ANALYSIS OF CONSTRUCTION ACCIDENTS IN SPAIN, 2003-2008.

Authors:

Antonio López Arquillos
Ingeniero Industrial
University of Málaga
E.T.S.I.Industriales
C/Dr. Ortiz Ramos, s/n (Teatinos)
29071 Málaga
investigacioncatedra@gmail.com
+34951952538

Juan Carlos Rubio Romero
Dr. Ingeniero Industrial
Cátedra de Prevención y Responsabilidad Social Corporativa
University of Málaga

Alistair Gibb
RAEng Professor of Complex Project Management
European Construction Institute
School of Civil & Building Engineering
Loughborough University, UK

ABSTRACT

The research objective for this paper is to obtain a new extended and updated insight to the likely causes of construction accidents in Spain, in order to identify suitable mitigating actions. Method: The paper analyzes all construction sector accidents in Spain between 2003 and 2008. Ten variables were chosen and the influence of each variable is evaluated with respect to the severity of the accident. The descriptive analysis is based on a total of 1,163,178 accidents. Results: Results showed that the severity of accidents was related to variables including age, CNAE (National Classification of Economic Activities) code, size of company, length of service, location of accident, day of the week, days of absence, deviation, injury, and climatic zones. Conclusions: According to data analyzed, a large company is not always necessarily safer than a small company in the aspect of fatal accidents, experienced workers do not have the best accident fatality rates, and accidents occurring away from the usual workplace had more severe consequences. Impact on the industry: Results obtained in this paper can be used by companies in their occupational safety strategies, and in their safety training programs.

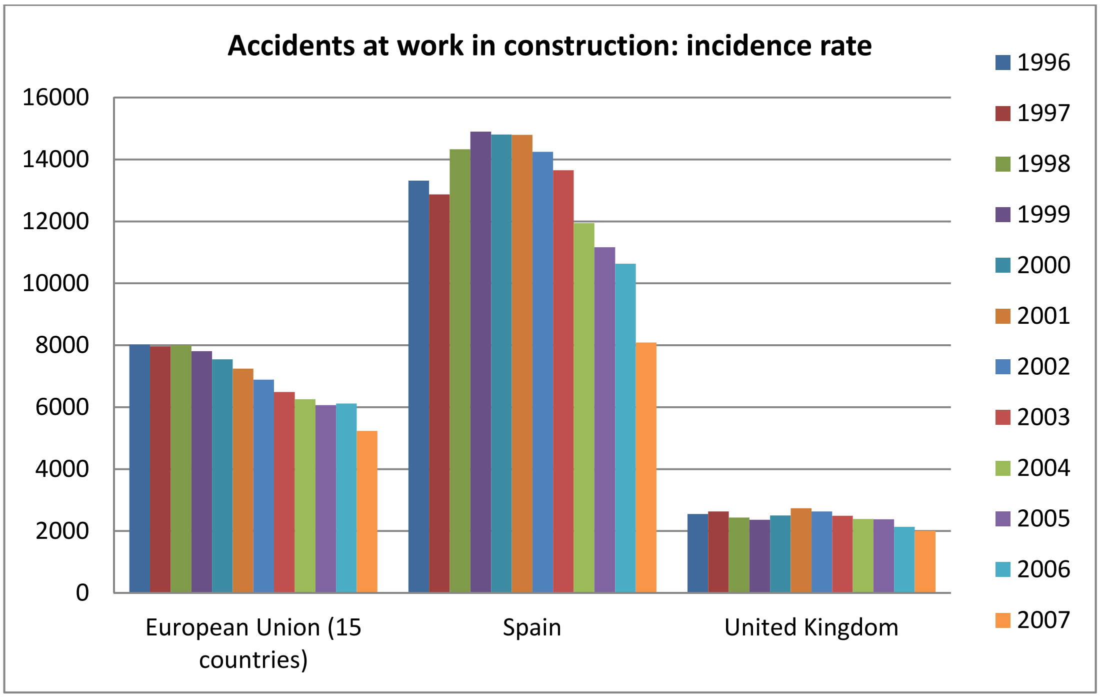
Keywords: Construction, accidents, severity, rates, variables.

1. Introduction

Accident rates in construction continue to be an international cause of concern. This concern is justified because construction has the highest casualty rates in many countries (Camino López, Ritzel, Fontaneda, & González Alcantara, 2008). There are significant differences in the submission of reports and work accident registration procedures in different EU countries, such as the definition of a workplace accident and consideration of road traffic accidents (Aires, Rubio, & Gibb, 2010). Harmonization of the data by Eurostat allows some comparison of the results of member states, but it is important to note that these comparisons between countries are still not completely reliable (Aires et al.). An example is provided in Fig. 1 where we see the accident rates in construction across the European Union, Spain, and UK in recent years (Eurostat, 2010). Incidence rates in Spain are around twice those of the European average. On the other hand, the United Kingdom rates are very low compared to the rest of Europe. Although incidence rates have decreased in the last decade in the majority of European states, Spain has not decreased enough to reach the European average levels.

Figure 1.

Accidents at work in construction: incidence rate. Source Eurostat, 2010.



***Footnote Figure 1. Incidence rate considered is the number of accidents at work with more than 3 days' absence that occurred during the year/number of persons in employment in the reference population) x 100 000. An accident at work is a discrete occurrence in the course of work which* *leads to physical or mental harm. It excludes accidents on the way to or from work, occurrences having only a medical origin, and occupational diseases.*

In order to identify solutions for accidents in construction, different researchers have investigated the problem in many countries. Examples of these studies for various countries include: Taiwan (Cheng, Leu, Lin, & Fan, 2010), Scotland (Cameron, Hare, & Davies, 2008), Turkey (Etiler, Colak, Bicer, & Barut, 2004; Mungen & Gürcanli, 2005), Portugal (Macedo & Silva, 2005), and South Korea (Im et al., 2009). A significant investigation in the UK (Brace, Gibb, Pendlebury, & Bust, 2009) identi- fied that the underlying factors in fatal accidents and high-potential incidents can be grouped into three categories: (a) macro factors, relating to stakeholders such as society, education, industry, corporate organization and trades unions; (b) mezzo factors, referring to aspects such as project management, organization, and procurement; and (c) micro factors, meaning worker, workplace, and supervisor issues. When an accident is analyzed, many variables and factors are present. For example, a study about contributing factors in construction accidents in the UK (Haslam et al., 2005) concluded that problems arising from workers or the work team were present in 70% of the accidents, workplace issues in 49%, shortcomings with equipment (including PPE) in 56%, problems with suitability and condition of materials (27%), and deficiencies with risk management in 84% of accidents.

The influence of the difference variables in the severity of the injuries must be considered. There are a number of research studies in this direction. For example, Sawacha, Naoum, and Fong (1999) showed that operatives between the ages of 16–20 were more likely to have accidents than others. Further analysis of the data in the same paper suggests that the level of accidents tends to decline steadily after the age of 28 to reach a low point in the mid-40s. In a similar way, Salminen (2004) concluded that young workers had a higher injury rate than older workers, however, the injuries of young workers were reported as less often fatal than those of older workers. In addition, Chau et al. (2004) showed that risks of injury for each worker depend on age, body mass index, hearing disorders, sleep disorders, and sporting activities. If you are young, or overweight, or have any hearing or sleep disorder and no sports activities, then your risk is higher than another person without these risk factors. However, it is necessary to remember that construction accidents arise from a failure in the interaction between workers, their workplace, and the materials and equipment they are using (Haslam et al., 2003). In this paper, the research objective is to obtain a new extended and updated insight to the likely causes of construction accidents in Spain, in order to identify appropriate mitigating actions.

2. Methodology

2.1 Accidents Data

Since 2003, the Spanish National Institute of Safety and Hygiene at Works must be notified of all accidents that result in an absence from work of one or more days. This is compulsory according to Spanish Law (BOE. Boletín Oficial del Estado [BOE], 2002; ORDEN TAS/2926/ 2002, de 19 de noviembre, por la que se establecen nuevos modelos para la notificación de los accidentes de trabajo y se posibilita su transmisión por procedimiento electrónico). Notification must be sent through the electronic system called DELT@, filling an Official Workplace Incident Notification Form. [Parte Oficial de Accidente de Trabajo]. For this study, the Ministry of Labour and Immigration supplied the anonymous data of all workplace accidents in the Spanish construction sector as defined by the National Classification of Economic Activities in Spain (CNAE 93.Rev 1) during the period 2003- 2008. A total number of 1,163,178 Notification Forms were supplied. Although reporting is mandatory, it is possible that some cases remain unreported.

2.2 Analysis Design

The analysis design for this paper was based on previous research by Camino López et al. (2008). First the study variables were chosen and then categorized in groups to assess the relationship between all the variables and the severity of the outcomes of each accident. Although main aspects of the methodology employed are similar to Camino Lopez et al., this research introduces some differences in the following aspects:

- Data periods of time analysed are different.
- Data analysed in the present study included, in line with the law, all the accidents reported in the construction sector between 2003-2008. In Camino et al's previous study (2008) it is possible that more accidents were not included, because from 1990-2000 reporting accidents through Delt@ system was not compulsory.
- Some of the chosen variables were not analysed in the previous paper.
- In the results, the severity of the accident is shown in four different levels, light, serious, very serious and fatal.

2.3 Variables and period of time.

The authors' original idea was use a similar methodology to Haslam et al (2005) studying shaping factors and originating influences. However, differences between data sets did not allow us to implement it properly. Haslam et al analyzed fewer accidents (only 100 individual accidents) but more deeply and gathered site-based data entailing interviews with accident-involved personnel and their supervisor or manager, inspection of the accident site, and review of relevant documentation such as accident notification form. In our case, we only had access to the official accident notification form, but from 1,163,178 accidents.

In a preliminary approach we analyzed all variables included in the accident notification form (57 variables) elaborating contingency tables. In some variables the majority of the values in the contingency tables did not reach a statistical significance of 95% in order to reject the hypothesis of independence of variables, and we could not confirm the existence of more than a random influence for severity-variable. Accordingly, the majority of the 57 variables were rejected for this paper.

Therefore, variables chosen were categorized into five groups after Camino et al (2008). These groups are personal, business, material, temporal and geographic.

- **Personal variables** describe characteristics of the worker involved in the accident. Included in this group is variable age.
- **Business variables** describe aspects about the activity and its organisation. Included in this group are: National Classification of Economic Activities (CNAE), company staff, length service and the location of the accident.
- **Temporal variables** include day of the week, days of absence.
- **Material variables** include deviation from accepted practice, as a not expected event, and injury.
- **Geographic variables** used in this study describe the severity of the accidents in the different zones according to the climatic zone.

Table 1.
Summary of variables.

Variable Group	Variable
Personal	Age
Business	National Classification of Economic Activities (CNAE) Company Staff Length service Location of Accident
Temporal	Day of the week Days of absence
Material	Deviation Injury
Geographic	Climatic Zones

The period of time between 2003 and 2008 was elected for this study because, in this period, the National Classification of Economic Activities in Spain (CNAE 93.Rev 1) was not changed. Before 2003 and after 2008 there were some modifications to this classification.

2.4 Statistical Analysis.

Continuing with the methodology performed by Camino et al (2008) contingency tables were made and chi-square values were calculated to test hypotheses of the independence of the each variable with respect to severity.

Again following Camino et al (2008), the corrected standardised residuals (csr) were also calculated. When their absolute value was less than 1.96, they were marked with an asterisk because they do not reach a statistical significance of 95% in order to reject the hypothesis of independence of variables, and we could not confirm the existence of more than a random influence for severity-variable.

In a preliminary approach we analyzed all variables included in the anonymised Official Workplace Incident Notification elaborating their contingency tables. Variables whose majority of the values in their contingency tables did not reach a statistical significance were rejected for this paper. Finally, we chose the statistically better ten variables.

The classification of the accidents analysed is based on medical criteria, because Spanish health authorities have the obligation to diagnose the severity of each accident. For this purpose the severity of an accident can be classified into four different levels: Light accident, Serious accident, Very serious accident, and Fatal accident. The severity level marked in the Official Workplace Incident Notification Form, must be the same severity level described by a doctor, in the Medical Injuries Form (ORDEN TAS/2926/2002, de 19 de noviembre, por la que se establecen nuevos modelos para la notificación de los accidentes de trabajo y se posibilita su transmisión por procedimiento electrónico). In addition, different accident ratios were calculated and expressed in percentage terms.

Rates were obtained by dividing the number of accidents chosen in the community studied by the number of total accidents chosen. Thus, the Total Accident Rate (TAR) was obtained dividing the number of total accidents in the community studied by the number of total accidents analysed. The Light Accident Rate (LAR) was obtained by dividing the number of light accidents in the community studied by the number of total light accidents. The Serious Accident Rate (SAR) was obtained by dividing the number of serious accident in the community studied by the number of total serious accidents. The Very Serious Accident Rate (VSAR) was obtained by dividing the number of very serious accidents in the community studied by the number of total very serious accidents. Finally, the Fatal Accident Rate (FAR) was obtained by dividing the number of fatal accidents in the community studied by the total number of fatal accidents.

It is very important not to forget that data studied are only about accidents that have occurred. Rates obtained in this study are not the typical incidence rate (number of accidents per number of workers at risk) because data about workers at risk in each category studied are not available. However rates calculated in this paper have allowed the difference between the severities of the accidents that have occurred to be studied. In this way, the findings show the probability of an accident to be serious or fatal once it occurs, but not the probability that the accident occurs in the first place.

The statistical analysis package SPSS (Statistical Package for the Social Sciences) was used to analyse the data.

3. Results and Discussion.

3.1 Personal Variables.

Results obtained in Table 2 showed that, when an accident happens, the probability that severity will be high increases with the age of the worker. This fact is especially significant in groups of ages between 60 and 65 years, and between 20 and 24 years. In the older group it was observed that the light accident rate had very similar value to the total accident rate (LAR 2.10 %, TAR 2.12 %) but the fatal accident rate was more than double (FAR 5.94%). In the younger group the light accident rate and total accident rate were very similar too (LAR 15.21%, TAR 15.13%) but the fatal accident rate decreased considerably in this group (8.48 %).

Table 2.
Total accidents in Spanish construction comparing age and severity.

Chi-Squared	1820.92									
	d.f = 27	Sig=0.000								
	Total Accidents		**Light Accidents**		**Serious Accidents**		**Very Serious Accidents**		**Fatalities**	
	N=**1163165**		N=**1145675**		N=**14993**		N=**764**		N=**1733**	
Age	Number	**TAR %**	Number	**LAR %**	Number	**SAR %**	Number	**VSAR %**	Number	**FAR %**
<16	68	**0.01**	65	**0.01**	2	**0.01***	1	**0.13**	0	**0.00***
16-19	57564	**4.95**	56943	**4.97**	541	**3.61**	40	**5.24***	40	**2.31**
20-24	176038	**15.13**	174277	**15.21**	1534	**10.23**	80	**10.47**	147	**8.48**
25-29	207681	**17.85**	205263	**17.92**	2095	**13.97**	107	**14.01**	216	**12.46**
30-39	347958	**29.91**	343081	**29.95**	4226	**28.19**	220	**28.80***	431	**24.87**
40-49	228121	**19.61**	223916	**19.54**	3630	**24.21**	162	**21.20***	413	**23.83**
50-59	120546	**10.36**	117596	**10.26**	2443	**16.29**	125	**16.36**	382	**22.04**
60-65	24654	**2.12**	24013	**2.10**	511	**3.41**	27	**3.53**	103	**5.94**
65-70	428	**0.04**	414	**0.04**	11	**0.07**	2	**0.26**	1	**0.06***
>70	107	**0.01***	107	**0.01***	0	**0.00**	0	**0.00**	0	**0.00**

*: Corrected Standardised Residuals <1.96 in absolute value

3.2 Business Variables

3.2.1 CNAE

Activity of the organisations is one of the aspects to be considered when analysing accidents in construction. Using the National Classification of Economic Activities (CNAE-93 Rev1) the construction sector in Spain in the period of time 2003-2008 can be classified in five groups (Table 3).

Table 3.
Construction Activities.

Activity	CNAE CODE
Preparation of construction sites	451
(Demolitions, earth moving, land survey, excavations)	
Construction of buildings and civil construction	452
(Buildings, civil works, electrical nets, hydraulic works)	
Fit out of construction work	453
(Partitions, acoustic, electrical, plumbing works, etc)	
Completion of construction works	454
(Painting, Glazing, wood, others)	
Hiring of construction equipment with a worker	455
(Not including contractors with their own equipment)	

Table 4 shows that the distribution of the accidents is concentrated in activities 452 *Construction of buildings and civil construction*, and 453 *Fit out of construction works*. The incidence rates cannot be calculated because the total of workers occupied in these specific activities is not known, but we can evaluate the percentage evolution in the calculated rates.

Table 4.
Total accidents in Spanish construction comparing CNAE and severity.

Chi-Squared	234.142									
	d.f=12	**Sig=0.000**								
	Total Accidents		**Light Accidents**		**Serious Accidents**		**Very Serious Accidents**		**Fatal Accidents**	
	N=**1163178**		N=**1145688**		N=**14993**		N=**764**		N=**1733**	
CNAE CODE	Number	**TAR %**	Number	**LAR %**	Number	**SAR%**	Number	**VSAR %**	Number	**FAR %**
451	5800	**0.50**	5646	**0.49**	129	**0.86**	4	**0.52***	21	**1.21**
452	928214	**79.80**	913976	**79.78**	12232	**81.58**	616	**80.63***	1390	**80.21***
453	215530	**18.53**	212763	**18.57**	2363	**15.76**	125	**16.36***	279	**16.10**
454	13054	**1.12**	12741	**1.11**	257	**1.71**	18	**2.36**	38	**2.19**
455	580	**0.05**	562	**0.05**	12	**0.08**	1	**0.13***	5	**0.29**

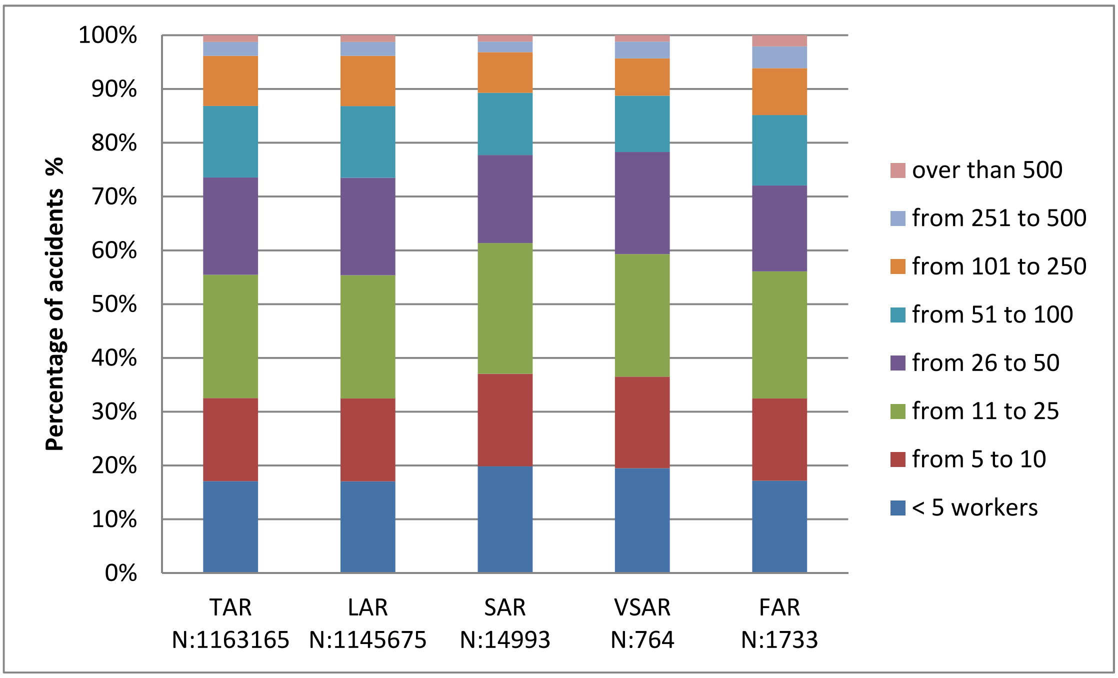
*: Corrected Standardised Residuals <1.96 in absolute value

It is significant that, although activity 454 *Completion of construction works* only has 1.12% of the total accidents (TAR) in the sector, the percentage increases with the severity of the accidents (SAR (1.71%) > LAR (1.11%)) and peaks at VSAR (2.36%). The fatal rate is lower but very close (2.19%).

3.2.2. Company Staff

Figure 2 compares accident outcome severity with company size. Comparing TAR and FAR, the data tend to suggest that the larger the company the more likely the chance of having a fatal accident.

Figure 2.
Total accidents in Spanish construction comparing company staff and severity.



According to the percentages calculated of fatal accidents respect total accidents occurred for each company size, shown in table 5, an accident that occurred in a big company was more likely to be fatal than one occurring in a smaller one. Companies with more than 500 workers obtained the worst result (0.2489% of accidents that occurred in the company were fatal). On the other hand companies from 26 to 50 obtained the best result (0.1316% of accidents that occurred in the company were fatal). Companies with up to 250 workers obtained similar percentages between 0.13 and 0.16 %, and big companies over 250 workers obtained percentages bigger than 0.23 %.

Table 5.
Percentages of fatal accidents respect total accidents.

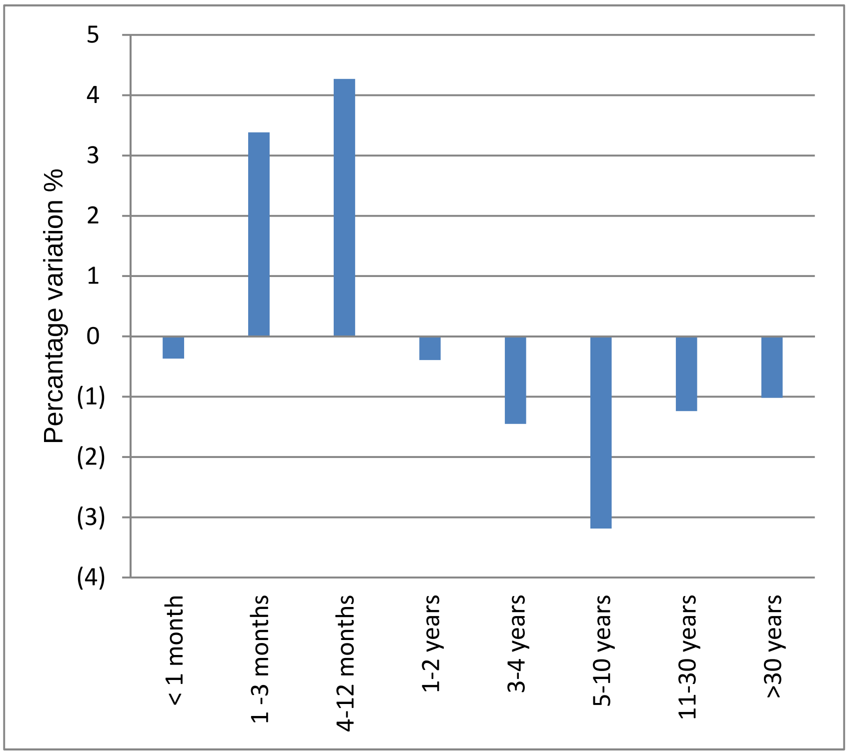
Company Staff	Number of Total accidents (NTA)	Number of Fatal Accidents (NFA)	% (NFA/NTA)
< 5 workers	198802	298	**0,1499**
from 5 to 10	179659	265	**0,1475**
from 11 to 25	266766	409	**0,1533**
from 26 to 50	210446	277	**0,1316**
from 51 to 100	154558	227	**0,1469**
from 101 to 250	108428	151	**0,1393**
from 251 to 500	30058	70	**0,2329**
over 500	14461	36	**0,2489**

However, these data are only from accidents that occurred, and do not take account of the numbers of people employed in these companies and therefore could be misleading. It has been shown that a large company is associated with better safety levels than a small one (Hinze & Gambatese 2003). In this sense a study of 231 deaths in the construction industry (Buskin & Palouzzi 1987) concluded that there was a significant trend towards increasing mortality with decreasing company size in the proportionate mortality ratios (PMRs) studied.

3.2.3 Length of service with the company.

This factor was studied by Cattledge et al (1996), with particular reference to falls from different levels. Length of employment with the company at the time of injury ranged from one week to more than 30 years. It is important to note that these data deal with how long the person has been employed by a particular company rather than their experience in the industry as a whole. Despite the wide range, 60% of all accidents claimed were employed for two years or less, of which 26% were employed for six months or less. In our study, accidents involving workers with less than three years' experience in the company represented 81% of the total number of accidents. This percentage gets lower when considering fatal accidents of this group of workers (74%). It is remarkable that the FAR decreases compared with TAR, when the individual's experience in the company increases from a month to one year's experience, but this tendency is the opposite from one year to more experienced people. That can be observed better by calculating the difference between TAR and FAR in each experience group (Figure 3). Figure 3 shows in terms of variation of the rates, the best rate improvement of FAR with respect to TAR, is in the group of workers with experience between 4-12 months (TAR-FAR= 4.27%) and the worst rate difference is in worker with 5-10 year experience (TAR-FAR= -3.19%). The problem in the first temporal group with less than one month's experience could potentially be fixed with safety training programs (Xiuwen et al 2004). In the group of workers with 5-10 years' experience, this solution it is less likely to be successful, because hazards are often misjudged by them (Huang & Hinze 2003). In a study of causality of fatal accidents for the UK Government, Brace et al (2009) argued that workers often developed a 'risk accepting' attitude towards construction hazards – claiming 'it won't happen to me'. Other strategies must be developed to prevent fatal accidents in this group.

Figure 3.
Difference between rates. TAR-FAR (%), against length of service.



Length service	TAR - FAR
< 1 month	-0.37
1 -3 months	3.38
4-12 months	4.27
1-2 years	-0.39
3-4 years	-1.45
5-10 years	-3.19
11-30 years	-1.24
>30 years	-1.02

3.2.4 Location of accident

Safety of construction sites has been considered in various studies (Sawacha, Naoum & Fong 1999, Toole 2002), but not all accidents occurring in the construction sector actually occur at the construction site. The workforce of construction firms do not work all the time in their habitual worksite, sometimes they are moving between sites or between different areas of their habitual site. Considering results of table 6, a high percentage of accidents analysed occurred on the habitual worksite (TA 83%), but their fatality rate was considerably lower (FA 48%). On the other hand, accidents occurring on a non-habitual site represented less than 11% of TA, but 25% of fatalities. These data highlight the problem with fatalities of workers not based on one specific worksite, which is a problem that must be considered more deeply in future research. The other two categories, on the way from worksite to worksite, and going to the worksite or back home, are difficult to evaluate because many times they are considered only traffic accidents and they are not considered work accidents so are not entered in the industrial sector statistics.

Table 6.
Total accidents in Spanish construction comparing accident location against severity.

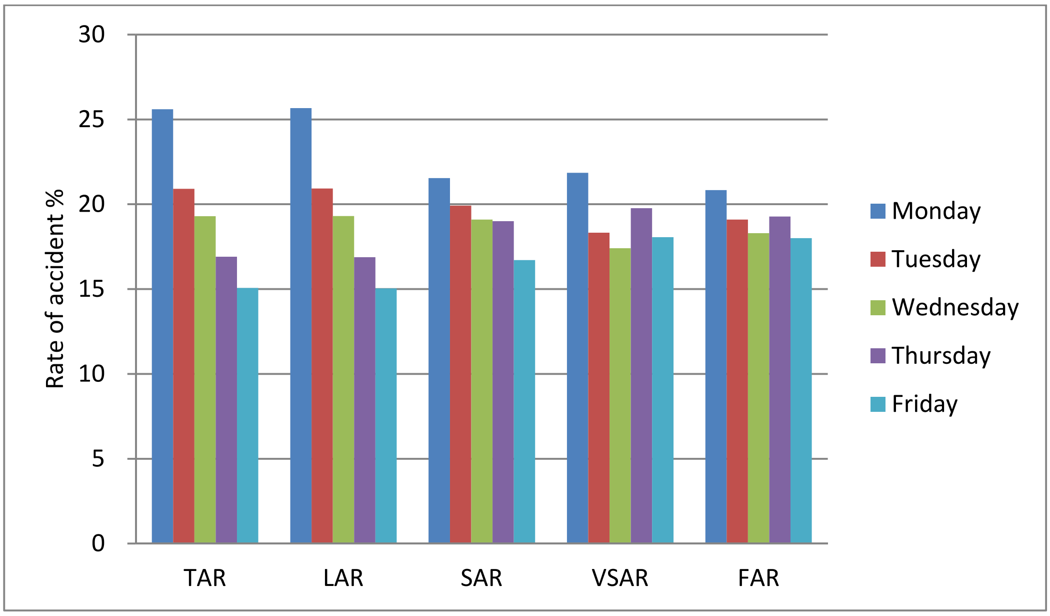
Chi-Squared	5404.93									
	d.f=9	**Sig=0.000**								
	Total Accidents		**Light Accidents**		**Serious Accidents**		**Very serious Accidents**		**Fatal Accidents**	
	N=**1163178**		N=**1145688**		N=**14993**		N= **764**		N= **1733**	
Accident Place	Number	**TAR %**	Number	**LAR %**	Number	**SAR%**	Number	**VSAR%**	Number	**FAR%**
Habitual worksite	962628	**82.76**	951247	**83.03**	10120	**67.50**	435	**56.94**	826	**47.66**
On the way from worksite-worksite	22388	**1.92**	21693	**1.89**	489	**3.26**	62	**8.12**	144	**8.31**
Going worksite or backing home	54795	**4.71**	52654	**4.60**	1571	**10.48**	137	**17.93**	433	**24.99**
Non-habitual worksite	123367	**10.61**	120094	**10.48**	2813	**18.76**	130	**17.02**	330	**19.04**

*: Corrected Standardised Residuals <1.96 in absolute value

3.3.1 Day of the week.

In figure 4 we see that Monday is the day of the week with more accidents. This fact, called the "Monday Effect", has been studied by Card & McCall (1996) and Campolieti & Hyatt (2006). This effect assumes that some of the injuries reported on Monday actually occurred on the weekend, but they were not reported the real day of the accident, one explanation for this effect is because social benefits from the insurance company would change with more compensation paid for work-related injuries than for those incurred during leisure activities. The values for light accidents (LAR) and serious accidents (SAR) are very similar to their respective TAR, but rest of the rates, VSAR, and FAR decrease from Monday to Wednesday , increase from Wednesday to Thursday and decrease again from Thursday to Friday .

Figure 4. Accident rates comparing day of the week against severity.



3.3.2 Days of absence.

In table 7, days of absence are shown. It must be considered that sometimes light accidents are longer than a few days because their real recovery time is longer than nominally expected recovery time. Another consideration must be made in respect of fatal accidents. If the death is instantaneous or in the same day, one day of absence is registered in the database. In the rest of cases, the difference between the day of the accident and the day of the death are registered. It is remarkable that the group of accidents resulting in time off work of between 16-30 days, presented the highest value in three of the five rates calculated (TAR, LAR, VSAR). In the other two rates this group was not the first but it was the second. So accidents, causing 16-30 days of absence must be considered and investigated especially because they represented nearly a third of the accidents occurring.

Table 7.
Total accidents in Spanish construction comparing days of absence with severity.

Chi-Squared	540441									
	d.f=21	**Sig=0.000**								
	Total Accidents		**Light Accidents**		**Serious Accidents**		**Very Serious Accidents**		**Fatal Accidents**	
	N= **1163178**		N= **1145688**		N= **14993**		N= **764**		N= **1733**	
Absence	Number	**TAR %**	Number	**LAR %**	Number	**SAR%**	Number	**VSAR%**	Number	**FAR%**
1 day	3148	**0.27**	1675	**0.15**	69	**0.46**	12	**1.57**	1392	**80.32**
2 - 7 days	307141	**26.41**	306869	**26.78**	163	**1.09**	50	**6.54**	59	**3.40**
8- 15 days	306764	**26.37**	306441	**26.75**	291	**1.94**	27	**3.53**	5	**0.29**
16-30 days	366289	**31.49**	362037	**31.60**	3742	**24.96**	238	**31.15***	272	**15.70**
1-3 months	137725	**11.84**	134978	**11.78**	2698	**18.00**	49	**6.41**	0	**0.00**
4-6 months	30036	**2.58**	25020	**2.18**	4835	**32.25**	179	**23.43**	2	**0.12**
7 months-12 months	10895	**0.94**	7971	**0.70**	2747	**18.32**	175	**22.91**	2	**0.12**
more than 1 year	1180	**0.10**	697	**0.06**	448	**2.99**	34	**4.45**	1	**0.06***

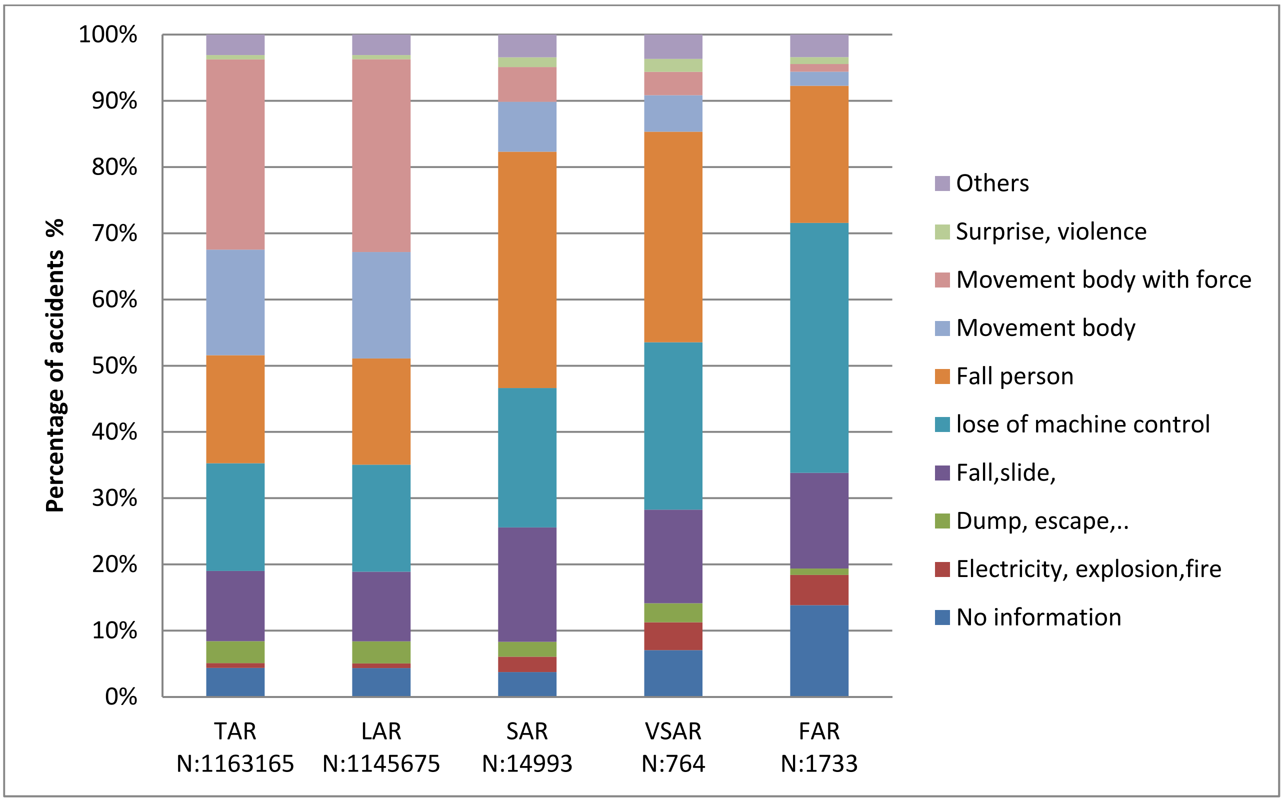
*: Corrected Standardised Residuals <1.96 in absolute value

3.4 Material

3.4.1 Deviation.

Accidents produced by loss of machine control and falls are the third of the total accidents. This percentage is more than half when we compare the aggregate of both deviations with serious, very serious, and fatal accidents (Aggregates: TAR 33%, SAR 57%, VSAR 57%, FAR 51%). Therefore these deviations must be given special attention, and must be reduced as far as possible with preventative measures, training workers in safety and safety equipment. In addition to this data, a study about causes of accidents (Gibb et al 2006) concluded that greater attention should be given to the design and selection of tools, equipment and materials. Safety, rather than price, should be the paramount consideration.

Figure 5. Total accidents in Spanish construction comparing deviation and severity.



3.4.2 Injuries.

In Spain, wounds and superficial injuries, dislocations sprains and strains, are 80% of TAR (from table 8). This group of accidents have an insignificant impact on fatalities (0.75%). The most dangerous injuries are concentrated in: concussions and internal injuries, multiple lesions, heart attacks, strokes and other non-traumatic diseases. Special attention should be given to heart attacks, strokes and other non-traumatic diseases, because they represented only 1319 of the 1,163,178 total accidents (0.11%), but they represented 287 accidents of the 1733 fatalities (17%). The FAR value increase with respect to TAR value is especially high in this group. A solution could be training workers or supervisors in first aid for these cases. This finding is supported by the general increase in availability of equipment such as defibrillators in work places and public areas.

Table 8.
Total accidents in Spain compared to injury-severity.

Chi-Squared	165752									
	d.f=42	**Sig=0.000**								
	Total Accidents		**Light Accidents**		**Serious Accidents**		**Very Serious Accidents**		**Fatal Accidents**	
	N= **1163178**		N= **1145688**		N= **14993**		N= **764**		N= **1733**	
Injury	Number	**TAR %**	Number	**LAR %**	Number	**SAR %**	Number	**VSAR%**	Number	**FAR%**
Unknown	19557	**1.68**	19221	**1.68**	238	**1.59***	23	**3.01**	75	**4.33**
Wounds. superficial injuries	451352	**38.80**	449924	**39.27**	1391	**9.28**	29	**3.80**	8	**0.46**
Bone crushing	83982	**7.22**	76126	**6.64**	7671	**51.16**	147	**19.24**	38	**2.19**
Dislocations, sprains and strains	474939	**40.83**	474098	**41.38**	812	**5.42**	24	**3.14**	5	**0.29**
Amputations	2414	**0.21**	1744	**0.15**	642	**4.28**	21	**2.75**	7	**0.40**
Concussions and internal injuries	61775	**5.31**	59975	**5.23**	1349	**9.00**	169	**22.12**	282	**16.27**
Burns	12916	**1.11**	12531	**1.09**	349	**2.33**	17	**2.23**	19	**1.10***
Poisonings and infections	1557	**0.13**	1541	**0.13***	13	**0.09**	1	**0.13***	2	**0.12***
Drowning and asphyxiation	1359	**0.12**	1277	**0.11**	19	**0.13***	7	**0.92**	56	**3.23**
Effects of noise. Vibration and pressure	996	**0.09**	984	**0.09***	12	**0.08***	0	**0.00**	0	**0.00***
Extreme Temp Effects	919	**0.08**	908	**0.08***	9	**0.06***	0	**0.00**	2	**0.12***
Psychic trauma. traumatic shock	2049	**0.18**	1958	**0.17**	49	**0.33**	6	**0.79**	36	**2.08**
Multiple lesions	14944	**1.28**	12099	**1.06**	1795	**11.97**	248	**32.46**	802	**46.28**
Heart attacks. strokes and other non-traumatic diseases	1319	**0.11**	610	**0.05**	369	**2.46**	53	**6.94**	287	**16.56**
Other injuries	33100	**2.85**	32692	**2.85**	275	**1.83**	19	**2.49***	114	**6.58**

3.5 Climatic Zones

The severity of accidents vary depending on the climatic zone where they happened. This is demonstrated in table 10. Spain has been divided into four climatic zones according to data obtained from Spanish National Weather Service (AEMET, 2011). These climatic zones have been called Continental, Mediterranean, Oceanic, and Tropical. The main characteristics of each zone are described in table 9.

Table 9.
Summary of climatic zones characteristics.

Continental	Winters are cold enough for snow and most of the rainfall occurs in late spring. Summers can be hot
Mediterranean	Temperatures are moderate and there is not a wide range between the summer highs and winter lows.
Oceanic	Winters are not as cold as in the continental climate zones. Summers tend to be warm, but not hot. Precipitation is relatively consistent throughout the year.
Tropical	Winters are relatively warm-mild, but not as hot as the summer season

Climatic zones showed different evolutions of their severity rates. In the area under influence of Mediterranean weather, the Fatal Accident Rate is lower than the Total Accident (FAR 41%, TAR 48%). On the other hand, continental weather rates increased when Total Accidents Rates were compared with fatalities rates (FAR 38%, TAR 35%). The conclusion that Mediterranean weather is more conducive to safety than continental is not valid because the evolution of the serious accident rate is opposite in each case. In order to get better results about the climatic influence in accidents in construction, a more detailed study must be performed about this phenomenon.

Table 10.
Total accidents in Spanish construction comparing climatic zone-Severity

Chi-Squared	335.904									
	d.f=9	**Sig=0.000**								
	Total Accidents		**Light Accidents**		**Serious Accidents**		**Very Serious Accidents**		**Fatal Accidents**	
	N= **1163178**		N= **1145688**		N=**14993**		N= **764**		N= **1733**	
CLIMATIC ZONE	Number	**TAR %**	Number	**LAR %**	Number	**SAR%**	Number	**VSAR%**	Number	**FAR%**
Continental	405221	**34.84**	399521	**34.87**	4751	**31.69**	294	**38.48**	655	**37.80**
Mediterranean	562586	**48.37**	553891	**48.35**	7655	**51.06**	325	**42.54**	715	**41.26**
Oceanic	128052	**11.01**	125655	**10.97**	1984	**13.23**	123	**16.10**	290	**16.73**
Tropical	67319	**5.79**	66621	**5.81**	603	**4.02**	22	**2.88**	73	**4.21**

4 CONCLUSIONS.

These analyses showed that seriousness of accidents are related to various different variables studied. Concluding remarks for each variable are described as follows.

- Age. Analysis of the data, does not show whether the accident rate varies with age, but rather, the likely consequence of any accident does vary with age – with the lowest consequence being at the 20-24 age group. An accident involving an older worker would probably have more severe consequences. Special training plans must be considered for older workers and fitness for work regimes established. Assignment of the tasks inside the works must be adapted to the age of the worker, a task with low risk for a young worker can become a high risk task for an older one.

- CNAE Code. Regarding different National Code of Activities in construction studied, the “completion of construction works” activity had the worst severity rates. More dangerous activities will need more specific preventive measures and more stringent safety procedures.
- Size of company. It may be concluded that a large company is not always necessary more safe than a small company in the aspect of fatal accidents. According to the data analyzed, the ‘safest’ size of a company with respect to fatal accidents is between 26 and 50 workers because their FAR is significantly lower than their TAR. However, these data could be misleading due to the numbers of employees and the effect of employing subcontractors and subcontract data not being included in these figures. Hence, if a worker employed by a large company has an accident it is more likely to be fatal than if they worked for a small organization. Differences and similarities between safety management procedures, safety integration in the tasks, and work organization must be identified relative to the size of the company with the aim to identify the best safety behaviors and promote their adoption to other companies.
- Length of service. Comparing again FAR with TAR from accidents occurred, it can be concluded that accidents suffered by workers with 5-10 years’ experience had the worst consequences. On the other hand, workers with 4-12 months experience had the best accident fatal rates comparing the same cited rates. Experienced workers must be specially trained with specific programmes according their needs. Often, refreshing safety knowledgem is not enough. Training for more experienced workers must address their predisposition not to accept training or instruction and the likelihood that they have become risk accepting with regards to construction hazards.
- Place of accident. It was found that accidents occurred away from the usual workplace had more severe consequences, than accidents occurred at the usual workplace. More effort is required to improve the knowledge of risk, and preventive measures, when a worker changes his working location. Specific procedures must be designed and implemented when a worker is assigned for a task in a non-habitual worksite. New management techniques should be introduced in construction works to reduce the fatalities in this group

  The problem with fatalities of workers not based on one specific worksite, is a problem that must be considered more deeply in future research.
- Deviation. In addition, analysis of the data showed that loss of machine control and falls from height cause a third of the light accidents. The addition of both deviations, caused

more than half of the rest of accidents. Activities where machines and work at height are present must be designed taking into account the possible deviation of these important factors. Risk assessment in these tasks must be exhaustive and procedures for their normal development very accurate and clear.

- Injury. Heart attacks, strokes and other non-traumatic diseases are especially fatal, when they are present in an accident. Workers and supervisors must be trained in first aid for these cases and life-saving equipment be made readily available. Training in first aid can save workers lives.

4.1 Implications for the Industry and Government.

Identification of main variables present in construction accidents is the first step to minimize and reduce accidents and their consequences. The conclusions of this paper can be used by companies in their occupational safety strategies, and in their safety training programmes. Specific training can be designed taking account of specific needs for each group of workers and for each type of company.

Special attention must be given to the group of workers with 5-10 years' experience. Too often their hazards are misjudged by everybody in the works. Their managers, supervisors and themselves tend to rely on their experience and skill, but experience is not a never-failing life guard, and it can be a double-edged sword, leading to a greater acceptance of risk.

Effort must be made in all companies, relative to their size and each worker's location especially when they are not at the habitual worksite.

The findings of this research are based on the data avaialable from the official accident notification forms. Further knowledge could be derived from such studies if richer data were collected for accidents, such as factors proposed by Haslam et al (2005). However, the authors acknowledge the challenges associated with such a proposal and further work is required to establish appropriate strategies.

4.2 Study Limitations.

Data analyzed are only from Spain, so the conclusions may be different to other countries, but they can give some indications of sensitive common variables.

Accidents where the employee was not absent from work are not compulsory to report to the government, so these accidents are not included. In addition, accidents that are not reported are, of course, also excluded, because there is no data about them.
The data of the people employed for each variable analysed have not been segregated, so the probability of an accident to be serious or fatal has only been studied once it occurs. The probability that the accident occurs in the first place has not been considered.

4.3 Future research.

Some variables should be studied more in-depth in future research to obtain a more accurate approach about their influence. An example of this it is the climatic zone variable, because it is not clear why differences in severity of accidents between Mediterranean and Continental Zones exist.
Different training strategies should be investigated and developed, in order to improve the effectiveness of training in experienced workers. Tasks away from the habitual worksite must be addressed better; new safety procedures and measures must be implemented.

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Antonio López Arquillos, industrial engineer graduated in School of Industrial Engineering of Málaga in 2008, Technician in Prevention of Occupational Risk . Now, he is a student of industrial organization, he has a full time research grant, and he is elaborating his doctoral thesis about health and safety in construction.

Juan Carlos Rubio-Romero, is an industrial engineer and lecturer in "Safety at work" in the Escuela Técnica Superior de Ingenieros Industriales of the University of Málaga. He got his doctorate in 2000 in workplace health and safety in industry, and at present directs the Cátedra de Prevención y Responsabilidad Social Corporativa in the University of Málaga and also a Research Group, "Operaciones and Sostenibilidad: Calidad, and Prevención de Riesgos Laborales". Dr Rubio has spent more than 13 years researching into workplace health and safety and has published various manuals and papers, especially on management of workplace health and safety in industry and in the building trade.

Alistair Gibb is a Chartered Engineer, Chartered Builder and the Royal Academy of Engineering Professor of complex project management, joining UK's Loughborough University in 1993, following a career in civil engineering and construction management. He is Project Director of the European Construction Institute's Safety, Health and Environment task force (ECI) and has worked closely with a number of Spanish research teams. Internationally he is coordinator of the Conseil Internationale de Batiment (cib) working commission on construction health & safety. He has led many health and safety research projects funded both by the UK Government and industry.