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Safety inspections in construction sites: A systems thinking perspective

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ABSTRACT

Although safety inspections carried out by government officers are important for the prevention of accidents, there is little in-depth knowledge on their outcomes and processes leading to these. This research deals with this gap by using systems thinking (ST) as a lens for obtaining insights into safety inspections in construction sites. Thirteen case studies of sites with prohibited works were carried out, discussing how four attributes of ST were used in the inspections. The studies were undertaken over 6 years, and sources of evidence involved participant observation, direct observations, analysis of documents and interviews. Two complementary ways for obtaining insights into inspections, based on ST, were identified: (i) the design of the study itself needs to be in line with ST; and (ii) data collection and analysis should focus on the agents involved in the inspections, the interactions between agents, the constraints and opportunities faced by agents, the outcomes of interactions, and the recommendations for influencing interactions.

1. Introduction

External pressure through regulations and inspections is widely accepted as necessary for safety[1] at work, since it can be a hindrance to short-term cost and time goals. Such regulations are constantly evolving and are often prescriptive (Haupt, 2003). An underlying assumption of prescriptive regulations and their enforcement is that safety arises from following rules, independently of the context (Dekker, 2003). However, this linear view of safety has been increasingly questioned by safety management perspectives informed by systems thinking (ST) (Hollnagel et al., 2006). Indeed, ST has been used as a lens to understand several safety management problems (e.g. Hollnagel, 2014a,b; Leveson, 2011; Goh et al., 2010), offering insights as a result of thinking in terms of interconnections and causal links that are distant in space and time from actions of agents (Skyttner, 2005; Flood, 1990).

This research explores the limits of safety through rule following as applied to safety inspections carried out by government officers. In fact, inspections take place in complex socio-technical systems and therefore trigger interactions that may create unexpected and undesired effects (Dekker, 2011). Earlier studies have provided varying results concerning the impacts of inspections on the reduction of accident rates (Auld et al., 2001). Levine et al. (2012) argue that the contrasting results are due to the methodological difficulties of isolating the effect of inspections. In order to overcome such difficulties, Levine et al. conducted a randomized controlled experiment to evaluate the impact of inspections. They concluded that inspections reduced injury rates with no evidence that this improvement came at the expense of employment, sales, credit rating, or firm survival.

Although quantitative studies may provide statistical generalizations about the effectiveness of inspections, this does not mean that individual construction sites are immune to a mix of desired and undesired impacts. In this respect, ST might offer a more nuanced analysis of safety inspections, supporting the analysis of their effects in specific cases. Thus, the research question addressed in this paper is stated as follows: how can ST offer insights into safety inspections? This work fills a gap in the literature, since qualitative research is necessary to understand the processes by which workplace inspections affect outcomes (Levine et al., 2012). It is also worth noting that safety inspections have not been investigated from the perspective of ST, and inspections have been an under explored topic in safety management research (Woodcock, 2014).

The research question is investigated through multiple case studies of construction sites that were partially or fully closed down by an occupational health and safety (OHS) inspectorate in Brazil. The author was involved as a participant observer in these case studies, which occurred over 6 years. This provided an insider's

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[1] In this paper the term "safety" refers to the presence of good work conditions in general, instead of only the prevention of traumatic type injuries.

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perspective on the nature and impacts of inspections, conferring a distinctive character to this study in comparison with earlier studies mostly based on questionnaire surveys (e.g. Geminiani et al., 2013; Niskanen et al., 2014).

2. Safety inspections: overview of regulations and of how they are conducted

Convention 81 of the International Labor Organization sets guidelines for the design and operation of labor inspection in industrial workplaces (ILO, 1947). The governments of many countries, including Brazil, ratified this convention. One of the key requirements of Convention 81 is that inspectors have to perform both the role of providing advice and that of enforcing legislation (ILO, 1947). If enforcement is necessary, national legislation defines what counts as a situation that requires closing down a site. In Brazil, regulation NR-3 states that inspectors are entitled to close down sites if they identify situations of "serious and imminent risk". In turn, these are defined by NR-3 as working conditions or situations that may cause accidents or work-related diseases, implying serious damage to the worker's physical integrity (Brasil, 2011). Similar definitions exist in other countries (Hopkins, 2007).

There is little literature on how the safety inspection task is really done, which is in contrast with a more abundant knowledge base on quality inspections (Woodcock, 2014). According to Hopkins (2007) traditional safety inspections carried out by regulators are based on monitoring compliance with prescriptive regulations, rather than carrying out a broader evaluation of the effectiveness of the organization's risk management system. Also, there has been discussion regarding the effectiveness of the responsive regulation concept, which refers to the idea of concentrating inspection efforts in companies that present lower safety performance (Nielsen, 2006). While no definitive conclusion has been made on the superiority of this approach, it is intended to support the better use of limited regulatory resources (Tombs and Whyte, 2013).

Woodcock (2014) demonstrates that safety inspection decisions are not unambiguous pass-fail choices, and the inspector does not intuitively know how to identify and assess hazards when they exist. Hopkins (2007) supports this conclusion, adding that in order to impose a prohibition order an inspector must make a judgment about the risk level, a judgment that is informed by the inspector's expertise and that cannot be deduced simply from any regulatory requirement. In fact, the "what you look for is what you find" principle of accident investigation (Lundberg et al., 2009) is likely to apply to inspections. Thus, the focus of inspections may reflect personal biases of inspectors and their unspoken assumptions about accident causation. Studies in different countries (e.g. Niskanen et al., 2014, in Finland, and Geminiani et al., 2013, in South Africa) have concluded that there is a need for more uniform and harmonized criteria between inspectors as well as that there is a need for improving their professional competencies.

In order to counter such shortcomings, some studies have proposed tools to standardize inspections to some extent. For example, Liao and Chiang (2012) proposed a computerized tool to support inspections, which is intended to help inspectors to use scarce resources more effectively. Dias (2009) developed a manual for guiding safety inspections in construction sites, which presents a number of checklists for the evaluation of safety equipment and criteria for selecting construction enterprises and sites for inspection. Some studies have also offered insights into which specific inspection strategies yield the best results. For example, in the U.S. manufacturing industry, Haviland et al. (2010) concluded that citations for violations of the standard requiring personal protective equipment had the largest impact on preventing injuries. Another finding of that study was that the preventive effects of inspections were not limited to the hazards addressed by inspectors.

3. ST attributes adopted in this research

The attributes of ST identified by Wilson (2014) were adopted as a basis in this research: concern for context; systems focus; holistic approach; acknowledgment of interactions and complexity; recognition of emergence; and the need to consider diverse perspectives (referred to by Wilson as embedding). In this research, the attribute concern for context is assumed to account for system focus and holism. The definitions of the attributes are presented below:

(a) *Concern for context*: this implies the need for identifying performance-shaping factors, which place constraints and opportunities on agents (Wilson, 2014). Due to the dynamics of these factors, those designing or inspecting a system should account primarily for work-as-done, rather than work-as-imagined in written procedures (Hollnagel, 2014a,b). The more thorough the account for context, the more the notion of holism is considered. Of course, while the full description and knowledge of a complex system is impossible (Cilliers, 1998), holism encourages us to think "up and out" (Dekker, 2011), meaning we should think in terms of interconnections and causal links that are distant in space and time from actions of agents (Skyttner, 2005; Flood, 1990).

(b) *Acknowledgment of interactions*: ST focuses on understanding and designing interactions themselves and not on components of things interacting (Wilson, 2014). Interactions have peculiar characteristics when the system of interest is complex (Cilliers, 1998): there is a large number of interacting elements, the interactions are dynamic, non-linear, have a fairly short-range, and they have loops, meaning that the effect of any activity can feedback into itself, sometimes directly, sometimes after a number of intervening stages.

(c) *Recognition of emergence*: emergence is a manifestation of unexpected variability, and it arises from interactions among the elements, independently of any central control or design. Emergent phenomena have new properties that are not found in the individual interacting elements (Cilliers, 1998). An example of emergence may be the functioning or operation of a system in ways not expected or planned for by designers – e.g. the possibility of widespread texting was little thought of by early mobile phone developers (Wilson, 2014).

(d) *Consideration of diverse perspectives*: system elements differ according to a number of categories such as hierarchical levels, division of tasks, inputs and outputs. While this creates coordination difficulties, it may be an asset for making better decisions (Dekker, 2011). In fact, a systems approach also refers to the way in which we carry out our work, and with whom it is done (Wilson, 2014). Effective safety management is participatory and so, as much as possible, the perspectives of all key stakeholders and subject matter experts should be accounted (Hinze et al., 2013).

The aforementioned attributes were chosen due to three main reasons: (i) they encapsulate key ST ideas which are fairly consensual (e.g. Skyttner, 2005; Clegg, 2000; Stacey et al., 2000; Flood, 1990) – regardless of this, some earlier studies on ST views of safety management have adopted a looser approach, without adopting any explicit set of ST attributes (e.g. Leveson, 2011); (ii) Wilson (2014) found the attributes to be aligned with the values and mission of ergonomics – i.e. the scientific discipline concerned with the design of socio-technical systems (IEA, 2015), which may encompass decisions related to the design of safety inspections;

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