Accident Analysis and Prevention 94 (2016) 107–118

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Strategies for improving safety performance in construction firms

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ARTICLE INFO

Article history:
Received 21 February 2016
Received in revised form 10 May 2016
Accepted 20 May 2016

Keywords:
Accident rate
Chile
Construction company
Prevention practice
Safety management
Strategy

ABSTRACT

Over the years many prevention management practices have been implemented to prevent and mitigate accidents at the construction site. However, there is little evidence of the effectiveness of individual or combined practices used by companies to manage occupational health and safety issues. The authors selected a sample of 1180 construction firms and 221 individual practices applied in these companies to analyze their effectiveness reducing injury rates over a period of four years in Chile. Different methods were used to study this massive database including: visual analyses of graphical information, statistical analyses and classification techniques. Results showed that practices related to safety incentives and rewards are the most effective from the accident rate viewpoint, even though they are seldom used by companies; on the other hand, practices related to accidents and incidents investigation had a slight negative impact on the accident rate because they are frequently used as a reactive measure. In general, the higher the percentage of prevention practices implemented in a strategy, the lower the accident rate. However, the analysis of the combined effect of prevention practices indicated that the choice of the right combination of practices was more important than just the number of practices implemented.

1. Introduction

Occupational safety and health have always been sensitive issues in the construction industry, particularly considering its high number of accidents (Hallowell, 2012; Pellicer et al., 2014). These accidents not only affect the health of workers, but also the future lives of entire families (Hinze, 2002a). They are also a source of losses for construction companies (Waehrer et al., 2007; Pellicer et al., 2014). Any contribution to help reduce occupational accidents in the construction industry can be considered worthy.

Throughout the years, the occurrence of accidents has gone from being considered a random phenomenon (Greenwood and Woods, 1919) to being the result of a series of factors that are possible to determine and control; there are many sources, at the individual and organizational level, that can cause accidents (Bird and Germain, 1990). Razuri et al. (2007) suggested that a combination of practices generates an incremental contribution of safety performance. Hence, prevention has become multifocal, meaning that there is no single formula to prevent accidents, but rather efforts or strategies to cover multiple areas of work. Therefore, detecting the best performing combinations of practices or strategies for different sizes of companies with different needs is a promising field; this is the point of departure of this research.

In order to pursue this exploration further, the authors contacted the Safety Mutual of the Chilean Chamber of Construction; this a non-profit organization that provides medical insurance and technical assistance on safety management to companies in all types of industries. The authors, working with the Safety Mutual of the Chilean Chamber of Construction, selected a data sample of more than one thousand construction firms, and two hundred individual safety practices applied in these companies, so as to analyze their effectiveness in increasing safety performance over a period of four years. The analysis of safety performance (specifically the accident rate) and the implemented safety practices allows the identification of combined practices (strategies), and the selection of analysis techniques that have the potential to support the design of safety management strategies in the near future.

In the context of this research, a safety practice is a managerial process that implements one or more tools and techniques aiming to increase the occupational safety of the employees in a systematic way (Vinodkumar and Bhasi, 2010; Bridi et al., 2013). These safety practices can lead to a safety culture in the organization, where collective behaviors of people become a pattern (Fung et al., 2005). From this research viewpoint, safety performance is mea-

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http://dx.doi.org/10.1016/j.aap.2016.05.021
0001-4575/

sured using the accident rate, since it is a quantitative, reliable and common indicator (Vinodkumar and Bhasi, 2010; Hallowell et al., 2013; Wachter and Yorio, 2014). This indicator measures only those incidents that turn into injures or fatalities of workers (accidents). According to the Chilean law, information regarding accidents, and therefore the accident rates, is obtained directly from the official occupational accident report submitted to the Safety Mutual, which is considered to be a reliable source of information.

The rest of the paper is organized as follows. First, a literature review of safety management practices is carried out, and the knowledge gap is identified. Later, the research method is explained. This section is followed by a description and discussion of the results, considering different analysis techniques. Finally, the main contributions, limitations and future research are highlighted in the Conclusions section.

2. Literature review

Accidents happen in spite of the efforts that are done to prevent them. Knowing the underlying causes of accidents would allow attacking the root of this problem. Several authors have proposed different theories to predict their occurrence. First, Greenwood and Woods (1919) proposed the theory of accident-proneness; it states that accidents do not only happen randomly but rather some people are more prone to have an accident. Later research has not obtained conclusive evidence either for or against this theory, arguing that people can go through more accident-prone periods according to their psychological state.

In 1931, Heinrich developed the domino theory, proposing that a sequence of factors led to accidents. These factors were mostly focused on the person, and how they are influenced by personal mistakes combined with dangerous or unsafe behavior. This behavior causes the accident, which ends up in injury or property damage. Heinrich (1931) postulated that if dangerous or unsafe behavior was removed, then accidents could be prevented. The domino theory was modified by Adams (1976), focusing not on personal characteristics, but on properties of the organization. Adams (1976) suggested that it was the organizational structure that determines the occurrence of operational errors, which are the cause of incidents or accidents. Bird and Germain (1990) specified that accidents had "multiple sources." In other words, there are many causes that can explain an accident; therefore, identifying sources will avoid accidents. This idea is the basis of the studies that try to identify the factors behind the accident, finding that multiple variables affect the outcome.

Later, Howell et al. (2002) proposed a completely different theory based on cognitive systems engineering. These authors highlight that previous approaches do not take into account factors such as the nature and dynamics of work on the construction site. Individual and organizational pressures push workers into hazardous conditions. Howell et al. (2002) argue that there is a safe area in which workers perform their work, bounded by the pressures of economic failure of the organization, personal exertion and acceptable performance. These external pressures can make the worker start working in the area where there is a loss of control.

Through the years, the occurrence of accidents has gone from being considered a random phenomenon to being the result of a series of factors that are possible to determine and control. Meanwhile, the main cause of accidents stopped being the person as an individual, or his/her characteristics or the company itself, to a much more complex scenario, in which there are multiple sources at the individual and organizational level that can cause accidents (Bird and Germain, 1990). Therefore, identifying the main factors affecting safety performance in projects has been a goal for researchers and practitioners over many years and not only in the construction industry. Since the nineties, there have been many studies that attempt to identify the practices that are most effective in reducing accidents. Most of these studies have been based on surveys or case studies considering the preventive activities performed in construction projects. Table 1 shows a historical overview of the most relevant studies and practices identified so far, as well as the data collection method employed.

One of the most relevant papers in the field was published by Jaselskis et al. (1996) who proposed specific practices to improve safety at the project and company level. The additional merit of this work is that it used empirical data, such as recordable incident rates (or accident rates) and experience modification rates. Using a survey of corporate safety coordinators, these authors found that the most significant practices were: upper-management attitude, project-management team turnover, time devoted to safety by field safety representatives, formal and informal safety meetings with supervisors, specialty sub-contractors, site safety inspections, and worker safety performance penalties.

Later, a research report issued by the Construction Industry Institute identified the five practices with the greatest impact in reducing accidents (Liska et al., 1993; Hinze and Wilson, 2000): pre-project and pre-task planning, safety orientation and specialized training, evaluation and reward, drug and alcohol testing, and accident and incident investigation. Later on, Hinze (2002a) extended these five techniques to nine, adding the following: management commitment, staffing for safety, worker involvement, and subcontractor management.

Besides these nine factors that are widely recognized among researchers and practitioners (Hallowell et al., 2013; Hinze et al., 2013), three additional ones have been included in the literature review (see Table 1): safety equipment, safety audits, and management safety training. In 1999, Sawacha and colleagues carried out a survey of construction workers in the United Kingdom; they concluded that the supply and use of safety equipment was among the top five most effective practices (Sawacha et al., 1999). Similar studies, such as the ones developed by Fang et al. (2004), Tam et al. (2004), Fung et al. (2005), Vinodkumar and Bhasi (2010), and Wu et al. (2015) corroborated this finding. Regarding safety audits and inspections, Jaselskis et al. (1996) considered them to be key recommended practices; this proposal was later supported by Fang et al. (2004), Huang and Hinze (2006), Vinodkumar and Bhasi (2010), Hallowell (2012), and Olutuase (2014), among others.

Training of upper management in safety issues is not a common practice among contributors; however, the authors of this research have added it because of personal conviction of its importance. Pellicer and Molenaar (2009) stated the key importance of education and training for engineering managers, especially in the construction industry, and how it influences the safety culture. Even though most of the authors analyzed proposed training up to the supervisor level, as described in Guo and Yiu (2016), just a few (Razuri et al., 2007; Hallowell, 2012) have taken into consideration training of the managers; Fang et al. (2004) measured the hours of safety education per year for a manager, including it as a main factor regarding safety education in construction.

After reviewing the most relevant literature in the field, very few contributions regarding safety management practices implemented by construction companies deal with empirical studies that relate these practices to better safety performance. Jaselskis et al. (1996) were pioneers in this matter, setting the course. However, it was not until recently that Yorio and Wachter (2014) and Wachter and Yorio (2014) developed an empirical study of safety management practices based on the accident rate as well as the days away, restricted duty, or job transfer rate. Furthermore, the authors of this paper have found few studies that analyze a combination of practices, instead of the effect of individual practices. Therefore,