



CAMPBELL INSTITUTE™

Transforming **EHS performance**
measurement through leading indicators 



OVERVIEW AND KEY FINDINGS

This Campbell Institute publication:

- 】 Provides a definition of leading indicators, developed by an expert panel of EHS leaders
- 】 Describes eight critical characteristics of successful leading indicators
- 】 Suggests multiple ways in which leading indicators can be categorized or classified
- 】 Identifies several key enablers of successful leading indicator implementation and use, including:
 - Executive buy-in on (not technical knowledge of) leading indicators
 - Roll-up and use of leading indicators at the corporate level
 - Communication and understanding of the predictive value of leading indicators by EHS and corporate leadership
 - Targeted leading indicator data collection used to analyze specific measurable actions rather than collected prior to development of response actions
- 】 Identifies several common barriers to successful leading indicator implementation and use, including:
 - Inability to develop consistently actionable leading indicators
 - Lack of reliable, consistent relationship between leading and lagging indicator performance
 - Sporadic, infrequent, and non-standardized benchmarking
 - Continuing C-suite reliance on traditional lagging indicators
- 】 Identifies examples of leading indicators commonly used by several world-class organizations, including:
 - Key procedure audits
 - Worker engagement actions

EXECUTIVE SUMMARY

This report describes a research project conducted by the Campbell Institute to advance the state of knowledge and practice on the topic of using leading indicators to measure Environmental, Health, and Safety (EHS) performance of organizations. Today, EHS practitioners continue to rely on injury rates, absenteeism, and other lagging metrics despite the growing acceptance of the fact that these failure-focused measures are ineffective in driving continuous improvement efforts. Leading indicators, on the other hand, appear to offer a more useful gauge of EHS activity by providing early warning signs of potential failure and, thus, enabling organizations to identify and correct deficiencies before they mature into accidents and injuries.

The project's specific research aims were to:

- 】 describe the extent to which EHS practitioners understand leading indicators;
- 】 explore organizational practices pertaining to tracking, analyzing, and applying information provided by leading indicators to improve EHS performance; and
- 】 identify barriers and factors that enable the use of leading indicators.

These research questions were addressed through a combination of qualitative and quantitative techniques. An initial discussion with industry experts was held to explore the meaning of the term leading indicator and the relationship between leading and lagging indicators, identify desirable characteristics of leading indicators, and discuss practical applications of information provided by leading indicators regarding EHS performance. The expert panel agreed that leading metrics have been gradually gaining credibility and legitimacy in the field of EHS. They defined leading indicators as *proactive, preventative, and predictive measures that monitor and provide current information about the effective performance, activities, and processes of an EHS management system that drive the identification and elimination or control of risks in the workplace that can cause incidents and injuries.*

The panel described effective leading metrics as those that correspond with EHS performance as measured by lagging indicators and are also actionable, achievable, meaningful, transparent,

easy to communicate, valid, useful, and timely. The experts drew attention to the critical differences between leading and lagging metrics, but also acknowledged that under certain circumstances the line between them may be blurred. All in all, creating a sense of balance between leading and lagging indicators and trying different approaches to determine what works and what does not work from the standpoint of performance improvement were said to be keys to success.

The expert panel also discussed the relationship between EHS practitioners and top-level executives in setting performance measurement strategies. It was noted that EHS professionals' ultimate responsibility is to equip senior management with the most accurate and up-to-date knowledge in order to increase their awareness, support, and commitment to conducting rigorous assessment of EHS results.

In the next phase of the project, qualitative data was obtained from the Campbell Institute Charter Members, including past Campbell Award winners, through the completion of an online survey. Responding EHS practitioners (N=18) represented the Mining, Construction, Manufacturing, and Professional, Scientific, & Technical Services industries. The survey probed the participants' perceptions toward leading indicators and their level of competence as well as their executives' level of competence in this area. Survey questions also focused on specific organizational practices with regards to tracking corporate- and site-level indicators, identifying remedial action based on leading metrics, benchmarking, contractor management, executive compensation, EHS professional accountability, and factors that may impede or enable the implementation of leading indicators.

Results from the survey confirmed and extended those that emerged from the expert panel discussion. Respondents viewed the issue of leading indicators as rather important to their organizations and actively used various leading metrics to (a) anticipate, prevent or eliminate risks and losses, (b) monitor and evaluate performance, (c) motivate safe behavior, personal commitment, and continuous improvement, and (d) communicate results to management and workers. The majority of respondents indicated that the effort and resources their organizations allocate to implementing leading indicators were substantial.

The emphasis in measuring corporate-level performance was on lagging metrics, whereas leading indicators received more consideration in site-level performance evaluations. Not all companies tie leading indicators to specific goals, but those that do focus on tracking key procedure audits and worker engagement actions. Survey respondents were in agreement that it is important to have consistency and alignment between site- and corporate-level metrics. In general, the more impact a leading metric has on the corporate EHS management system, the more likely it is to be consolidated and to be taken up to the corporate level.

Slightly more than half of survey respondents viewed themselves as either proficient or expert-level users of leading indicators. However, even those with the highest level of expertise acknowledged that proactively identifying and taking advantage of learning opportunities and new sources of knowledge are absolutely critical for professional growth in EHS. Survey respondents rated their corporate executives' technical knowledge of leading indicators lower than their own. Lack of training may explain why corporate executives have a lower level of appreciation for leading indicators. At the same time, active engagement in EHS policy development, a strong safety culture, experience with and understanding of what happens at the shop floor level, and EHS training were mentioned as the factors that facilitate the acquisition of EHS knowledge among top-level decision makers.

About two-thirds of survey respondents said that leading indicators receive either quite a bit or a great deal of attention in their communications with company executives. During such conversations, the most commonly asked question was *"How are leading indicators connected to actual EHS performance on lagging indicators?"* Statistical analyses determined that several factors were correlated with the level of attention paid to leading indicators in EHS professional-executive conversations.

Over half of survey respondents said that executive compensation is tied very little or not at all to performance on leading indicators. When asked to

what extent EHS managers are held accountable for leading indicators, most answers were a great deal or quite a bit. Leading metrics were said to have direct bearing on EHS managers' performance appraisal, compensation, and promotion.

The respondents were nearly equally divided in their views about the level of difficulty associated with identifying corrective or preventive actions on the basis of information provided by leading data. They described in detail what their organizations do to transform data into insight. Additional analyses determined several factors correlated with the actionability of leading metrics.

The results of this research strongly suggest that a key concern is whether there is a verifiable relationship between leading and lagging metrics. Survey respondents seemed fairly adamant in their desire to find statistical evidence of this relationship; however, there was no agreement on what that evidence should be or how to obtain it.

Among other results, this research finds that management commitment, engagement, understanding, and support are essential to effective EHS performance measurement. Other factors cited as enablers for the implementation of leading indicators were open communication and knowledge sharing, high-quality technology and information systems for data management, linking leading indicators to incentives, and instilling a proactive safety mindset among key staff and stakeholders.

Primarily because of the small, non-random sample, the survey findings should be interpreted with caution, yet this research offers a close look at the trends and approaches to EHS performance evaluation among world-class EHS organizations. This research suggests that leading indicators are a largely untapped source of data for the journey to EHS excellence. Because their use is very likely to increase in the foreseeable future, it is our hope that more active research and practice in this area will lead to evidence-based solutions with implications well beyond any particular organization or industry.

INTRODUCTION

When organizations elevate Environment, Health, and Safety (EHS) to the level of a core organizational value, they must inevitably commit considerable investments in resources to measuring the performance of their EHS programs. The proliferation of EHS management systems that has been observed globally since the 1990s (Robson et al., 2007), has dramatically increased the focus on performance measurement techniques and tools. The vast majority of EHS initiatives are still evaluated relying primarily on lagging metrics, such as fatality and injury rates, despite the growing acceptance of the fact that these failure-focused measures are less useful in helping organizations drive continuous improvement efforts. Leading indicators, on the other hand, offer promise as an improved gauge of EHS activity by providing early warning signs of potential failure and, thus, enabling organizations to identify and correct deficiencies before they trigger injuries and damage.

The literature regarding leading indicators is a multifarious compilation of thoughts, opinions, case studies, and even empirical research from a variety of industry, academic, government, and non-governmental sources. Although a general consensus exists for the use of leading indicators as a measure of EHS performance, simple elements associated with its nature and utility, including a basic definition, remain murky; Reiman and Pietikainen (2010) report that the concept is “all but clear.”

One component of the definition that continues to contribute to the confusion surrounding the term involves semantics. The signifier *leading* is the most common expression used to describe this particular type of indicator, yet numerous authors embrace additional descriptive terms throughout the literature in order to retain the most relevant qualities of indicators in respect to their own message. In a recent article, Hinze, Thurman, and Wehle (2013) draw attention to this inconsistency by pointing out that the terms *upstream*, *heading*, *positive*, and *predictive* have been used to describe essentially the same concept. Spear (2010) refers to *process* indicators when describing key performance indicators such as safety audits, behavior-based safety, safety perception surveys, safety training, and corrective action measurements, while both the Organisation for Economic Cooperation and Development (OECD) report (2008) and the Health and Safety Executive (HSE) Guide (2009) refer to these metrics as *activities* indicators.

Some authors even make an effort to distinguish between different types of leading indicators, alluding to the fact that not all leading indicators serve the same purpose. Reiman and Pietikainen (2010) differentiate between input, feedback, drive, and monitor indicators, Grabowski and colleagues (2007) claim that leading indicators can be objective or subjective, and Hinze et al. (2013) describe the difference between passive and active leading indicators. The nature of leading indicators has been described as predictive (Hinze et al., 2013; Grabowski et al., 2007; Hohn & Duden, 2009; Wurzelbacher & Jin, 2011; Hudson, 2009), proactive (Hinze et al., 2013; Hohn & Duden, 2009; OECD, 2008), and preventative (Toellner, 2001; Hohn & Duden, 2009; OECD, 2008; API, 2010).

Furthermore, characteristics of leading indicators often form the bulk of their definitions. Stough (2012) offers five key components of leading indicators, including: simply and closely connected to outcomes, objectively and reliably measurable, interpretable by different groups in the same way, broadly applicable across company operations, and easily and accurately communicated.

An obvious way to define leading indicators is to describe their relationship to *lagging*, also known as *trailing* or *outcome*, indicators. Hopkins (2009) states that in terms of personal safety, the term lagging typically refers to injuries and fatalities, whereas for process safety, lagging indicators are direct measures of harm and failure and do not have the ability to provide information about the current state of the environmental, health and safety management system (EHSMS). In this sense, leading indicators of personal safety would measure the events leading up to injuries and fatalities, whereas in process safety, they would be precursors to harm and failure, providing information about the current state of the EHSMS. Leading indicators are not so much the opposite of lagging indicators, but are instead a facet of safety present prior to a negative event, similar to two points along a continuum (Harms-Ringdahl, 2009; Hale, 2009). There is a wealth of literature on whether there exists a correlation or link, if not causal relationship, between leading and lagging indicators of EHS (Diaz & Cabrera, 1997; Iyer, et al. 2004; Nielsen et al., 2008; Reiman & Pietikainen, 2012; Spear, 2010).

Another theme present in many existing definitions of leading indicators is that one of their primary functions is to measure the effectiveness of EHS processes (Hinze et al., 2013), systems (Hohn & Duden, 2009; CCPS, 2008), and organizational performance (Reiman & Pietikainen, 2010).

Specifically, leading indicators are designed to flag potential problems early enough for corrective action to be taken (API, 2010) and help uncover weaknesses in the organization's procedures or employee behavior before they have a chance to cause real harm (Janicak, 2010). Some reports even suggest leading indicators' ability to detect the deterioration of the EHSMS (API, 2010; Harms-Ringdahl, 2009). Due to the time-sensitive nature involved in preventing this deterioration and, furthermore, injuries or fatalities, it is important for leading indicators to actively monitor the state of EHS (Hopkins, 2009). Other functions often attributed to leading indicators include benchmarking current practices, demonstrating continuous improvement over time (Hohn & Duden, 2009), measuring safety performance against a tolerance level, and calling for action when that level is exceeded (OECD, 2008).

To complicate matters further, the root of the term, *indicator*, is often substituted for *metric*, *measure*, or *index* and used not only to describe activities, but also conditions, or events (Grabowski et al., 2007).

This lack of agreement on the definitional issues creates a potential source of uncertainty and confusion for users interested in translating some of this conceptual knowledge into practice. EHS practitioners, especially those in formal positions of authority, exert a critical influence over EHS matters, and their knowledge, attitudes, and observations may prove useful in identifying ways to encourage further adoption of leading indicators. Therefore, the key objectives of this research were to: 1) describe the extent to which EHS practitioners understand leading indicators; 2) explore organizational practices pertaining to tracking, analyzing, and applying information provided by leading indicators to improve EHS performance; and 3) identify barriers and factors that enable the use of leading indicators.

METHODS

The study began with a panel discussion with industry experts to explore the meaning of the term *leading indicator* and the relationship between leading and lagging indicators, identify desirable characteristics of leading indicators, and discuss practical applications of information provided by leading indicators regarding EHS performance.

The panel included a total of 17 experts, including 15 practitioners (14 active and one retired) and

two researchers. All panelists identified EHS, or occupational safety and health, as their primary area of expertise. Three panelists — two practitioners and one researcher — were employed in the public sector. Fifteen panelists were male and two were female.

The expert panel ran approximately 3 hours and was led by a trained facilitator-scribe team. A semi-structured questionnaire was used to present topics for discussion and pose questions to the panel. Discussion topics were pre-determined and formulated based on the most relevant research and trends as determined by a comprehensive literature review on the subject completed prior to the panel discussion. Throughout the discussion, participants were encouraged to share information based on their personal experience in this area and the experience of their organizations. The responses of the panelists were audio recorded to ensure accuracy in data collection, and then transcribed verbatim to aid in the interpretation of findings. The scribe also recorded some of the responses on large flipcharts which were on display for the entire panel throughout the discussion. The transcript and flipchart notes were subjected to content analysis by members of the research team to identify key points and emerging themes.

In the next phase of the study, a survey of Campbell Institute Charter Members, including previous Campbell Award winners, was conducted to better understand the use of leading indicators in world-class organizations. The survey questions were developed by Institute researchers and included a series of closed- and open-ended questions on a variety of issues concerning the use of leading indicators in EHS performance measurement. Members of the Campbell Institute Research & Knowledge Subcommittee were asked to review the survey questionnaire in order to ensure content validity.

The survey was administered online at surveymonkey.com. Respondents were initially contacted via email and asked to complete the survey within a two-week period in July of 2013. After one week, members of the research team sent out email reminders to encourage non-respondents to complete the survey before the deadline. There were no incentives offered for survey completion.

The survey was sent to 30 individuals. A total of 18 surveys were returned, yielding a total response rate of 60 percent. The survey sample was comprised of companies from the Mining, Construction, Manufacturing, and Professional, Scientific, &

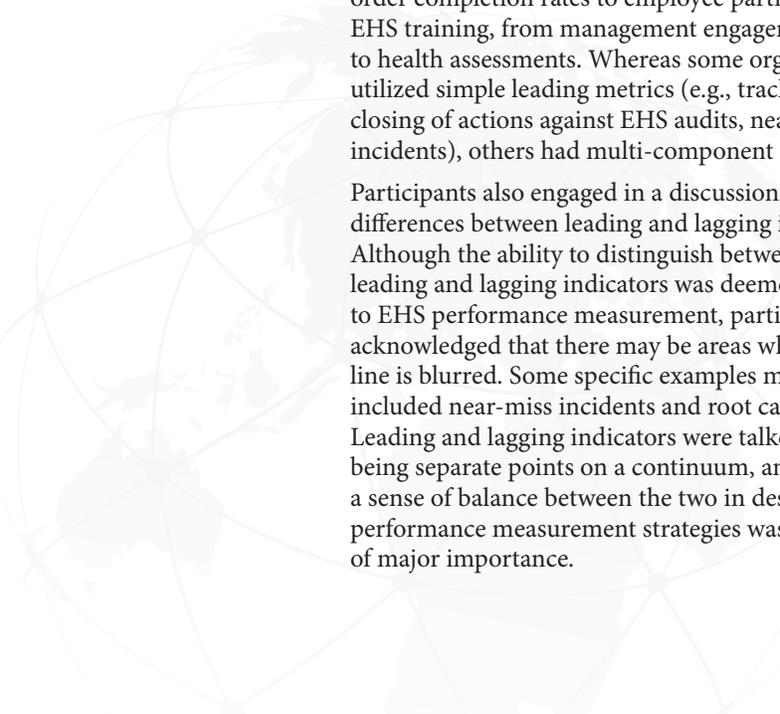


Technical Services industries. Company size ranged from 500 to 202,000 employees with a median size of about 12,000. All survey respondents had job titles of manager or higher (e.g., director, senior director, vice president) and reported an average of approximately 16 years of experience in the field of EHS. All survey respondents indicated EHS as one of their primary areas of expertise. Average time to complete the survey was 23 minutes.

The data gathered by closed-ended questions (e.g., Likert-type scales) were analyzed using simple frequency distributions, percentages, and, where appropriate, mean response values. Bivariate correlation analyses were then performed with Spearman's rho coefficient for nonparametric data to investigate the strength and direction of the statistical relationship in a subset of survey items. All findings for which the level of significance exceeded 95 percent are provided in this report. In addition, qualitative analytical techniques were used with open-ended survey questions. Two members of the research team attempted to identify emerging themes and categorize the data in order to carry out quantitative analyses (e.g., counts, frequency distributions).

RESULTS

EXPERT PANEL



Initially, participants of the expert panel were asked to name and describe the most utilized leading indicator of EHS performance at their organization. Responses were extremely varied, ranging from safety work order completion rates to employee participation in EHS training, from management engagement metrics to health assessments. Whereas some organizations utilized simple leading metrics (e.g., tracking the closing of actions against EHS audits, near-miss incidents), others had multi-component indices.

Participants also engaged in a discussion of the differences between leading and lagging indicators. Although the ability to distinguish between leading and lagging indicators was deemed vital to EHS performance measurement, participants acknowledged that there may be areas where the line is blurred. Some specific examples mentioned included near-miss incidents and root cause analyses. Leading and lagging indicators were talked about as being separate points on a continuum, and creating a sense of balance between the two in designing performance measurement strategies was considered of major importance.

A natural progression of this conversation brought up the topic of finding a relationship between leading and lagging indicators and how important this task is to the ability of EHS professionals to establish the linkage between EHS and business performance. Some respondents' attempts to correlate their metrics were not necessarily statistical, but involved investigation into components of their EHSMS when an incident or near miss occurred. Others stressed that lagging indicators may correlate with both site-level and corporate-level leading indicators. Still other respondents utilized an automated system to do the calculation for them by looking at a trend versus the actual measurement.

The panel then aimed to determine the specific characteristics of leading indicators. Participants described effective leading metrics as those that, first and foremost, correspond with EHS performance as measured by lagging indicators and also possess the following characteristics – actionable, achievable, meaningful, transparent, easy to communicate, valid, useful, and timely. Next, participants explored how to categorize leading indicators. It was suggested that one practical approach would be to describe a spectrum from predictors of low-risk events to predictors of high-risk events. Another way to categorize leading indicators is to differentiate between personal (i.e., organizational, behavioral) and process (i.e., operational, equipment) metrics. In general, participants raised concerns that taxonomies should not be too granular or static. By having a taxonomy of leading and lagging EHS metrics in place, the data analyst should be able to use it to organize the data, the EHS professional should be able to communicate this information up and down the organizational hierarchy, and others, including senior executives, should be able to understand and act on it.

The conversation also touched on how to operationalize leading indicators. There was agreement that leading indicators are used to determine the health and effectiveness of the components of EHSMS. For example, there are indicators that determine how effective safety training is by looking at the level of training activity and also at the extent to which lagging indicators map back to training deficiencies. Leading indicators are also used to close gaps when they are identified during an EHSMS audit, which would ultimately lead to an improvement in lagging metrics. Lastly, participants acknowledged the need to track metrics that can measure EHS performance both at the site and corporate levels.

Raising the level of awareness about leading indicators among senior management was an important topic of discussion. It was noted that tracking leading indicators and how they relate to EHS and business performance is well understood and accepted by top-level executives. Management is always looking for tools that will increase their own competency and there is a clear recognition that the traditional approaches to EHS performance measurement may not be sufficient. Also, there is a realization that organizations have to try different approaches to determine what works and what does not work from the standpoint of continuous improvement. Nonetheless, some executives are better informed than others in this area, which creates opportunities for EHS professionals to educate their senior leaders. It was noted that once leading indicators become a priority at the highest level, the rest of the organization has a tendency to follow and embrace this concept.

EHS professionals' role in "selling" leading indicators to management was then discussed. Many participants were of the same opinion that the EHS professional's monologue about the value of leading indicators in the modern-day organization has progressed to resemble more of a dialogue with corporate leadership. In the past, executives focused entirely on recordable incidents and their impact on the bottom line. It is now EHS professionals' responsibility to engage and educate senior leaders about the intricacies of EHS performance measurement and demonstrate how tracking leading indicators contributes to building a stronger organizational safety culture. Several participants acknowledged that they still find themselves in the position to show senior leadership the value of leading indicators by using business language and establishing linkages to the bottom line in order to make this dialogue more successful. Ultimately, responsibility is with EHS professionals to equip senior management with the knowledge about leading indicators in order to increase their awareness, support, and commitment to conducting rigorous evaluation of EHS performance.

The panel acknowledged that there are always challenges associated with tracking leading indicators. Because some leading indicators are process or activity specific, rolling them all the way up to the global enterprise level is a significant challenge. Also, collecting the complex data, across all levels, as well as periodically reassessing leading indicators in use that may be ineffective due to their inability to accurately assess critical incidents over time, can be difficult to do consistently. In this sense, a new leading indicator must be selected based on its predictability. In addition, finding successful incentive programs based on leading indicators has been challenging based on the type of program, whether it be group level or individually based, the quality of behaviors selected for reward, and also the prize itself. Finally, making employees at all levels aware of what leading indicators the organization has chosen to measure is necessary in order to generate the momentum and traction for successful performance measurement.

At the conclusion of the discussion, the facilitator sought participants' insights to develop a working definition of leading indicators to inform future research on the subject. The facilitator reiterated the key points of the discussion and explained why it was important to form a thorough understanding of the issue in order to agree on a single definition. Based on the discussion that ensued, the following definition was created:

Leading indicators are proactive, preventative, and predictive measures that monitor and provide current information about the effective performance, activities, and processes of an EHS management system that drive the identification and elimination or control of risks in the workplace that can cause incidents and injuries.

The comments and recommendations of the expert panel were taken into account and used as a foundation for a survey of EHS practitioners, in which the goal was to provide a more in-depth understanding of their views and organizational practices related to leading indicators.

“ We use leading indicators to identify risks and take action on those risks before an accident takes place, non-compliance results, a client is disappointed or the overall safety culture is damaged. ”

— Anonymous survey respondent

SURVEY RESULTS

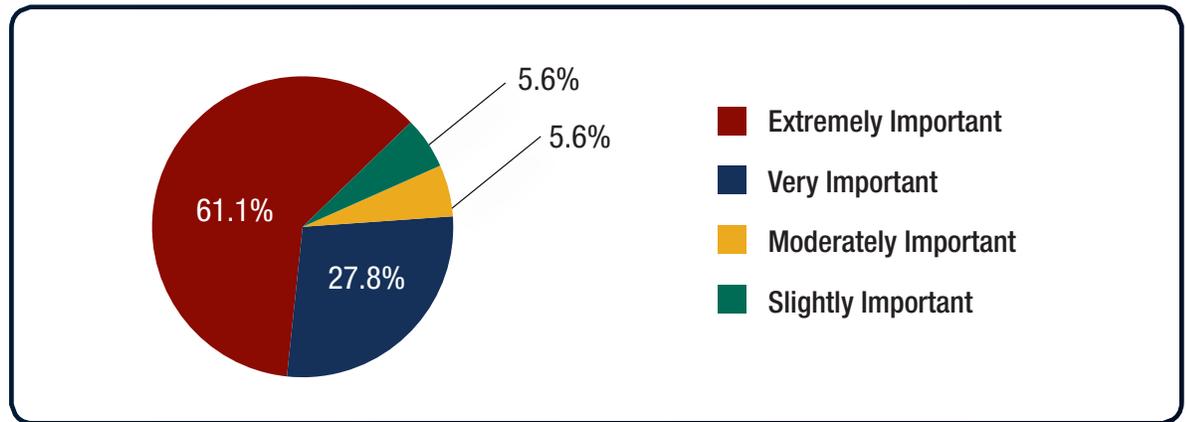
THE IMPORTANCE AND PURPOSE OF LEADING INDICATORS

The majority of survey respondents (61%) said that their organizations' ability to measure EHS performance with leading indicators was extremely important and an additional 28% said that it was very important. No one deemed the use of leading indicators as not at all important.

Content analysis of the open-ended responses yielded four general categories referring to the specific purposes for which leading indicators of EHS are used:

- › Anticipate, prevent or eliminate risks and losses
- › Monitor and evaluate performance
- › Motivate safe behavior, personal commitment, and continuous improvement
- › Communicate results

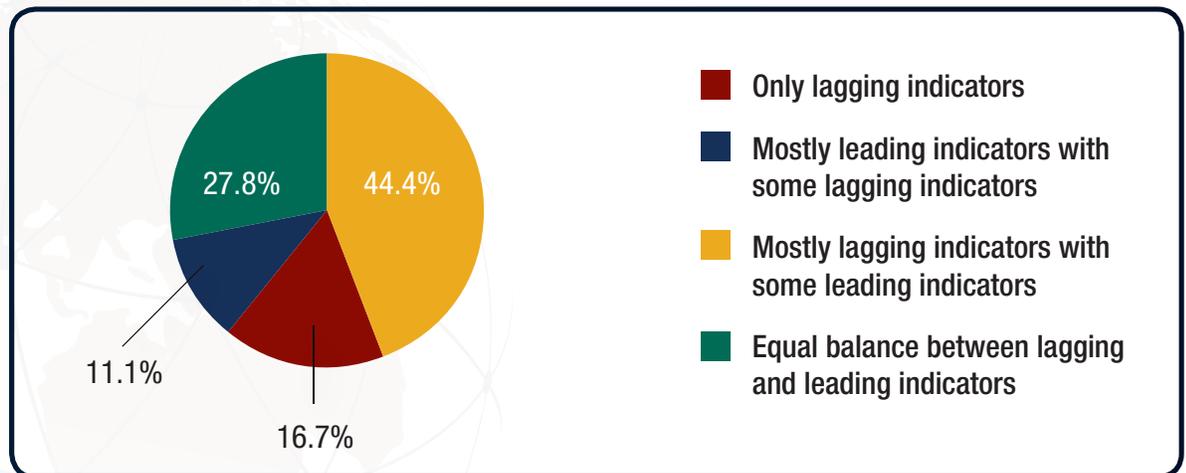
IMPORTANCE OF MEASURING EHS PERFORMANCE USING LEADING INDICATORS



EHS PERFORMANCE METRICS

Nearly half of the respondents (44%) answered that EHS performance at the corporate level was measured by mostly lagging indicators with some leading indicators. No one responded that corporate-level EHS performance was measured purely with leading indicators.

THE USE OF LEADING AND LAGGING INDICATORS TO MEASURE EHS PERFORMANCE - CORPORATE LEVEL



The major types of leading metrics that companies track at the corporate level were:

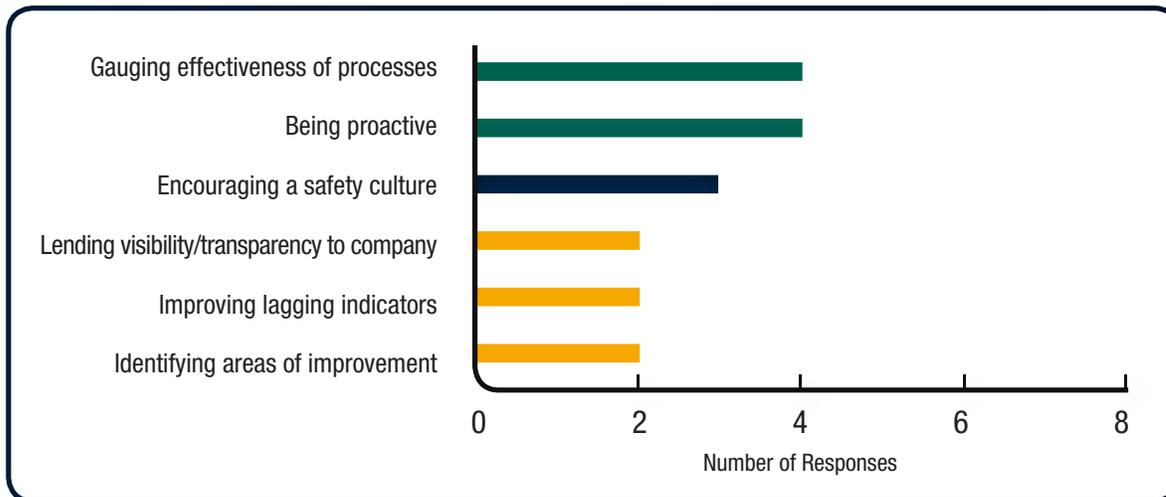
- 】 behavior-based observations (e.g., safe or unsafe behaviors);
- 】 near-miss incidents (e.g., incidents with serious injury or fatality potential);
- 】 audits (e.g., tracking overdue audit items, monitoring the speed of closing action items);
- 】 training (e.g., EHS training for workers, managers, executives);
- 】 meetings (e.g., EHS committee, management review, action planning); and
- 】 other actions (e.g., noncompliance, incident investigation, EHS ideas and suggestions).

According to survey participants' comments, company-wide data management systems built on proprietary software are created to collect data on leading metrics both at the departmental and organizational levels. Real-time data is typically available through a virtual dashboard that allows data users to communicate EHS critical information quickly. Some companies provide access to real-time data to all employees to improve data visibility and strengthen employee engagement. Reports are reviewed regularly (monthly or quarterly) by EHS staff and in high-level team meetings (e.g., management review, corporate board meetings). Additional feedback on leading metrics of EHS is obtained from other enterprise systems such as quality or production.

THE ADVANTAGES TO USING SPECIFIC LEADING INDICATORS

As indicated in the chart below, respondents listed a variety of advantages these specific leading indicators have for their companies. The main advantages respondents identified included being proactive, gauging the effectiveness of safety policies, and encouraging a culture of safety among management and workers.

ADVANTAGES OF USING LEADING INDICATORS



“We are currently not good at closing action items which are generated from incidents, safety meetings, audits, etc. This of course makes us vulnerable and could lead to repeat incidents or violations. It also indicates that we are not using these opportunities to improve performance. To help us close action items on a timely basis, we established a system which creates not only an action owner, but also a verifier.”

— Anonymous survey respondent

LEADING INDICATORS MOST ASSOCIATED WITH SPECIFIC PERFORMANCE GOALS

Not all companies tie leading indicators to specific EHS performance improvement goals, but those that do put emphasis on tracking key procedure audits and worker engagement actions (e.g., EHS meetings, talks, suggestions, ideas).

LEADING INDICATORS THAT ARE ASSOCIATED WITH SPECIFIC PERFORMANCE GOALS

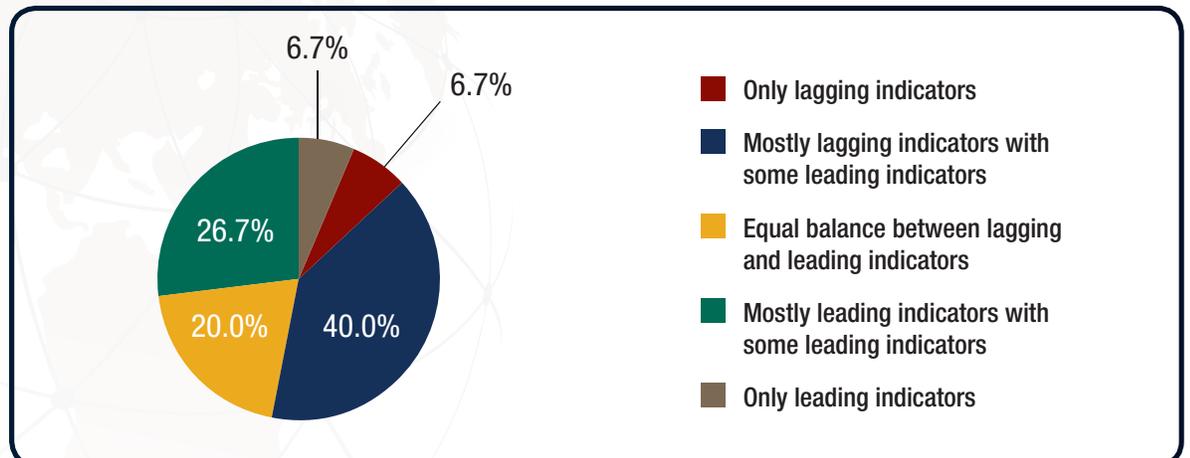


Other leading indicators associated with future performance improvement goals included:

- › Emergency exercises (planned, carried out)
- › EHS culture survey results
- › Recycling indicators
- › Environmental impact evaluation
- › Contractor pre-qualification and post-work evaluations

When asked about the use of leading indicators at the site level, six respondents (40%) answered that site-level EHS performance is measured with mostly lagging with some leading indicators. Four respondents (27%) said that performance at the site level is measured with mostly leading with some lagging indicators. The chart below shows the distribution of responses to this question.

USING LEADING AND LAGGING INDICATORS TO MEASURE EHS PERFORMANCE - SITE LEVEL



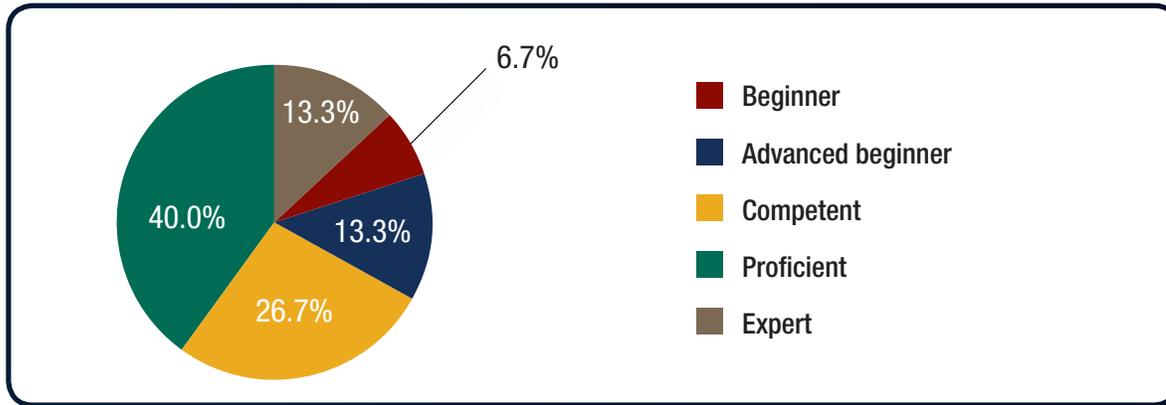
In their comments, survey respondents were in agreement that it is important to have consistency and alignment between site- and corporate-level metrics. Essentially, companies roll out a standard suite of leading indicators for all corporate locations, but also allow individual units to monitor additional metrics based on their unique needs determined by task specification, process complexity, personnel expertise, or unit size.

When asked to describe how leading indicators are rolled up from the site level to the corporate level, four respondents said that this is not a standard practice for their companies. In such cases, individual sites have the flexibility to monitor and evaluate their own performance and the discretion, within the guidelines established by the corporate EHS policy, in implementing corrective action. When leading indicators are aggregated across multiple locations and rolled up to the corporate level, it is typically done through the enterprise data management and reporting system and in a way that allows data users to assess EHS performance at various organizational levels (e.g., location, section, division, business, corporate). In general, the more impact a leading metric has on the corporate EHS management system, the more likely it is to be consolidated and to be taken up to the corporate level.

TECHNICAL KNOWLEDGE OF LEADING INDICATORS AMONG EHS MANAGERS

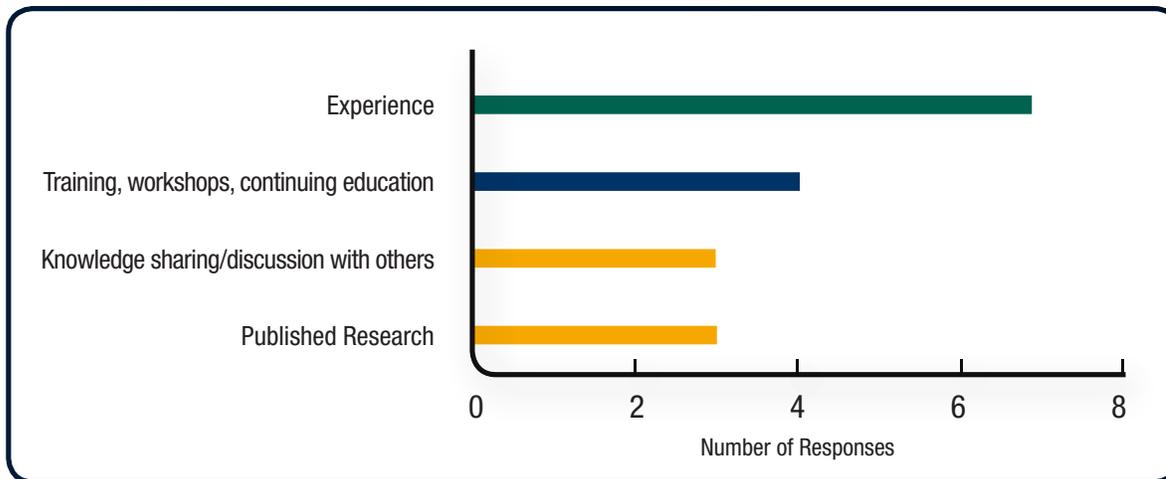
The survey also intended to elicit information about the experience and perceptions of EHS professionals concerning the use of leading indicators in their daily work practice. Specifically, one survey question aimed to gauge the level of technical knowledge among EHS professionals. Of the 15 respondents who answered this question, eight (53%) considered themselves either proficient or expert-level users of leading metrics. The average response score on this question was 3.40 (st.dev. = 1.12) based on a five-point scale of 1 (*Beginner*) to 5 (*Expert*).

EHS PROFESSIONALS' TECHNICAL KNOWLEDGE OF LEADING INDICATORS



When asked what has contributed to their level of technical knowledge of leading indicators, respondents largely cited experience and training.

SOURCES OF TECHNICAL KNOWLEDGE OF LEADING INDICATORS

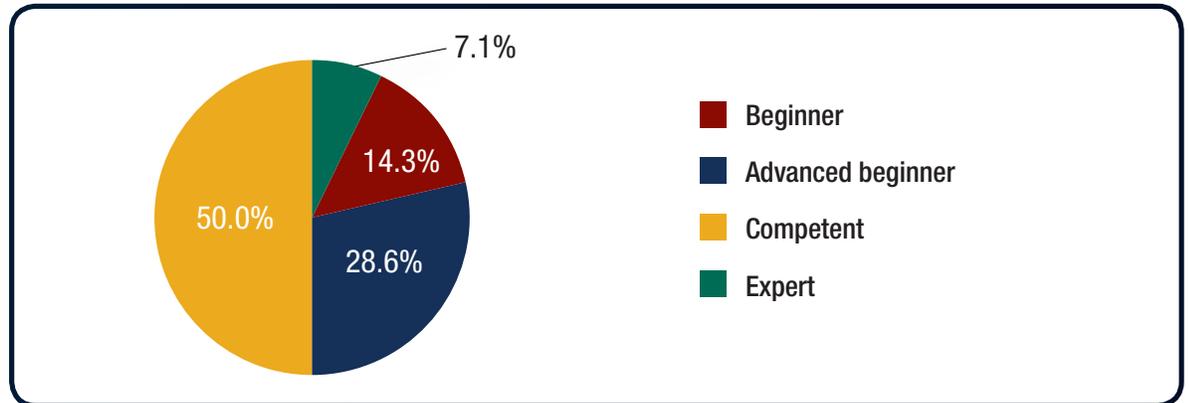


When asked if their technical knowledge of leading indicators is sufficient for them as EHS practitioners, virtually all respondents answered that they may know enough to meet their companies' current demand for expertise in this area; however, proactively identifying and taking advantage of learning opportunities and new sources of information are absolutely critical for continuous improvement efforts in EHS.

TECHNICAL KNOWLEDGE OF LEADING INDICATORS AMONG EHS MANAGERS

Using the same five-point competency scale of 1 (Beginner) to 5 (Expert), the average value of respondents' views on the technical knowledge level of company executives was 2.57 (st.dev. = 1.02). Statistical analysis shows that respondents rated their company executives' technical knowledge of leading indicators lower than their personal knowledge (Wilcoxon signed rank test was used to compare responses, p value < 0.05). Half of respondents rated their executives as competent in leading indicators. No one described their executives as proficient and only one described their executives as experts.

EHS PROFESSIONALS' VIEWS ON TECHNICAL KNOWLEDGE OF LEADING INDICATORS AMONG EXECUTIVES

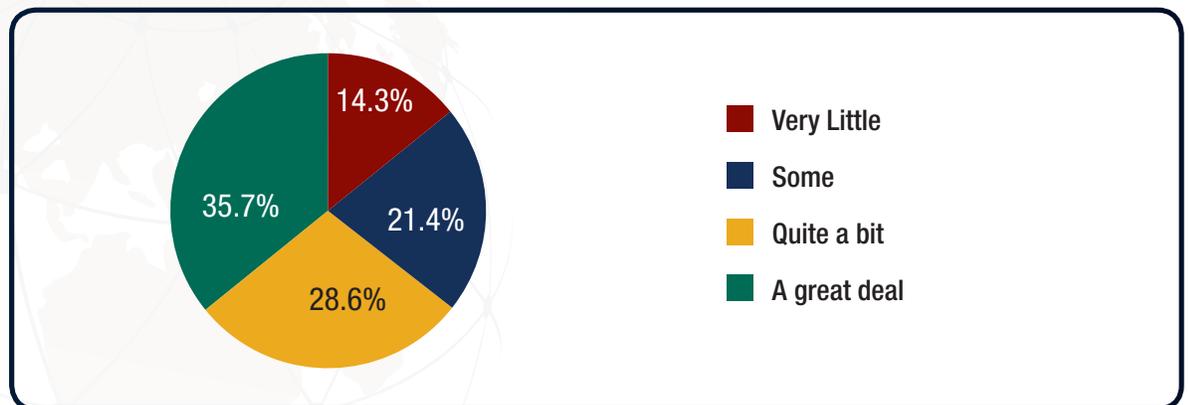


Those who described their executives as at least competent, cited active engagement in EHS policy development, a strong safety culture, experience with and understanding of what happens at the shop floor level, and EHS training as the reasons why their executives have attained their higher level of knowledge. At the same time, lack of training was mentioned as one potential factor explaining why corporate executives may have a lower level of appreciation for tracking EHS performance through leading indicators.

COMMUNICATION AND QUESTIONS REGARDING LEADING INDICATORS

Collectively, about two-thirds of respondents (64%) answered that leading indicators receive either quite a bit or a great deal of attention in their communications with company executives.

ATTENTION PAID TO LEADING INDICATORS IN COMMUNICATIONS WITH EXECUTIVES



During these conversations, the question that company executives ask by far the most is “How are leading indicators connected to actual EHS performance on lagging indicators?” Other, specific questions EHS managers receive from their company executives include:

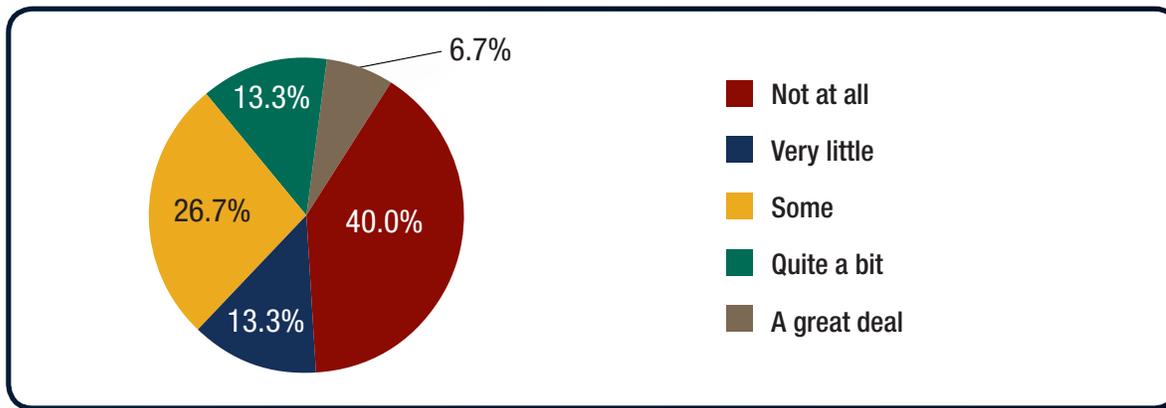
- › How are we evaluating near misses?
- › How are we measuring compliance or conformance?
- › Are we closing incident investigations?
- › Why aren't we doing as well as other industries?
- › Why don't we introduce other leading indicators?
- › Can we do more analysis of certain leading indicators?
- › How much is this initiative going to cost?
- › Are our recycling efforts yielding less waste?

Bivariate analyses were performed to determine whether the level of attention paid to leading indicators in EHS professional-executive conversations is correlated with other factors explored in the survey. The outcomes of these analyses are presented at the end of the Results section.

ACCOUNTABILITY FOR LEADING INDICATORS OF EHS PERFORMANCE

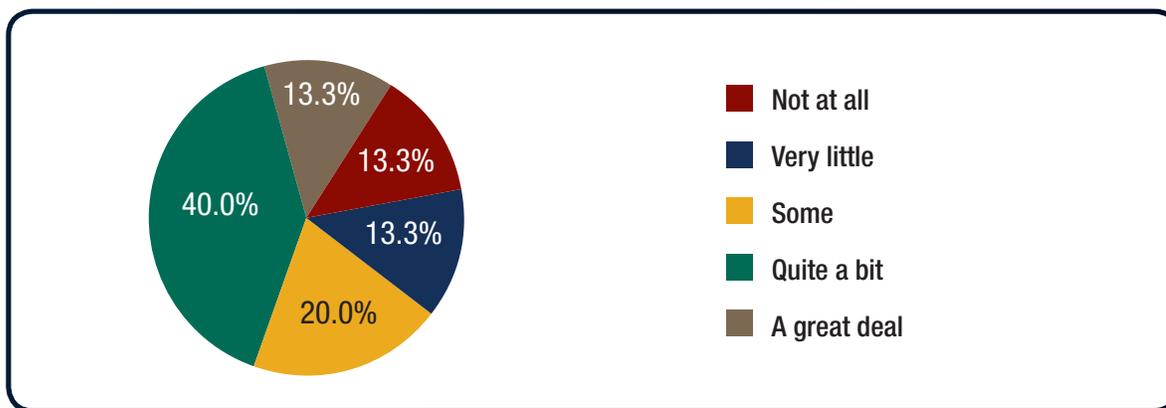
Over half of survey respondents (53%) said that executive compensation is tied very little or not at all to performance on leading indicators.

EXTENT TO WHICH EXECUTIVE COMPENSATION IS TIED TO LEADING INDICATORS



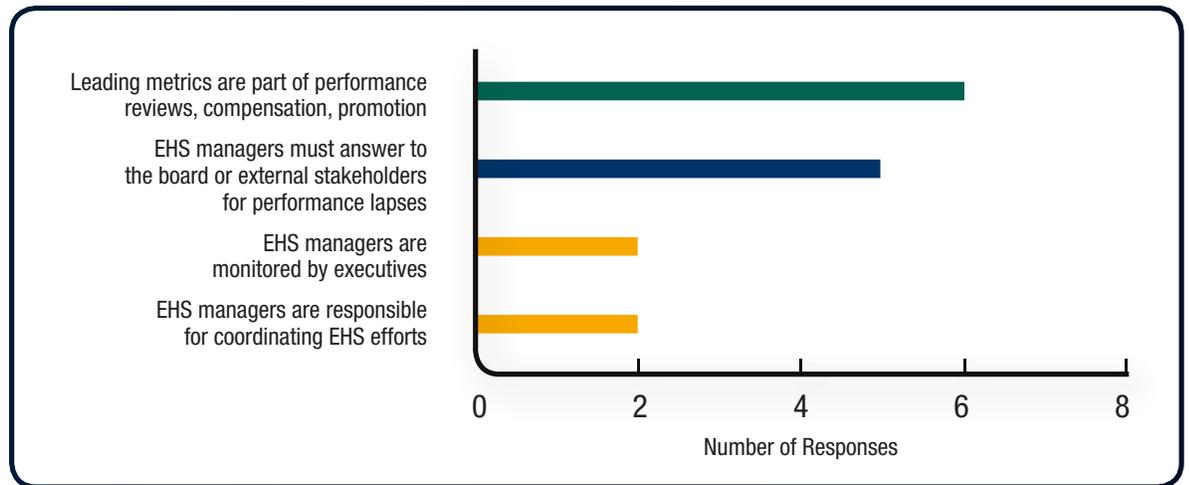
When asked to what extent EHS managers are held accountable for leading indicators, most respondents' answers were a *great deal* or *quite a bit* (53%).

EHS PROFESSIONALS' ACCOUNTABILITY FOR PERFORMANCE OF LEADING INDICATORS



EHS managers are held accountable for leading indicators in many ways. As illustrated in the chart below, most answered that leading metrics of EHS play a major role in performance reviews and therefore have direct bearing on compensation and promotion.

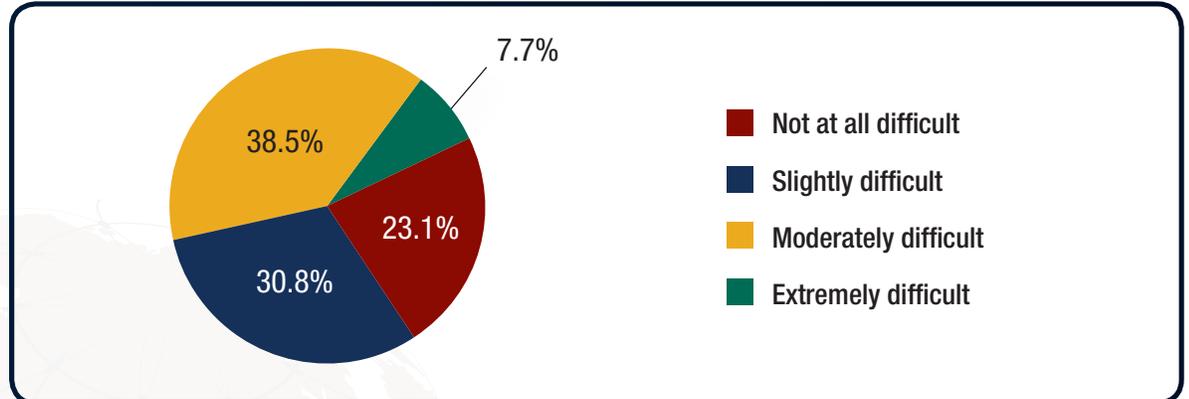
HOW EHS MANAGERS ARE HELD ACCOUNTABLE FOR LEADING INDICATORS



IDENTIFYING CORRECTIVE OR PREVENTATIVE ACTIONS WITH INFORMATION PROVIDED BY LEADING INDICATORS

Just over half (54%) of respondents stated that identifying corrective or preventative actions with leading indicators was not at all difficult or only slightly difficult. The other half of the survey sample felt that it was either moderately difficult (39%) or extremely difficult (8%).

LEVEL OF DIFFICULTY IN IDENTIFYING PREVENTATIVE OR CORRECTIVE ACTIONS WITH INFORMATION FROM LEADING INDICATORS



Respondents also provided examples of how leading indicator data can bring about remedial action. This is a multistep process which starts with information sharing i.e., someone with access to leading metrics data, typically an EHS professional, decides to share new information with a group of internal stakeholders. At the site level, these stakeholders are likely to be members of a safety committee, whereas at the corporate level, aggregate data may be presented during management review meetings. This step is followed by a concerted effort to turn data into insight. That is, the stakeholders must work together to analyze the data and look for patterns and abnormalities that may require special attention. At this point, additional feedback or interpretation may be sought from individuals or business units whose knowledge and expertise may improve the group's shared understanding of the data. Once the stakeholders determine what the data is saying and agree on the lessons learned, this information may be distributed broadly to enable corrective action either at the site or corporate level. The following scenarios were described by the survey participants:

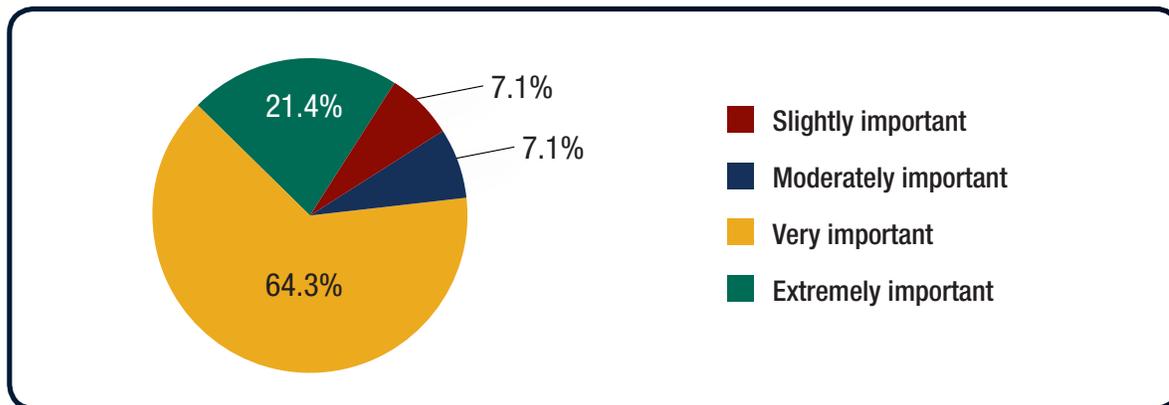
- › Behavior-based safety observations were used to identify the need for additional training in lockout and confined space procedures.
- › Key procedure audits highlighted the need to revise specific procedures and fill in gaps between procedures and practices.
- › Employees' ideas and observations were converted to maintenance notifications and forwarded to the appropriate departments for implementation.
- › Near misses and observations within a business unit indicated a higher risk of hand injuries due to improper gloves; a glove standardization project was undertaken to address this risk factor.

Bivariate analyses were performed to determine whether the ability to identify and implement corrective action on the basis of information provided by leading metrics is correlated with other factors explored in the survey. The outcomes of these analyses are presented at the end of the Results section.

THE LINK BETWEEN LEADING AND LAGGING INDICATORS

The vast majority of respondents stated that having the ability to tie changes in leading indicators to stronger or weaker performance on injury rates and other lagging indicators is very important (64%) or extremely important (21%).

IMPORTANCE OF LINKING PERFORMANCE ON LEADING INDICATORS TO CHANGES IN LAGGING INDICATORS

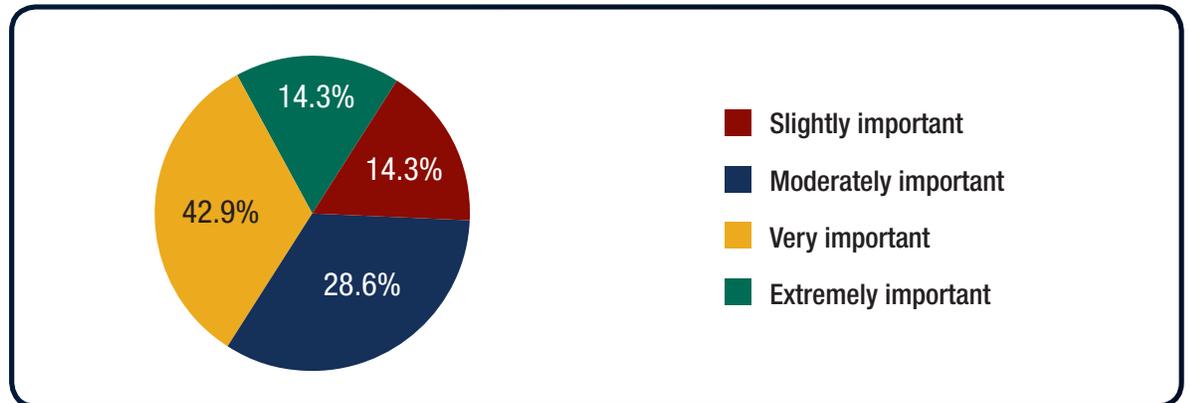


In a follow-up question, respondents were asked if they were able to establish a statistical relationship between leading and lagging indicators, and if so, how they were able to do so. Six out of thirteen respondents (46%) were able to definitely state that they have found a statistical link between leading and lagging indicators. At the same time, seven respondents (54%) have not yet been able to establish a statistical relationship. The methods used by organizations to measure this relationship was limited to finding a general trend or a temporal association between leading and lagging metrics (e.g., sites with higher volume of near miss reporting or fewer behavior-based safety observations have lower injury rates).

COMPANY BENCHMARKING OF EHS PERFORMANCE

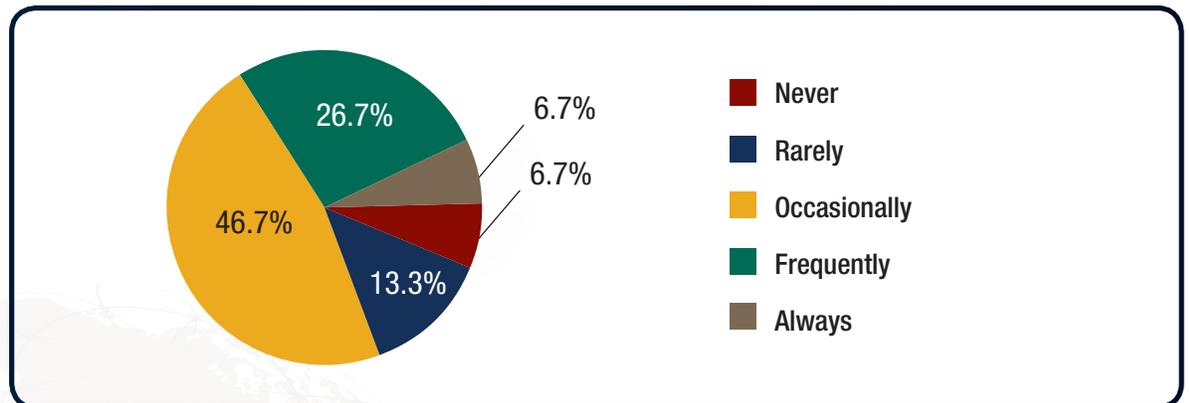
Benchmarking is commonly used by companies interested in continuous improvement and is a technique for identifying and implementing best or better practices based on the experience of peers. Over half of respondents (57%) answered that benchmarking EHS performance on leading indicators with other organizations within or outside their industry is either very important or extremely important. No one responded that benchmarking against other organizations is not at all important.

IMPORTANCE OF BENCHMARKING EHS PERFORMANCE ON LEADING INDICATORS



When asked about the frequency of benchmarking leading indicators against other organizations, 47% reported doing it occasionally and an additional 27% frequently.

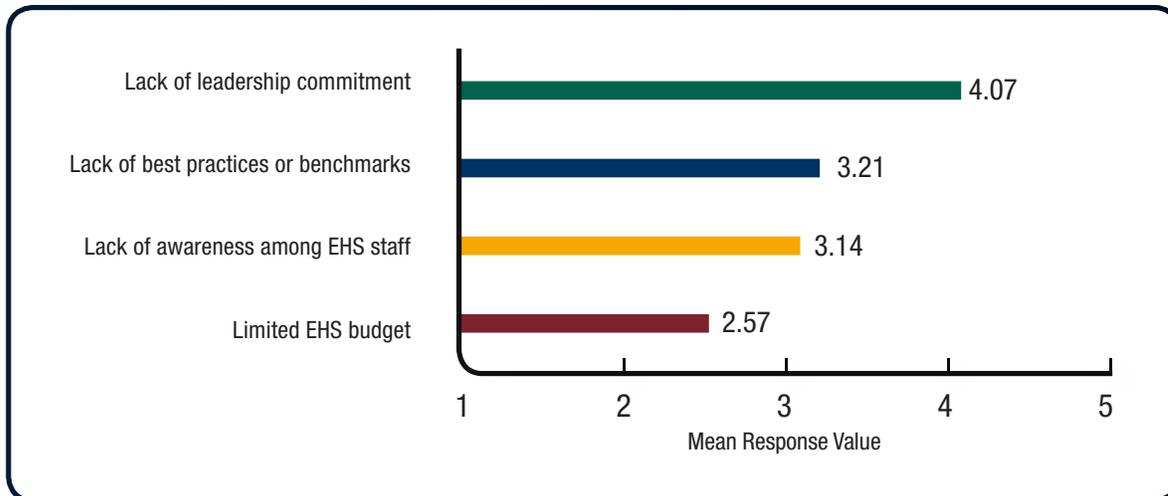
FREQUENCY OF BENCHMARKING LEADING INDICATORS AGAINST OTHER ORGANIZATIONS



BARRIERS AND ENABLING FACTORS TO THE IMPLEMENTATION OF LEADING METRICS

Using a five-point scale of 1 (*Not at all significant*) to 5 (*Extremely significant*), respondents rated the significance of the following potential barriers to the implementation of leading indicators: lack of awareness among EHS staff, limited EHS budget, lack of leadership commitment, and lack of best practices or benchmarks. The chart below compares the average response values for each of these factors. Overall, the two main barriers to the implementation of leading indicators appear to be lack of leadership commitment and lack of best practices or benchmarks.

MEAN RESPONSE VALUES FOR POTENTIAL BARRIERS TO LEADING INDICATOR IMPLEMENTATION



Other factors identified as barriers to the implementation of leading indicators included:

- › Lack of time or competing priorities
- › Lack of quality data to assure accuracy and reliability of leading indicators
- › Choosing the correct leading indicators and knowing when to retire unsuccessful leading indicators

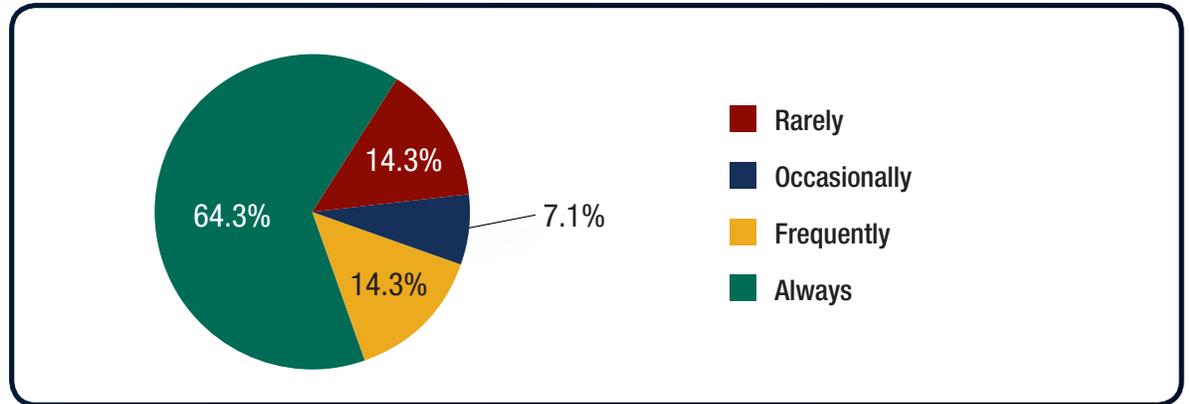
Respondents also provided a list of the most important factors that have enabled their companies to implement leading indicators as part of their safety management systems. By far, the most common response was the importance of leadership commitment, engagement, understanding, and support for implementing leading indicators. Other important enabling factors mentioned were:

- › Open communication and knowledge sharing across company sites
- › Technology to track leading indicators
- › Linking leading indicators to incentives
- › Quality information technology systems
- › Proactive safety mindsets among key staff and stakeholders

THE INCLUSION OF CONTRACTORS AND TEMPORARY OR SEASONAL WORKERS IN LEADING INDICATOR REPORTING

The majority of respondents (64%) answered that they always include contractors and temporary or seasonal workers when it comes to reporting of leading indicators. This is in keeping with results from the Campbell Institute's EHS Leadership Survey (2013) that found most world-class companies thoroughly vet contractor companies before doing business with them.

FREQUENCY OF INCLUSION OF CONTRACTORS AND TEMPORARY/SEASONAL WORKERS IN LEADING INDICATOR METRICS

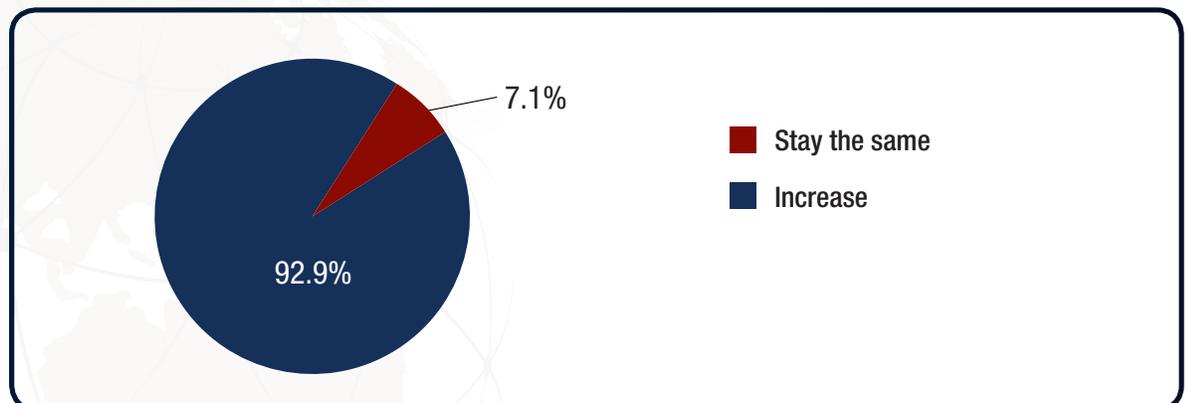


Another question in the survey asked how the inclusion of contractors and temporary or seasonal workers affects their companies' EHS performance on leading metrics. Some respondents said that it has no effect, either positive or negative. Others felt that including these workers does make EHS goals harder to achieve, but at the same time it provides a more accurate picture of the organization's overall performance. More importantly, several respondents recognized specific benefits of this inclusion as it leads to improved corporate image, stronger team spirit, and developing a shared vision and common goals for EHS, which eventually translates into superior financial performance.

THE FUTURE OF LEADING INDICATORS

The overwhelming majority of respondents (93%) reported that their use of leading indicators was likely to increase over the next five years. Some of the specific examples of future actions found in the open-ended comments were introducing new leading metrics to better reflect organizational changes and updates to the EHS management system, introducing new data tracking and analytical tools to enable action planning, and benchmarking performance against other organizations.

PROJECTED USE OF LEADING INDICATORS OVER THE NEXT FIVE YEARS



ADDITIONAL ANALYSES

Based on the outcome of the expert panel discussion and survey results, we performed additional statistical analyses to determine what factors may be correlated with the level of attention paid to leading metrics in communications between EHS professionals and company executives. Similar analyses were performed to determine the correlates of EHS professionals' ability to identify and implement corrective or preventive actions using leading indicator data.

Using Spearman's rank correlation coefficient (ρ) for non-parametric data, we found that the level of attention paid to leading indicators in communications with executives was strongly correlated with survey respondents' perceived importance of leading indicators in measuring EHS performance ($\rho = .772$), frequency of benchmarking ($\rho = .764$), and ability to identify and implement corrective/preventive actions ($\rho = .704$). In addition, there was a weaker, but statistically significant, correlation with executives' level of technical knowledge of leading indicators ($\rho = .663$).

Respondents' ability to identify and implement corrective or prevention actions based on the information provided by leading indicators was correlated with tracking leading indicators at the corporate and site levels ($\rho = .608$ and $.622$, respectively) and frequency of benchmarking leading indicators ($\rho = .630$), although not as strongly as executives' level of technical knowledge of leading indicators ($\rho = .696$). Table 1 provides complete information on the correlations between the aforementioned factors.

CORRELATION MATRIX ^a									
	Mean	SD	2	3	4	5	6	7	8
1. ATT	3.86	1.10	.704**	.772**	.663**	.287	.420	.578*	.764**
2. ACTION	3.62	1.12		.487	.696**	.204	.608*	.622*	.630*
3. IMP	4.44	.86			.686**	.147	.333	.599*	.632*
4. EXEC	2.57	1.02				.008	.513	.607*	.405
5. PRO	3.40	1.12					-.145	.068	.107
6. CORP	2.33	.91						.793**	.460
7. SITE	2.87	1.13							.498
8. BENCH	3.13	.99							

* $p < .05$ (two-tailed)

** $p < .01$ (two-tailed)

^a Spearman's rank correlation coefficient (ρ).

SD = standard deviation; ATT = Attention paid to leading indicators (LI) in EHS professional-executive communications; ACTION = Ability to identify and implement corrective/preventative action; IMP = Perceived importance of LIs in measuring EHS performance; EXEC = Level of technical knowledge among company executives; PRO = Level of technical knowledge among EHS professionals; CORP = Tracking LIs at corporate level; SITE = Tracking LIs at site level; BENCH = Frequency of benchmarking LIs against other organizations.

DISCUSSION

As noted in the introduction to this report, the main objectives of this study were to:

- › describe the extent to which EHS practitioners understand leading indicators;
- › explore organizational practices pertaining to tracking, analyzing, and applying information provided by leading indicators to improve EHS performance; and
- › identify barriers and factors that enable the use of leading indicators.

Our findings illustrate that leading indicators play a big part in enabling decision making on EHS matters. The appeal of leading metrics appears to be in their potential to predict and prevent adverse outcomes by giving organizational leaders an additional set of forward-looking EHS targets for improvement. Organizations also use leading metrics to support communication and employee morale building strategies aimed at transforming organizational culture from being passive and problem focused to being proactive and solution driven.

Being achievable, meaningful, transparent, easy to communicate, valid, useful, and timely were identified as some of the valuable qualities of lead metrics. But perhaps most importantly, leading indicators should be actionable, that is, they can be utilized to identify and implement steps intended to reduce or eliminate risk. Our research indicates that turning data into action is a struggle for many organizations. One feasible solution to this problem is to make sure that leading metrics are built into the continuous improvement process right from the beginning. Organizations would find it much easier to formulate action plans and produce better results if their leading metrics were created on the basis of specific EHS-related actions (e.g., training, behavior-based safety observations), rather than collecting data on a large number of metrics, and then trying to tie them to a specific activity. Other steps along the process – sharing collected data with key stakeholders, analyzing the data, developing a shared understanding of the data, identifying lessons learned, and disseminating this information among those responsible for the implementation of remedial action – are also used to identify potential areas for EHS management improvement.

Our analysis also showed that several factors are correlated with the actionability of leading metrics. Organizations find it easier to identify corrective or preventative actions through leading indicators when:

- › leading indicators receive more attention in communications with executives;
- › executives' expertise level in leading indicators is higher; and
- › leading indicators are used to track performance at the corporate and site levels.

EHS practitioners seem to agree that their organizations' success in reducing the impact of environmental, health, and safety concerns is intimately linked to how well they can track, manage, and use information provided by leading metrics. Most respondents in our study reported investing a significant amount of time, money, energy, and other resources into implementing leading metrics and indicated that this effort is likely to increase in the foreseeable future. The inclusion of contractors and other seasonal or temporary workers in calculating leading metrics is another way organizations demonstrate commitment to accurately depict the status of EHS even if it makes their goals more difficult to achieve. While many respondents identified barriers, such as lack of standard practices and lack of awareness among EHS staff, which can inhibit the implementation of leading indicators, most respondents also identified executive leadership's commitment and support as the most important enabling factor for leading indicator use.

Because one of the most important roles of corporate executives is to set clear expectations for EHS performance, they need to at least understand and preferably be visibly engaged in decision making with regards to EHS performance evaluation strategies. It should not come as a surprise that EHS practitioners describe themselves as having a better technical knowledge of leading indicators than their senior executives. Furthermore, some top-level executives still exhibit a tendency to solely embrace lagging indicators to the exclusion of leading metrics. There could be a number of potential reasons behind such a narrow viewpoint. At the individual level, some combination of age and work experience would explain why the focus of older executives, for example, may be more on the traditional metrics. Leading indicators, as a measure of organizational performance in EHS, have been introduced relatively recently and perhaps is in conflict with the more traditional knowledge that has become entrenched in the views of senior executives. At the same time, this focus could also be driven by the organizational practices set, governed, and expected by corporate board members.

Other top-level managers are looking for opportunities and tools to increase their own competence because they realize that competence

increases credibility and credibility means power (Kanter, 1993). The comments of the expert panel and, to some extent, the results of the survey support the notion that leading indicators, and how they relate to business performance, at least pique the curiosity of corporate leaders. Judging by the fact that leading indicators receive a good deal of attention in EHS manager-executive communications, it becomes obvious that some corporate leaders do appreciate the intrinsic value of having a broader array of EHS measurement tools. Furthermore, statistical analysis revealed that the level of attention leading indicators receive in communications with executives is positively correlated with executives' level of technical expertise in this area, EHS practitioners' perceived importance of leading metrics and ability to take remedial action, the likelihood of using leading indicators at the site level, as well as the amount of effort invested in the implementation of leading indicators. In addition, it is interesting to note that EHS practitioners' technical competence was not correlated with the level of attention paid to leading metrics, which may justify the need for EHS practitioners to educate not only themselves, but also their senior executives about the value of looking at the lead aspect of EHS performance measurement. While these correlations do not imply causation, they serve to improve the understanding of the modifiable factors that may influence the level of attention paid to EHS performance measurement issues inside the c-suite.

Managing EHS effectively requires the examination of the role of EHS practitioner in performance measurement. This includes an understanding of their knowledge, competence, perceptions, experience, and responsibilities. Even though the majority of participants in our study possessed a fairly high level of confidence in their own knowledge of leading indicators, they were virtually unanimous in their desire to acquire more knowledge and skills in this rather complex area in order to be able to stay abreast of and get the most out of the transition that is taking place in the field of EHS. This shift away from using only lagging indicators towards adding more leading metrics is particularly noticeable among world-class companies, and this example will sooner or later encourage the entire EHS profession to expand the role of leading metrics in the business world. Professionals with EHS responsibilities are viewed to have expert power, or the ability to affect behavioral change in others because of recognized knowledge and skills (Lunenburg, 2012). By and large, this power is directed laterally or downward to influence the actions of peers and subordinates (Yukl & Falbe, 1990). The views of the expert

panel combined with the survey results have identified two interrelated areas where the EHS practitioner's expertise should be directed upward – first, to educate top-level decision makers about the technical aspects of effective performance measurement and, second, to use the power of persuasion to give leading metrics more attention in corporate conversations at the highest level.

The introduction of leading metrics, the integration of environmental, safety, health, wellness, and even quality management systems, the fast growing adoption of the triple-bottom-line philosophy, and other salient trends affecting the way companies do business today will transform how EHS practitioners' performance is judged, as well. Our research indicates that a lot of organizations already hold EHS practitioners accountable by incorporating quantifiable leading metrics into their performance reviews and tying them to compensation, promotion, and succession schemes. However, our findings also raise additional questions. For example, how much weight should leading metrics have relative to lagging metrics in performance appraisals and would the leading-to-lagging metrics ratio need to be adjusted depending on the employee's position of authority? More importantly, does the inclusion of leading metrics into individual-level performance review translate into better results on lagging metrics for the organization?

Although limited in scope, this study suggests that there is a difference in how leading indicators are typically dealt with when it comes to measuring corporate- and site-level EHS performance. At the corporate level, EHS performance appears to be mostly measured with lagging indicators with increasing attention being paid to leading indicators. At the site level, the balance shifts in favor of leading metrics. In fact, some organizations claim that the focus of their approach to site-level performance measurement is solely on leading indicators. It should be noted that these results track with those of the 2013 EHS Leadership Survey of the Campbell Institute (Campbell Institute, 2013), which found that EHS performance at the corporate level is mostly evaluated on lagging indicators while site-level performance is mostly evaluated on leading indicators. At least two factors could help explain this discrepancy. First, leading indicators are by nature very process-specific, meaning that they are tied to certain functions or activities at individual sites. Due to this specificity, leading indicator data often become less actionable and less informative as one moves from the site to the corporate level of analysis. Second, organizations may find it



difficult to roll up site-level leading indicators to the corporate level because the sites themselves may differ in terms of size, location, operations, structure, culture, EHS procedures, and many other characteristics that make them difficult to normalize and sometimes impossible to compare.

The present study indicates that a methodology for establishing a statistical relationship between leading and lagging metrics is greatly needed across industries to ensure the continued and progressive use of leading indicators. For EHS practitioners, addressing this need may be particularly important because, as our findings illustrate, company executives first and foremost want to know about the relationship between leading and lagging indicators. The lack of solid data combined with inability to turn data into action can certainly have a chilling effect on the level of commitment and buy-in among top-level executives, whose job is to achieve measurable results in social, economic, and EHS performance.

The majority of respondents assigned a high level of importance to using leading indicators for benchmarking EHS performance against other organizations, yet relatively few do it on a regular basis. Comparing EHS performance is a common practice, particularly among large enterprises, because it challenges participants to find new and better ways to manage EHS in the workplace. Several factors are considered to be prerequisites for undertaking a benchmarking initiative, including availability of adequate resources and expertise, management commitment to continuous improvement, and data availability. However when it comes to benchmarking leading metrics, even the most experienced and well-funded companies run by the most enlightened leaders may find it difficult to answer questions like: *What specific leading metrics do we want to compare? How do we determine what is “best performance”?* *Is implementing better lead practices likely to result in performance improvement on lagging metrics?* The difficulty answering these questions perhaps helps to explain why there is a mismatch between what is viewed as important and what is feasible.

What is clear from this research is that the use of leading indicators to gauge performance in EHS is a relatively new area of scientific inquiry and has raised far more questions than answers for practitioners. Nonetheless, our findings suggest that private-industry stakeholders, including world-class EHS leaders, are actively honing their analytical skills and knowledge. In this process, they are generating a wealth of practical

information that can be used to encourage wider adoption of if not proven, then at least promising, practices in EHS performance measurement by organizations on the journey to EHS success.

LIMITATIONS AND FUTURE DIRECTIONS

This research has limitations. First, the survey sample was small and assembled using convenience sampling. Survey participants were not randomly selected and represent organizations with occupational injury and illness rates that are well above the respective industry average values. Second, the study sample included mostly large employers and, therefore, generalizing the survey results to small and medium size companies should be done with caution. Third, the survey participants were experienced EHS practitioners with job titles of manager or higher and may not be representative of the entire population of professionals employed in this field. Finally, the validity of subjective ratings has been questioned due to a variety of factors (e.g., desirability bias).

With these limitations in mind, this report presents a strong case for continued growth in the use of leading indicators in EHS management and research. Future research can have an in-depth focus on investigating the work activities and competencies of EHS practitioners in relation to EHS performance measurement. On a more practical level, this report suggests that providing guidelines for making the business case for leading indicators to top-level executives may be of benefit to the EHS profession at large. As discussed in the expert panel, a mechanism for establishing a statistical link between leading and lagging metrics is greatly needed across industries to ensure the progressive use of leading indicators. More research in this area may reveal how companies identify the most successful leading indicators and how they directly impact EHS performance. We believe that there may be a desire for creating and validating a standard index of leading indicators that could be used for benchmarking across organizations. However, we also suspect that finding the right metrics, or combinations of metrics, may prove to be a major challenge. As the Honorable Jessie Hill Roberson noted in her comments on the Deepwater Horizon oil spill, “A small set of meaningful, actionable leading indicators that bears direct relationship to the work and the organization is more useful than a multitude of metrics without clear focus.”

WORKS CITED

API (2010). Process Safety Performance Indicators for the Refining and Petrochemical Industries.

CCPS (2008). Process Safety Leading and Lagging Metrics. Center for Chemical Process Safety, New York. Retrieved from <http://www.aiche.org/ccps>.

Campbell Institute (2013). Defining EHS Leadership in World-Class Organizations. Retrieved from <http://www.thecampbellinstitute.org>.

Diaz, R.I., & Cabrera, D.D. (1997). Safety climate and attitude as evaluation measures of organizational safety. *Accident Analysis & Prevention*, 29(5), 643-650.

Hale, A. (2009). Why safety performance indicators? *Safety Science*, 47(4), 479-480.

Harms-Ringdahl, L. (2009). Dimensions in safety indicators. *Safety Science*, 47(4), 481-482.

HSE (2009). Application of performance indicators in the explosives sectors. Health and Safety Executive. HSE Books.

Hinze, J., Thurman, S., & Wehle, A. (2013). Leading indicators of construction safety performance. *Safety Science*, 51(1), 23-28.

Hohn, T. & Duden, D. (2009). Session No. 501: Benchmarking your leading safety indicators to manage jobsite risk [webinar]. In ASSE Professional Development Conference. Retrieved from <http://members.asse.org/2007/proceedings/2009/docs/501.pdf>

Hopkins, A. (2009). Thinking about process safety indicators. *Safety Science*, 47(4), 460-465.

Hudson, P. (2009). Process indicators: Managing safety by the numbers. *Safety Science*, 47(4), 483-485.

Iyer, P., Haight, J., Castillo, E., Tink, B., & Hawkins, P. (2004). Intervention effectiveness research: Understanding and optimizing industrial safety programs using leading indicators. *Chemical Health & Safety*, March/April, 9-19.

Janicak, C. A. (2010). *Safety Metrics: Tools and Techniques for Measuring Safety Performance* (2nd ed.). Lanham, MD: Government Institutes.

Grabowski, M., Ayyalasomayajula, P., Merrick, J., Harrald, J.R., & Roberts, K. (2007). Leading indicators of safety in virtual organizations. *Safety Science*, 45(10), 1013-1043.

Kanter, R.M. (1993). *Men and women of the corporation*. New York: Basic Books.

Lunenburg, F.C. (2012). Power and Leadership: An Influence Process. *International Journal of Management, Business, and Administration*, 15(1), 1-9.

Nielsen, K.J., Rasmussen, K., Glasscock, D., & Spangenberg, S. (2008). Changes in safety climate and accidents at two identical manufacturing plants. *Safety Science*, 46(3), 440-449.

OECD. (2008). Guidance on developing safety performance indicators related to chemical accident prevention, preparedness and response. For industry. Second Edition. OECD Environment, Health and Safety Publications. Series on Chemical Accidents No. 19. Paris: OECD Publications.

O'Connor, P., Buttrey, S.E., O'Dea, A., & Kennedy, Q. (2011). An assessment of the relationship between safety climate and mishap risk in US Naval Aviation (No. NPS-OR-11-004). Naval Postgraduate School Monterey CA Dept Of Operations Research.

Reiman, T. & Pietikainen, E. (2010). Indicators of safety culture – selection and utilization of leading safety performance indicators. Swedish Radiation Safety Authority, Research Report 2010:07.

Reiman, T. & Pietikainen, E. (2012). Leading indicators of system safety - Monitoring and driving the organizational safety potential. *Safety Science*, 50(10), 1993-2000.

Roberson, J.H. (2012, July 23). Using leading indicators to avoid major accidents. Statement given at U.S. Chemical Safety Board's public hearing on Deepwater Horizon. Houston, TX. Retrieved from [http://www.csb.gov/UserFiles/file/Roberson%20\(DNFSB\)%20Testimony%20-%20printed.pdf](http://www.csb.gov/UserFiles/file/Roberson%20(DNFSB)%20Testimony%20-%20printed.pdf).

Robson, L.S., Clarke, J.A., Cullen, K., Bielecky, A., Severin, C., Bigelow, P.L., Irvin, E., Culyer, A., & Mahood, Q. (2007). The effectiveness of occupational health and safety management system interventions: a systematic review. *Safety Science*, 45(3), 329-353.

Spear, J. (2010). Measuring safety and health performance: A review of commonly-used performance indicators, J.E. Spear Consulting, 1-6.

Stough, J. (2012). Using leading indicators to continuously improve EHS & sustainability performance. *IHS*, 1-13.

Toellner, J. (2001). Improving safety and health performance: Identifying and measuring leading indicators. *Professional Safety*, 46(9), 42-47.

Wurzelbacher, S. & Jin, Y. (2011). A framework for evaluating OSH program effectiveness using leading and trailing metrics. *Journal of Safety Research*, 42(3), 199-207.

Yukl, G. & Falbe, C.M. (1990). Influence tactics and objectives in upward, downward, and lateral influence attempts. *Journal of Applied Psychology*, 75(2), 132-140.

ABOUT THE CAMPBELL INSTITUTE

The Campbell Institute (Institute) at the National Safety Council is the environmental, health, and safety (EHS) Center of Excellence. Built on the belief that EHS is at the core of business vitality and intrinsic to operational excellence and financial performance, the Institute helps organizations of all sizes and sectors achieve and sustain excellence.

THANKS TO:

The National Safety Council Research and Safety Management Solutions Group

The Campbell Institute Research & Knowledge Sub-committee

The Campbell Institute Charter Members (as of September 16, 2013) APM Terminals • Bahrain Petroleum Company (BAPCO) • BST • Chevron • Cummins • DM Petroleum Operations Company • The Dow Chemical Company • DuPont • Exxon Mobil • Firmenich • Fluor • General Motors • Georgia-Pacific • Gulf Petrochemical Industries Company (GPIC) • Honeywell • IHS • Industrial Scientific • Microsoft • NANA Development Corporation • Owens Corning • PotashCorp • Qatar Fertilizer Company • Schneider Electric • USG • United States Steel Corporation • UTC Climate, Controls & Security • Whirlpool

Authors Sergey Sinelnikov, Joy Inouye and Sarah Kerper

Campbell Institute Staff Gary Rosenblum, John Dony, Katherine Smith and Katie Knee

ABOUT THE CAMPBELL AWARD

The Campbell Award recognizes exemplary organizations that achieve excellence through the integration of EHS management in business operations. Supported by a network of 22 Global Partners across five continents and underwritten by the Exxon Mobil Corporation, the Award provides the unique opportunity for winners to share their EHS system innovation to help organizations, of all sizes and sectors, achieve and sustain excellence.

AWARD WINNERS Noble Corporation • Johnson & Johnson • Alcan • DM Petroleum Operations Company • Bahrain Petroleum Company (BAPCO) • Fluor Hanford • Gulf Petrochemical Industries Company (GPIC) • Schneider Electric North America • The Dow Chemical Company • UTC Fire & Security • Firmenich • DuPont

CONTACT INFORMATION

Campbell Institute

NATIONAL SAFETY COUNCIL

CALL +1-630-775-2283

WEB thecampbellinstitute.org

EMAIL campbellinstitute@nsc.org