employee or other	Employed by company	1.306	1.068	0.492	1.017	0.663
	Others	1	1	1	1	1
Workforce	≤ 5	1.117	0.804	1.289	0.906	1.376
	> 5	1	1	1	1	1
Risk assessment	Yes	0.892	1.032	1.096	1.082	1.032
	No	1	1	1	1	1
H&S organization	Outsourced H&S	0.94	1.054	1.114	0.918	1.226
	Other H&S system	1	1	1	1	1
Temporary employment agencies	Yes	1.885	0.952	0.703	1.889	0.328
	No	1	1	1	1	1
Place of accident	Usual workplace	2.055	0.733	0.528	0.939	2.673
	Outside usual workplace	1	1	1	1	1
Number of workers injured	> 1	0.635	1.272	0.963	0.894	2.055
	1	1	1	1	1	1
Monday	Yes	0.883	1.189	0.843	1.077	0.826
	No	1	1	1	1	1
Usual job	Yes	1.55	0.776	0.702	0.926	2.115
	No	1	1	1	1	1

H&S, health and safety.

independently associated with a lower probability to superficial wounds (OR = 0.635; 95% CI, 0.523–0.770).

3.2. Dislocations and sprains

Dislocations and sprains, meanwhile, were statistically significantly and independently associated with Spanish nationality (OR = 1.175; 95% CI 1.121–1.231), with more than one worker injured (OR = 1.272; 95% CI 1.063–1.522), and with the accident occurring on Monday (OR = 1.189; 95% CI, 1.153–1.226). Monday, and not other days of the week, as a risk factor for this type of injury is consistent with the so-called Monday syndrome studied in the scientific

literature [23]. In contrast, male sex was reported as a protective factor in this kind of injury (OR = 0.496; 95% CI, 0.456–0.532).

3.3. Bone fractures

Bone fractures are associated significantly and independently to a greater extent with companies with five or fewer workers (OR = 1.289; 95% CI, 1.219–1.362), and with companies that outsource their health and safety organization (OR = 1.114; 95% CI, 1.047–1.186). By contrast, workers employed by a company (OR = 0.492; 95% CI, 0.403–0.599) and workers in their usual workplace (OR = 0.528) have lower probability of suffering bone fractures.

Table 2
Number and percentage of injured per category

Variable	Variable value	Superficial wounds	Dislocations and sprains	Bone fractures	Concussion and internal injuries	Burns, scalding and freezing	Overall
Sex	Male	36,425 (98.2)	33,408 (95.6)	5,391 (96.9)	4,576 (96.7)	1,735 (98.8)	87,215 (97.0)
	Female	672 (1.8)	1,527 (4.4)	170 (3.1)	158 (3.3)	21 (1.2)	2,739 (3.0)
Nationality	Spanish	33,240 (89.6)	31,969 (91.5)	5,074 (91.2)	4,335 (91.6)	1,568 (89.3)	81,581 (90.7)
	Foreign	3,857 (10.4)	2,966 (8.5)	487 (8.8)	399 (8.4)	188 (10.7)	8,373 (9.3)
Employee or other	Employed by company	36,759 (99.1)	34,575 (99.0)	5,448 (98.0)	4,684 (98.9)	1,728 (98.4)	87,372 (97.1)
	Others	338 (0.9)	360 (1.0)	113 (2.0)	50 (1.1)	28 (1.6)	2,582 (2.9)
Workforce	≤ 5	13,542 (36.5)	11,185 (32)	2,258 (40.6)	1,559 (32.9)	745 (42.4)	31,507 (35.0)
	> 5	23,555 (63.5)	23,750 (68.0)	3,303 (59.4)	3,175 (67.1)	1,011 (57.6)	58,447 (65.0)
Risk assessment	Yes	15,189 (40.9)	15,043 (43.1)	2,486 (44.7)	2,103 (44.4)	761 (43.3)	38,307 (42.6)
	No	21,908 (59.1)	19,892 (56.9)	3,075 (55.3)	2,631 (55.6)	995 (56.7)	51,647 (57.4)
H&S organization	Outsourced H&S	8,533 (23.0)	8,467 (24.2)	1,420 (25.5)	1,052 (22.2)	482 (27.4)	21,281 (23.7)
	Other H&S system	28,564 (77.0)	26,468 (75.8)	4,141 (74.5)	3,682 (77.8)	1,274 (72.6)	68,673 (76.3)
Temporary employment agencies	Yes	37,078 (99.9)	34,907 (99.9)	5,555 (99.9)	4,732 (100)	1,752 (99.8)	89,884 (99.9)
	No	19 (0.1)	28 (0.1)	6 (0.1)	2 (0)	4 (0.2)	70 (0.1)
Place of accident	Usual workplace	34,160 (92.1)	29,992 (85.9)	4,456 (80.1)	4,131 (87.3)	1,669 (95.0)	79,081 (87.9)
	Outside usual workplace	2,937 (7.9)	4,943 (14.1)	1,105 (19.9)	603 (12.7)	87 (5.0)	10,873 (12.1)
Number of workers injured	> 1	150 (0.4)	217 (0.6)	29 (0.5)	23 (0.5)	19 (1.1)	486 (0.5)
	1	36,947 (99.6)	34,718 (99.4)	5,532 (99.5)	4,711 (99.5)	1,737 (98.9)	89,468 (99.5)
Monday	Yes	8,608 (23.2)	9,268 (26.5)	1,207 (21.7)	1,225 (25.9)	373 (21.2)	22,087 (24.6)
	No	28,489 (76.8)	25,666 (73.5)	4,354 (78.3)	3,509 (74.1)	1,383 (78.8)	67,867 (75.4)
Usual job	Yes	34,837 (93.9)	31,780 (91.0)	4,970 (89.4)	4,335 (91.6)	1,687 (96.1)	82,864 (92.1)
	No	2,260 (6.1)	3,155 (9.0)	591 (10.6)	399 (8.4)	69 (3.9)	7,090 (7.9)

Data are presented as n (%).

H&S, health and safety.

3.4. Concussion and internal injuries

The results obtained in the category of concussion and internal injuries were the least conclusive since different variables yielded confidence intervals that include 1, making it impossible to claim that the ORs obtained with these confidence intervals are statistically significant.

3.5. Burns, scalding and freezing

Finally, we found that suffering burns, scalding, or freezing is associated significantly and independently with the male sex (OR = 2.627; 95% CI, 1.706–4.046), with companies with five or fewer workers, (OR = 1.376; CI 95, 1.25–1.514), with outsourced health and safety organization (OR = 1.226; 95% CI, 1.103–1.363), with the usual workplace (OR = 2.673; 95% CI, 2.153–3.319), with more than one worker involved (OR = 2.055; 95% CI, 1.296–3.259), and with the usual job (OR = 2.115; 95% CI, 1.66–2.693). In contrast, workers from temporary employment agencies had the lowest OR value for this kind of injury (OR = 0.328; 95% CI, 0.119–0.901).

4. Discussion

Table 3 summarizes the way in which the study variables affect different types of injury, either as a risk factor or as a protective factor based on the binary value assigned to the variable itself. It is interesting to note that none of the variables contain a value that serves as a protective factor against all types of injury.

Belonging to a small company with five or fewer workers is a risk factor of suffering three of the five types of injuries studied. Several researchers agree that there is evidence to suggest that smaller companies have a higher accident risk [24–26]. Several studies have indicated that the smaller the company, the greater the exposure to physical and chemical agents [27,28]. The reason for this, according to these studies, lies in the difficulty in controlling different risks due to the limited material and human resources of such companies. Frequently, small enterprises are organizations with their resources focused on their survival. The responsible of the company have to handle different issues at the

same time, and health and safety is not always a priority [29]. In addition, many owners of small companies consider occupational safety as responsibility of the employees [29], and regulations and demands to improve health and safety standards as a financial burden. Because of their limited resources, many small companies, particularly microcompanies, find it difficult to comply with legal requirements at all.

The findings of this study suggest that in this regard the automotive repair workshop sector is similar to other sectors, where the size of the company is a protective factor against most of the types of injury studied. Larger companies, commonly will have more adequate management of prevention issues, better training activities, and education and information than similar small companies [24].

In terms of where accidents occur, the usual workplace variable yielded similar results to the usual job or usual task variable, both being protective factors against dislocations and sprains, and also against bone fractures. These results are consistent, since it is commonplace in this sector for the usual job to be performed in the usual workplace. Accidents occurring outside the usual workplace are usually associated with driving vehicles either while *on a mission*, i.e., performing exceptional tasks, or while travelling to and from work. Accordingly, one of the most common injuries from nonfatal traffic accidents is bone fracture [30], making it logical to conclude that extraordinary jobs performed outside the usual workplace involving driving vehicles are a risk factor for this type of injury, an assumption borne out by the findings of this study. In consequence, preventive measures related to prevent traffic accidents of the workers (e.g., courses of anticipatory driving [31]) would reduce this kind of injuries.

With regard to Monday syndrome in which workers claim accidents occurring over the weekend outside usual working hours to be occupational accidents [23], it is interesting to note that Monday is a risk factor for dislocation and sprain injuries, suggesting that these could be associated with this syndrome. However, it is also a risk factor for concussion and internal injuries that are not usually associated with this syndrome, since the seriousness of the injury would prevent the individual involved from delaying medical treatment. It is unsafe, therefore, to conclude that there is enough evidence to suggest that Monday syndrome is found in this sector.

Table 3
Effect of variables on injuries

Variable		Superficial wounds	Dislocations and sprains	Bone fractures	Concussion and internal injuries	Burns, scalding, and freezing
Sex	Male	Risk	Protective	NS	NS	Risk
	Female	Protective	NS	NS	NS	Protective
Nationality	Spanish	Protective	Risk	NS	Risk	Protective
	Foreign	Risk	Protective	NS	Protective	Risk
Employee or other	Employee	Risk	NS	Protective	NS	Protective
	Other	Protective	NS	Risk	NS	Risk
Workforce	≤ 5	Risk	Protective	Risk	Protective	Risk
	> 5	Protective	Risk	Protective	Risk	Protective
Risk assessment	Yes	Protective	Risk	Risk	Risk	NS
	No	Risk	Protective	Protective	Protective	NS
Outsourced H&S consultant	Yes	Protective	Risk	Risk	Protective	Risk
	No	Risk	Protective	Protective	Risk	Protective
Temporary employment agencies	Yes	Risk	NS	NS	NS	Protective
	No	Protective	NS	NS	NS	Risk
Place of accident	Usual workplace	Risk	Protective	Protective	NS	Risk
	Outside usual workplace	Protective	Risk	Risk	NS	Protective
Number of workers injured	> 1	Protective	Risk	Protective	NS	Risk
	1	Risk	Protective	Risk	NS	Protective
Monday	Yes	Protective	Risk	Protective	Risk	Protective
	No	Risk	Protective	Risk	Protective	Risk
Usual job	Yes	Risk	Protective	Protective	NS	Risk
	No	Protective	Risk	Risk	NS	Protective

H&S, health and safety; NS, not significant.

Based on the study findings, we can say that the characterization of the worker, company, and accident is not the same for all types of injuries, and the probability of suffering an accident varies for each type of injury. Similar conclusions have been obtained in other sectors as construction [3,5,32,33], coal mining [34], or nursing sector [35], but these results were not focused on the automotive workshop sector.

It is interesting to note that, unlike other sectors such as the construction industry, where the variables male and immigrant are a risk factor for accidents [36], in the automotive repair workshop sector both these and the other characteristics of the worker can be either a risk or protective factor, depending on the type of injury caused by the accident.

In conclusion, health and safety strategies and accident prevention measures should be individualized, adapted, and implemented with particular consideration for the type of worker most likely to be injured in each type of accident. Some of these solutions could be: occupational health and safety training courses designed according to worker profile, improving the participation of the workers in small firms creating regional or roving safety representatives [29], or implementing and following some specific interventions on the sector as the experience conducted by Parker et al [37].

4.1. Limitations of the study

It is important to bear in mind, as a limitation of the study, that variables studied are general variables from accidents registered in the official accident notification system (Delt@). There are some factors contributing in accidents that are not registered in the official form, because there are not fields included about them. In consequence, the findings obtained here are general and can differ in some specific cases. In addition incidents not reported were not considered because of the lack of records about them.

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Conflicts of interest

The authors have no conflicts of interest to declare.

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