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Systems thinking applied to safety during manual handling tasks in the transport and storage industry

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ABSTRACT

Injuries resulting from manual handling tasks represent an on-going problem for the transport and storage industry. This article describes an application of a systems theory-based approach, Rasmussen's (1997. Safety Science 27, 183), risk management framework, to the analysis of the factors influencing safety during manual handling activities in a freight handling organisation. Observations of manual handling activities, cognitive decision method interviews with workers ($n = 27$) and interviews with managers ($n = 35$) were used to gather information about three manual handling activities. Hierarchical task analysis and thematic analysis were used to identify potential risk factors and performance shaping factors across the levels of Rasmussen's framework. These different data sources were then integrated using Rasmussen's Accimap technique to provide an overall analysis of the factors influencing safety during manual handling activities in this context. The findings demonstrate how a systems theory-based approach can be applied to this domain, and suggest that policy-orientated, rather than worker-orientated, changes are required to prevent future manual handling injuries.

1. Introduction

Injuries resulting from manual handling tasks represent an on-going problem for the transport and storage industry in Australia and worldwide. In Australia the rates of serious claims are the highest of all industries (21.4 compared to 12.6 per 1000 employees) with 42% of claims caused by muscular stress due to manual handling (2009–2010 data; Safe Work Australia, 2012a). As a result, transport and storage has been identified as a priority industry in nationally-led government strategies since 2002; however, significant headway in reducing these injuries has not been achieved (Safe Work Australia, 2012b). Internationally, a survey of baggage handlers revealed that 46% had suffered a back injury while at work (Dell, 1998). Two epidemiological studies, each conducted among more than 31,000 American workers in warehouse superstores, show a link between manual handling activities and back pain (Gardner et al., 1999; Kraus et al., 1997). This suggests that the approaches currently employed in this industry are insufficient for understanding and addressing the factors that impact on safety during manual handling tasks. In other safety critical domains the systems approach has been successfully adopted as a way of understanding and enhancing safety and performance. This article describes an application of a systems theory-based approach, Rasmussen's (1997) risk management framework and associated Accimap technique, to the analysis of the factors influencing safety in a freight handling organisation.

1.1. Rasmussen's (1997) risk management framework

Rasmussen's framework is underpinned by the idea that sociotechnical systems comprise various levels; actions and decisions across these levels interact with one another and contribute to the control of hazardous processes. The system for controlling these processes is described as a hierarchy across multiple levels including:

- a *Government* level at which laws and regulations are developed;
- a *Regulatory* level at which industry standards are developed based on laws and regulations;
- a *Company* level where company policies and procedures based on industry standards govern work processes;
- a *Management* level where company policies and procedures are implemented;
- a *Staff* level representing the activities and characteristics of workers performing the processes; and

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- a *Work* level representing the equipment and environment within the work context.

In order to maintain operations within the limits of safe practice, decisions at higher levels (i.e. *Company, Regulatory, Government*) should influence actions at the lower levels, while information about the current state of affairs (i.e. from workers) should transmit up the hierarchy and shape the decisions at the higher levels; a process known as *vertical integration* (Rasmussen, 1997; Svedung and Rasmussen, 2002).

In conjunction with this framework, Rasmussen developed the Accimap technique to graphically represent the conditions that produce accidents (Rasmussen, 1997; Svedung and Rasmussen, 2002). Using Accimap involves constructing a causal diagram of the components, decisions and actions that interact with one another to create the system in which the accident in question occurred, as well as the relationships between them. This technique has been used to represent large-scale organisational accidents in multiple domains (e.g. Branford, 2011; Cassano-Piché et al., 2006; Jenkins et al., 2010; Johnson and de Almeida, 2008; Salmon et al., 2013; Vincente and Christoffersen, 2006) and to aggregate across situations for a particular hazard domain (Svedung and Rasmussen, 2002) to devise risk management strategies.

Rasmussen's framework and the Accimap technique were developed to better understand the mechanisms underpinning rare, large scale accidents in high risk industrial settings. The type of accidents considered occurred due to the loss of control of hazardous physical processes that would normally have been isolated from disturbances. In contrast, the current paper is concerned with the frequent, small-scale occupational accidents that occur within repetitive task settings (i.e. occupational accidents; Hovden et al., 2010). The work conditions at the time of the injury are unlikely to be considered abnormal, although they may present a continual risk to the worker. When it comes to injury prevention in such settings, most experts and practitioners tend to focus on the immediate task context.

However, there are a number of reasons why a systems approach (Rasmussen's in particular) may provide useful insights into the causes of occupational injuries. First and foremost, accident models primarily consist of a set of assumptions about how accidents happen and what the important factors are. Hence, you only find what you look for Lundberg et al. (2009). The assumption that the causes of injuries resulting from manual handling tasks are constrained to the task setting needs to be tested. Second, although Australian codes of practice (e.g. Safe Work Australia, 2011a,b) recognise that multiple factors (e.g. environmental conditions, workplace layout, nature of objects to be handled, systems of work, psychosocial factors) contribute to workplace accidents, no guidance is provided on how to model this system of factors. Third, typical risk assessment frameworks for manual tasks (e.g. Safe Work Australia, 2011a) tend to involve the decomposition of tasks into a series of steps to identify potential hazards. While this provides useful insights, the task analyst cannot foresee all the contingencies within the future work context: workers often develop "short cuts" to achieve work goals in response to pressures in the environment. A proactive approach to risk management requires a consideration of the factors that shape decision-making and behaviour in the work context (i.e. performance shaping factors), as well as an understanding of the hazards inherent to the activity (i.e. risk factors) (Rasmussen and Svedung, 2000). Rasmussen's framework and Accimap technique provide a means by which to integrate these perspectives in order develop an overall picture of the factors influencing the safety of operations.

The following section illustrates how the factors identified in previous research in this domain align with Rasmussen's framework.

1.2. Previous research on manual handling in the transport and storage industry

Relevant research has been conducted in two key contexts in the transport and storage industry: baggage handling in aviation and stock management in warehouses. Studies in these contexts focus on two types of manual handling injuries: accident-related injuries and musculoskeletal disorders related to repeated exposure. Considering the causal factors involved in both types of injuries should provide a holistic picture of the factors impacting on safety during manual handling activities in this domain.

Fig. 1 depicts a summary of the system of factors that have been found to influence safety during manual handling activities in these contexts, classified according to Rasmussen's framework. The majority of the factors identified in the literature can be placed at the *Work* level, with most studies identifying workspace layout and product-related factors (e.g. item weight, size, type, labels) as potentially hazardous. Fewer studies identified factors at the higher levels. Similarly, the majority of relationships identified represent interactions between the lower levels (i.e. *Staff* and *Work* levels). For example, across both contexts, the impact of workspace layout on worker posture was frequently identified as a hazard. Low aircraft ceilings force baggage handlers to squat or kneel (Dell, 1998; Rückert et al., 1992; Stålhammar et al., 1986). Poor shelf design force warehouse workers to adopt awkward postures, increasing their physical workload (Denis et al., 2006; St-Vincent et al., 2005). Other relationships between these levels include: fatigue caused by constant exposure to aircraft noise, and wearing gloves (PPE) that reduce the ability to grip (Tapley and Riley, 2005); equipment incompatibilities increase time pressure and the physical effort required by workers (St-Vincent et al., 2005). Only two relationships were identified between factors at the *Management* and lower levels: poor planning of work activities leads to poor workspace layout and increased time pressure (St-Vincent et al., 2005; Denis et al., 2006).

The lack of factors at the higher levels and few relationships between factors is inconsistent with the view that accidents in sociotechnical systems are caused by a range of interacting human and systemic factors (e.g. Leveson et al., 2009; Rasmussen, 1997; Reason, 1997), suggesting that knowledge of the important factors influencing safety in this domain is incomplete. It is apparent from the literature that the methodologies used to study safety in this domain have been insufficient to support the collection of 'systems' data. For example, the majority of studies reviewed employed direct observations of manual handling activities (Denis et al., 2006; Junior, 2012; Kecojevic et al., 2007; Korkmaz et al., 2006; St-Vincent et al., 2005; Stålhammar et al., 1986; Tapley and Riley, 2005). As a result, factors at the higher levels were not captured because in most cases they are not directly observable. The review suggests that studies which have employed surveys (e.g. de Koster et al., 2011; Dell, 1998) and/or interviews with workers and managers (e.g. Denis et al., 2006; St-Vincent et al., 2005; Tapley and Riley, 2005) seem better able to capture factors at the higher levels, as they can assess aspects that are not observable or that may only reveal themselves over time. This suggests that a systems perspective on manual handling safety will be best supported through a multi-method approach.

1.3. Transport and storage industry manual handling case study

The aim of this study is to examine the factors influencing safety during manual handling tasks in the transport and storage