HOW TRADITIONAL CONSTRUCTION SAFETY PERFORMANCE INDICATORS FAIL TO CAPTURE THE REALITY OF SAFETY

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ABSTRACT

Measuring safety performance provides feedback for proactive safety management and continuous improvements. Safety performance indicators can be considered as filters through which the reality is perceived, experienced and understood. This paper aims to assess the ability of existing safety performance indicators in the construction industry to capture the reality of safety. To fulfil the objective, an extensive literature review was conducted and three types of measurement methods were identified (e.g., outcome indicators, auditing, leading indicators). This paper discusses the limitations of each type of measurement method. The review reveals that the three types of measurement method are selected based on the safety management system (SMS) model. This paper argues that it may be inappropriate, and even dangerous, to use safety performance indicators that are selected based on the normative SMS approach as an evaluative tool to identify safety problems, offer solutions and measure safety performance. Given our limited knowledge about complex safety phenomena, safety performance indicators should be selected to first develop a valid description of a level of safety, before they are used as norms for evaluating safety performance and making decision.

Keywords: construction safety, safety indicator, safety performance measurement

INTRODUCTION

Safety performance measurement is an essential part of safety management systems. It aims to provide feedback for proactive safety management and continuous improvements. Traditionally, safety performance on construction sites has long been measured and evaluated by objectives and easy-to-collect safety outcomes (e.g., accident rates, TRIFR (Total Recordable Injury Frequency Rate), fatality rates). As increasing companies develop and implement safety management systems, auditing has become another popular tool to measure safety performance. More recently, leading indicators have received growing attention, despite the fact that the development of safety indicators is still at pre-scientific stage and remains a difficult problem in safety field(HSE 2001).

The objective of this paper is to discuss the limitations of existing safety performance indicators in capturing the reality of safety on construction sites. To achieve the objective, an extensive literature review was conducted and three types of safety performance indicators were identified: outcome indicators, auditing, and leading indicators. These indicators were examined in light of the nature of safety indicator and the purpose of safety performance measurement.

TRADITIONAL SAFETY PERFORMANCE INDICATORS

Outcome indicators

Like other industries, the pursuit of safety in the construction industry started from investigating and analysing accidents. The obsession with analysing these failures has led to a strong preference for recording accidents as a primary tool to measure safety performance. As a consequence, outcome indicators (e.g., accident rates, TRIFR (Total Recordable Injury Frequency Rate), or fatality rates) have been widely used by construction companies to evaluate the level of safety on sites. Despite the fact that recording safety outcomes is objective and time-saving, this approach is not without limitations.

First, outcome indicators provide little information about the cause of accidents (Hinze *et al.* 2013). These indicators may be able to reflect the level of safety in a reactive way (where we were) and help establish safety objectives (where we should go), but they are unable to provide guidance to assist people to fulfil the objectives (how to get there) (Hale *et al.* 1997, Grabowski *et al.* 2007, Sgourou *et al.* 2010).

Second, outcome indicators have been criticized for being historical in nature (HSE 2006, Hinze *et al.* 2013). Safety efforts are made only after accidents occur. Due to this limitation, this approach is “too late and too costly” (HSE 2006). Arguably, a safety indicator is of little use when it is unable to provide early warnings prior to accidents. Managing safety in a proactive manner requires foresights, rather than hindsight. However, relying on recording incidents and accidents may not generate insights into how complex relationships between contributing factors lead to these failures (OECD 2003). Foresights are derived from thorough understandings of complex safety phenomenon.

Last but not least, outcome indicators place emphasis on the negative side of safety (the presence/absence of accident), instead of the positive side (how safety is achieved). Rose (1994) asks the question of "If we are in the business of promoting OHS, why do we use failures as the measure of our success?" It is true that the positive side of safety includes many confounding and ambiguous variables which are difficult to define and measure. But our understanding of safety will not improve with the avoidance of such a difficulty.

Auditing

The limitations of outcome indicators point to a strong need of proactive tools to measure safety performance. As safety management systems (SMS) become a primary tool for companies to manage safety, auditing arises as a means of measuring safety performance. The Australian/New Zealand Standard (AS/NZS 4801) defines an audit as follows:

"A systematic examination against defined criteria to determine whether activities and related results conform to planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve the organization's policy and objectives".(Standards Australla Standards New Zealand 2001)

Auditing is an important part of a safety management system. In principle, safety performance is evaluated against audit criteria. Evaluation data then form a basis for organizational decision-making. In this sense, how well the auditing captures the reality of safety performance is determined to a great extent by the reliability and validity of the criteria. In practice, however, audit criteria are often problematic. Some of them are legal compliance-oriented. Auditing which are based on such criteria tend to assess safety performance against legislative and regulatory requirements. The problem here is that being compliant with legislative requirements is far from sufficient to produce safety. In addition, this may lead to a proliferation of the paperwork audit in the industry by encouraging companies to produce and keep relevant documentation so that good audit performance can be obtained and legal compliance can be met(Blewett and O'Keeffe 2011).

More comprehensive audit criteria assess safety performance against standardized safety management systems. This approach focuses on the performance of an SMS, checking either the presence or the effectiveness of individual safety practices. This approach is based on the faulty assumption that so long as an SMS is in place and all individual safety practices function effectively, accidents can be prevented. However, it is not the case in practice. Hopkins (2007), in the analysis of Gretley mine accident, concludes that "experience is now teaching us that safety management systems are not enough to ensure safety" (p 124). Another example is that the Esso Longford Gas Plant exploded just six months after the plant passed an auditing with highest level(Hopkins 2000).

Leading safety indicators

Growing concern over the limitations of outcome indicators and auditing has promoted a wide search for leading safety indicators (OECD 2003, HSE 2006, Aksorn and Hadikusumo 2008, Dingsdag *et al.* 2008, Cipolla *et al.* 2009, Øien *et al.* 2011a, 2011b, Reiman and Pietikainen 2012, Hinze *et al.* 2013). In the construction industry, a number of sets of leading indicators have been developed to help people measure safety performance and manage safety in a proactive manner (see Table 1).

Table 1

Developments of leading safety indicators in the construction industry

References	Main themes	Examples
NOHSC's Positive Performance Indicators (PPIs) (NOHSC 1999)	• commitment by management to safety, • an effective OHS management system, • risk management and control of hazards, • auditing of both management systems and physical hazards, • training and education, • communication and consultation	• Number of system audits undertaken • Number of tool box meetings held • Number of accidents/near misses investigated • Frequency of site safety meetings • Number of sub-contractor plans audited • Number of reported incidents
Safety Effectiveness Indicators (SEIs) (Cipolla *et al.* 2009)	• Carry out project risk assessment; • Carry out workplace and task hazard identification, risk assessments and controls; • Plan and deliver toolbox talks; • Consult on and resolve issues; • Challenge unsafe behaviour/attitude at any level when encountered; • Make site visits where a site worker is spoken to directly about OH&S in the workplace; • Recognize and reward people who have positively impacted on OH&S; • Carry out formal incident investigations; • Carry out formal inspections of workplace and work tasks; • Monitor subcontractor activities; • Understand and apply general legislative OH&S requirements; • Understand and apply general regulatory workers' compensation requirements; • Work with people to solve safety problems.	• Does the project team demonstrate a clear understanding of the tools and systems needed to conduct an accurate project risk assessment? • Are monitoring and review activities for risk assessment outcomes discussed, planned, specified and allocated? • Are hazards involved with each task element identified? • Are action owners consulted by facilitator/leader before task allocation? • Is toolbox talk accurately documented and distribution process agreed? • Are project team members actively encouraged to identify and raise issues and concerns? • Is there consistent and visible leadership by management in OH&S behaviours and actions?
Site Safe's three tiers of Key Performance Indicators (KPIs)	• Tier One: Safety systems • Tier Two: Safety behaviours • Tier Three: Safety leadership	• Subcontractor tender documents have site specific safety activity requirements • Regular tool box talks • A training/competency register for all subcontractor employees

Site Safe, New Zealand(2013)		• All management positions have safety roles and responsibilities that are clearly defined within the organization • Senior managers has monitored at least two on-site activities in the past 2 months
Hinze et al.(2013)	• Active leading indicators • Passive leading indicators	**Active leading indicators:** • Percent of jobsite toolbox meetings attended by jobsite supervisors/managers • Percent of jobsite pre-task planning meeting attended by jobsite supervisors/managers • Number of close calls reported per 2000,000h of workers exposure **Passive leading indicators:** • Number or percent of management personnel with 10-h (or 30-h) OSHA certification cards. • Number or percent of field employees with 10-h (or 30-h) OSHA certification cards. • Number or percent of subcontractors selected, in part, on the basis of satisfying specific safety criterion prior to being awarded the subcontract.

While these developments represent a shift from outcome indicators towards proactive ones, they are not without limitations. Dingsdag et al.(2008) argue that PPIs: 1) may not directly reflect actual success in preventing injury and/or disease; 2) may not be easily measured; 3) may be difficult to compare for benchmarking or comparative purposes; 4) may be time-consuming to collect and collate; 5) may be subject to random variation; 6) may encourage under or over reporting depending on how they are measured; 7) only measure the number of events and do not provide any indication or measure of effectiveness of each measured event. They also point out that the relationship between PPIs and safety outcomes (e.g., injuries) is arbitrary. Based on interviews, focus group and workshop, Dingsdag et al.(2006) develop a construction safety competency framework and identify 39 safety management tasks (SMTs) that are considered critical to improving safety performance. SEIs were designed to measure the effectiveness of these SMTs. However, the framework has not been validated and whether or not the sum of effectiveness of individual tasks equals the effectiveness of safety management as a whole still remains an open question. In addition, the evaluation of the effectiveness of SMTs is highly subjective. For example, SEIs emphasize the importance of hazard management, but do not specify what hazards should be managed. In general, traditional safety management focuses only on physical hazards, but psychosocial hazards are often ignored. This may lead to a biased and inaccurate evaluation of the effectiveness. The problem with the KPIs is that they were primarily developed for Site Safe’s Charter Accreditation program (Site Safe New

Zealand 2013). As to Hinze's active and passive leading indicators, it seems that the relationship between passive indicators and safety outcomes is correlational, rather than causal. Dyreborg (2009) argues that "…, an essential prerequisite is that performance indicators must be based on practical or scientific evidence about the causal relationship between the indicators used and the unwanted outcomes."

DISCUSSION AND CONCLUSION

Safety performance indicators can be seen as proxies for perceiving and understanding the reality of safety. In principle, traditional safety performance indicators discussed above were selected based on the safety management system (SMS) approach (see, Figure 1). An SMS is defined as a system which comprises a set of safety policies and practices and aims at influencing employees' behaviours and creating a safe and healthy workplace (Kirwan 1998, International Labour Office 2001, Fernández-Muñiz *et al.* 2007). Hale et al.(1997) produce a safety management systems model, with an attempt to "provide a systematic and complete description of what elements should be present in an SMS and how they should be related to each other".

There are limitations with the SMS approach as a framework for selecting safety indicators. The SMS approach gives a normative statement about how a safety management system should be structured and should operate(Hale 2003). According to Hale (2003, p.199)), the knowledge about the structural frame of SMS is robust enough, but current understanding of other frames (e.g., human resources, cultural and political frame) is rather limited. The knowledge gaps have partly led to a phenomenon that ideal safety management systems are not common in the construction industry. Another contributing factor to the lack of ideal SMSs is that current safety management systems rest on some fallacious beliefs about why accidents occur and how safety is achieved. For example, Howell et al. (2002) point out that current safety management systems rest on the following beliefs: "1) rules and procedures can be developed which if followed will keep people safe; 2) incidents happen because of worker error; i.e., failure to follow the rules; 3) reducing incidents will flow from improved motivation and training; i.e., getting people to follow the rules."

These beliefs reflect a linear reasoning behind site safety management, which is likely to cause two fundamental problems: incomplete risk profile and oversimplification of safety phenomena. These two problems are closely linked to the limitations of aforementioned safety performance measurement methods. With these two problems, safety indicators are unable to provide a full picture of safety, which may lead to ineffective decision and action.

To solve these problems requires a different perspective from which the reality of safety is captured. Such a perspective must represent a way of thinking about why accidents happen and how safety can be achieved. This means that safety indicators should move beyond solely measuring the structure of an SMS. Instead, they should first develop a valid description of complex safety phenomenon and then produce scientific knowledge to fill gaps with regard to other frames of safety management systems. Only in this way can safety indicators represent a meaningful and useful part of an SMS. Indeed, current knowledge of safety management system is limited and safety management is governed by fashion and not evidence (Hale 2003). In this sense, it may be inappropriate, and even dangerous, to use safety indicators that are selected based on the normative SMS approach as an evaluative tool to measure safety performance, identify safety problems and offer solutions.

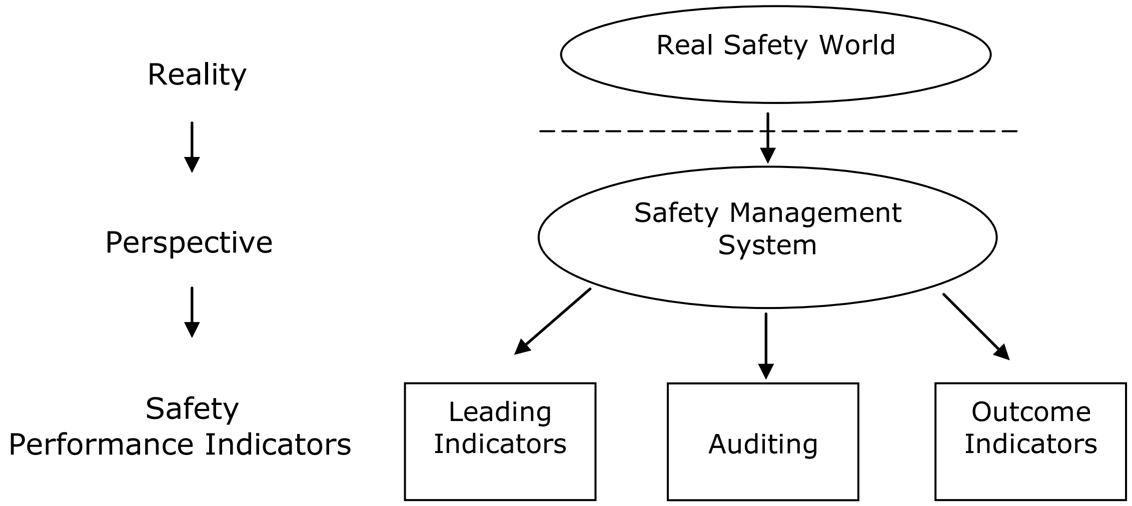

Figure 1 SMS-oriented safety performance indicators

Given the limitations of existing safety performance indicators in the construction industry, future research should focus on selecting safety indicators based on a safety model which explicitly explains how accidents occur and how safety can be achieved. Before they are used as evaluative norms for decision making, safety indicators should develop a valid description of the level of safety of an organization or a project. However, safety phenomena are complex in nature. This poses theoretical and practical challenges that can make it difficult for people to obtain a simplified, but valid, description. As Klein (2004) points out, "'Reality' is a nexus of interrelated phenomena that are not reducible to a single dimension". To capture complex reality, interdisciplinary approaches are often recommended (Klein 2004, Le Coze 2005).

ACKNOWLEDGEMENT

The authors would like to show their appreciation of BRANZ Ltd.'s financial support on the PhD research project. The authors also thank the anonymous reviewers for their time and valuable insights on this paper.

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