Measuring the leading indicators of occupational health and safety: A snapshot review

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Executive Summary

This review is the first stage in a larger research project that aims to identify, evaluate and validate a scale that could be used to obtain a preliminary measurement of the leading indicators of occupational health and safety (OHS) performance in Victorian workplaces.

The primary purpose of this report is to review the literature on leading indicators of occupational health and safety (OHS) to find validated scales that measure this construct. The secondary purpose is to evaluate the psychometric properties of those measures and to compare them to the IWH Organizational Performance Metric (IWH-OPM: Amick, 2010; IWH, 2011). The IWH-OPM is an eight-item scale that was developed at the Institute of Work and Health (IWH) in Canada to measure leading indicators of OHS performance.

Two questions were addressed in this review:

1. Have any scales been developed to measure leading indicators of OHS performance?
2. Is the IWH-OPM a suitable and reliable tool to measure leading indicators of OHS performance?

A search of academic and grey literature was conducted in order to gather information relevant to leading indicators of OHS performance. Specific inclusion and exclusion criteria were used to evaluate the scales included in this review.

The scales sourced for this review were evaluated and compared to the IWH-OPM on the basis of their content, convergent, discriminant and criterion validity. While only one scale (the IWH-OPM) was developed to specifically represent leading indicators of OHS performance, a range of scales were found that address this construct or some dimensions of it. An evaluation of the psychometric properties of the scales sourced indicates that the IWH-OPM has been evaluated to an acceptable level and is concise and easy to administer. In sum, the IWH-OPM is the most suitable and reliable scale for the purposes of this project.

On the basis of this review, the primary recommendation is that the IWH-OPM be validated in a Victorian sample of employers. Alternative recommendations, of adapting an existing scale or developing a new scale, are also presented.

Introduction

This report is the first stage in a larger research project that aims to identify, evaluate and validate a scale that could be used to obtain a preliminary measurement of the leading indicators of occupational health and safety (OHS) performance in Victorian workplaces.

The primary purpose of this report is to review the literature on leading indicators of occupational health and safety (OHS) and search for validated scales that measure this construct. The secondary purpose is to evaluate the psychometric properties of those measures and compare them to the IWH Organizational Performance Metric (IWH-OPM: Amick, 2010; IWH, 2011). The IWH-OPM is an eight-item scale that was developed at the Institute of Work and Health (Canada) to measure leading indicators of OHS performance.

As the purpose of the review is to determine the availability and quality of tools that could be used to obtain a preliminary measurement of leading indicators of OHS performance, each scale sourced for this review will be compared to the IWH-OPM on the basis of the psychometric analysis conducted: validity (content, convergent, discriminant and criterion validity) as well as reliability (Cronbach's alpha). This review and analysis will assist us in answering two questions:

1. Have any scales been developed to measure leading indicators of OHS performance?
2. Is the Organizational Performance Metric scale a suitable and reliable tool to measure leading indicators of OHS performance?

In order for a scale to be considered a suitable and reliable measure of leading indicators of OHS performance, the scale should:

1. Address the construct of leading indicators of OHS performance;
2. Measure OHS performance at the organisational or workplace level;
3. Have already been validated to an acceptable level; and
4. Be concise and easy-to-administer.

To provide background to the literature related to leading indicators, we first discuss the workplace context of OHS management. We note that efforts to understand leading indicators have led many scholars and professionals to identify safety culture and safety climate as closely related constructs.

The Workplace Context for OHS Management

OHS is a multi-disciplinary field focused on protecting and enhancing the safety, health, environment and welfare of all people engaged in employment and work. The Joint ILO/WHO Committee on Occupational Health (1950) identified the three objectives of occupational health as:

1. The "maintenance and promotion of workers' health and working capacity";
2. The "improvement of working environment and work to become conducive to safety and health"; and

3. "Development of work organizations and working cultures in a direction which supports health and safety at work and in doing so also promotes a positive social climate and smooth operation and may enhance productivity of the undertakings" (ILO, accessed 2012).

Managing occupational health and safety

OHS encompasses the physical, physiological and psychosocial conditions of an organisation's workforce, related to macro- and micro-level aspects of work and the work context. With this broad perspective, a substantial body of academic and professional literature shows that effective OHS management relies on a systemic and strategic approach. An OHS management system involves policy and programs that cover the planning, implementation, maintenance, evaluation and improvement of OHS in an organisation. The OHS policy typically includes OHS goals for the organisation. The written OHS policy, approved by top management, is typically accompanied by a set of OHS programs, rules and instructions that identify OHS accountabilities and set out the ways in which OHS compliance will be met. OHS programs, or plans designed for policy implementation, identify the OHS procedures, practices and people necessary to reach policy objectives (De Cieri et al., 2008; for a review of OHS management literature see Zanko & Dawson, 2011).

Efforts to identify indicators of OHS performance have identified several organisational constructs that capture important dimensions of the workplace that drive OHS performance (Grote & Kunxler 2000; Nahrgang, Morgeson & Hofmann, 2011; Payne, Bergman, Beus, Rodriguez & Henning, 2009). Numerous scholars and safety professionals have focused on organisational safety culture as "a primary driver and predictor of improving safety performance" (Carder & Ragan, 2003; Flin, Mearns, O'Connor & Bryden, 2000 cited in Blair & O'Toole, 2010: 30). An organisation's 'safety culture' and/or 'safety climate' (Zohar, 1980, 2010) has been identified as fundamental to an OHS management system. As reported by Guldenmund (2000), in a review of the literature on safety culture and climate, numerous definitions and models of each have been offered. Safety culture refers to the underlying values, assumptions, artifacts and values held or espoused by members of an organisation about safety (Janssens, Brett & Smith, 1995; Payne et al., 2009). Safety climate, as defined by Zohar (1980, 2003, 2010) refers to employees' perceptions of the policies, procedures, and practices concerning safety in an organisation. Numerous safety climate scales have been developed (for reviews, see Flin et al., 2000; Guldenmund, 2000; Payne et al., 2009). As Payne et al. (2009) point out, indicators such as safety climate may be considered and investigated as either/both leading or lagging indicators of OHS performance. Safety climate encompasses employee perceptions of:

- Organisational policies and procedures for OHS; and
- OHS practices that are implemented and maintained by managers within work groups (Payne et al., 2009).

In sum, over the past three decades, there has been debate over the dimensions that comprise the constructs of safety culture and safety climate constructs, and the ways of measuring these constructs (Guldenmund, 2000; Zohar, 2010). While it is beyond the scope of this report to review this body of literature, it provides helpful background information for the identification of leading indicators of OHS performance.

Overall, the research literature on safety culture and safety climate is consistent with broader efforts to measure OHS performance and identify indicators of OHS performance. The identification of indicators of OHS performance has arisen in the field of safety but has not been a major focus for academic research on the measurement of safety performance.

Measuring OHS Performance

According to Standards Australia (2001: p35): "*An organisation should measure, monitor and evaluate its OHS performance, and take preventive and corrective action*". OHS performance measurement can be used in a variety of ways to benefit organisations and workers, including:

- To provide information about whether OHS targets and policy objectives are being achieved;
- To allow identification of poorly-performing organisations (or sub-units);
- To identify areas for improvement and/or corrective action;
- To evaluate the effectiveness of OHS interventions such as training;
- To review OHS policy and practices; and
- For comparative analysis and benchmarking (National Occupational Health and Safety Commission, 1999).

OHS performance indicators may span a wide range, including quantitative measures such as number of injuries in a timeframe, and qualitative measures, such as judgements about management commitment to OHS. The use of multiple indicators in combination, as part of a systemic strategic approach to OHS, is likely to be much more effective than the use of a single set of indicators (Reason, 1997). Carson and Snowden (2010: p13) have advocated, "*strategies should combine leading (measure what is being done) with lagging (measuring the effectiveness) indicators*".

The focus of the next section of this report is on leading and lagging indicators of OHS performance. To discuss leading indicators, we first need to consider the complex relationship between leading and lagging indicators.

Leading and Lagging Indicators of OHS Performance

There has been substantial debate and discussion about OHS performance indicators. A common approach is to categorise these into leading and lagging indicators (Dyreborg, 2009; Hopkins, 2009; Kjellén, 2009). Leading indicators can be thought of as precursors to harm, while lagging indicators are measures of harm because they measure events or outcomes that have already happened (Hopkins, 2009). Leading indicators are inputs that provide an idea of how to improve future OHS performance, while lagging indicators are outputs and provide a measure of past performance (Eriksen, 2009).

Hopkins (2009) has examined the meaning of the terms "leading" and "lagging" in two recent influential publications: Baker et al. (2007) and HSE (2006). Hopkins identified several implications and limitations of these reports. As Erikson (2009) points out: "*the Baker report does not provide us with a satisfactory account of the distinction between lead and lag indicators [and] the HSE document does not provide us with a single, consistent account of the lead/lag distinction*". Hopkins suggests that there may be little achieved by trying to

develop precise meanings of the terms because in different contexts these terms are used to refer to different indicators. It is possible that a lagging indicator may also act as a leading indicator if, for example, it is able to predict another OHS outcome or event (Dyreborg, 2009). Additionally, Dyreborg argues that there should be more investigation of the potential causal relationships between leading and lagging indicators.

Leading indicators of OHS performance

Leading indicators of OHS performance can be defined as measures of the positive steps that organisations take that may prevent an OHS incident from occurring (Grabowski, Ayyalasomayajula, Merrick ,Harrald & Roberts, 2007; Lingard et al., 2011). Baker et al., (2007: H2) define leading indicators as: "*A metric that attempts to measure some variable that is believed to be an indicator or precursor of future safety performance*". Leading indicators are key to a proactive approach to OHS and the measurement and monitoring of OHS performance. Leading indicators are by definition measures of the predictors, or root causes, of OHS performance (Dyreborg, 2009). As Blair and O'Toole (2010: 29) explain: "*Leading indicators measure actions, behaviors and processes, the things people actually do for safety, and not simply the safety-related failures typically tracked by trailing [lagging] measures*".

Leading indicators can provide effective early warnings, by enabling risks or risk increases to be detected and mitigated, before an OHS incident occurs or a hazardous state is reached. However, there may be a trade-off between the indicator's level of sensitivity and its capacity to provide an effective warning; highly sensitive leading indicators may trigger false positive warnings (Dulac, 2007). Table 1 below shows some examples of indicators that have been classified in studies or reports as leading indicators.

As one example of the broad interest and activity in identification of OHS indicators in Australia, the National Occupational Health and Safety Commission (NOHSC – now Safe Work Australia) has conducted research on the development of Positive Performance Indicators (PPIs) for the Australian construction industry. This led to the identification of PPIs across five key areas: planning and design, management processes, risk management, psycho-social working environment, and monitoring (NOHSC, 1999). PPIs can be used to identify problem areas and provide an opportunity to see where remedial action should be taken (Mitchell, 2000). These PPIs may be viewed as macro-level indicators rather than specific measures. They can be used to build a broad, high-level picture of an organisation's OHS performance.

Concurrent discussions of leading and lagging indicators have been mainly in professional/ practitioner publications and have tended to focus on more specific, micro-level indicators (as will be discussed in the following section of this report). Macro-level indicators may be generic and able to be applied across workplace contexts in order to obtain a broad, and comparable overview of OHS. However, these may be complemented by more specific and sensitive micro-level indicators that allow for a more in-depth, fine-grained understanding of OHS performance in a particular work context or organisation. There is recognised value in both macro and micro-level indicators of OHS performance.

Table 1: Examples of leading indicators

Leading indicators
Source: Carson & Snowden (2010)
• Number of inspections • % accidents/incidents/near misses investigated • Number of hazards identified • Number of risk assessments • Number of safety meetings • % attendance at safety meetings • Number of people contravening instructions, work-permits • Number of training courses not completed within specified timeframe • % employees trained • Environmental (biological) monitoring data outside action limits • Number of relevant case histories studied • Number of tool box studies • Number of near miss reports • Number of outstanding corrective and preventative actions reported from audits • Ratio of first-aid events: more serious recordable injuries • Time between reporting of incident and investigation • Number of spills of hazardous materials • Energy consumption • Quantity of waste • Number of HSE [Health and Safety Executive] awards (internal and external)
Source: Senior Public Sector OHS Roundtable (March, 2011)

• Management commitment
  o OHS policy
  o OHS criteria
• Consultation
  o DWG structures and issue resolution procedures
• Risk management
  o Regular internal audits conducted
  o Issues identified actioned
• Training
  o Managers trained
  o Health and Safety Representatives trained
• OHS surveys
  o Perception survey

Despite the apparent value of leading indicators, there has been very little development of academic research that focuses on the measurement of leading indicators (Lingard et al., 2011). This may be at least partly explained by the perceived difficulty of measuring leading indicators. The examples in Table 1 show that leading indicators may be at a broad, macro-level (e.g., OHS policy), and/or be more specific (e.g., number of hazards identified).

While there has been little theorization of leading indicators, to summarise the available literature, it can be suggested that the construct of leading indicators encompasses domains or dimensions that are shown below. It should be noted that the list below is an initial categorization only and these have not been empirically tested as domains of leading indicators:

1. *OHS systems (policies, procedures, practices).* Organisational systems should be established in the workplace to control and monitor OHS, and implemented and maintained by managers and in work groups (Payne et al., 2009).
2. *Management commitment and leadership.* As with any organisational initiative, management commitment is key to OHS (e.g., Lingard et al., 2011; Zohar, 2010). There may be several aspects of this commitment. First, this includes managers at all levels of the organisation, from senior executive levels to front-line supervisors. Second, the commitment should not be limited to rhetoric about OHS but should be demonstrated in active engagement in areas such as information gathering about OHS, building trust so all employees view mangers as committed to OHS, managers' behavior demonstrating that they are OHS role models; and managers demonstrating that OHS is a high priority across the organisation.
3. *OHS training, interventions, information, tools and resources.* Along with the resourcing of OHS with suitably qualified OHS specialist expertise, the provision of OHS training, information, tools and resources are key leading indicators of OHS performance (Lingard et al., 2011). This includes preparedness to act and having a response plan in place.
4. *Workplace OHS inspections and audits.* A phrase often attributed to management scholar Peter Drucker: is "*What gets measured, gets managed*." An important implication of this is that the conduct of an audit or inspection may not in itself be adequate as a leading indicator of OHS performance. Inspections and audits should be designed to provide appropriate and comprehensive information (Carson & Snowden, 2010).
5. *Consultation and communication about OHS.* Regular, formal and informal, communication and consultation about OHS, including issue resolution procedures, is an important indicator for OHS performance (Grabowski et al., 2007). Employee surveys may be one way of gathering information from employees regarding their perceptions of OHS.
6. *Prioritisation of OHS.* The tendency for safety to be traded off against productivity has been discussed at length in OHS literature (Zanko & Dawson, 2011). Rather than view safety and productivity as competing goals, OHS should be embedded in the organisation as a high priority alongside efficiency and productivity.
7. *OHS empowerment and employee involvement in decision making.* Drawing on general management literature, it is widely understood that employee involvement in decision making will lead to 'ownership' of their behavior and positive outcomes, such as safety behavior (Zacharatos, Barling & Iverson, 2005). Several researchers (e.g.

Nahrgang et al., 2011) have investigated the role of empowerment and engagement in OHS, such that workers and supervisors should feel empowered and have the autonomy to make decisions with regard to OHS (e.g., to stop work that is unsafe).

8. *OHS accountability.* As has been documented across areas of management research, a workplace culture that emphasizes a sense of shared responsibility and accountability for OHS, by actively applying scrutiny and transparency in reporting, is likely to influence behavior in the workplace (Dyreborg, 2009).
9. *Positive feedback and recognition for OHS.* Again drawing on the general management literature, it is suggested that high performance on OHS will be reinforced by positive feedback and recognition for past performance (Zacharatos et al., 2005). Such recognition should not, however, include rewards that might lead to under-reporting of incidents or injuries (Daniels & Marlow, 2005).
10. *Risk management.* Risk management should be integral to the management of OHS (Kjellén, 2009); aspects of risk management include risk assessment, control, inspection and maintenance (Hopkins, 2009).

This list of the dimensions or domains of leading indicators may not be conclusive, given the paucity of existing research on this construct. Empirical research is needed to investigate, identify and validate the construct. Further, it is important to recognise that each of these domains of the leading indicators construct is complex and detailed. The purpose of this research project is not to develop a tool that will provide a detailed measure of all of these domains. Rather, the intention is to identify and evaluate a tool that will provide a simple, preliminary measure that is reliable and valid. This tool may be used in workplaces as an initial step, to be followed by more in-depth analysis of each of the indicators of OHS performance.

Lagging indicators of OHS performance

To date, lagging indicators are the most commonly used measures of OHS performance. Table 2 shows some examples of indicators that have been classified in studies or reports as lagging indicators. There are variations in indicators used, which is inevitable particularly where indicators might be specific to an industry, occupation, workforce or workplace. However, this variation causes some challenges for comparisons across jurisdictions and studies.

Table 2: Examples of lagging indicators

Lagging indicators
Source: Carson & Snowden (2010)
• Fatalities • Injuries (e.g. number of work-related illnesses or injuries per 100 employees, resulting in one or more days absence from work per year) • Absenteeism due to work activities (number of days absent) • Number of fines/prosecutions • Number of claims • Number of worker/neighbourhood complaints • Number of unacceptable emissions to the environment
Source: Biggs, Dingsdag Kirk & Cipolla (2009)
• First aid injury frequency rate • Fatality incidence frequency rate • Lost time injury frequency rate • Medically treated injury rate • Non-medically treated injury rate • Notifiable dangerous occurrence rate • Non-injury incident or near miss/ near hit • Return to work rate • Workers' compensation claim rate • Workers compensation premium rate
Source: Senior Public Sector OHS Roundtable (March, 2011)
• Incidents and hazards: Number and rate of incidents • Claims o Number and rate of standard claims o Number and rate of time-lost claims o Number of claims exceeding 13 weeks • Fatalities: Number of fatalities • Claim costs: Average cost per claim • Return to work index: Percentage of claims (with 10 days or more off work) where worker has returned to work within 6 months of when the claim was lodged with Work Safe agent

Lagging indicators tend to be specific and quantifiable measures of OHS performance. In general terms, the advantages of lagging indicators include:

- They are relatively easy to collect;
- They are easily understood; and
- When based on standard formulae, they may be appropriate for benchmarking or comparative analyses (National Occupational Health and Safety Commission, 1999).

While lagging indicators are valid measures of past OHS performance, their reliability as predictors of future OHS performance is open to debate (HSE, 2001). Despite their benefits, lagging indicators have several limitations or problems, as evidenced in several studies (e.g. Lingard, Wakefield & Cashin, 2011; Mitchell, 2000):

- By definition, these indicators lag after the OHS event, so do not allow for prevention (at least of the initial event);
- Lagging indicators are of limited use in the diagnosis of OHS problems because they typically do not assist with identification of the cause of an OHS event;
- Outcomes focused on reportable injuries and illnesses may have very low levels of reporting and therefore low variation. These measures may not be sensitive enough to identify differences in OHS performance between two units;
- A focus on lagging indicators may be counter-productive, as it may not guarantee that workplace hazards and risks are being monitored or controlled; and
- Lagging indicators may not occur with enough frequency to be reliable indicators of performance and because they are measured after an event they are not useful as a preventative measure of safety.

Further, inappropriate workplace practices may allow lagging indicators to be used in ways that do not help to improve OHS performance. For example, where OHS claim reduction is used as a reward or incentive for managers or employees, it may lead to under-reporting of OHS events (Daniels & Marlow, 2005). Recent research in the Australian construction industry found that traditional lagging indicators need to be considered with care; organisations performing well on OHS may, somewhat paradoxically, record higher injury and OHS incident statistics than other, poorer OHS performers (Trethewy, 2001, cited in Trethewy, 2003). This is suggested to be due to superior OHS performers actively encouraging and promoting a culture of reporting accidents and incidents. For such reasons, reliance on lagging indicators will not enable a full understanding of an organisation's OHS performance.

The Need for Valid Measurement

While lists of OHS indicators such as those shown in Tables one and two may be useful as a practical checklist, they do not enable measurement of the relationships between indicators or the summative effect of indicators. If we wish to develop leading indicators such as those in Table 1 into a scale that represents the leading indicators construct, then a necessary criterion is for that measure to have demonstrable validity. This means that the items we select and the measure as a whole must have some correspondence to the underlying construct it is supposed to represent, in this case, leading indicators of OHS performance. When the items of a scale meaningfully represent the construct they are said to be measuring then that scale can be considered valid (Adcock & Collier, 2001). A systematic process needs to be conducted to demonstrate this validity.

Paying careful attention to the validity of a scale is important because regardless of what construct is being measured decisions will be made on the basis of those measurement outcomes. Developing and validating a reliable scale requires rigorous attention to well-established procedures that are conducted over a number of stages using both qualitative and quantitative methods. This process requires not only the initial establishment of a scale's validity and reliability, but also ongoing evidence from subsequent studies that supports the initial latent structure and reliability over time. An additional consideration to be taken into account is that characteristics of scales validated using techniques such as exploratory factor analysis and confirmatory factor analysis may be dependent on the sample in which they were developed (Hambleton & Jones, 1993). This sample dependency can reduce the usefulness of a scale, particularly given that it is necessary to re-validate a scale when using

it with a different population in order to confirm the factor structure and reliability in that new population. Alternatively, properties of scales developed using Rasch analysis are considered to be independent of the sample on which the scale is developed.

As Lingard et al. (2011: p31) have stated:

> *Validity is sometimes difficult to gauge, especially in the measurement of abstract concepts like attitudes towards OHS. This is because abstract ideas sometimes do not correspond to the observable indicators we use to measure them. However, validity is an important consideration in any measurement and, particularly when developing new measures, validity needs to be carefully assessed.*

Scale development and validation requires evidence from most of the following processes, but over time, ideally all aspects of validation will be embraced for a comprehensive understanding of the new scale:

- Latent structure: which is tested using exploratory and/or confirmatory factor analysis or alternatively item response theory (e.g. Rasch analysis);
- Reliability: established using Cronbach's alpha;
- Validity: the main ways of validating a scale include establishing content validity, construct validity (convergent, discriminant, known groups), criterion validity (concurrent, predictive) and incremental validity.

The latent structure of a scale refers to the underlying dimensions represented by the items in a scale. An investigation of latent structure is often conducted using exploratory factor analysis, which aims to reduce a larger number of items to a smaller number of underlying dimensions. This process essentially summarises the information contained in the items; for example, Chen and Chen (2012) investigated the latent structure of their Safety Management System using exploratory factor analysis and reported that the 23 items that make up their scale represent five underlying dimensions (e.g. executive management commitment, safety training).

Once the latent structure of a scale is established we need to test the scale's reliability, which is also known as *internal consistency*. Reliability is tested using Cronbach's alpha (Cronbach, 1951), which tells us how much conceptual variability there is for items within a scale (DeVellis, 1996). If the items are conceptually more homogenous we will obtain higher levels of Cronbach's alpha; which in turn results in a more reliable scale with lower levels of measurement error (Kline, 1986). Cronbach's alpha is a figure that ranges from zero to one; the minimum acceptable Cronbach's alpha is suggested as 0.7 (Nunnally, 1978) or possibly as high as 0.8 but higher than 0.9 may indicate redundancy (DeVellis, 2003). The number of items incorporated into a scale may affect the level of Cronbach's alpha where increasing the number of items may result in higher levels of reliability. Again, using the Safety Management System by Chen and Chen (2012) as an example we can see that all subscales have good reliability (greater than 0.8) with the two longer subscales exceeding 0.9; while this suggests a high level of reliability, it also indicates that these two subscales could be shortened.

While latent structure and reliability focus primarily on the basic structure of a scale, validity focuses more on testing what the scale actually measures. There are four types of validity:

content, construct (convergent, discriminant, known groups), criterion (concurrent, predictive) and incremental validity. To establish content validity a scale should be reviewed by subject matter experts to ensure the included items are representative of the construct being measured and that the domain of interest is well covered by the included items. Construct validity allows us to determine what the scale measures and what it does not measure usually using correlational analysis between the new scale and other measures that may or may not be conceptually related. For example, for convergent validity we expect moderate correlations with constructs that are conceptually related (what the scale is said to measure); and for discriminant validity we would expect weak or no correlations with constructs that are predicted to be conceptually unrelated (what the scale does not measure). Sometimes it may not be possible to find acceptable scales to test a new scale against; in such cases, known groups validity, which involves comparing scale scores for groups that have known characteristics on other external factors (e.g. injury rates), can be used. Alternatively, structural equation models can be used to test convergent and discriminant validity (Bollen, 1993). Concurrent validity is based on correlations to constructs that are associated with the new scale. Predictive validity is based on correlations to constructs that are predicted by the new scale. A more detailed discussion of these issues can be found in DeVellis' (2003) guide to scale development and validation.

Review Questions

Two questions will be addressed in this review:

1. Have any scales been developed to measure leading indicators of OHS performance?
2. Is the IWH Organizational Performance Metric scale a suitable and reliable tool to measure leading indicators of OHS performance?

Method

The search for validated instruments was conducted through an academic literature search and a grey literature search. Specific inclusion and exclusion criteria were applied and are discussed below.

Peer Reviewed Academic Research Literature

A search of the academic literature was conducted for scales used to measure leading indicators of OHS performance. We took two approaches to this search: 1) a search of academic databases; and 2) tables of contents of relevant academic journals.

The main databases that were searched for scales to measure leading indicators of OHS performance were:

- Business Source Complete
- EMBASE
- PsychInfo
- Emerald
- Science Direct

A systematic search was conducted of table of contents for academic journals that publish articles on OHS or safety. The following journals were searched:

- Academy of Management Journal
- Accident Analysis and Prevention
- Journal of Applied Psychology
- Journal of Management
- Journal of Occupational and Organizational Psychology
- Journal of Occupational Health and Safety in Australia and New Zealand
- Journal of Safety Research
- Professional Safety
- Safety Science
- Scandinavian Journal of Work, Environment & Health
- Work and Stress

The search was conducted for scales used to measure leading indicators of OHS performance from 2000 to the present (May 2012). Where scales were identified, the original paper detailing the development and validation of that scale was sourced where possible.

The purpose of the larger research project is to identify and validate a scale in a sample of Victorian workplaces that can be used to obtain a preliminary assessment of the predictors of OHS performance in a workplace. Hence, to be considered for this purpose, a scale is required to address predictors, or leading indicators of OHS performance. In addition, as the

intended application is at organisational or workplace level, the scale is required to be focused at that level of analysis and to be worded appropriately for responses by organisational representatives. Finally, as the scale is expected to serve as a preliminary assessment tool rather than an in-depth, detailed analytical tool, the scale should be easy to administer and to analyse, so Likert-style items are considered the most appropriate.

For scales to be included in this review, they were required upon initial reading to address the specified criteria to some extent; that is, each scale should:

1. Address the construct of leading indicators of OHS performance;
2. Measure OHS performance at the workplace level; and
3. Contain a series of Likert-style items.

Studies were generally excluded from the review if the scales they used were to be administered at the employee level; for example, safety climate is usually measured from an employee perspective (e.g. Neal & Griffin, 2006). Additionally, studies that investigated leading indicators of OHS through extensive surveys but did not present their items as a well-defined scale were also excluded (e.g. Geldart, Smith, Shannon & Lohfield, 2010; Marsical, Herrero & Otero, 2012). However, few scales designed to measure leading indicators of OHS performance at the employer level were found in the literature. Therefore, we have also included scales that were administered at the employee level if the language of the items was generic; that is, if the items referred to organisational safety practices from a general perspective rather than from a personal employee perspective. Also, some employee scales were included if their items could be readily adapted to a management level scale without sacrificing the meaning of the items.

Grey Literature

The search of grey literature included information from several sources:

- Health & Safety Executive (HSE), Great Britain
- Institute of Work & Health (IWH), Canada
- International Labour Organisation (ILO)
- National Institute of Safety & Occupational Health (NIOSH), USA
- Safe Work Australia
- Safety Institute of Australia (SIA)
- SAI Global
- Work Safe Victoria (WSV)
- Work Safe WA
- Work Cover NSW
- World Health Organisation (WHO)

Search Terms and Procedure

Several constraints were applied to the search procedure: 1) the timeline was restricted to 2000 to the present (May 2012); and 2) freely available in the public domain; and 3) only articles and scales written in English were considered. As the construct *leading indicators* is primarily an economic term, a search using leading indicator as a key search term resulted in more than 10,000 hits so we coupled the term *leading indicator* with other safety terms to focus the search. The search terms used are listed below.

Search terms:

- Antecedents of safety performance
- Behaviour AND safety assessment
- Health and safety committees / health and safety management (measurement)
- Injury / illness prevention
- Leading (lagging) indicators AND occupational health and safety
- Leading (lagging) indicators AND safety
- Measuring occupational health and safety
- Occupational health and safety (scale)
- Occupational health and safety AND indicator
- Occupational health and safety AND Leading (lagging) indicator
- Occupational health and safety AND performance indicators
- Occupational health and safety AND performance measurement
- Organisational predictors AND health and safety
- Organisational safety
- Organisational safety measurement
- Positive performance measures
- Positive performance indicator AND work safety
- Safety climate / safety culture / safety leadership
- Safety management system / safety management practices
- Safety measurement /safety metrics / safety performance
- Work safety indicator
- Work safety measurement AND performance

Criteria for Assessing the Validity of Included Scales

For the purposes of assessing scale validity we examined each article to determine whether the authors had reported:

- The origin and development of the items in their scale (content validity);
- Analysis that examined the underlying structure of their scale (latent structure)

- Cronbach's alpha of their scale (reliability); and
- Correlations to other external constructs that are both conceptually related and unrelated; or confirmatory factor analysis to examine the distinctiveness of the constructs used in their study (construct validity)

These criteria are fundamental to scale development and validation; however they will also allow us to evaluate the individual scales against the overall criteria for this project. An examination of content validity will allow us to determine whether the scale meets our first and second criterion: that the scale should address the construct of leading indicators of OHS performance; and be a measure of OHS performance at the organisational level. The examination of latent structure, reliability and construct validity will allow us to determine whether the scale meets our third criterion: that the scale already has been validated to an acceptable level. Finally, with regard to the fourth specified criterion, that the scale be concise and easy-to-administer, we applied the rubric that the scale should have no more than ten Likert-style items.

Results

Leading Indicators of Occupational Health and Safety Performance

Our search of the literature found 21 safety scales that addressed what could be described as leading indicators of OHS performance. A summary of these scales can be found in Table 3 below. A summary table of analyses conducted on each individual scale can be found in thr Appendix.

The scales found in this review were evaluated as being suitable or not suitable with regard to the four criteria specified for this project. Our first and second criterion were that the recommended scale would be a measure of leading indicators of OHS performance and that OHS performance was to be measured at the workplace level. Only one scale (the IWH-OPM) was described by its authors as developed to measure leading indicators of OHS performance (Amick, 2011; IWH, 2011). Although the other scales were not labelled as measures of leading indicators, they measured constructs that are not distinct from the construct of leading indicators of OHS performance. Table 3 reveals that of the 21 scales found only seven safety scales were designed to measure leading indicators of OHS at the employer level; eight scales were validated at the employee level but were worded in a generic way so it is possible to re-validate them at the employer level without changing the wording; and six scales were developed and validated at the employee level but could be readily adapted for validation at the employer level.

Our third criterion states that the recommended scale should be validated to an acceptable level and this was the case for most scales (81%) where at least latent structure and reliability analysis had been conducted. In nearly half of the studies examined authors conducted an analysis of latent structure, reliability and some form of construct validity; a third of the studies analysed only latent structure and reliability; one study conducted an analysis of latent structure only; two studies conducted reliability analysis only and one study did not test their scale. With regard to our fourth criterion, most scales (66%) exceeded ten items. Few of the scales would be easily administered. Additionally, seven scales were single factor scales but the majority (thirteen) were multi-dimensional scales (one study used their items as single indicator items but with testing this may prove to be a single factor scale).

Table 3: Summary of leading indicator scales

Review summary	N	%
Measurement level		
Employer level	7	33
Employee level (generic wording)	8	38
Employee level (potential for re-write)	6	29
Number of items		
1 to 10 items	5	24
11 to 20 items	9	43
21 or more items	7	33
Validation process		
Latent structure	18	86
Reliability	19	90
Construct validation	10	48
Extent of scale validation		
Latent structure, reliability, construct validity	10	48
Latent structure, reliability only	7	33
Latent structure only	1	5
Reliability only	2	10
No validation or reliability	1	5
Scale criteria for this project		
Addresses leading indicators of OHS performance	21	100
Measured at the employer level	7	33
Validated to an acceptable level	17	81
10 items or less	5	24
Overall suitability (i.e. meets all four criteria)	3	14

N=21

Description of Leading Indicator Scales

Only one of the scales was specifically described as a *leading indicator* scale; the main foci of the included scales were either organisational/management policies and practices or safety climate followed by safety leadership and safety culture. Table 4 below summarises the types of scales that were found in the literature. Most scales in this review were validated in organisations or with employees from specific industries: transport, manufacturing, construction, resources, health, telecommunications and government; few scales were validated across industries. Nearly all scales were multi-factorial; only seven were single factor scales. Only one study that had validated their multi-factor scale tested it for a higher order construct.

Table 4: Description of leading indicator scales

Review summary	N	%
Scale context		
Organisational & management policies/practices	6	29
Positive performance indicators	1	5
Safety climate	6	29
Safety culture	2	10
Safety leadership	4	19
Safety management system	2	10
Industry		
Across multiple industries	5	24
Industry specific	16	76
Number of factors		
Single factor scale	7	33
Multi-factor scale	13	62
Not reported	1	5
Domains of multi-factor scales		
Documentation, policy & procedures	9	43
Value/promote safety	7	33
Management commitment & leadership	9	43
Clear accountability for safety	1	5
Safety versus productivity	10	48
Communications between employees & management	16	76
Audits, inspections & risk management	8	38
Preparedness (preventative planning, proper tools & equipment)	10	48
Response plan in place	6	29
Reporting safety concerns encouraged	5	24
Teamwork & co-operation	5	24
Employee training	10	48
Employee motivation (rewards, incentives for promotion, pay etc)	13	62
Employee involvement/engagement	6	29
Employee responsibility	3	14
Recruitment practices emphasise safety	2	10
Outcomes (measure outcomes of OHS practices; benchmarking)	2	10

N=21

The labelling of the subscales within the included scales was diverse even when reportedly measuring the same overall construct (e.g. safety climate). While this suggests a different outlook across scales, an examination of item wording indicates that studies have consistently addressed several core ideas to some degree in their scales. For instance, the incorporation of communications between management and employees and employee motivation was observed in most studies. Other constructs such as: documentation, policy

and procedures; management commitment and leadership; safety over productivity; preparedness (preventative planning, proper tools and equipment) and employee training arose in nearly half of the studies reviewed. Approximately one-third of the studies also addressed issues such as: the value and promotion of safety, conducting audits, inspections and other risk management objectives; employee involvement or engagement; having a response plan in place; encouraging the reporting of safety concerns; and teamwork or other co-operative activities. Issues least likely to be addressed were: employee responsibility; a clear path of accountability for safety; recruitment practices that emphasise safety; and measuring the outcomes of safety practices or benchmarking against other organisations or workplaces.

Evaluation of Reviewed Scales

The scales included in this review can be considered with regard to the four criteria specified for this project. The majority of the scales failed to meet all four criteria.

Only one of the scales (the IWH-OPM) was specifically described as a *leading indicator* scale; however, it could be argued that the scales included in this review addressed constructs that are closely related to, and not distinct from, leading indicators of OHS performance (e.g., organisational/management policies and practices or safety climate, safety leadership and safety culture).

In general, most of the scales sourced for this review have been developed and validated to an acceptable level. Fit statistics and reliability figures, where reported, were within acceptable ranges making them reliable measures of their respective safety constructs. However, there are several drawbacks for most of the scales reviewed: many were lengthy and developed for a specific industry. Several scales demonstrated wording artefact that could be improved. Most scales contained more than ten items, which is helpful for a more in-depth assessment of organisational safety but less suitable for survey research or in practice when a ‘pulse check’ of safety in the organisation is required. Nearly all scales were either validated in specific industries and some scales contained industry-specific wording (e.g. Arboleda et al., 2003; Glendon & Litherland, 2001; Hahn & Murphy, 2008). Such scales would at least require re-validation in an all-industries survey and may also require revision of items to remove industry-specific terms or items. Finally, two of the scales developed by Wu, Lin and Shiau (2010) contained repetitive wording, which is not ideal as wording may have an impact on the final outcome of a factor analysis (Spector, van Katwyk, Brannick & Chen 1997).

Even though most scales reviewed in this report have been validated to an acceptable level, few are short, easily administered scales. Only three scales met the requirements of being brief and validated to an acceptable level: the IWH-OPM (Amick, 2010; IWH, 2011) and the safety climate scales (hospital and Department of Energy variants) by Hahn and Murphy (2008). Of these three scales only the IWH-OPM is recommended for further analysis as this scale has been developed and validated across multiple industries and at the employer level. Further, the IWH-OPM does not need the revisions that would be required if one of the Hahn and Murphy scales was selected. Finally, the IWH-OPM addresses a wider range of safety issues compared to the Hahn and Murphy scales.

There are four other validated scales that are potentially useful: two safety management systems scales developed by Chen and Chen (2012: 23 items) and Fernández-Muñiz, Montes-Peón and Vázquez-Ordás (2009: 29 items); and the variants of the Organisational Policies and Practices scales by Amick, Habeck, Hunt et al. (2009: 19 items) and Tang, McDermid, Amick and Beaton (2011: 11 items). The main drawbacks of these scales are that in most cases they are substantially longer than the IWH-OPM or may require some modifications to remove items that may be considered lagging indicators such as the return to work items in the scales by Amick et al. (2000) and Tang et al. (2011).

Discussion

While the importance of identifying and measuring leading indicators of OHS performance has been recognised by OHS academics and professionals, there has been a paucity of research focused on the measurement of leading indicators and OHS performance. However, there have been valuable advances in research that has identified factors that are associated with organisational safety and developed these into safety measurement scales.

Our first research question was: *Have any scales been developed to measure leading indicators of OHS performance?* The results from this review indicate that there is only one specific measurement instrument of leading indicators. However, there are instruments that address the underlying constructs that are speculated to be leading indicators of OHS performance. Consequently, the dominant approach to measuring leading indicators appears to be through: 1) safety management systems; 2) safety culture and safety climate scales; 3) scales to measure leadership and management safety practices; and 4) organisational policies and practices.

In this study the areas covered in the scales were consistent with the domains of the leading indicators construct identified earlier in the literature review. The most prevalent elements of the safety scales found were: communications between management and employees; employee motivation; documentation, policy and procedures; management commitment and leadership; safety over productivity; preparedness; and employee training.

Our second research question was: *Is the IWH-OPM a suitable and reliable tool to measure leading indicators of OHS performance?*

To answer this question we have specified several criteria that would be required of the recommended scale. The recommended scale should:

1. Address the construct of leading indicators of OHS performance;
2. Measure OHS performance at the organisational or workplace level;
3. Have already been validated to an acceptable level; and
4. Be concise and easy-to-administer.

With regard to our first criterion, only one of the scales in this review was labelled as addressing the construct of leading indicators but it could be argued that the other scales addressed constructs that are closely related to, and not distinct from, leading indicators of OHS performance (e.g., organisational/management policies and practices or safety climate, safety leadership and safety culture). Given that the focus of the scales reviewed varies substantially not all scales necessarily addressed all of the relevant elements of the OHS leading indicator construct. The domains of leading indicators identified earlier in this report were not all explicitly represented in the scales; however, the purpose of this research project is not to develop a tool that will provide a detailed measure of all of these domains. Our intention is to identify and evaluate a tool that will provide a simple, preliminary measure that is reliable and valid. This tool may be used in workplaces as an initial step, to be followed by more in-depth analysis of the indicators of OHS performance.

The IWH-OPM can be argued to adequately address the leading indicators construct as it covers a wide range of safety issues for a short scale. With regard to our second criterion, the reviewed scales either addressed OHS performance at the organisational or workplace level, or could be modified to do so. The IWH-OPM is one of only seven scales that would require no modification in this respect.

With regard to our third criterion, we have identified a range of scales that have been developed and validated to an acceptable level. Most scales have been developed to an acceptable level (i.e. latent structure and reliability analysis), although the IWH-OPM is one of ten scales that have been validated to a more extensive level (latent structure, reliability, construct validity). However, several of safety scales sourced for this review were often developed with a specific purpose or industry in mind and therefore developed and validated within specific industries or addressed specific industry concerns (e.g. nuclear safety, transport). These scales would either require modification or would not be suitable for an administration across industries. With regard to our fourth criterion, the IWH-OPM is concise, easy-to-administer, and has fewer than 10 Likert-style items.

In sum, while the scales met one or more of the specified criteria, the IWH-OPM is one of three scales identified in this review that meets all four of the criteria specified for the purposes of this project. However, an examination of content indicates that of these three scales, the IWH-OPM is the most appropriate to use in the next stage of this project.

Recommendations

Recommendation 1

On the basis of this review, it is recommended that the IWH Organizational Performance Metric (IWH-OPM) should be validated in a sample of Victorian workplaces. This recommendation is subject to further investigation of the IWH-OPM (e.g., Rasch analysis of the Canadian data) and completion of qualitative investigation to be conducted with OHS experts familiar with the Victorian workplace context (in Stage 2 of this project). It is feasible that some modification of the IWH-OPM, e.g., rewording of item(s) or inclusion of additional item(s) may be considered appropriate for Victorian workplaces.

While this is the primary recommendation of this review, we acknowledge options that may arise if further investigation shows the IWH-OPM to be unsuitable for validation in Victorian workplaces.

Recommendation 2

It may be appropriate to select another scale with good psychometric properties, revise it to a short form version and validate it in a Victorian sample. Potential scales that could be considered are: the safety management systems scales developed by Chen and Chen (2012) and Fernández-Muñiz, Montes-Peón and Vázquez-Ordás (2009); or the variants of the Organisational Policies and Practices scales by Amick, Habeck, Hunt et al. (2009) and Tang, McDermid, Amick and Beaton (2011). This approach would be likely to be more costly and time-consuming than validating the IWH-OPM.

Recommendation 3

As this review provides an overview of leading indicators of OHS performance, it could be used as a first step to develop and validate a new measure that would meet the four criteria specified for this project. This approach would be likely to be more costly and time-consuming than either validating the IWH-OPM or adapting another existing measure.

Conclusion

The conclusion of this review is that the IWH-OPM is the most suitable scale for validation in a sample of Victorian workplaces. While other scales have been found to address leading indicators of OHS performance there are several drawbacks. These drawbacks include the fact that not all of the reviewed scales have been validated to an acceptable level. Of those scales that have been validated, many have been developed for or validated in industry specific surveys and would require revisions prior to validation. Further, some are lengthy and therefore may be cumbersome to administer. Overall, while several scales have been identified that meet one or more of the specified criteria, the IWH-OPM is the only scale identified in this review that adequately meets all four of the criteria specified for the purposes of this project.

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Appendix: Validity and reliability of reviewed scales

Scale Authors (Year)	Items	Item development	Dimensions	Latent structure	Reliability	Construct validation
IWH Organizational performance metric Amick (2010) and IWH (2011)	N=8	Items were developed from consultation with industry experts.	OHS performance (8)	EFA One factor % variance not reported	α = 0.82	Concurrent validity established with injury and illness claims rates.
Organizational policies & practices questionnaire (OPP-19 items) Amick, Habeck, Hunt, Fossel, Chapin, Keller & Katz (2000)	N=19	Items were developed from earlier studies: Hunt et al., 1993; Habeck et al., 1991; Habeck et al., 1998.	People-oriented culture (4) Safety climate (7) Ergonomic practices (2) Disability management (6)	EFA Four factors % variance not reported	People-oriented culture α = 0.92 Safety climate α = 0.95 Ergonomic practices α = 0.76 Disability management α = 0.92	Criterion validity: higher scores on all four subscales are associated with a higher likelihood of 6-month return to work.
Safety culture Arboleda, Morrow, Crum & Shelley II (2003)	N=4	Items were developed from literature reviews, industry focus groups, and site visits to 13 workplaces.	Four items plus one additional item to measure top management commitment to safety.	Not reported: used as single item measures.	α = 0.88	Not reported: used as single item measures.
Safety management system Chen & Chen (2012)	N=23	Items were developed from interviews with experts and international aviation safety practices.	Documentation & commands (7) Safety promotion & training (7) Executive management commitment (4) Emergency preparedness & response plan (4) Safety management policy (3)	EFA Three factors 68% variance CFA X2 (df) = 375.39 (210) RMSEA = 0.06 CFI = 0.98 NFI = 0.96	Documentation & commands α = 0.90 Safety promotion & training α = 0.93 Executive management commitment α = 0.89 Emergency preparedness & response plan α = 0.87 Safety management policy α = 0.87	CFA used to establish discriminant validity.

Scale Authors (Year)	Items	Item development	Dimensions	Latent structure	Reliability	Construct validation
Safety management system Fernández-Muñiz, Montes-Peón & Vázquez-Ordás (2009)	N=29	Items were developed from a review of international standards and guidelines for safety management, prior academic literature and interviews with industry experts.	Safety Policy (3) Employees' Incentives (4) Training (5) Communication (3) Preventive planning (3) Emergency planning (4) Internal control (5) Benchmarking (2)	EFA Eight factors % variance not reported CFA S-B X2 (df) = 855.6 (349) p = 0.001 RMSEA = 0.06 CFI = 0.92 AGFI = 0.85 GFI = 0.88 IFI = 0.92	Safety Policy α = 0.71 Employees' Incentives α = 0.73 Training α = 0.78 Communication α = 0.81 Preventive planning α = 0.76 Emergency planning α = 0.85 Internal control α =0.85 Benchmarking α = 0.82	CFA used to establish convergent and discriminant validity.
Safety climate Glendon & Litherland (2001)	N=32	Items adapted from Glendon et al., (1994).	Communication & support (10) Adequacy of procedures (6) Work pressure (6) Personal protective equipment (4) Relationships (3) Safety rules (3)	EFA Six factors 69% variance	Cronbach's alpha for subscales ranged from α = 0.72 to α = 0.93.	Not reported.
Operational safety scale Grote & Kunzler (2000)	N=20	Items developed from management interviews and observations made on site tours.	Enacted safety (10) Formal safety (7) Technical safety (3)	EFA Three factors 59% variance	Enacted safety α = 0.91 Formal safety α = 0.87 Technical safety α = 0.78	Not reported.
Safety climate (Hospital measure) Hahn & Murphy (2008)	N=6	Items sourced from a safety climate scale developed by De Joy et al., (2000); highest loading items used.	Safety climate (6)	EFA One factor 48% variance CFA One factor model X2 (df) = 21.74 (9) p = 0.01 RMSEA = 0.05 CFI = 0.99 NNFI = 0.98 GFI = 0.99	α = 0.71 – 0.92 Alpha varies depending on the subset of participants (e.g. nurse, physician, technologist).	Convergent validity established with relevant measures e.g. environmental conditions (cleanliness), policies and procedures (safety equipment) and training. Discriminant validity established with relevant measures e.g. demographics.

Scale Authors (Year)	Items	Item development	Dimensions	Latent structure	Reliability	Construct validation
Safety climate (Department of Energy measure) Hahn & Murphy (2008)	N=6	Items sourced from a safety climate scale developed by De Joy et al., (2000); highest loading items used.	Safety climate (6)	EFA One factor 66% variance CFA One factor model X2 (df) = 57.89 (9) p = 0.001 RMSEA = 0.08 CFI = 0.98 NNFI = 0.96 GFI = 0.98	α = 0.84 – 0.92 depending on subset of participants (e.g. administrative assistances, engineers).	Convergent validity established with relevant measures e.g. environmental conditions (injuries), organisational climate (communication, feedback). Discriminant validity established with relevant measures e.g. demographics.
Safety leadership Lu & Yang (2010)	N=16	Items adapted from earlier studies: Bass & Avolio (1990), Cooper (1998), Carrillo & Simon (1999), O'Dea & Flin (2001), Yule (2003) and Wu et al. (2007).	Safety motivation (7) Safety policy (4) Safety concern (5)	EFA Three factors 75% variance	Safety motivation α = 0.92 Safety policy α = 0.89 Safety concern α = 0.92	CFA used to establish convergent and discriminant validity.
Safety culture Martínez-Córcoles, Gracia, and TomásPeiró (2011)	N=24	Not reported.	Safety culture (24)	CFA One factor X2 (df) = 861.36 (252) p < .01 RMSEA = .073 CFI = .987 NNFI = .985 AGFI = .982	α = 0.95	Not reported.
Positive performance indicators Mitchell (2000)	N=23	Items developed from a review of OHS practices and case studies in the construction industry.	Planning & design (5) Management processes (6) Risk management (7) Psychosocial working environment (3) Monitoring (2)	Not tested.	Not tested.	Not tested.

Scale Authors (Year)	Items	Item development	Dimensions	Latent structure	Reliability	Construct validation
Manager attitudes to health, environment & safety Nja & Fjelltun (2010)	N=32	Items based on interviews with the National Association of Transport Enterprises.	Concerned about formalities (12) HES work improves health, environment and safety (5) HES work is inefficient (6) HES regulation is appropriate (7) HES work can be improved (2)	EFA Five factors 55% variance	Concerned about formalities α = 0.91 HES work improves health, environment and safety α = 0.91 HES work is inefficient α = 0.75 HES regulation is appropriate α = 0.85 HES work can be improved α = 0.73	Not reported.
Safety climate O'Dea & Flin (2001)	N=7	Items based on literature review and industry expert interviews.	Safety climate (7)	Not reported.	α = 0.75	Not reported.

Scale Authors (Year)	Items	Item development	Dimensions	Latent structure	Reliability	Construct validation
OSCI: Safety climate questionnaire (four scales) Silva, Lima & Baptista (2004)	N=46	Items developed from a literature review and were based on competing value model by Quinn (Quinn, 1988); and earlier diagnostic tools (Neves, 2000; van Muijen et al., 1999; Vala et al., 1994).	Content of safety climate (11): Support, goals, innovation and rules Safety as an organisational value (5) Org safety practices (22): Management safety activities, safety training, safety effectiveness, quality of safety communication, effects of required work pace on safety and organisational learning from accidents Personal involvement with safety (8): Personal commitment to safety, safety internalisation and safety pride	Content of safety climate Not reported. Safety as an organisational value Not reported. Org safety practices CFA X2/df = 3.41 RSMR = 0.04; GFI = 0.93; NNFI = 0.92; CFI = 0.94; RMSEA = 0.06 Personal involvement with safety X2/df = 3.95 RSMR = 0.02; GFI = 0.98; NNFI = 0.97; CFI = 0.98; RMSEA = 0.06 Safety climate (2nd order) X2/df = 4.39 RSMR = 0.03; GFI = 0.91; NNFI = 0.95; CFI = 0.96; RMSEA = 0.07	Support α = 0.78 Goals α = 0.72 Innovation α = 0.72 Rules α = 0.79 Safety as organisational value α = 0.83 Management safety activities α = 0.77 Safety training α = 0.82 Safety effectiveness α = 0.77 Quality of safety communication α = 0.72 Effects of required work pace on safety α = 0.77 Organisational learning from accidents α = 0.79 Personal commitment to safety α = 0.73 Safety internalisation α = 0.75 Safety pride α = 0.78	Predictive validity established for accident rate; known groups validity.
Organizational policies & practices questionnaire (OPP-11) Tang, MacDermid, Amick III & Beaton (2011)	N=11	Items developed from earlier studies: Habeck et al., 1991; Habeck et al., 1998; Amick et al., 2005 and Amick et al., 2000.	Safety practices (3) Ergonomic practices (1) Disability management (5) People oriented culture (2)	CFA Four factors X2 = 97.2 (36), p = 0.001 CFI = 0.98 TLI = 0.97 RMSEA = 0.06	Safety practices α = 0.91 Ergonomic practices Disability management α = 0.91 People oriented culture α = 0.91	Construct validity established using known groups validity: Criterion validity: more favorable 12-Month Work Disability Outcomes

Scale Authors (Year)	Items	Item development	Dimensions	Latent structure	Reliability	Construct validation
Management safety practices Vredenbugh (2002)	N=18	Items were adapted from Ostrom et al., (1993) and then pilot tested with risk managers from three hospitals.	Not reported.	EFA Six factors 69% variance	Not reported.	Not reported.
Employer safety leadership scale Wu, Lin & Shiau (2010)	N=12	Items adapted from Wu (2008) and Wu et al., (2008).	Safety caring (4) Safety coaching (4) Safety controlling (4)	EFA Three factors 72% variance	Safety caring α = 0.87 Safety coaching α = 0.85 Safety controlling α = 0.85	Not reported.
Operations manager safety leadership scale Wu, Lin & Shiau (2010)	N=12	Items based on management roles identified by Mintzberg (1973).	Safety decision-making (4) Safety informing (4) Safety informing (4)	EFA Three factors 78% variance	Safety decision-making α = 0.90 Safety informing α = 0.88 Safety informing α = 0.91	Not reported.
Safety professional safety leadership scale Wu, Lin & Shiau (2010)	N=10	Items based on safety professional roles proposed by Hale (1995).	Safety counseling (4) Safety regulating (3) Safety coordinating (3)	EFA Three factors 78% variance	Safety counseling α = 0.94 Safety regulating α = 0.89 Safety coordinating α = 0.88	Not reported.
Zohar & Luria (2005) Safety climate	N=16	Items developed from activities outlined in the British Standards Institute's (2000) safety management code, known as OHSAS 18001.	Managerial commitment	EFA Details not reported	α = 0.91	Predictive validity reported using correlations to safety engineering audit score.

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