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Organizational Factors which Contribute to Fatal Workplace Accidents in Brazil

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Abstract

The information about fatal workplace accidents (totaling 3,632) in Brazil from 2007 to 2011 was analyzed. The data were collected from the reports in the Federal Inspection of Labor System, which is conducted by the Ministry of Labor and Employment of Brazil. The analysis of the accident causes showed that factors related to organization, task and material were the most common concerning fatal workplace accidents. The present paper examines the nature of factors involved in those fatalities. The most common factors related to organization were those connected with procedures and no risk analysis. However, the most common factors in relation to task were those caused by improper use of tools and equipment as well as detection risk failure. The relationship between factors was studied and correlation between some of them was found. Those findings provide evidence for the understanding that aspects of the organisation lead to the circumstances from which later events may precipitate the accident. Moreover, the data suggest that being able to identify the precursors of critical events can provide a specific focus for prevention.

Keywords: workplace accident; factor; accident analysis.

1 Introduction

Injuries from accidents are a threat to health in every country. In 1990 they were responsible for 6–7% of world mortality (Murray; Lopez, 1997). Workplace accidents are very costly (Hamalainem; Takala; Saarela, 2006). In Brazil, about 2 500 fatal workplace accidents were reported in 2010 for a direct cost of nearly $6 billion (Gonçalves, 2011). An understanding of the underlying causes of accidents is essential for their prevention. An accident investigation allows a view into an organization that is normally not possible. There is little doubt that human factors represent the most important single causal factor in critical incidents, including industrial accidents (Feyer; Williamson; Cairns, 1997; Hale; Glendon, 1987; Reason, 1997). Unfortunately, simply counting the presence of human factors does not provide very clear direction for preventive efforts. The human factor is not a unitary phenomenon and part of the problem with understanding its role and dealing with its impact arises from the complexity of such a large category. Aspects such as the nature and timing of errors, as well as the involvement of poor organizational practices, all need to be considered because the remedial actions required as part of preventive efforts are very much dependent on the nature of the human factors involved. Furthermore, the network of relationships between human factors, as well as between human factors and other factors may also provide insights about targets for prevention by identifying critical points in the chain of events leading to accidents. The challenge is not only to describe how accidents occur but also to show where and how effective remedial measures might be applied.

Hence, attempting to distinguish between the conceptual phenomena among human factors involved in accidents would seem to have considerable potential for directing preventive efforts. In a recent theoretical framework, Reason and colleagues have incorporated the wider human and organizational components of accident causation in high hazard low risk settings (Reason, 1990; Hudson et al., 1994). It is argued that organizational and managerial factors constitute latent failures in work systems analogous to latent pathogens in biological systems. It follows then that important human contributions to accidents

can occur well before their impact is detected, can involve organizational processes as well as actions and complex sequential relationships. Besides, it is proposed by these authors that intervention is likely to be much more effective if underlying features of the causal sequence are targeted rather than the active failures at the sharp end of the causal sequence because latent failures are the origins of the sequence and are likely to be of a few types only while human active failures are likely to be many and varied (Reason, 1990).

An important question, however, is whether the considerations pertinent in high hazard low risk situations such as major disasters are indeed applicable to industrial accidents in general. At a theoretical level, the importance of organizational and managerial factors in industrial accidents is well recognized (Feyer,Williamson and Cairns, 1997; Hale and Glendon, 1987; Reason, 1990).

Yet, evidence detailing such factors is limited. Analysis of aggregated accident data rather than single case analysis is needed to provide a quantitative basis for the distinction between different categories of factors in accident causation and the relative importance of such distinctions.

The present paper presents the main factors which contributed to fatal workplace accidents in Brazil from 2007 to 2011 and the correlation between them aiming to show the nature of those multi causal events, help to understand it and propose measures for their prevention. This paper also presents the analysis of the nature of these factors and clusters them in categories. The data were collected from the reports inserted in the Federal Inspection of Labor System (FILS) by Federal Auditing of the Ministry of Labor and Employment of Brazil.

2 Accident Causation Models

Many accident investigations do not go far enough. They identify the technical cause of the accident, and then connect it to a variant of "operator error" – the line worker who forgot to insert the bolt, the engineer who miscalculated the stress, or the manager who made the wrong decision. But this is seldom the entire issue. When the determinations of the causal chain are limited to the technical flaw and human failure, typically the actions taken to prevent a similar event in the future are also limited: fix the technical problem and replace or retrain the individual responsible. Putting these corrections in place leads to another mistake – the belief that the problem is solved (Columbia, 2003).

The traditional approach to accidents assumes that compliance with procedures and norms protects the system from accidents and that these events are caused by the faulty behavior of workers, which results partly from personality aspects. Identification of these behaviors can be based on comparing them with the standard "safe working practices", which safety experts are aware of ahead of time. In recent decades, new alternative views have expanded the perimeters of accident analyses and opened the way to questioning the assumption of the traditional approach to the concepts of the human being and work. These new approaches help to highlight the sterile results of traditional practices: blaming and punishing victims, recommending training, and proposing norms without changing the systems in which the accidents took place. The new approaches suggest that the traditional approach is totally worn out and emphasize the importance of operator contribution for system safety (Almeida, 2006).

During the 19th and early 20th centuries many safety practitioners and factory inspectorates took the view that preventative physical measures such as machine guarding, housekeeping and hazard inspections were the best to prevent accidents (Cooper, 1998). This view was predicated on the belief that controlling physical work conditions would prevent the majority of accidents. Despite these types of precaution, however, accidents continued to increase at an alarming rate in British factories during and after the First World War. This led to the commissioning of government committees to examine whether accidents were caused by physical working conditions (situational factors) or individual characteristics (personal factors). This differentiation was partly based on the hereditary versus environment debate brought about by Darwin's racial theory of evolution, and partly because in-depth knowledge about the causes of accidents could lead the appropriate counter-measures being applied (Cooper, 1998).

Despite recognition by early researchers of the role that managerial and organisational factors played in the accident causation chain, most practitioners focused almost exclusively on the prominence of employee's unsafe acts. This research led to Heinrich's seminal work 'Industrial Accident Prevention", published in 1931. Heinrich postulated that accidents were caused by either an unsafe act, an unsafe condition, or both. Termed the 'Domino' theory, this work provided the first sequential of the accident causation process. In Brazil, many practitioners have continued to investigate accidents based on dichotomic conception of unsafe act and unsafe condition; yet, frequently, the result of these investigations blame the individual for the unsafe act, or merely identify and rectify the immediate unsafe conditions, rather than examining how and why the unsafe act occurred, or how the unsafe condition was created (Cooper, 2000; Vilela; Iguti; Almeida, 2004).

Within the social sciences there are various 'ways of seeing' the accident phenomena: Marxist (Nichols, 1997), functionalist (Perrow, 1984), and phenomenological. Dwyer, reflecting upon the lack of an adequate theoretical conceptualization of the causes of industrial accidents, the lack of systematic analyses of workplaces and the conceptual blindspots of the predominant preventive techniques, concluded that detailed case studies of workplaces would generate new theoretical ideas on the production of accidents and lead to more effective prevention techniques (Dwyer, 1989, 1991). His theory of accident causation aims to link macro with micro-social elements. The theory reflects the dynamic nature of workplaces and seeks to analyze the social relations which manage people and the relationships to their work at the moment when the dangers of the job result in an accident, and to thereby discover the social relation that causes the event. As Dodier (1993) pointed out, an important aspect of the theory is that Dwyer integrated into his analyses the demands of the workers and their points of view on safety. Dwyer's theory is that the day-to-day working out of the social relations that govern relationships between workers and employers (or their representatives) produces accidents.

Although the 'Domino' theory model described above have proved useful in identifying the sequence of events in the accident causation chain, they have largely failed to specify how and under what conditions each of the sequential elements might interact to produce accidents. A more recent causation model by Reason (1997) has largely overcome these shortcomings. Reason likened the accident causation process to 'resident pathogens' in the human body. Similar in concept to physiological immune systems, Reason (1997) argued that all organisational systems carry seeds of their own demise in the form of these pathogens. Reason termed these resident pathogens as 'latent' conditions. He suggested that the 'latent' conditions lie dormant, accumulate and subsequently combine with other latent failures which are then triggered by 'active' conditions (e.g. unsafe acts) to overcome the system's defenses and cause accidents. Reason proposed that 'active' conditions were caused by poor collective attitudes or by unintentionally choosing the 'wrong' behavioural response in a given situation, both of which may result in a breach of the system. According to Reason (1997), it is now recognised that people working in complex systems make errors or violate procedures for reasons that generally go beyond the scope of individual psychology. These reasons are latent failures. In this paper the theory defined by Reason is applied, although it is not always easy to draw a hard and fast line between individual and organisational accidents, according to Reason. In later works, Reason recognised the limitations of his original resident pathogen model and, in conjunction with Wreathall, identified how and where latent and active failures might be introduced into an organisational system. This modified model suggests that pathogens are introduced into the system by two routes:

- latent conditions caused by organisational or managerial factors (e.g. top-level decision-making).
- Active failures caused by individuals (e.g. psychological or behavioural precursors).

3 Method

The 3 632 cases analyzed were collected from the reports inserted in the Federal Inspection of Labor System (FILS) by Federal Auditors of the Ministry of Labor and Employment of Brazil. The reports of workplace accidents occurred in Brazil throughout the years 2007-2011 were all analysed.

The FILS is a system developed by the Ministry of Labor and Employment of Brazil where all workplace accidents reports are inserted by Federal Auditors. The access to insert and to consult data in FILS is restricted to the Federal Auditors of the Ministry of Labor and Employment of Brazil. The reports are elaborated and inserted in the FILS after the analysis of workplace accident by a Federal Auditor. The Federal Auditor's reports are relatively comprehensive. They contain a textual account of the circumstances of the accident and subsequent fatality, as well as demographic information about the person, cause of death and details of all investigations into the causes of death.

The factors related to workplace accident identified in the Federal Auditor's report were clustered into the following categories:

- environment - factors resulting from location of the accident (e.g. noise, heat, ventilation, housekeeping, etc)
- task - factors related to the development of the real activity. The rules and procedure to execution of the activity are not included.
- organisational - factors resulting from latent conditions, such as poor design, gaps in supervision, undetected manufacturing defects or maintenance failures, unworkable procedures, clumsy automation, shortfalls training, less than adequate tools and equipment.
- material - factors resulting from machinery, tools, personal protective equipment or safety equipment
- human - factors resulting from physical, psychological and physiological characteristics, experience and qualification of the individual.
- maintenance - factors resulting from actions and measures needed to restore or to conserve items (e.g. installations, equipment, builds, machine, etc). Include lubrication, cleanness, unscheduled repair, inspections, planned preventive and predictive maintenance, calibration and testing.

After analyzing the data from FILS, the factors were identified and associated with the five categories described above. As many factors were identified for each category, it would be impractical to list all of them here, so only the five most frequently factors identified in each category were chosen.

4 Results

Table 1 shows the five most frequent factors for environment category and the frequency that each one of them was identified. The most frequent factor identified was *Inadequate temporary access mean* that was detected in 221 fatal workplace accidents. This shows that the temporary or permanent access to the place where the task was performed was unsafe, so there was risk of fall of the employees. The factor *Circulation difficulty* was identified in 179 fatal workplace accidents. This result indicates that a bad housekeeping and that the employees had difficulty with locomotion in the workplace environment. The factor *Energized exposed part* reveals that there were machines, tools and equipment with energized exposed part, so the risk of electric shock was present in workplace. This was identified in 111 fatal workplace accidents.

Table 1: Five factors for environment category

Factors	Frequency
Inadequate temporary access mean	221
Circulation difficulty	179
Inadequate permanent access mean	167
Energized exposed part	111
Others	174

Source: FILS of Ministry of Labor and Employment

Table 1 shows the five most frequent factors for task category and the frequency that each one of them was identified. The most frequent factors were risk detection failure, that means that the employees were

not able to detect the risk to prevent the accident in advance (this was identified in 1352 fatal work-related accidents), also inadequate operative manner safety, which shows that the employees operated in an unsafe way - for example, operated with body part close to mobile part of machine. Besides those two, improvisation reveals that tools and material were used to do different tasks for which they were not projected. This was identified in 539 fatal workplace accidents. In 239 fatal workplace accidents analyzed improper use of tools, material and equipment was identified; for example, the use of wrong raw material and the use of tool or equipment beyond their capacity. In 226 fatal workplace accidents it was identified that there was not any protection against fall for habitual job in height, so there was risk of fall for the employees.

Table 2: Five factors for task category

Factors	Frequency
Risk detection failure	1352
Inadequate operative manner safety	1105
Improvisation	539
Improper use of tools, material and equipment	239
Habitual job in height without protection against fall	226

Source: FILS of Ministry of Labor and Employment

The most frequent factors identified which are associated with organisational category are shown in Table 1. The factor *No or Inadequate risk analysis* was the most frequent factor identified. This factor contributed to 817 fatal workplace accidents. This depicts that risk analysis was not a work practice in the organisations where the accidents occurred. The factor *No or poor training* contributed with 792 fatal workplace accidents. This reveals that the employees were not trained or were poorly trained to perform the task. This is an evidence that training is essential to prevent workplace accidents. The factor *No job procedure* is related to 608 fatal workplace accidents and *No task planning* is related to 424 fatal workplace accidents. This shows that there was neither job procedure nor task planning in the workplace. The factor *No or poor supervision* is related to 359 fatal workplace accidents. This result is indicative that a good supervision is necessary to prevent accidents.

Table 3: Five factors for organisational category

Factors	Frequency
No risk analysis or inadequate risk analysis	817
No training or poor training	792
No job procedure	608
No task planning	424
No supervision or poor supervision	359

Source: FILS of Ministry of Labor and Employment

The factors which were most frequently identified concerning material category are shown in Table 1. The factor *Personal protective equipment not provided* was identified in 231 fatal workplace accidents and the factor *Personal protective equipment not used (unknown if provided)* is related to 80 of them. According to Brazilian laws, the employer must provide personal protective equipment for employees and make them use it. The factor *No or Inadequate protection system* contributed with 160 fatal workplace accidents and the factor *protection system away for suppression* is related to 72 of them. This shows that the protection system against accidents did not exist or was out because it was suppressed for someone. The factor *Protection system, poorly designed tools and equipment related to safety* contributed with 132 fatal workplace accidents. This points out that tools and equipment were not adequately designed for

protection against workplace accidents, so they caused to the accident to occur. The existence of tools and equipment with adequate accident protection is important to prevent accidents.

Table 4: Five factors for material category

Factors	Frequency
Personal protective equipment not provided	231
No protection system or inadequate protection system	160
Protection system/tools/ poorly designed equipment relating safety	132
Personal protective equipment not used (unknown if provided)	80
Protection system away for suppression	72

Source: FILS of Ministry of Labor and Employment

According to the data in Table 1 the two most frequent factors are related to the individual's inexperience. The *Inexperienced to occupy no habitual post* and *Inexperienced for little time in the organisation* appear with frequency 131 and 125, respectively. This result is an indicative that the employees' inexperience is a factor that contributes to workplace accident. Another factor related to human category is the employee's fatigue, which was identified in 144 fatal workplace accidents. These data show that excessive labor hours and little or no rest influence in workplace accidents. Another factor that contributed with 104 fatal workplace accidents was the employee's lack of knowledge in how to operate the equipment or the equipment condition.

Table 5: Five factors for human category

Factors	Frequency
Inexperienced to occupy no habitual post	131
Inexperienced for little time in the organisation	125
Fatigue	144
Ignorance to operate equipment/equipment condition	104
Others	188

Source: FILS of Ministry of Labor and Employment

No preventive maintenance was the most frequently identified factor related to maintenance category, according to Table 1. This factor contributed with 101 fatal workplace accidents. *Maintenance* with energized or moving equipment was identified in 78 fatal workplace accidents. These results show that the maintenance was executed in an unsafe way. These results indicate that preventive and predictive maintenance of equipment and performance with safety are important factors to accident prevention.

Table 6: Five factors for maintenance category

Factors	Frequency
No preventive maintenance	101
No or inadequate signaling	64
Maintenance with energized equipment	48
Maintenance with moving equipment	30
No predictive maintenance	24

Source: FILS of Ministry of Labor and Employment

The results in Table 1 were obtained by summing up the frequency of the correspondent factors of each category. As an accident analysis can identify more than one factor for the same category (e.g., in some accident analysis the factors - circulation difficulty and risk detection failure related to task category – can be identified), the total frequency does not correspond to the total number of accidents. The results show that the most identified factors were first those related to task category and secondly were those factors related to organisation category. The factors related to human category were the fifth among the most frequent ones. These results show that the human-related factors are not the most frequent in workplace accidents. Other factors are more important to accident prevention than factors related to humans, such as factors which are related to task and organisation.

Table 7: Frequent for each category

Category	Frequency
Task	3461
Organisational	3000
Environment	852
Material	675
Human	662
Maintenance	267

Source: FILS of Ministry of Labor and Employment

5 Examination of the relationship between factors

The *Pearson correlation coefficient* was used to examine if there is a relationship between some factors described above. The coefficient value has to lie between -1 and +1. A coefficient +1 indicates that the two factors are perfectly positively correlated, so as one factor increases, the other increases by a proportionate amount. Conversely, a coefficient of -1 indicates a perfect negative relationship: if one variable increases, the other decreases by a proportionate amount. A coefficient of zero indicates no linear relationship at all and so if one factor changes, the other stays the same. The measure of + or -1 is commonly used and represent a small relationship; + or - .3 is a medium relationship and + or -.5 is a large relationship (Field, 2009). Although it can analyse the correlation between factors, it is not possible to draw direct conclusions about causality from a correlation. In this paper, only the relationship between factors from task and organisational category with larger frequency were analysed, because it would be impractical to establish a relationship to every 30 factors.

There was a significant relationship between the factors *risk detection failure* (task category) and *No or Inadequate risk analysis* (organisation category), r=.942, p (one-tailed) <.01. This result shows that when the *no or inadequate risk analysis* was done, the frequency of the factor *risk detection failure* increased.

The factor *improvisation* was significantly correlated with *no job procedure,* r=.959, p (one-tailed) <.01. Although we cannot come to direct conclusions about causality from correlation, this significant correlation shows that no job procedure can result in improvisation of the employees. The *improvisation* was also significantly correlated with *no or inadequate risk analysis*, r=.959, p (one-tailed) <.01.

The factor *inadequate operative manner safety* was significantly related to the factor *no or poor supervision,* r=.810, p (one-tailed) <.05. *Inadequate operative manner safety* was also correlated with the factor *no or poor training,* r=.844, p (one-tailed) <.05. These obtained results indicate that no or poor training and no or poor supervision can influence the employees to operate safety in an inadequate way.

There was a significant relationship between *fatigue* and *risk detection failure,* r=.909, p (one-tailed) <.05. *Fatigue* was also correlated with both *inadequate operative manner safety,* r=.918, p (one-tailed) <.05, and

maintenance with energized equipment, r=.810, p (one-tailed) <.05. These results show that fatigue, which causes wakefulness reduction, can cause the employees' unsafe performance and failure in risk detection.

Habitual job in height without protection against fall was significantly correlated with the following factors: *risk detection failure* (r=.836, p (one-tailed) <.05), *no or inadequate risk analysis,* (r=.894, p (one-tailed) <.05) and *no job procedure* (r=.925, p (one-tailed) <.05). These results indicate that an inadequate or no risk analysis and no job procedure can put the employees' work in height without protection against fall in serious danger.

There was not any relationship between *improper use of tools, material and equipment* and the factors *No or Inadequate risk analysis, no or poor training, no job procedure, no or poor supervision and no task planning*.

6 Discussion

The data presented depict the multiple causality of the fatal workplace accidents occurred between 2007 and 2011 in Brazil. This shows that workplace accidents are complex events with multiple causal factors; therefore, accidents are difficult events to understand and control. These interacted causal factors cause fatal workplace accidents, as it was described earlier. The understanding of these interactions is essential to propose measure to prevent them. Preventive measures based on few factors are limited and do not cover all of them.

Organisational factors played an important role in the happening of workplace accidents. These factors were the second most frequently identified, but they had significant correlation with task factors - the first most frequently identified factor. The human factors were only the fifth most frequently identified and with low frequency when compared with both task and organisation factors. Therefore, the discovery of human factors immediately prior to the bad outcome would not have closed the book on the investigation of an accident. Today, neither investigators nor responsible organisations are likely to end their search for the causes of an accident with the mere identification of "sharp-end" human failures. Such human failures are now seen more as consequences than causes, because accidents can, and usually do, have organisational origins, according to Reason (1997). It is still usual to claim that human factor is implicated in 80-90 per cent of all accidents, because people design, build, operate, maintain, manage and defend hazardous technologies. It is hardly surprising, therefore, that the human factor plays the major part in both causing and preventing accidents. While probably close to the truth, this statement adds very little to our understanding of how and why accidents happen.

7 Conclusion

Workplace accidents have still happened with large frequency, are very costly and bring suffering to people, families, society, organisations' and countries' economy and environment. Thus, it is an important task and challenge for researchers, engineers, psychologists and other professionals involved with safety. The understanding of how the accidents happen allows to propose measures for prevention. This paper presented the large number of factors involved in fatal workplace accidents and the correlation between some of them, evidencing, therefore, the multi causal nature of these events and its complexity. In addition, the findings reinforce the need for analysis of aggregated accident data in order to obtain a clear understanding of the common factors underlying accident causation in workplaces. This form of analysis not only shows how accidents are caused, but also the form that preventive action should take in response to these accident causes. In conclusion, it will hopefully contribute to its understanding and prevention in order to reduce the large number of accidents.

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