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The Impacts of Human Factors in Fatal Workplace Accidents

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Abstract

The article shows the impacts of human factors in fifteen fatal workplace accidents analyzed by Ministry of Labor and Employment of Brazil from August 2007 to August 2011. The main human factors contributing to each accident were tabulated. It is necessary to learn lessons from them and take precautions in order to reduce risk and prevent their recurrence.". Organizational factors play an important role in almost all accidents. Thus identifying them is a critical success factor for the understanding, prevention and controlling of these very accidents.

Keywords: human factors; workplace accidents; risk.

1 Introduction

1.1 Workplace Accident – Traditional Approach

The traditional approach to accidents assumes that compliance with procedures and norms protects the system against accidents and that these events are caused by the faulty behavior of workers, originated, in part, on aspects of their personalities. Identification of these behaviors is based on comparing the pattern that is based on a "secure way of doing" known in advance by safety experts. The beginning of the systematic process of accident analysis is characterized by the structuring of policy practical assistance or Occupational Health and Safety Management System (OHSMS), divided into four phases, shown in Table 1. The emergence of proposals for systematized analysis changes these phases, in general, expanding the scope of the investigation.

Table 1: Phases of systematic process of accident analysis

Phase	Description
1	Analysis preparation, defining of event to be analyzed and its consequences
2	Analysis itself with suggestions of correction and written report
3	Implementation of corrections and their follow up
4	Retro-feeding of system with updated data based on analysis learning

Source: Dwyer (2000)

The essence of this traditional safety paradigm is summarized by Dwyer (2000) and Cattino (2002) to have the following characteristics: a) the improvement of health and safety can be achieved through technological improvements, disciplinary sanctions, strengthening of standardization, and expert control, b) the human being is unreliable and the cause of system insecurity, and c) error is seen as a "failure" or "defect" originating in the negligence of the operators..

Other authors refer to this approach as "anticipationist" (Hood, Jones, 1996), to emphasize the fact that the risk factors that may cause an accident or disaster are considered, in principle, as known. This

knowledge is reflected in instruments used in accidents analysis, which take the form of "causes" checklists to be used by safety teams.

1.2 Workplace Accident – Current View with Emphasis on Organizational Culture

According to Almeida (2006), workplace accidents are socially determined and predictable phenomena. Instead of becoming a matter of chance, as suggested by the word accident, workplace accidents are predictable phenomena, given that the factors capable of triggering them are present in the work situation (which can be identified), long before they are triggered.

The influence of organizational factors on workplace accidents have been studied for more than two decades, but there is great need to develop tools to detect, describe and classify these factors, in order to analyze their impacts on work safety (Vuuren, 2000).

Vuuren (2000) classifies the organizational factors that influence workplace accidents in: factors relating to the organization structure; factors related to strategies and objectives; and, factors related to the culture of safety. According to him, the impact of the culture of safety and risk management in the causes of accidents is considerable. A survey conducted by the author shows that 35-40% of the factors related to workplace accidents have organizational origins.

Claiming that workplace accidents are socially determined is equivalent to saying that they result from social phenomena, especially the participation of workers in production and therefore in consumption, expressing the power relationships in real societies.

In these terms, prevention is beyond the scope of actions developed or coordinated by ministries such as the Labor, Health and Security or the Social Security. In other words, changes in health and work safety conditions need to go necessarily through the existence of public policies on education, health and work safety, also to stimulate social pressures in Brazil.

The thought that a workplace accident is a product of fate leads to the understanding that prevention is lacking. Realize, however, that events are happenings coming mainly from unsafe actions perpetrated by workers, suggests focusing the preventive actions on the behavior of workers.

The accident analysis is a tool that can help in this learning process. To do so, it is important to conduct it in a systematic manner, based on concepts or techniques that exploit the network of factors involved in the origins of these events, without neglecting aspects incubated for years in the system history (Almeida, 2006).

Inquiries that attribute the occurrence of an accident on worker's misconduct, whether by negligence, recklessness or inattention, develop recommendations focused on behavioral changes such as greater attention when performing a certain activity, and strengthening personnel training. These recommendations require demonstrating that workers are trained to holding high level of attention throughout the workday; even being this conflicting with the characteristics of human beings.

Accidents represent an organizational dysfunction in their socio-technical system (Turner, 1978; Gherardi et al, 1998; Hopkins, 2001). The aforementioned system is comprised of an interaction of both social and technical components, the latter being the facilities, equipment, tools, productive processes and materials of which organizations use to achieve the products of their nature. The social components, however, influence and are influenced by environmental forces represented by unions, mechanisms of internal and global competitions, exchange rates, as well as safety, environmental and health legislations and the temporal values of dominant social groups in a space of time and place.

According to recent conceptions, workplace accidents result from modifications or deviations that occur within production systems. These changes or deviations themselves result from the interaction of multiple factors. Conceiving the company as an open socio-technical system and the accident as a sign of malfunction of this very system, investigate it means to analyze aspects of the technical subsystem as plant, machinery, layout, technology, products, and the social subsystem of the company as age and sex

of workers, professional training, organization of work, personal and hierarchical relationships, corporate culture and psychosocial context (Almeida, 2006).

1.3 Human Factors

In the past, industrial accidents were reported mainly in terms of technological malfunctions and the human element in the cause of the accident tended to be ignored. Since the frequency of the technological failures has diminished, the role of human factors has become more apparent. Accidents such as the Piper Alpha disaster illustrate that the performance of a highly complex socio-technical system, is dependent the interaction of technical, human, social, organizational, managerial and environmental elements and these factors can be important co-contributors to incidents which could potentially lead to catastrophic event. Human factors were deemed to be the root cause of many major disasters, such as Chernobyl, Three Mile Island and Piper Alpha and as were well-researched by those interested in the human contribution to the causes of accidents, such as psychologists, reliability engineers and human factors specialists (Gordon, 1997).

The terms 'human factors' and 'human error' are often exchanged without clear definition as to what is actually meant by these labels. They are often used interchangeably as general terms referring to the cause of an accident being related to people as opposed to a technical fault. The traditional definition of human factors is the scientific study of the interaction between man and machine. This definition in recent years encompasses the effects which individual, group and organizational factors have on safety (Gordon, 1997).

Both human error and human factors are usually studied separately and any relationship between them is often overlooked. This may be caused by the difficulty of the task or because there is still no agreement between the two separate areas as to their precise nature and definition. However, a number of high reliability industries have attempted to combine these two subjects in their accident reporting forms. The way individual error tendencies interact with complex organizations where workers deal with high-risk technologies is still a source of human error, though still a little one.

When considering human factors in accidents, two kinds of errors can be involved. Firstly *active errors,* whose effects are generally almost immediate (such as an omission or using the wrong rule) and secondly, *latent errors*, whose adverse consequences may lie dormant within the system for a long time, only becoming evident when they combine with other factors to breach the systems defenses (such as design or training). *Active errors* are most likely to be caused by front-line operators, whereas *latent errors* are more likely to be caused by those who are removed from the direct control interface. In most cases, safety programs are designed to reduce active failures committed by the operators in order to reduce specific causes that are unlikely to occur in the same combination (Gordon, 1997).

2 Scope

Considering the studies based on fifteen reports of analysis of fatal workplace accidents carried out in Bahia by Ministry of Labor and Employment from August 2007 to August 2011, this article aims to show that the reality in workplace accidents confirms their theoretical content, and that the risks can be reduced if organizations take some precautions in their production system.

3 Methodology

The article is based on the study of fifteen reports of analysis of fatal workplace accidents occurred in the state of Bahia in companies fined by the Ministry of Labor and Employment from August 2007 to August 2011.

4 Results

The main organizational factors present in each accident were disposed on Table 2.

Table 2: Organizational factors related to workplace accidents

Accident	Organizational Factors														
	Communication Issue	Place inobservance	Environment	Bad Automation	Improper Attitude	Maintenance failure	Training failure	Supervision failure	Noncompliance with safety standards	Lack of inspection	Planning failure	Lighting	Layout failure	Improper tool or equipment use	Deficiency at assessing the work risk
1			X					X	X					X	X
2				X				X	X				X	X	
3	X						X	X	X						X
4	X	X	X					X		X		X			X
5	X		X					X	X	X				X	X
6	X		X			X	X	X					X		X
7		X	X		X		X		X		X				X
8			X					X	X			X	X		X
9		X							X	X			X		X
10	X		X			X		X	X		X	X		X	X
11		X	X					X	X						
12							X	X	X					X	X
13						X		X	X	X		X	X		X
14	X					X		X	X	X	X	X		X	X
15				X		X	X		X	X				X	X

Source: Ministry of Labor and Employment of Brazil (2007-2011)

Organizational factors play an important role in almost all accidents. Thus identifying them is a critical success factor for the understanding, prevention and controlling of these very accidents. Accidents versus organizational factors are shown in Table 3, along with their respective occurrence in this type of accident, showing that the noncompliance with Safety Standards and the deficiency in assessing the work risk are among the causes that influence workplace accidents in the state of Bahia.

Table 3: Phases of systematic process for accident analysis

	Accident Cause	Quantity of Accidents	Participation in Accidents
1	Noncompliance with safety standards	13	87%
2	Deficiency at assessing the work risk	13	87%
3	Supervision failure	10	67%

4	Environment	8	53%
5	Improper tool or equipment use	7	47%
6	Lack of inspection	6	40%
7	Communication Issue	6	40%
8	Lighting	5	33%
9	Layout failure	5	33%
10	Training failure	5	33%
11	Maintenance failure	5	33%
12	Place inobservance	4	27%
13	Planning failure	3	20%
14	Bad Automation	2	13%
15	Improper Attitude	1	7%

Source: Ministry of Labor and Employment of Brazil (2007-2011)

Real safety cannot be implemented without the involvement of safety personnel and company employees themselves in discussions regarding the strategic choices of the system on the methodology to be adopted for the production or service. The technical and social implementation of the safety in a company requires an open dialogue that considers different logics in the system. It is necessary to highlight safety with quality standards and the participation of the employee.

All workers involved in the investigated accidents were male with the following jobs (Figure 1): carpenter, mason assistant, mason, electrician, mechatronics, bagger, lifting mechanic and driver. In organizing the data, it has been taken into account only the 25 workers who have suffered the accidents (one worker alone has taken part of three accidents). The largest number of events occurred with workers in the role of workman (36%) and mason assistant (16%). The age group study (Figure 2) indicated they ranged between 20-56 years of age, with the highest percentage (40%) occurring among workers with 40 to 50 years of age. Analyzed data were from accidents that occurred from 2007 to 2011.

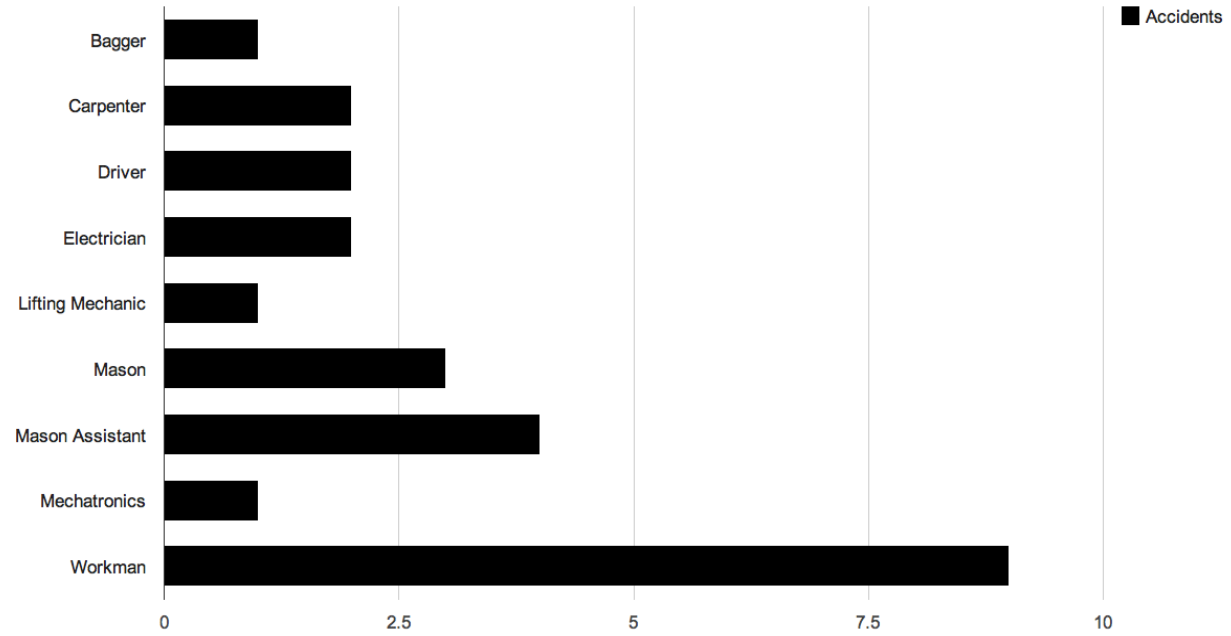

Figure 1: Accidents *versus* Profession. Source: Ministry of Labor and Employment of Brazil from August

Figure 2: Accidents *versus* Age group. Source: Ministry of Labor and Employment of Brazil from August

According to the data acquired during the investigative and interpretation stage of the analysis of workplace accidents, involving both employees and third parties, in the State of Bahia in companies fined by the Ministry of Labor and Employment from August 2007 to August 2011, the following active organizational factors were considered:

1. Insecure or improper act: it is a decision, choice or option that unnecessarily leads to an accident or contributes directly or indirectly for it to occur. When related to a human error, it is usually associated with distractibility, forgetfulness, non-compliance or willful violation of procedure, misuse or improvisation of equipment, lack of perceived risk, or non-use of personal protective equipment (PPE).
2. Control Failure: usually associated with the use of informal working method not stated in a procedure or its absence, execution of activity by an unskilled worker, work overload, inadequate specification of PPE, or presence of risk conditions in the workplace due to lack of appropriate control.
3. Technical failure: when related to the failure of equipment or materials, may be related to insufficient or improper maintenance, or equipment designs.

Consequently, the preconditions or present factors (points a, b, c, d), and the risk factors (points e, f, g, h, i, j, k) have been identified at the work place:

a) State of Mind: occurrence of fatigue, lack of attention, discomfort caused by external disturbance (wind, rain, heat, noise), dissatisfaction, stress. Plays an important role in the safety degree for the employee to perform his task.
b) Reasoning pattern: due to lack of knowledge, intelligence, experience, ability, inability to delegate, fear of failure.
c) Work organization: bad or nonexistent procedure, inadequate risk assessment for the activity, confusing layout, dirty, disorganized or insecure workplace, lack of training or qualifications for the job, excessive overtime.
d) Equipment characteristics: inadequate, unprotected or unreliable tools or equipment to use.
e) Project: related to ergonomically bad tools or equipment design, deviations from the original design.
f) Equipment: related to lack of condition, suitability or availability of materials.
g) Maintenance management: related to the management or inadequate performance of maintenance tasks and repair or its absence.
h) Training: related to lack of expertise and experience of employees (insufficient or inadequate training).
i) Communication: ineffective communication

j) Organization: related to deficiency in the structure, philosophy, organizational process or strategy, resulting in inappropriate management or low efficiency of the company.

Defenses: lack of protection for people, materials and environment against the consequences of the unexpected event that caused the work accident.

Technical experts, safety engineers of the Ministry of Labor and Employment, conducted the accidents investigation and analysis presented in this study. Learning from accidents and prevent their repetition is a duty for all parties involved. It should be emphasized that one should keep in mind the difference between training and education. Training aims to develop a specific skill, such as operating a machine, performing a routinely procedure or meeting people within a narrow range of responsibility. Education aims to increase the critical thinking of the individual (employee), as well as to enable this very individual to learn new content on his or her own. The training enables the professional. Education develops a person. In order to guarantee the results with respect to changes in attitude and, consequently, reduction in the number of workplace accidents, it is necessary for companies to invest continuously in behavioral education, in addition to the traditional risk awareness tools and technical procedures.

5 Conclusion

Based on fatal workplace accident studies, it is very important to keep in mind that the investigation of an accident is a collective construction process that involves members of the investigating team and other workers of the company. Regarding companies, injured ones, supervisors, coworkers, and, if any, responsible for maintenance, purchase of materials, technicians and safety engineers are people who hold knowledge about aspects that may be critical in identifying "causes of causes" of the episode investigated. It is essential that they be heard. It is also important to consult reports and other documents that may exist in respect of machinery and equipment directly or indirectly involved in the accident.

This paper presented an approach that incorporated organizational aspects as causes of workplace accidents, and their major contributions to establish a relationship between the basic risk factors and work accidents, identifying the organizational failures that contributed most to the occurrence and recognition of patterns of accidents through joint analysis of events involving employees and third parties. It is, ultimately, the preservation of the workers dignity. Thus the paper shows that the reality of workplace accidents corroborates their theoretical content.

6 Final Considerations

Reason (2006) mentions that it is easier to manage the workplaces and the organizations than the minds of employees, as it is not possible to change the human condition, but changing the conditions under which people work. For this, the commitment of the top management is important, without which it is not possible to make the necessary changes.

References

Almeida, I. M. (2006). The path of accident analysis: the traditional paradigm and extending the origins of the expansion of analysis. Interface - Comunic., Saúde, Educ., v.10, n.19, 185-202.

Cattino, M.(2002). Da Chernobyl a Linate. Incidenti tecnologici o errori organizzative? Carocci, Roma.

Dwyer, T. (2000) A study on safety and health management at work: a multidimensional view from a developing country. In: FRICK, K.; JENSEN, P.L.; QUINLAN, M.; WILHAGEN, T. Systematic occupational health and safety management. Pergamon, Amsterdam.

Gherardi, S., Nicolini, D., Odella, F. (1998). What do you mean by safety? Conflicting perspectives on accident causation and safety management in a construction firm. Journal of contingencies and crisis management. Vol.6, n. 4, 7-18.

Gordon, R.P.E. (1997). The contribution of human factors to accidents in the offshore oil industry. Reliability Engineering and System Safety 61, 95-108.
Hood, C., Jones, D. K. C. (1996). Anticipation in risk management: a stitch in time? University College of London, London.
Hopkins, A. (2001) Was Three Miles Island a 'Normal Accident? Journal of Contingencies and Crisis Management 9, n. 2, 65-72.
Reason, J. (2006). Managing the risks of organizational accidents. Ashgate, Surrey.
Turner, B. A. (1978). Man-Made Disasters. Wykeham, London.
Vuuren, W.V. (2000). Cultural influences on risks and risk management: six cases studies. Safety Science 35, 31-45.