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Construction accident causality: An institutional analysis of heat illness incidents on site

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A R T I C L E I N F O

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A B S T R A C T

The behaviour-based approach has been widely used to develop interventions for construction accident prevention. The actual effects of such interventions, however, often do not meet expectation or have only a short-term effect. Recent studies look beyond the immediate accident circumstances to shed light on systemic factors that lead to accidents. The authors present an institutional analysis of construction accident causality through investigation of heat illness cases on construction sites. Heat illness is a special type of incident in which the individual is both the victim and, to a certain extent, the agent. Its consequence can be fatal, but its spread to uninvolved personnel is limited. Like other construction accidents, it affects individuals but cannot be effectively managed without addressing the risks embedded in the institutional environment of the system in which the individual is situated. This provides a simplified event for identifying institutional factors affecting construction accident causation at different systems levels in construction projects. The analysis is based on 216 individual construction workers' cases from 29 construction sites, including 36 reported critical incidents of heat illness cases. These are triangulated with data from site observation, interviews with managers and field notes of stakeholders' meetings. Institutional factors that contribute to proactive and reactive behavioural intervention of heat illness development are identified at eight levels of systems. The findings can be used in guiding accident investigation, developing effective interventions and identifying improvement opportunities for stakeholders at different levels of systems related to a construction project.

1. Introduction

The behaviour-based approach has been widely used to develop interventions for construction accident prevention (Lingard and Rowlinson, 1998; Zhang and Fang, 2013; Zohar and Luria, 2003). The actual effects of such interventions, however, often are not as effective as expected. Recent studies look beyond the immediate circumstances of accidents to shed light on systemic and institutional factors that prevent, permit or cause the occurrence of accidents. In the following sections, we present an institutional analysis of construction accident causality through a systemic lens, using heat illness cases as core events. Heat illness on construction sites is a special type of incident in which the individual is both the victim and, to a certain extent, an agent. (This is because the factors of heat stress that contribute to the development of heat illness include both environmental heat and metabolic heat. The later is an outcome of the individual's physical activity. In this sense, heat illness is partially generated by the individual who suffers from it.) Yet as any other construction accidents, it cannot be prevented without addressing the risks embedded in the organisational and institutional environments. The consequences of heat illness can be serious, even fatal, but unlike the catastrophic accidents, the spread of its consequence to other people is limited. This provides a reasonable simplicity in accident analysis and clarity in tracing causal factors at different systems levels.

2. Accident causality through a systemic lens

Systems thinking is a lens to explain and accident causation, focusing on the system as a whole instead of on the discrete components apart. Institutions, defined as socially constructed order of behaviour, can be seen as patterns of connections between components of a system, signifying "what works" within a system. A systemic lens focuses research attention on the risks embedded in how the components of a system are connected in operation. An

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institutional analysis provides a viable methodology to identify these risks and lead to systemic intervention strategies.

Institutions are socially constructed rules and norms governing individual or group behaviours (Schotter, 1981). Initial awareness in the body of knowledge of institutional influences on accident causation can be traced to the 1930s when Heinrich (1941, 2nd ed.) brought to light the occurrence of industrial accidents as not purely a matter of luck but as being rooted in human unsafe behaviour and unsafe exposure. Thus, he propounded that, through proper management procedures and methods in the production system, risks could be eliminated. This is further elaborated by Bird (1974) in his domino theory. In the context of the construction industry, Lingard and Rowlinson (1998) developed a behaviour-based model, stressing the importance of management infrastructure in shaping individual behaviours. Here, institutional factors are recognised in terms of structures, policies, procedures and provisions, extending North's view of institutionalism (North, 1991).

Reason (1997, 2000) developed the Swiss Cheese model of accident causation based on an acceptance of the fallible nature of human beings and a tolerance of individual behavioural errors. Safety is conceptualised as an outcome of the complementary effect of multiple layers of defences in which deficiencies are expected in every layer. The task of systemic defence is to eliminate the trajectory of accident opportunity. Here, latent errors, including "psychological precursors", become the focus of accident causation analysis (Reason, 1990, p. 208).

The Swiss Cheese model has inspired two important construction accident causality models. The ConAC model (Gibb et al., 2006), developed from the study of non-fatal incidents, frames construction accident causation into three levels, i.e., immediate circumstances, shaping factors and originating influences (Haslam et al., 2003, 2005). The systemic model, developed by Hale et al. (2012) from the study of fatal construction accidents, frames accident causal factors into four levels of institutional factors, i.e., the environment, corporate systems, delivery systems, and output from delivery systems. The former has been applied in Australia (Cooke and Lingard, 2011; Lingard et al., 2013) and the USA (Behm and Schneller, 2013) and proved to be useful in guiding accident investigations to look beyond the immediate circumstances of an accident to identify the failures at the upper stream of construction projects such as the design, client actions, education and economic environment (Gibb et al., 2014). In both models, institutions have become the major variables identified.

From a social constructivism perspective, discursive institutionalism sees individual modification of local conditions as part of the existence of the system (Dekker, 2006; Schmidt, 2008). Behind the local operator's adaptation behaviour are motivations of production pressure, financial incentives, convenient work methods and personal priorities. Here, the institution is constructed as a dynamic outcome of the trade-off between conflicting goals and interests. Each local operator is an active agent, who is not only constrained by institutions but also defines the institutions through a process of sense making (Dekker, 2006; Weick et al., 1999). Deficiencies in defences are generated as a result of local operators' attempts to reconcile conflicting goals in response to diverse and changing local contingencies (Dekker, 2002, 2006; Rasmussen, 1997). Indeed, setting priorities amongst competing goals has been identified as a major challenge in construction project organisations (Cherns and Bryant, 1984). At the organisational level, Ju and Rowlinson (2014) illustrate how safety initiatives are twisted during implementation as a result of organisational efforts to reconcile the safety demand of external institutions and the production goals of the organisation.

Dekker (2006) identifies four social political drivers of accident investigation as (1) to allocate responsibilities, (2) to recover justice, (3) to invest in it and (4) to take action on prevention measures. The core question underlying these motivations is "who" is to be accountable for the accident and its prevention. Indeed, construction accident investigations often end up with finger pointing rather than improvement in the system; the question "who is to be responsible for what" or "who can do something about what" is left unanswered. In this light, recent construction safety research focuses on stakeholders in a construction project and their interrelations (Koh et al., 2013). The stakeholder perspective brings out the actors in a multiple institutional environment, enables us to understand the risks and preventions in contexts of accountabilities and responsibilities, and therefore leads to effective interventions.

3. Methodology

The study adopted an inductive approach. Data were collected with a 360-degree approach, coded with institutional analysis and synthesized with a grounded theory approach. Institutional analysis is adopted as a major method in this study. Hollingsworth's (2000) five components of institutional analysis are employed as a guideline for coding and identifying the institutional factors (Table 1). Underpinning institutional analysis is the systemic lens with a stakeholder focus, through which the players at different levels of systems are identified. Deviation analysis is employed as a supplementary analysis method to sort out the individual level factors. In this case, we argue that individual physiological or psychological factors are socially constructed variables between the individual and his/her environment that impact on the individual's repertoire of responses in a hazardous situation.

3.1. Data collection

Data of the study were collected during the process of a project commissioned by the Hong Kong Construction Industry Council (HKCIC) aimed at developing new heat stress guidelines for the construction industry. The participants and informants of the study include construction workers, management personnel and external stakeholders. Of the stakeholder population, a panel of Task Force members for this specific project and a panel of Committee members on construction safety were involved at different stages of the research process. The panel members were representatives of government regulatory department, major clients, major contractors, Contractors' Association, Workers' Union, Observatory, Occupational Safety and Health Council, and HKCIC council members. Therefore, one of the data sources was the field notes on stakeholder concerns and interests, in addition to discourses from six Task Force meetings and two Committee meetings. Of the management population, 96 questionnaires were collected from the managers of both client and contractor organisations under 37 different job titles, ranging from Managing Director and Project Manager to Site Agent. Amongst them, 38 site-based nurses, healthcare officers and safety officers participated semi-structured interviews. Data amongst the worker population and site-based management personnel were collected through baseline studies at three sites in March and April 2011 and summer studies from 29 sites during June to September 2011. Sampling of the field data collection was stratified by three project types (building work, civil engineering work, and repair, maintenance minor alteration and addition work) and major trades (steel bender and fixer, carpenter, bricklayer, plasterer, welder, HAVC fitter, MEP, tunnelling worker and concretor). A two-day data protocol was used for collecting these data. In two consecutive working days, researchers met a crew of six to twelve workers in four sessions before and after work, respectively, for health check, questionnaire survey and semi-structured interviews. Between these two