"ANALYSIS OF INVESTIGATION REPORTS ON OCCUPATIONAL ACCIDENTS"

ABSTRACT

The investigation of accidents is an occupational safety analytical tool aimed at discovering the causes of an accident. Conducting these investigations properly is essential to obtain useful information that helps avoid these accidents in the future.
To prepare this study we analysed 567 investigations, conducted by OHS technical advisors, on occupational accidents occurring in Spain from 2009 to 2012 in industries such as construction, manufacturing, agriculture and services, in order to obtain information to improve the use of this technique. In this study we analyzed how accident investigation reports are made identifying main flaws and omissions. Accident investigations lack details as they often do not consider the variables in the ESAW (European Statistics on Accidents at Work) Project. Likewise, they lack depth in determining the causes associated to active faults, preferably to latent faults, and to the company management and organisation systems. Similarly, they do not comply with the standards recommended by experts.
Finally, in the conclusions we recommend two priorities: having a harmonised European model to conduct occupational accident investigations, as well as being able to access databases that collect accident investigation reports of this kind.

Keywords

Investigation; Occupational Accidents; Causes; Preventive Measures; Eurostat Variables.

HIGHLIGHTS

Only 25.2% of the investigation reports analysed included ESAW variables.

The immediate causes were identified in 66.8 % of the cases.

Only 26.9% of the investigation reports meet quality criteria.

The accident investigation reports lack a methodological approach.

We need a European model for occupational accident investigation reports.

1. INTRODUCTION

The investigation of occupational accidents is a safety technique aimed at discovering the causes that led to the accident in question. Investigations are thus an essential first step in the design and implementation of adequate preventive measures, with the objective of preventing similar accidents from occurring again (Johnson and Holloway, 2003). Therefore, the importance of a good investigation lies in being able to extract some preventive benefit from what could be defined as "a safety failure", and for this we need to obtain information that allows us to detect the existing risks and control them sufficiently and adequately (Fraile *et al*.,1993).

As advance Fraile *et al.,*(1993) and reaffirmed authors like Dien *et al,.*(2012), it was difficult to conduct an accurate and precise assessment of the results of investigations conducted by numerous and diverse agents working for the administration, OHS technical advisors, both internal and external, direct managers of an ongoing investigation, etc. Furthermore, these same authors show how analyses conducted by the administration confirm that the preventive efficacy of the accident investigations carried out could be, to say the least, significantly increased. The same conclusion can also be found in other studies on occupational accident investigation reports (Goldberg, 1997; Jacinto and Aspinwall, 2003; Lunderg *et al.*, 2009; Lindberg *et al.,* 2010; Jacinto *et al*., 2011) which have tried to reveal the basic quality criteria that any accident investigation report should include, either in their full formal structure or in specific aspects.

As for the definition of these quality criteria when preparing accident investigation reports, as early as 1997 Goldberg defined the accident investigation process in three very basic phases: Phase 1 (initial report), Phase 2 (data and information collection) and Phase 3 (analysis and correction). Years later, Lundberg *et al.* (2009) defined their investigation process classified into the following 9 phases: 1 (initiation of an investigation), 2 (planning), 3 (data collection), 4 (representation), 5 (analysis of the accident), 6 (recommendations), 7 (documentation/writing the report), 8 (implementation of actions), 9 (follow-up of activities). More recently, Lindberg *et al.,* (2010) described six quality criteria: initial report, selection methodology, investigation methodology, dissemination of results, preventive measures and evaluation.

However, from the above approaches, we should highlight the work conducted by Jacinto and Aspinwall (2002 and 2003), since they created an investigation method known as WAIT (Work Accident Investigation Technique) which provides a model that is systematic, structured and easy to apply, even by “non-experts”. This method is based on the theoretical model of “organisational accidents” proposed by Reason (1997) and on that of “human error” by Hollnagel (1998). A particularly important aspect of this method is that it incorporates the variables proposed by Eurostat (2001). The WAIT method is comprised of nine steps grouped into two main stages. The first stage is a simplified investigation process that covers the legal requirements for information and focuses on the analysis of the immediate causes and circumstances, that is, the most "observable" elements of what happened. The second stage is an in-depth analysis, or complete investigation, identifying and analysing other possible weaknesses and conditions within the organisation. This second stage goes not only beyond the current legal obligations, but has the purpose of providing organisations with a structured tool to identify opportunities for improvement of their safety practices and policies, regardless of whether they have a formal safety management system or not. This method later evolved towards a new accident investigation report model known as RIAAT (The Recording, Investigation and Analysis of Accidents at Work process), which was conceived to analyse the full cycle of occupational accidents in order to help improve prevention effectiveness (Jacinto *et al.,* 2011).

Regarding the quality criteria referred to above, various authors have proposed solutions to improve results and the way investigation reports on occupational accidents are conducted. It has been found that the collection of information is highly heterogeneous and there is a need for homogeneous data in these reports. To this end, Jacinto and Aspinwall (2004a) support the suitability of including the ESAW coding for at least eight variables associated to the accident as main indicators in the collection of information, as they help better understand the causal factors and circumstances of accidents which, in turn, helps define more efficient preventive policies. On the other hand, Antao *et al*., (2008) indicated that, in the initial analysis, the active faults related to unsafe acts and unsafe conditions (immediate causes) should be identified, then an in-depth analysis should help to define the latent failures related to individual factors and job factors (basic causes), and finally the organization and work management conditions should also be detected. This, therefore, coincides with the model of Reason (2000) in that the three categories of faults must be taken into account to explain the causation of accidents.

Jacinto *et al*., (2009) criticised the procedures for recording and investigating accidents as they did not consider them thorough enough regarding the identification of causes and they recommended that accident investigations should include a broader analysis. Likewise, Suarez-Cebador *et. al.,* (2013) showed that the need to obtain relevant information on the causal factors of accidents is evident. After an analysis of the causes detected, authors such as Jacinto and Aspinwall (2003) or Weiwei *et al.,* (2010) agreed that the phase to determine adequate preventive measures is key in order to be able to provide feedback for risk assessments of companies affected by occupational accidents before unwanted events occur again. They also recognise that any accident investigation report should include an estimated cost analysis of the same, since the proper and thorough management of prevention in the company should provide insight on how much accidents cost. Therefore, together with details on the direct costs, which are easier to estimate, items should be included that provide the closest possible picture of indirect costs (Golberg, 1997). Likewise, Lindberg *et al*., (2010) highlighted two concepts to enhance the quality of investigation reports on occupational accidents, such as a description of the accident and the number of days elapsed until the investigation report is prepared. In fact, Katsakiori *et al.*, (2009) indicated that all accident investigation reports, after their initial phase and once the essential variables have been compiled for analysis, should include a description of the events that took place, with a certain level of detail, and in addition, Rozental (2002) highlighted that accident investigations should be conducted as soon as possible, as there is a risk that evidence and witnesses may be lost, distorted or even twisted.

We looked at empirical studies on the way investigation reports on occupational accidents are being carried out in an attempt to show the application of some of the accident investigation quality criteria described above, but we found few cases and with limited samples:

1. Antao *et al.* (2008) carried out a study on the causes of occupational accidents occurring in the fishing industry in Portugal, for which they analysed a total of 73 occupational accidents using the WAIT method.

2. Jacinto *et al.* (2009) conducted a study on the causes of occupational accidents in the food industry in Portugal with an analysis of 30 accident investigations using the WAIT method.

3. Rollenhagen *et al.* (2010), with a different approach, developed a questionnaire to analyse the organisation context in which accident investigations are done, in a study of 108 Swedish investigators in industries such as healthcare, transport, nuclear and the rescue sector.

4. Schroder-Hinrichs *et al.* (2011), completed a study based on 41 accident investigation reports related to explosions of maritime machinery in Sweden, using the HFACS (Human Factor Analysis and Classification System) method, in order to discover the organisation factors identified in said investigations.

This situation led us to undertake the present study, using a sample of 567 investigation reports on occupational accidents prepared by safety technicians in various settings. This study was carried out with the objective not only of analysing the types of causes or context of the investigations, but also with the idea of analysing all stages of the accident investigation process. The ultimate goal was therefore to identify the main gaps in the investigations and preparation of reports in accordance with the various criteria established by investigators on this matter. Therefore, we analysed collection of information, detection of causes, determination of preventive measures, cost analysis of the accidents, description of the accidents, investigation method and an analysis of the time used.

2 METHODOLOGY

2.1. SAMPLE SELECTION

In order to compile a broad sample of investigation reports on occupational accidents, from February to June 2013, we invited a total of 50 companies operating in Spain with external occupational health services (OHS) and others with internal OHS, to participate in the study. In the end, 13 entities decided to participate, of which 5 had external OHS and 8 internal OHS.

The 567 investigation reports provided, on accidents occurring from 2009 to 2012, were classified as show in Tables 1, 2 and 3, according to organisation mode, level of severity of the accident and business sector.

Table 1. Distribution of reports analysed

Organisation Mode	Nº of reports	%
Internal OHS advisors	333	58.7%
External OHS advisors	234	41.3%
TOTAL	**567**	**100%**

Table 2. Level of injury of accidents investigated

Accident Severity	Nº of reports	%
Incident	3	0.5%
Slight	487	85.9%
Severe	63	11.1%
Very Severe	2	0.4%
Fatal	8	1.4%
TOTAL	**567**	100.00%

In Spain, in terms of severity, accidents can be slight, severe, very severe or fatal. Medical criteria are applied by the physicians of the Mutual Insurance System of Occupational Injuries and Illnesses to classify the accident depending on the severity of the injuries and expected period of recovery (Carrillo-Castrillo *et al.,* 2013).

Table 3. Business sector of accidents investigated

Business Sector	Nº of reports	%
Manufacturing	263	46.4%
Construction	223	39.3%
Services	72	12.7%
Agriculture	9	1.6%
TOTAL	**567**	**100%**

Taking into account all of the occupational accidents corresponding to the study target population (see Table 4), the size of the sample considered is representative with a confidence interval of 95% and a sampling error of less than 5%.

According to the Statistics of occupational accidents rates provided by the Spanish Ministry of Employment and Social Security, the following formula for the calculation of monthly incidence rates is used (NTP-1):

$$\text{Incidence index} = \frac{\text{Accidents with sick leave per 100,000 workers}}{\text{Number of workers exposed*}}$$

*Affiliated Social Security with the contingency of work accident specifically covered

Table 4. Annual data of workers exposed, accidents with sick leave and incidence index

Years	Population employed in Spain	Accidents with sick leave in Spain	Incidence Index in Spain
2012	14,344,698	408,537	28,5
2011	14,582,759	512,584	35,2
2010	14,716,356	569,523	38,7
2009	14,950,121	617,440	41,3

2.2. DESIGN OF ANALYSIS

To conduct the analysis of the sample considered, we examined 28 variables in each one of the investigation reports on occupational accidents. These variables were extracted from literature review and related to quality criteria defined by the various authors cited in the introduction. These quality criteria were classified and arranged in a table (see Tables 5 to 9) according to the five phases defined in the RIAAT model (Jacinto *et al.,* 2011).

Phase 1. Collection of information:

Table 5. Variables for statistical analysis of accident investigations. Information gathering.

Variable	Assessment of Variable	Author
1.- Working environment	. Identified and coded	ESAW VARIABLES Jacinto & Aspinwall (2004a)
	. Incorrectly identified and/or not coded	
	. Not identified	
2.- Working process	. Identified and coded	
	. Incorrectly identified and/or not coded	
	. Not identified	
3. – Specific physical activity	. Identified and coded	
	. Incorrectly identified and/or not coded	
	. Not identified	
4.- Deviation	. Identified and coded	
	. Incorrectly identified and/or not coded	
	. Not identified	
5.- Contact -mode of injury	. Identified and coded	
	. Incorrectly identified and/or not coded	
	. Not identified	
6.- Material agent of contact	. Identified and coded	
	. Incorrectly identified and/or not coded	
	. Not identified	
7.- Type of injury	. Identified and coded	
	. Incorrectly identified and/or not coded	
	. Not identified	
8.- Part of the body injured	. Identified and coded	
	. Incorrectly identified and/or not coded	
	. Not identified	

Phase 2. Identification of causes.

Table 6. Variables for statistical analysis of accident investigations. Identification of Causes.

Variable	Assessment of Variable	Author
9.- Immediate causes. Unsafe acts	. Detected	Antao *et al.,* (2008)
	. Not detected	
10.- Immediate causes. Unsafe conditions.	. Detected	
	. Not detected	
11.- Basic causes. Individual factors.	. Detected	
	. Not detected	
12.- Basic causes. Job factors.	. Detected	
	. Not detected	
13.- Faults in Occupational Risk Prevention Management System	. Detected	
	. Not detected	

Phase 3. Determining preventive measures.

Table 7. Variables for statistical analysis of accident investigations. Determining preventive measures.

Control measures	Variable	Assessment of Variable	Author
Preventive measures to eliminate or reduce risks	14.- Preventive measures at source	. Determined	Jacinto and Aspinwall, (2002)
		. Not determined	
	15.- Organisational preventive measures	. Determined	
		. Not determined	
	16.- Collective protective measures	. Determined	
		. Not determined	
	17.- Personal protective measures	. Determined	
		. Not determined	
	18.- Training and information measures	. Determined	
		. Not determined	
Monitoring measures	19.-Monitoring workplace conditions	. Determined	
		. Not determined	
	20.- Monitoring organization and compliance with working methods	. Determined	
		. Not determined	
	21.- Monitoring workers health	. Determined	
		. Not determined	

Phase 4. Accident cost estimate

Table 8. Variables for statistical analysis of accident investigations. Accident cost estimate.

Variable	Assessment of Variable	Author
22.-Cost estimate of accident	. Yes	Goldberg, (1997)
	. No	

Phase 5. Additional information

Table 9. Variables for statistical analysis of accident investigations. Additional information

Variable	Assessment of Variable	Author
23. Applicable regulations	. Yes	Jacinto and Aspinwall, (2002)
	. No	
24. Sketches	. Yes	Lindberg *et al.,*(2010)
	. No	
25. Photographs	. Yes	
	. No	
26. Diagrams	. Yes	
	. No	
27. Specific method applied	. Yes	Roed-Larsen and Stoop, (2012)
	. No	
28. Days elapsed since accident occurred until report signed	. 1 to 7 days	Rozental, (2002)
	. 7 to 15 days.	
	. 15 to 30 days.	
	. Over 30 days.	
	. Not stated	

Research Questions.

To verify the level of compliance with the quality criteria established, we set the following research questions:

Question 1º.- To what extent do investigation reports include ESAW variables for the collection of information, in the phase of collecting information?.
Question 2º.- When identifying the causes of the accident, are all levels of causes identified in the reports? i.e., immediate causes, basic causes and faults in the company management systems?
Question 3º.- How often, and to what extent, do investigation reports include recommendations and proposals for preventive measures?
Question 4º To what extent do investigation reports determine the cost of accident?.
Question 5º.- At the stage of additional information, how often, and to what extent is the choice of methodology for the accident investigation conducted?. How often and to what extent are information sources such as regulations, sketches, photographs and diagrams used?.

Given that the hypotheses proposed refer to sets of variables, as in other studies (De Pasquale and Scott Geller, 1999), assessment of the level of compliance with the quality criteria in each hypothesis is based on the method applied by Jacinto and Aspinwall (2004b), that is, considering the mean acceptance value as a % of the quotient of the values obtained for each item used from all the factors identified. To accept the hypotheses, again using Jacinto and Aspinwall (2004b) and taking into the account the validation study conducted by Hollnagel (2000), we decided that an average compliance of 67.8% was adequate.

2.3. STATISTICAL ANALYSIS

To conduct the statistical analysis, the data obtained from the 567 accident investigation reports were tabulated according to the 28 variables described in Tables 5 to 9. Next, by using the statistical software SPSS V15, we extracted the frequencies and prevalence of the different variables individually and aggregately, which led to the results described below.

3 RESULTS

3.1.- COLLECTION OF INFORMATION

From the study of the eight ESAW variables considered most important (Jacinto and Aspinwall, 2004a) during the information collection phase, we found, as shown in Table 10, that the average frequency with which these variables are identified and coded properly in the accident investigation reports equals 25.2%. That is, in 74.8% of the cases they are not identified, or it is done incorrectly, which gives answer to research question nº 1.

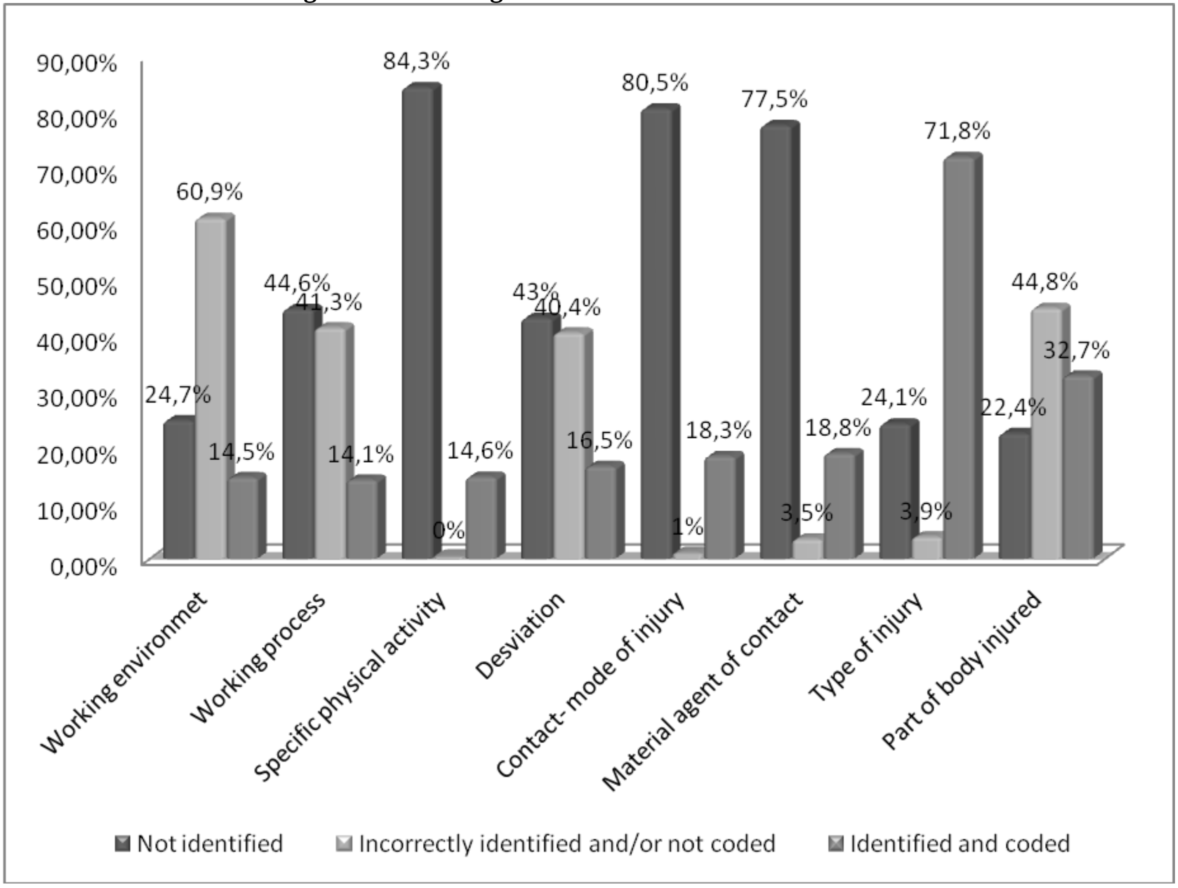
Table 10. Overall analysis of information collection frequencies

Descriptive	Identified and coded	Identified incorrectly and/or not coded	Not identified
Mean	25.2%	24.5%	50.1%
Median	17.4%	22.2%	43.8%
Standard Deviation	19.2	24.7	26.8

Furthermore, when we analysed the ESAW variables considered individually, as shown in Figure 1, we found that the variable most often and correctly identified in the investigation reports is “Type of Injury” with 71.8%. Of note were the results of the variable “Deviation”, which is identified and coded in only 16.5% of the reports analysed. Other variables such as “Working environment” with

60.9% and “Part of body injured” with 44.8%, show a higher percentage of identification, although incorrectly and/or not coded. However, it should be noted that the variables “Specific Physical Activity” with 84.3% and “Contact-mode of injury” with 80.5%, are those with the highest percentage not identified.

Figure 1. Percentage Distribution of ESAW Variables.



3.2.- IDENTIFICATION OF CAUSES OF ACCIDENTS

The analysis of the identification of the causes of accidents in the investigation reports considered, led us to determine that less than 1% of these reports jointly identify the immediate and basic causes and faults in the occupational health and safety management system, which gives answer to research question nº 2.

Regarding the individual analysis of several variables associated to the identification of causes of accidents, Figures 2 and 3 show the results obtained. We can say that in 2 of every 3 reports the immediate causes were identified, however, only 1 in 4 detected the basic causes, and the number of cases that identified faults in the occupational health and safety management system were small, only 5.8% of the investigation reports analysed.

Figure 2. Percentage Distribution of the Causes Detected by Level.

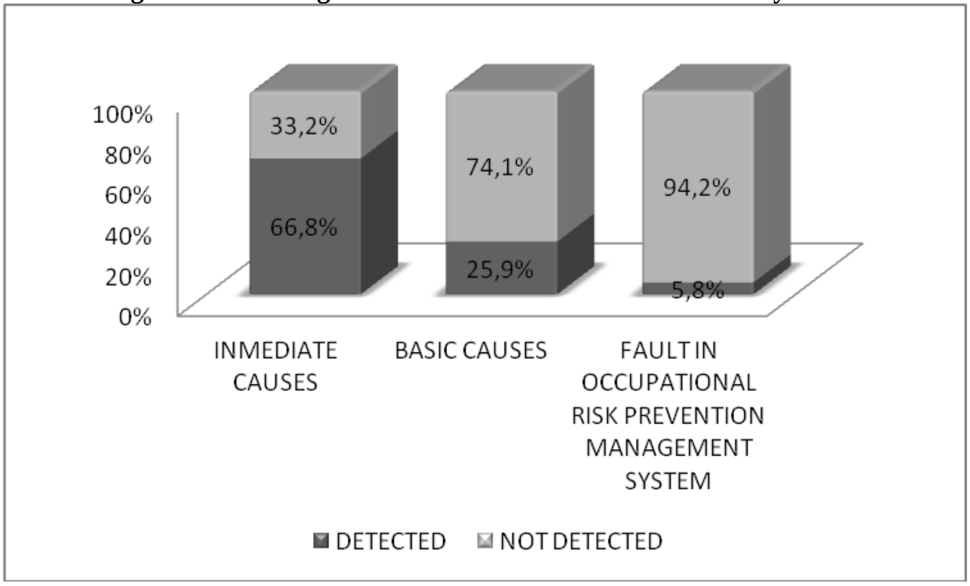
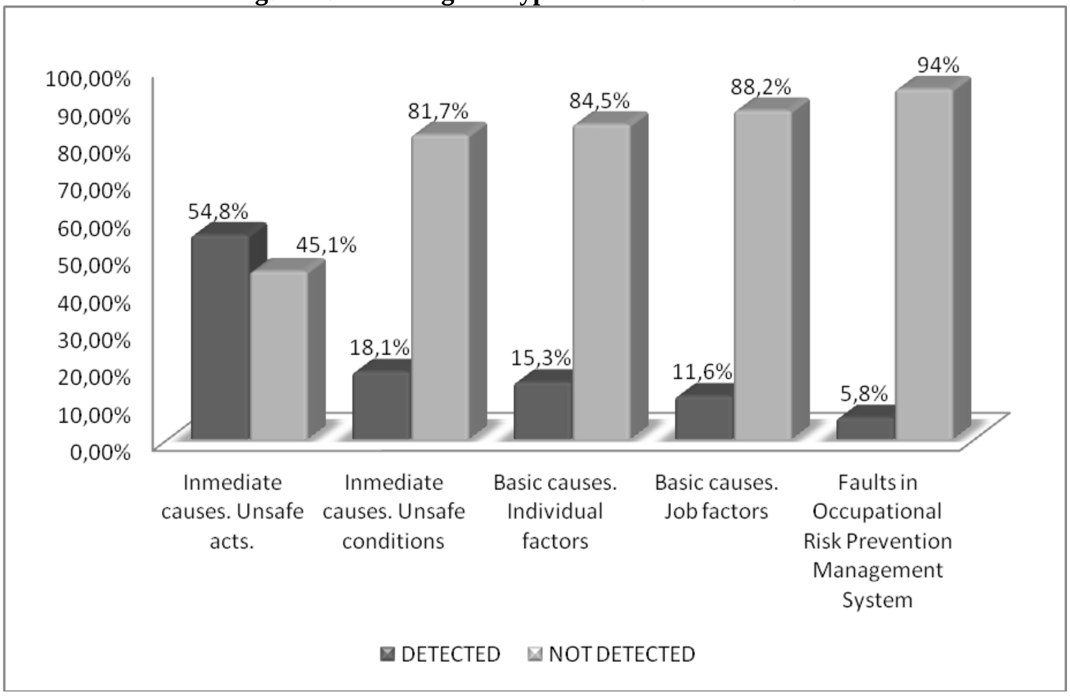


Figure 3. Percentage of Types of Causes Detected.

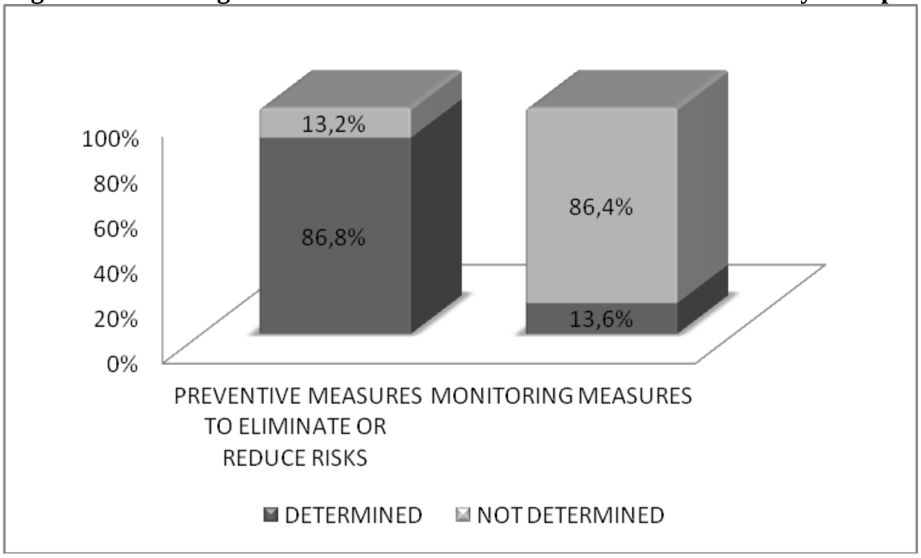


3.3.- DETERMINING PREVENTIVE MEASURES.

The analysis of the preventive measures proposed in the investigation reports considered led us to determine that 88.7% of these reports propose preventive measures.

It is interesting to note however, as can be seen in Figure 4, that in the great majority of these cases the recommendation is to preventive measures to eliminate or reduce risks. However, only 13.6% of the reports propose preventive monitoring measures, which gives answer to research question nº 3.

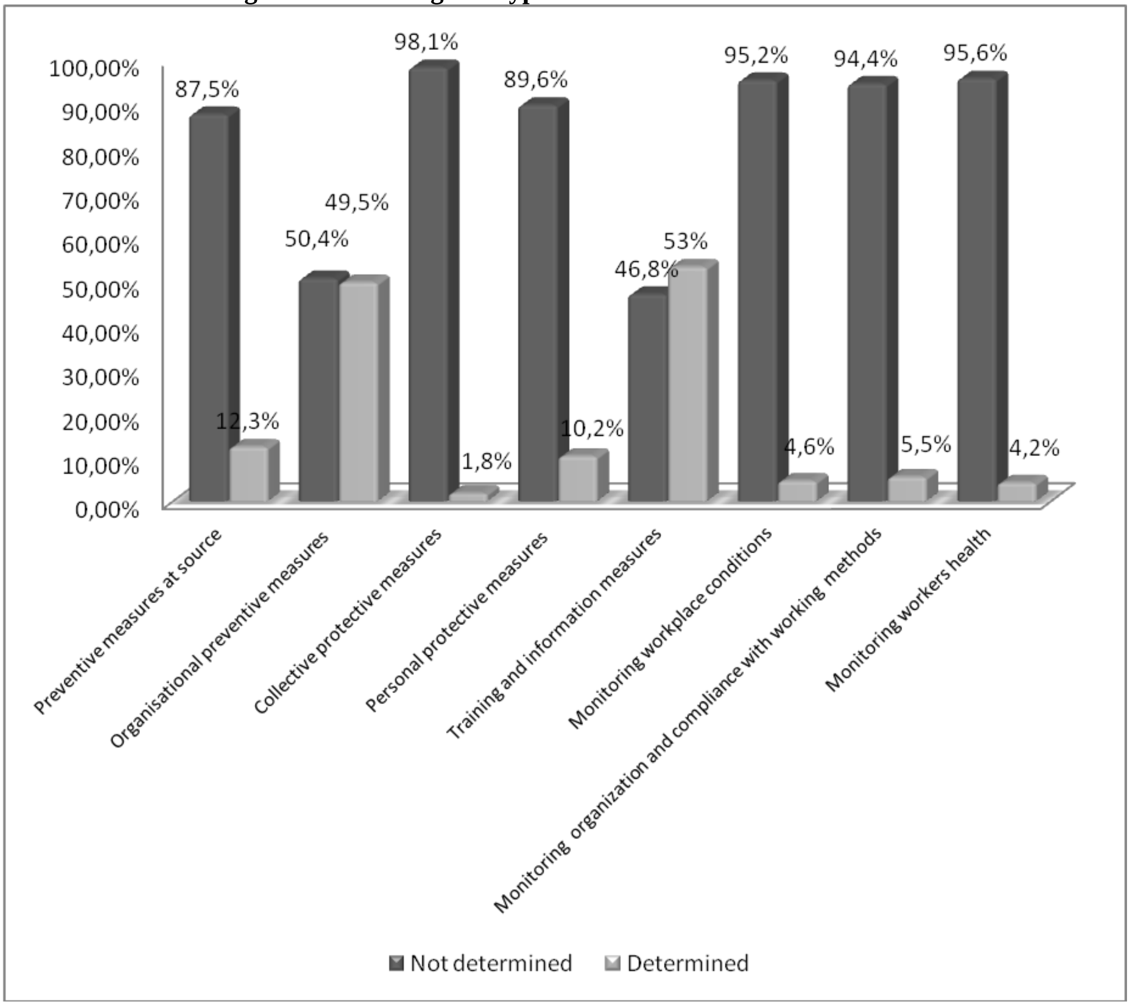
Figure 4. Percentage Distribution of Preventive Measures Identified by Groups.



From the in-depth analysis of this section, we found that among the preventive measures to eliminate or reduce risks, the measures aimed at planning information or education activities for workers reached 53% versus those contemplating prevention measures at source with 12.3%, collective protection measures with only 1.8% and personal protection measures with 10.2%. Also, for organisational preventive measures there was almost the same percentage between those identified, 49.5%, and those not identified, 50.4% (see Figure 5).

As for monitoring measures, there are hardly any measures aimed at the periodic control of workplace conditions, organization and compliance with working methods or workers' state of health.

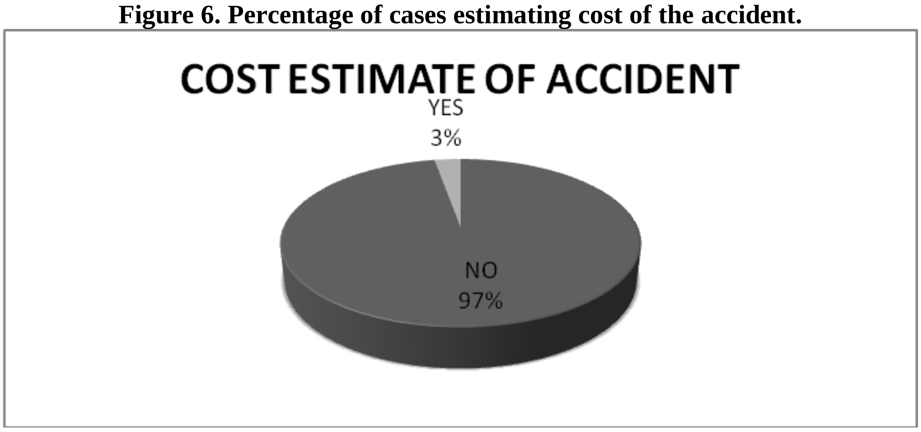
Figure 5. Percentage of Types of Preventive Measures Identified.



3.4.- ESTIMATE OF ACCIDENT COST

As shown in Figure 6, the cost of the accident is not determined in practically any of the investigation reports analysed, with a very low 3% of the total, which gives response to the fourth research question.

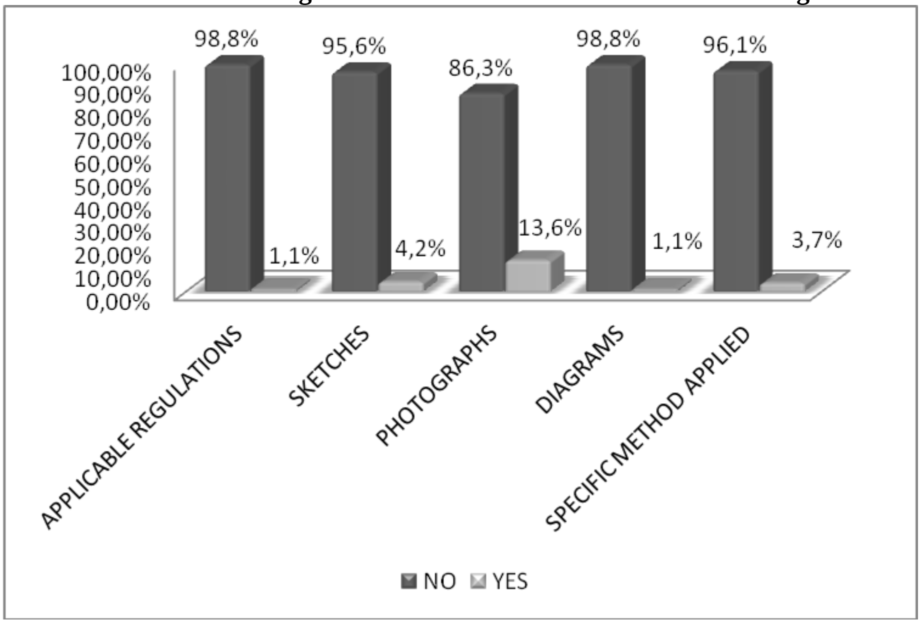
Figure 6. Percentage of cases estimating cost of the accident.



3.5.- ADDITIONAL INFORMATION

The analysis of the additional information included in the investigation reports considered, led us to determine that 16.6% of the cases included some type of additional information. Of note is that fact that 3.7% of the investigation reports analysed used a specific method, namely, a causal tree (see Figure 7).

Figure 7. Distribution Percentage of Variables Included in Accident Investigation Annexes.



3.6.- OVERALL RESULTS

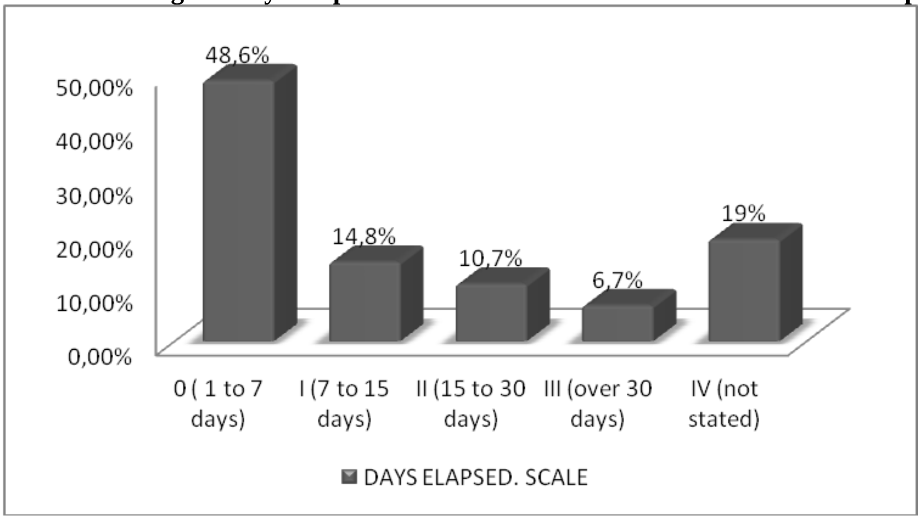
Finally, Table 11 shows a summary of the percentages in each section of the accident investigation reports assessed as acceptable based on the proposed research questions, that is, considering the mean acceptance value as a % of the quotient of the values obtained for each item used from all the factors identified (Jacinto y Aspinwall, 2004b). These allows us to deduce that as an overall result, only 26.9% of the investigation reports analysed have followed the quality criteria recommended by experts in this matter.

Table 11. Summary of Results

FACTORS ANALYSED	% of agreement
Information collection. Identification of ESAW III variables	25.2%
Identification of active faults, latent faults and management system faults	0.9%
Determining preventive measures	88.7%
Estimate of accident cost	3%
Additional information (regulations, sketches, photographs, diagrams and method)	16.6%

Moreover, as anticipated in the introduction, various authors (Lindberg *et al.,* 2010; Rozental 2002) pointed out that accident investigations should be prepared in the shortest time, and the site of the accident visited as soon as possible since conditions could change almost immediately. To control this situation, the statistical analysis used the variable “Days Elapsed until the Investigation Report was Prepared", which showed that almost half of the investigation reports are drafted within 7 days of the accident. This situation could be considered acceptable according to the study by Rozental (2002), but nearly one in every five reports does not identify this variable and almost one in every three was conducted more than 7 days and even a month after the accident. (See Figure 8).

Figure 8. Percentage of Days Elapsed Between the Time of the Accident and the Report.



4 DISCUSSION

In light of these results, we found that, although reference authors such as Jacinto and Aspinwall (2004a) have confirmed that the ESAW variables are a valuable contribution to the analysis of accidents given the objective information they provide, they are not being used to the extent necessary in investigation reports as evidenced by the analysis of the research question 1, which contemplates that investigation reports do not include the ESAW variables. The most relevant result of this study from the information gathering phase is the limited use of the deviation variable, given that it is a variable of crucial importance for the causal analysis of accidents (Kjellen, 1984; Jacinto *et al.,* 2009).

As for the process for identification of causes, using the ESAW variables is a major step, as it entails employing a common, harmonised language across the European Union for the collection and analysis of the information available on accidents at work. However, as argued by Jacinto *et al.,* (2009) this is not enough, since the analysis of these variables allows establishing only a snapshot of the immediate causes. In fact, the immediate causes due to unsafe acts are identified in this study 54.8% of the analyzed accident investigation reports. This may mean that either these are usually easy to identify and therefore more clearly observable (Lundberg *et al.,* 2009; Jacinto *et al,* 2011) or because most researchers pay more attention to this category of causes (Jacinto and Aspinwall, 2002). In contrast, the fact that latent failures that are detected in 25.9% of the analyzed reports may be due to their difficulty to be found because they correspond to weaknesses hidden in the organisation, thus coinciding with the arguments Jacinto *et al.,* (2011) and Schroder-Hinrichs *et al,.* (2011). This situation leads to confirm the theory of Lundberg *et al.,* (2010), based on which, a particular limitation found in accident investigations is that many of them end their analysis at the level of "preventable causes".
Therefore, as evidenced by the answer of the research question nº 2, which stated that not all levels of causes are identified in accident investigations, immediate causes are those most frequently identified, which is indeed an important first step. However, in line with Schroder-Hinrichs *et al.*, (2011), in order to be able to fully understand accidents, it is essential to also identify the underlying causal factors, that is, those in the organisation and in the company management.

Similarly, although the results of the research question nº 3, confirm that preventive measures are included in accident investigations, they do support conclusions by authors such as Benner (1985), Jacinto *et al*., (2009) and Rollenhagen *et al*., (2010) with regard to the fact that as well as proposing preventive measures to eliminate or reduce risks, it is necessary to consider monitoring measures in accident investigations.

According to the literature, reducing accidents decreases company costs in the long-term (Goldberg, 1997). With the confirmation of the research question 4, we should ask ourselves why the cost of accidents is hardly analysed or, when it is, why it is done in such a limited manner.

Likewise, with answer of the research question 5, we found, as already identified by Roed-Larsen and Stoop (2012), that the reports analysed show a worrying lack of standardised and validated methods during the analytical phase of the investigation process. This weakens the analytical rigour of the investigation process and makes it difficult to establish adequate preventive measures, which should be based on the results and conclusions of the analysis. Furthermore, as stated by Katsakiori *et al*., (2009), any accident investigation method should serve as a guide to be able to identify the whole set of relevant circumstances in an accident. Yet, as this study shows, the lack of a scientific method prevents investigation reports from including a detailed description of the events and circumstances leading up to them.

In short, as noted by Lundberg *et al.* (2010), at present, the investigation of occupational accidents is in an anomalous situation, since investigation reports are prepared with data of highly questionable value. As pointed out by Lundberg *et al.,* (2010), the reasons for this may be diverse and should be analysed in depth, but this same author also states that the main cause is the fact companies do not usually have a permanent organisation to investigate occupational accidents, but rather technicians conduct these investigations in addition to their regular job, that is, without working full-time on accident investigation.

5 CONCLUSIONS.

Many studies have been carried out to improve the quality of investigation reports on occupational accidents, however, the alarming accident rates of recent years should drive us to continue researching in this field, in order to reduce the number of accidents. This study, following the conclusions of various investigators and safety technicians, has identified the main gaps in accident investigation reports. Applying a compulsory investigation technique across the EU Member States and in many other places around the world would act as a continuous improvement mechanism, and would not only affect the area of safety, but would also have an influence on productivity and quality, since it would attempt to limit the flaws in the system that can generate human and material losses.

The fact that only 26.9% of the investigation reports on occupational accidents analysed in this study were prepared following the quality criteria recommended in the literature, shows that the situation is worrying. This study does not provide data to determine the causes for this deviation, which could be addressed in future research. In any case, these gaps could be overcome by improving the training and skills of the professionals who prepare the accident investigations in the areas of investigation techniques and implementation methodologies. Given the significance of the work to be done, we should consider whether these professionals should have administrative certification based on specific qualifications and training to guarantee the best results in accident investigations. Moreover, the right structural and functional conditions should be established to allow a truly independent investigation, with organisational freedom and transparency, both regarding what is published in the report and in the monitoring of preventive measures.

To guarantee the proper implementation and effectiveness of accident investigations, the Administration must establish monitoring mechanisms to help verify how they are carried out.

Finally, as part of the harmonisation project of European Statistics on Accidents at Work led by Eurostat, it would be very important to create a common European model for reporting occupational accident investigations. In addition, in the future, there should be a database with records of occupational accident investigation reports in different fields. This would include the results of the investigations, the causes found, the preventive measures proposed and how they will be monitored, which would certainly result in better occupational accident investigations and therefore in a reduction of accident rates.

ACKNOWLEDGEMENTS

We would like to express our gratitude to all the companies that have collaborated in the undertaking of this study, providing the accident investigation reports that have served as the basis for this research.

REFERENCES

Antao, P., Almeida, T., Jacinto, C., Guedes Soares, C. (2008). Causes of occupational accidents in the fishing sector in Portugal. *Safety Science*, Vol 46, Issue 6, pp. 885-899.

Benner, L. (1985). Rating accident models and investigation methodologies. *Journal of safety Research*, Vol16, Issue 3, pp. 105-126.

Bestraten Bellovi, M., Turmo Sierra, E. Estadisticas de accidentabilidad en la empresa.[Accident statistics in the business] (Technical Note NTP 1-1982). Madrid, Spain: Instituto Nacional de Seguridad e Higiene en el Trabajo; 1997. from: http://www.insht.es/InshtWeb/Contenidos/Documentacion/FichasTecnicas/NTP/Ficheros/001a100/ntp_001.pdf.

Carrillo-Castrillo, J.A., Rubio-Romero, J.C., Onieva, L. (2013). Causation of severe and fatal accidents in the manufacturing sector. *International Journal of Occupational Safety and Ergonomics*, Vol 19, nº 3, pp. 423-434.

Depasquale, J., Scott Geller, E. (1999). Critical success factors for behaviour-based safety: a study of twenty industry-wide applications. *Journal of safety Research*, Vol 30, Issue 4, pp. 237-249.

Dien, Y,, Decchy, N.,Guillaume, E. (2012). Accident investigation: From searching direct causes to findings in-depth causes- Problem of analysis or/and of Analyst?. *Safety Science*, Vol 50, Issue 6, pp. 1398-1407.

Eurostat, (2001), "European Statistics on Accidents al Work (ESAW)- Methodology, 2001 ed., DG Employment and Social Affairs, European Commission, Luxembourg. http://europea.eu.int/comm/employment_social/h&s/index_en.

Fraile, A., Lopez F., Maqueda, J., Muñoz, A., Obregon, P., Pique, T., Rosel, L. (1993). Proyecto INVAC: Una contribución a la modernización de la investigación de accidentes de trabajo. *Salud y Trabajo*, nº 99, pp. 29-44.

Goldberg, A.T., (1997). Taming the Cost of Accidents while improving safety. *Occupational Health & Safety*, vol.66, nº 10, pp. 66-70.

Hollnagel, E. (1998). Cognitive Reliability and Error Analysis Method-CREAM. *Elsevier Science*, Oxford.

Hollnagel, E. (2000). Looking for errors of omission and commission or The Hunting of the Snark revisted. *Reliability Engineering & System safety*, Vol 68, Issue 2, pp. 135-145.

Jacinto, C., Aspinwall, E. (2002). WAIT- a new method for the investigation and Analysis of accidents al work. Institution of Occupational Safety and Health, UK, IOSH Journal, Vol. 6(1), pp.15-37. ISSN 1366-1965.

Jacinto, C., Aspinwall, E. (2003). Work accidents investigation technique (WAIT)- Part I. *Safety Science Monitor*, Vol 7, Article IV, Issue 1.

Jacinto, C., Aspinwall, E. (2004a). A survey on occupational accidents reporting and registration systems in the European Union. *Safety Science*, Vol 42, Issue 10, pp. 933-960.

Jacinto, C., Aspinwall, E. (2004b). WAIT (Part III)- Preliminary validation studies. *Safety Science Monitor*, Vol 8, Article 3, Issue 1.

Jacinto, C., Canoa, M,, Guedes Soares, C. (2009). Workplace and organizational factors in accident analysis within the food industry. *Safety Science*, Vol 47, Issue 5, pp. 626-635.

Jacinto, C., Guedes Soares, C., Fialho, T., Silva, A.S. (2011). The recording, investigation an analysis of accidents al work (RIATT) process. *Policy and Practice in Health and Safety*, nº 9, pp. 57-77.

Johnson, C., Holloway, C.M., (2003). A survey of logic formalisms to support mishap analysis. *Reliability Engineering and System Safety*, vol. 80, nº 3, pp. 271-291.

Katsakiori, P., Sakellaropoulos, G., Manatakis, E. (2009). Towards an evaluation of accident investigation methods in terms of their alignment with causation models. *Safety Science*, Vol 47, Issue 7, pp. 1007-1015.

Kjellen, U. (1984). The desviation concept in occupational accident control- Part I- definition and classification. *Accident Analysis and Prevention*, Vol 16, nº 4, pp. 289-306

Lindberg, A., Ove Hansson, S., Rollenhagen, C., (2010). Learning from accidents-what more do we need to know. *Safety Science*, Vol 48, Issue 6, pp. 714-721.

Lundberg, J., Rollenhagen, C., Hollnagel, E., (2009). What you look for is what you find. The consequences of underlying accident models in eight accident investigation manuals. *Safety Science*, Vol 47, Issue 10, pp. 1297-1311.

Lundberg, J., Rollenhagen, C., Hollnagel, E., (2010). What you find is not always what you fix-How other aspects than causes of accidents decide recommendations for remedial actions. *Accident analysis and prevention*, nº 42, pp. 2132-2139.

Reason, J. (1997). Managing the Risks of Organisational Accidents. Ashgate Publishing Ltd, Aldershot Hants, U.K.

Reason, J., (2000). Human errors: models and management, *British Medicine Journal*, Vol 320, nº 7237, pp. 768-770.

Roed Larsen, S., Stoop, J. (2012). Modern accident investigation-four major challenges. *Safety Science*, Vol 50, Issue 6, pp. 1392-1397.

Rollenhagen, C., Westerlund, J., Lundberg, J., Hollnagel, E. (2010). The context and habits of accident investigation practices: a study of 108 Swedish investigators. *Safety Science*, Vol48, Issue 7, pp. 859-867.

Rozental, J.D., (2002). Two decades of radiological accidents direct causes, roots causes and consequences. *Brazilian Archives of Biology and Technology*, nº 45, pp. 125-133.

Schroder-Hinrichs, J., Baldauf, M., Ghirxi, K. (2011). Accident investigation reporting deficiencies related to organizational factors in machinery space fires and explosions. *Accident Analysis and Prevention*, Vol 43, Issue 3, pp. 1187-1196.

Suarez-Cebador, M., Rubio-Romero, J.C., Lopez-Arquillos, A. (2013). Severity electrical accidents in the construction industry in Spain. *Journal of safety Research*, Vol 48, pp 63-70.

Weiwei, W., Gibb, A., Li, Q. (2010). Accident precursors and near misses on construction sites: an investigative tool to derive information from accident databases". *Safety Science*, Vol 48, Issue 7, pp. 845-858.