

“If you cannot measure it, you cannot improve it”: Measuring health and safety performance in the construction industry

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Abstract

The Australian construction industry has traditionally relied on ‘lagging’ indicators of health and safety performance. Lagging indicators, including lost time injury rates, are limited in usefulness because they rely on after the fact recording of statistically low probability events. They are subject to random variation, which can provoke ‘knee jerk’ reactions immediately following a reportable incident and encourage management complacency when no reportable incidents have occurred for a period of time. An update is provided on the development of a multi-level measurement method, which combines ‘leading’ safety performance indicators and safety climate measures. It is argued that leading performance indicators and climate measures can (in combination with lagging indicators) provide a more comprehensive analysis of health and safety performance in the construction industry. The opportunities for internal (between project) and external (between organization) benchmarking of health and safety performance are discussed.

Keywords: Health and safety performance, measurement, leading indicators, lagging indicators, benchmarking

1.0 Introduction

Sir William Thomson (better known as Lord Kelvin) famously commented on the importance of measurement, stating that “If you cannot measure it, you cannot improve it.” Occupational health and safety (OHS) performance measurement is an important part of the management of OHS. Reiman and Pietikäinen (2012) comment that the management of safety relies on the “systematic anticipation, monitoring and development of organizational performance” (p.1993). OHS performance measurement provides valuable information about how an organization is performing in an increasingly important aspect of business operations. The measurement of OHS performance enables the detection and resolution of problems and provides information needed to evaluate the effectiveness of organizational OHS initiatives.

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Most organizations engage in extensive strategic and operational planning processes, which include the establishment of corporate OHS objectives. Robust OHS performance measurement is critical to understanding whether objectives are being met, and if they are not, to understanding and responding to organizational vulnerabilities in relation to OHS.

This paper reports on an Australian initiative to develop a comprehensive set of OHS performance indicators (the RMIT OHS index). Harms-Ringdal (2009) defines indicators as “observable measures that provide insights into a concept – safety – that is difficult to measure directly” (p.482). OHS is notoriously difficult to directly measure because it is not an outcome in itself. Weike (1987) described safety as a “dynamic non-event” and noted that non-events cannot be counted. However, attempts to characterise safety for measurement purposes have focused on system dynamics and explored how the non-event is created (see, for example, Reiman and Pietikäinen, 2012). Thus, safety has been conceptualised as an emergent quality of a socio-technical system that produces a desired outcome – the absence of harm (see, also Lofquist, 2010).

There is also a general agreement that reliance on a single indicator of OHS performance is not sensible and that different indicators reflect different dimensions of OHS performance, for example, the nature and characteristics of hazards, technical safety features of a work system, safety organization or management systems, aspects of safety leadership or culture and economic outcomes (Harms-Ringdahl, 2009).

The RMIT OHS index comprises a suite of diverse indicators that provide insight into an organization’s overall OHS performance. None of these indicators, alone, provides a comprehensive picture of the state of OHS within an organization but, taken together, the indicators enable a meaningful assessment of how well, or otherwise, an organization is performing with regard to OHS. Key features of the RMIT OHS index are the multi-level and longitudinal approach used to collect, analyse and report data. The multi-level approach provides an understanding of differences in OHS performance of sub-units (i.e, projects, contractors or workgroups) within the same organization. The longitudinal measurement provides information that can be used to actively monitor OHS and detect important changes over time.

Several large construction client organizations will soon commence using this system to measure OHS performance of projects within their capital works/construction portfolios. These include an international manufacturing organization, a metropolitan rail organization, a state government department and a publicly owned port authority. This paper describes the components of the RMIT OHS index and explores opportunities for users to benchmark themselves against organizations operating in their own and other sectors of the construction industry, and against other organizations of a comparable size.

2.0 Different types of safety indicator

The safety literature generally differentiates between “leading” and “lagging” safety indicators, with increasing preference being placed on the use of the former. Mearns (2009) defines leading indicators as things “that provide information that helps the user respond to

changing circumstances and take actions to achieve desired outcomes or avoid unwanted outcomes” (p.491). Lagging indicators are the outcomes that result from actions. Similarly, Hale (2009, p.479) describes an indicator as leading or lagging in terms of whether it “leads or lags the occurrence of harm or, at least, the loss control in the scenario leading to harm.” Traditional “lagging” measures of OHS performance (such as accident frequency rates) focus on outcomes and are therefore reactive in nature. Outcome measures, by definition, do not tell us about current situations that can impact on future OHS performance.

2.1 The use of “lagging” indicators

“Lagging” indicators, including Lost Time Injury Frequency Rates (LTIFRs), can relatively easily be compared between companies and industries because they are calculated according to standard formulae. For example, *AS 1885.1-1990: Workplace injury and disease recording standard* specifies ways in which OHS statistics should be calculated. The LTIFR is the number of injuries x 1,000,000 divided by the total man hours worked. Lagging indicators have become standard measures of OHS performance in the Australian construction industry. They are useful because they are:

- relatively easy to collect;
- easily understood;
- easy to use in benchmarking or comparative analyses; and
- useful in the identification of trends (NOSHC, 1999).

However, lagging indicators of OHS are limited because they measure the absence, rather than the presence of safety (Arezes & Miguel 2003; Lofquist 2010) and are thus not a direct measure of the level of safety in an organization. Cadieux et al. (2006) comment that, even when there have been no accidents in a workplace, this does not necessarily mean that the workplace is any safer than another workplace at which an accident has occurred in the same period. In fact, when organizations are successful in reducing OHS risk, lagging indicators become even less useful because of random variation. Stricoff (2003) comments that even a stable safety system will produce a variable number of injury events.

Lagging OHS measures record failures ‘after the fact.’ They do not permit the timely implementation of preventive or corrective OHS measures. Reportable injuries and illnesses have a statistically low probability of occurrence and so measurement based on these events may not be sensitive enough to identify changes to OHS performance. Lofquist (2010) describes how a reliance on lagging performance measures (accidents) led to a failure to recognise the marked deterioration in the quality of safety that occurred during a period of deliberate organizational change in the Norwegian civil aviation industry. Industry participants (pilots and air traffic controllers) had observed a gradual decline in safety standards but no accidents had occurred, leaving decision-makers entirely unaware of the

negative impact of the organizational change programme. Lofquist (2010) argues that the time lag between changed safety performance and the occurrence of an accident can mask an organization's 'drift' to danger and provide an overly optimistic sense of system safety.

Managers' responses to fluctuations in accident rates can also create an 'accident cycle.' When accident rates increase, management expend considerable effort to reduce this rate. However, once the rate has fallen back to its original level, attention to OHS declines and the accident rate rises once again. This cycle of 'knee jerk' reactions to fluctuations in accident rates is counter-productive to continuous improvement in OHS (Stricoff, 2003). Further, a low accident rate does not guarantee that OHS risks are being controlled or that work-related injuries or diseases will not occur in the future because, although the accident rates may be a valid (or true) indicator of past OHS performance, their reliability as a predictor of future events is dubious (Mengolinim and Debarberis, 2008). This is especially true when the probability of accidents is low but major hazards are present in the work environment (HSE, 2001).

Injury frequency rates have sometimes been related to reward systems, managers' performance appraisals, bonus payments or future tendering opportunities. When used in this way, under-reporting is encouraged (Cadieux et al. 2006; Sparer and Dennerlein, 2013). In fact, the greater the emphasis that is placed upon outcome or lagging OHS indicators, the less valid (and useful) these measures may be, because people learn how to manipulate the figures. Under-reporting of injuries is a recognised problem. Indeed, Daniels and Marlow (2005) suggest that the level of reporting of non-fatal construction injuries in the UK construction industry is as low as 46%. Another practice widely believed to impact upon accident rates involves managing workers' injuries to reduce the financial impact on the organization. For example, injured workers are sometimes returned to work on 'light' duties to avoid reporting a lost time injury.

A further problem with most commonly used lagging OHS measures is that they do not accurately measure occupational illnesses with a long latency period, such as occupational cancers or chronic problems like musculoskeletal disorders. Neither do lagging measures assist in identifying the causes of incidents, reducing their usefulness in the diagnosis of OHS problems.

2.2 The use of "leading" safety performance measures

As a result of these limitations, there has been a move away from the exclusive use of retrospective data for the measurement of OHS performance. The use of leading safety performance indicators has become increasingly popular (WorkSafe Australia 1994; NSW WorkCover Authority 2001; DEWR/ASCC, 2005), receiving recent attention in construction safety research (see, for example, Lingard et al. 2011; Hinze et al. 2013). Leading indicators of safety can be defined as indicators that change before the actual level of risk to which people are exposed changes (Kjellén, 2009). There are a number of important advantages in the use of leading OHS indicators. First, leading indicators provide a more direct measure of how well an organization is managing health and safety risk than the occurrence of accidents, which include an element of chance. Leading indicators also provide an

immediate feedback mechanism, enabling organizations to improve OHS management processes, before deficiencies have resulted in incidents, injuries or illnesses (Hinze et al., 2013).

Leading indicators take many forms. In the development and use of leading indicators, what is measured, and how it is measured depend on the developers' theoretical perspective and beliefs about what explains safety (Mohaghegh and Mosleh, 2009; Reiman and Pietikäinen 2012). Assumptions and beliefs about the cause-consequence relationship between work system elements and safety are also important because leading indicators are theoretically positioned as antecedents to organizational safety, rather than consequences of organizational safety (Harms-Ringdahl, 2009).

Much of the safety management literature emphasises organizational safety structures and management systems, recommending third party audits to measure compliance (see, for example, Teo & Ling, 2006). Third party SMS audits are limited because they are costly and infrequent. Further, Zohar (2000) describes the 'implementation gap' that exists between organizational safety policies and procedures (the focus of SMS audits) and "lived" safety practices within organizations. There can be a marked difference between what organizations say they do and what they actually do, which compliance-based audits do not measure. Other disciplines place emphasis on the direct causes of accidents, such as hardware failures or operational errors, and develop metrics to measure these occurrences (Mohaghegh and Mosleh, 2009). Much of the literature has focused on worker behaviour as a causal factor in work accidents, resulting in the development of leading indicators to measure worker behaviour. For example, Sparer and Dennerlein (2013) describe the use of leading indicators of safety in an employee incentive program. The leading indicator measurement method they utilised was based on monthly inspections of a worksite and the expression of the number of physical work practices being undertaken safely as a proportion of the total number of practices observed. This method of direct observation and proportional rating was also used by Duff et al. (1994) and Lingard and Rowlinson (1997) in their analyses of the impact of behaviour-based safety programmes in the construction industry. It is noteworthy that although workers' behaviour is often involved in work accidents, it is rarely the only cause. Indeed, unsafe behaviour can often be traced back to systemic issues, such as excessive workload, fatigue, poor work design, inadequate training etc. Thus, focusing on workers' behaviour in the measurement of safety performance is inherently limited and arguably directs attention away from other important features of a work system.

2.3 Safety climate measurement

The measurement of safety climate is increasingly popular in safety research and practice. Evidence is emerging to indicate that safety climate is a valid leading indicator of OHS. That is, safety climate measured at one point in time statistically predicts the occurrence of accidents or injuries in a subsequent time period (see, for example, Zohar 2000; Wallace et al. 2006).

Safety climate represents the "surface features of the safety culture discerned from the workforce's attitudes and perceptions at a given point in time" (Flin et al 2000, p178). Many

tools have been developed to measure safety climate. However, the measurement of safety climate has been characterised by a lack of consistency in the number of climate components and a failure to replicate climate models across organizations and industries. Notwithstanding this, Flin et al. (2000) note that some common components of safety climate can be observed. These include: (i) management commitment to OHS; (ii) supervisory OHS behaviour; (iii) the relative priority of OHS over production and time pressure; and (iv) the quality of safety-related communication within the organization.

2.4 Multi-level measurement

Mearns (2009) argues that a single level perspective does not adequately reflect OHS performance because organizations are multi-level systems, i.e., micro phenomena are embedded within macro contexts. Within a single organization, research reveals significant variation in safety climate (Zohar, 2000) and the quality of OHS implementation between organizational sub-units (Sparer and Dennerlein, 2013). Thus, it is common for OHS performance to be 'patchy' within large organizations, with some sub-units performing consistently better than others, even when they are exposed to the same OHS risks. For example, significant between-group differences have been found in the OHS performance of subcontracted workgroups in the construction industry (Lingard et al. 2010). Thus, measuring OHS performance at a single macro level (i.e, the organization) can mask subtle but important differences between workgroup OHS practices and performance. It is therefore imperative to measure OHS at different levels within organizations (Zohar, 2008).

Construction projects are subsystems of an organization's larger portfolio of work (Blismas et al. 2004a; Blismas et al. 2004b). Each project is delivered through a temporary organizational structure in which professional services are 'bought in' under a variety of contractual arrangements and construction work is outsourced to a general contractor and a multiplicity of trade contractors. Uniformity of OHS practices cannot be assumed within a single construction organization as work is highly decentralised and local managers (project managers and workgroup supervisors) necessarily exercise discretion in deciding how to implement organizational policies and procedures (see also Aritua et al., 2009). Consequently, to understand OHS in the 'projectised' construction industry OHS performance needs to be measured at the level of the organization, the project and individual work group levels.

3.0 The RMIT OHS index

Given the strengths and limitations of different measurement methods, the use of a hierarchical set of linked measures has been recommended (Arezes & Miguel, 2003; Tinmannsvik & Hovden 2003). The RMIT OHS index adopts this approach. Building on work undertaken at a large civil engineering construction project (reported in detail in Lingard et al. 2011), the RMIT OHS index adopts a hierarchical structure, depicted in Figure 1. The index framework comprises three categories of measurement, including lagging indicators (category one), leading indicators (category two) and safety climate measures (category three).

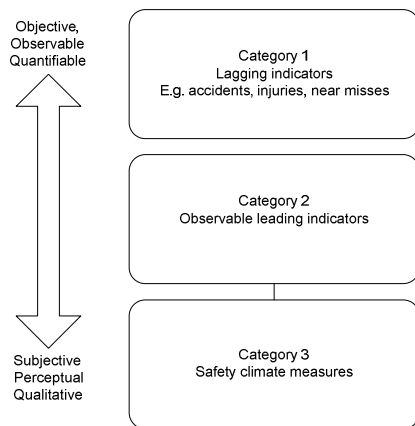


Figure 1: Components of the RMIT OHS index

Lagging indicators included in the index include lost time injuries, medical treatment injuries, minor (first aid) injuries and near misses. Observable leading indicators included in the index are founded upon the model of construction accident causation developed by Gibb et al. (2006). This model was empirically derived from an analysis of 100 construction accidents. The model identifies immediate circumstances involved in construction accidents as well as shaping factors and originating influences that contributed to the accident. Thus, it identifies proximal, as well as systemic causes of accidents. This model has been used in subsequent analyses of construction accidents in Australia and the USA and found to be useful in explaining the causes of fatal accidents (Cooke et al. 2011) and non-fatal accidents (Behm and Schneller, 2012). Leading indicators have been specified for each causal factor identified in the model. For example, leading indicators for “risk management” include “*RM1 A systematic assessment of health and safety risk is undertaken for all work tasks/activities*” and “*RM2 High level risk controls (eliminate/substitute/engineer) are implemented in preference to lower level risk controls (administration/PPE).*” Example leading indicators for “worker health/fatigue” are “*H1 Work hours are monitored to avoid overwork*” and “*H2 Recovery opportunities are built into work schedules*”

The safety climate measurement instrument adopts a multi-level approach in measuring: (i) perceptions of the extent to which safety is prioritised over other objectives, e.g. production efficiency, within the organization (at both client and contractor levels); (ii) perceptions of managers’ commitment to safety (at both client and contractor levels); (iii) perceptions of first level supervisors’ safety behaviour; and (iv) perceptions of the quality of safety communication within construction projects. These dimensions of safety climate reflect the ‘core’ dimensions identified by Flin et al. (2000). They have previously been measured effectively in a number of construction client and contracting organizations by Lingard et al. (2012; 2010b). In addition to these dimensions, an additional facet of group-level safety climate has been incorporated into the index relating to coworkers’ safety responses. Coworkers exert a cultural/normative influence on safety in workgroups that has been overlooked by a great deal of safety climate research (Lingard et al. 2011; Brondino et al. 2012)

3.1 Benchmarking opportunities

Wreathall (2009) comments that the data produced by safety performance indicators does not, in itself, improve safety. How data is used is as important as its quality. The RMIT OHS index can be used in performance benchmarking. Janicak (2010) defines benchmarking as “an ongoing process of measuring one company’s safety performance against that of competitors or organizations that are recognized as industry leaders” (p.15). The combination of lagging, leading and climate measures incorporated into the RMIT OHS index provides considerable depth and responds to calls to benchmark more than OHS outcomes. Reiman and Pietikäinen (2012) argue that it is insufficient to benchmark outcome measures only because they do not provide insight into the mechanisms behind the outcomes. It is also important to understand and compare organizational objectives and the way in which these objectives were pursued. Drawing comparisons of “why” and “how” an organization approached safety in a particular way will reveal what should be done to avoid or achieve similar outcomes (Reiman and Pietikäinen, 2012).

Figure 2 illustrates the potential to use the RMIT OHS index to benchmark performance within workgroups or projects within a single organization (as shown in organization 1), between organizations of a comparable size operating in different sectors within the construction industry (as shown between organizations 1, 4 and 6 and between organizations 2 and 5) or between organizations of different sizes within the same sector (as shown between organizations 1, 2 and 3 and between organizations 4 and 5).

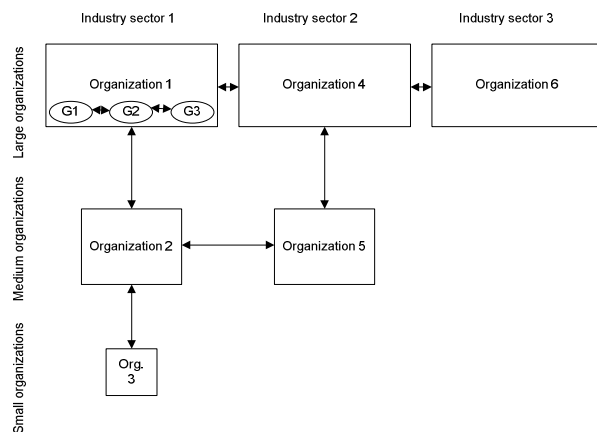


Figure 2: Internal and external benchmarking opportunities associated with the RMIT safety index

3.2 The relationship between leading and lagging safety indicators

Through combining the use of leading and lagging indicators of OHS performance with multi-level measures of workers’ OHS perceptions in the climate survey, it is likely that the RMIT measurement model presented in Figure 1, will provide a more comprehensive measure of OHS performance than single indicator measures, such as the traditional LTIFRs.

The RMIT OHS index will be used to measure performance over time. Thus, the measurement of lagging and leading indicators (including safety climate) will occur regularly over the life of construction projects within participating organizations. This provides the opportunity to detect changes in performance over time. This point is important because construction projects are dynamic and OHS commitment and performance have been demonstrated to change over a project's life cycle (Humphrey et al. 2004).

The longitudinal measurement of lagging and leading indicators of safety will also provide a more robust understanding of the relationship between leading and lagging indicators. The relationship between leading safety indicators and lagging (outcome) measures of OHS is often not known. Thus, it is unclear to what extent leading indicators predict future outcomes, such as accidents or injuries. Consequently, the validity of leading safety indicators has sometimes been questioned. For this reason, leading indicators have been recommended for use in addition to (rather than in the place of) traditional outcome measures of OHS performance (DEWR/ASCC, 2005).

The longitudinal measurement will provide an understanding of the predictive capability of specific leading indicators and safety climate measures in construction projects. No research to date has comprehensively demonstrated a link between leading and lagging measures of safety in the construction context.

Øien et al. (2011) argue that safety performance indicators must be carefully evaluated and the validity of measures may change over time. Therefore, in the coming months, the RMIT OHS index will be robustly tested and issues of reliability and validity will be examined. If the early results obtained using the index reveal an inconsistency between leading and lagging performance measures then this would suggest that the underlying model of OHS on which the index is founded could be flawed. If however, leading indicators indicate a high level of safety but lagging indicators reveal the occurrence of accidents, then it is possible that the leading indicators incorporated into the index do not adequately represent the requisite conditions for producing safety in construction projects. Alternatively, a decrease in lagging indicators with no prior change in one or more of the leading indicators would imply that the assumed causal relationship between leading and lagging indicators was problematic.

Ultimately the validity of Category 2 (leading indicators) and Category 3 (climate perceptions) variables included in the RMIT OHS index must be ascertained by the extent to which these measures are significantly correlated with objective outcome indicators of OHS performance, such as injury/incident rates.

4.0 Conclusions

The RMIT OHS index was developed on the basis of work carried out by two of the authors at a large civil engineering construction project in Melbourne. At this project, the index was well received and the general manager of the contracting organization has commented "*...the tool has been fundamental in helping promote positive safety behaviours and accountabilities within our business...the Safety Index has continued to provide an excellent barometer, combining critical lag and lead behavioural elements. It has been central in*

providing genuine impetus for improvement." The RMIT OHS index has been further developed and several large client organizations are commencing use of the index and, in the coming months, its reliability and validity will be comprehensively evaluated. After this evaluation and any further development required, it is hoped that the index will become a valuable benchmarking tool for construction OHS.

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