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HEALTH AND SAFETY PERFORMANCE INDICATORS IN GLOBAL STEEL COMPANY

MAARIT KOIVUPALO

Outokumpu Oyj, Salmisaarenranta 11, P. O. Box 245, FIN-00180 Helsinki, Finland. E-mail: maarit.koivupalo@outokumpu.com, tel. +358401678020. (Corresponding author)

ARTO REIMAN

Faculty of Technology, Industrial Engineering and Management, P.O. Box 4610, FIN-90014 University of Oulu, Finland.

ABSTRACT

The study describes local practices of health and safety (HS) performance measurement in a global steel company, including the concepts of leading and lagging HS performance indicators. The World Steel Association (WSA) and Oil and Gas Producers (OGP) were used for external HS performance benchmarking. The main indicator for the external performance benchmark was lost time injury frequency (LTIFR). Differences in terminology between WSA, OGP and OHSAS 18001 were identified. The primary empirical method was a case study, involving interviews with local safety managers (N=14). The eight main production sites for the case company were in Europe, the Americas and Asia. The internal documentation was reviewed and compared against the external benchmarks. The study revealed the current state of the local HS performance monitoring and its corporate requirements. The case company's HS performance was monitored in terms of leading and lagging indicators. An adequate balance was achieved between these leading and lagging indicators. The indicators satisfactorily met the requirements for a good HS indicator construct. The HS indicators and terminology used by the case company were similar to those of OHSAS 18001, WSA and OGP. General corporate social responsibility reporting principles were also followed in the sustainability reporting. A decade ago, when compared to the benchmarks (OGP and WSA), the case company did not even come close to them regarding LTIFR performance, but recently, it has closed this gap. Recommendations for further development of HS performance management are given. The need to make adjustments to the HS indicator construct and the internal requirement standards were observed, but the general practice was similar to that of the external benchmarks and standards.

Keywords: health and safety management, health and safety statistics, health and safety performance, leading indicators, performance measurement.

1 INTRODUCTION

Socially responsible companies want to ensure that their activities have a sustainable foundation. Management of health and safety (HS) is an essential part of a business, a core organisational value. Organisations and company structures are constantly changing. This is emphasised in today's business environment and poses a range of challenges to HS management. Performance monitoring plays an essential role. When an organisation grows and includes new sites, it creates challenges including the need to ensure uniform HS management throughout the scattered sites. Several issues arise, for example how to ensure that everyone is fulfilling at least the basic level requirements for HS management, how to improve HS performance and whether it is possible to compare the HS performance of sites in different countries with their different cultures and backgrounds?

Øien et al. (2011) concludes that there is no such thing as universal model or method for the development of HS performance indicators and suggests that the use of several different methods would provide the best outcomes. In terms of HS indicators, it is of greatest importance to focus on preventive actions (leading indicators). However, if good external practises are to be taken into account and a comparison made between internal and external HS performance levels, it is also necessary that reactive (lagging) indicators should be monitored as well.

This study discusses the utilization and the need for development of HS performance indicators in one global company. The company selected for this case study (with about 11 700 employees) is a global steel company that has undergone extensive organisational change, for example, due to acquisitions during the years 2012–2015. Its current industrial sites (in this study, N=8 main production sites) have remarkably different backgrounds and the sites had earlier utilized their own site specific HS indicators, which hampered comparisons. Le Coze (2011) emphasises the impact of change, including organisational changes, on accident prevention.

Corporate standards define the framework and requirements for HS indicators and reporting in the case company. However, it is known that there are differences in how the sites interpret the indicators, for example, due to different legal requirements in the various countries (Koivupalo et al., 2015b). Although all the sites follow the OHSAS 18001 based HS management system, not all sites have official OHSAS 18001 certification. The practical arrangements for local HS performance follow-up and reporting varied significantly. It is assumed that the corporate requirements are exceeded in some of the sites, which measure HS performance according to other indicators, while other sites are just meeting the minimum requirements.

This study reviews in-depth HS performance follow-up in the case company. Furthermore, this study describes how HS performance is measured and monitored in the case company and compares these results against external standards, requirements and results. Two research questions (RQ) were used to gather the information required for this study:

RQ1: What differences can be found in HS indicators within the case company?

RQ2: How is the case company performing in comparison to the benchmark sources?

In addition to answering the research questions 1 and 2, this study discusses proposals for the next steps towards advanced HS performance. The research process is described in detail in Figure 1.

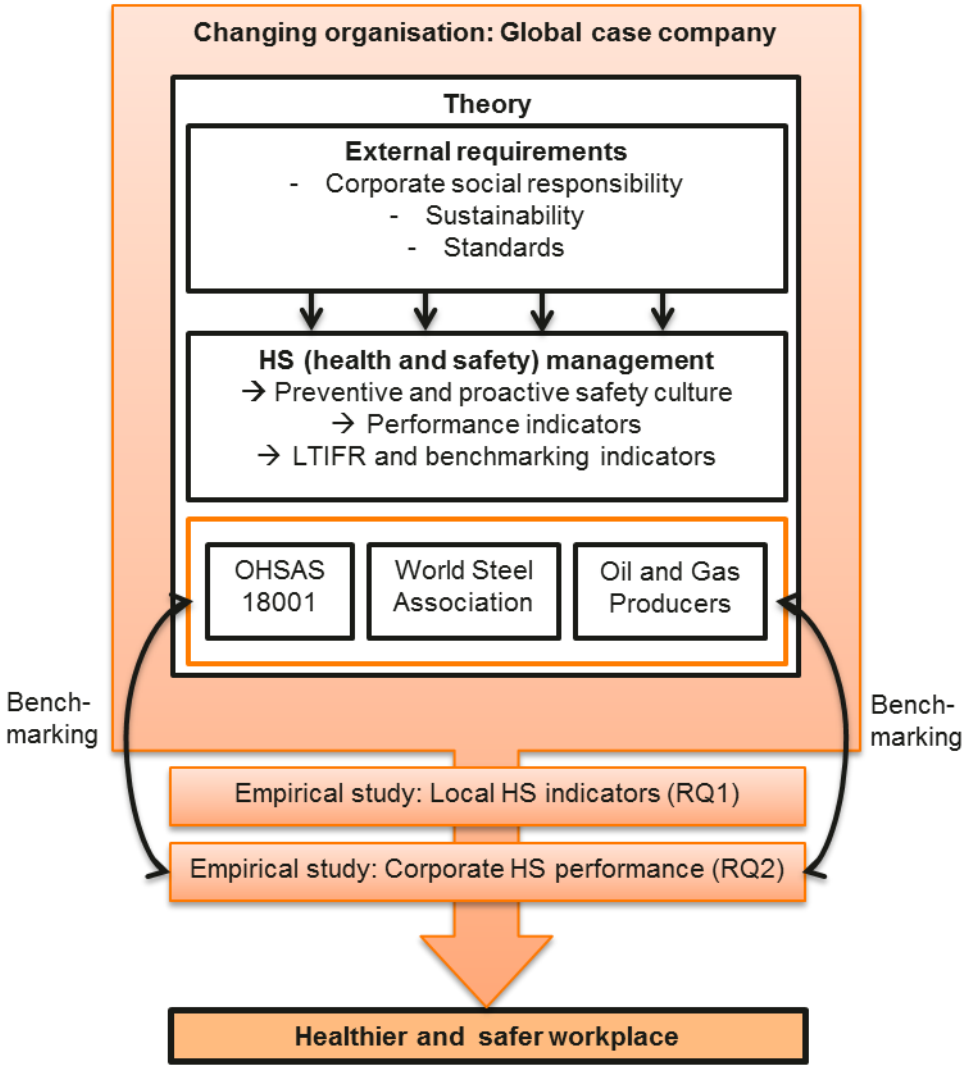

Fig. 1. An overview of the study design (LTIFR=lost time injury frequency).

1.2 Theory

In this study, HS is used as a term equivalent to occupational health and safety (OH&S and OHS) and occupational safety and health (OSH). Safety management and a safety culture are essential aspects of HS management, and cover the safety aspects of the scope of this research. This research focuses on HS performance since the structure of the corporate organisation with its reporting systems includes health and safety. HS can be linked to broader strategic management processes as Zink (2014) emphasises. According to Zink (2014), there is a need for a different understanding of the overall performance of a company, which will be seen in the following discussion about corporate social responsibility. This will generate new possibilities for human factors, including the three dimensions of sustainability: economic, ecological and social.

Sustainability and corporate social responsibility (CSR) include many of the same dimensions and principles as health, safety, environment and quality management and sustainable manufacturing. The ISO 26000 social responsibility standard provides guidance on how businesses and organisations can operate in a socially responsible way. This means acting in an ethical and transparent way that will contribute to the health and welfare of society (ISO, 2010). The Global Reporting Initiative (GRI, 2013) is a framework for reporting CSR issues. It includes HS indicators in its social category. The sustainability reports of the company used for the case study follow the GRI reporting guidelines (Outokumpu, 2015a).

The ISO 45001 requirements for HS management systems are still being prepared (ISO, 2015). This will take into account the international standards for HS such as OHSAS 18001 (2007), the International Labour Organization (ILO, 2009) OSH guidelines, various national standards and the ILO's international labour standards and conventions. It will follow the approaches of other generic management systems such as ISO 14001 and ISO 9001. Currently, OHSAS 18001 is compatible with the ILO-OSH requirements (OHSAS 18001, 2007). Kauppila et al. (2015) conclude from their research that the current trend involve the harmonization of the high-level structure of ISO HS with environmental and quality management systems.

Clearly defined safety indicators play an important role if a company is seeking to improve its safety culture. It is not possible to measure a safety culture directly, but common safety culture characteristics can be reviewed to 'measure' an organisation's safety culture indirectly (Taylor, 2010). As Morrow et al. (2014) conclude, a safety culture may be correlated with the current measures of safety performance and may be related to future performance. The relationship between a safety culture and safety performance is highly dependent on how and when both the safety culture and safety performance are measured.

The importance of preventive safety actions and the investigation of near misses is emphasised by Bellamy et al. (2013). They conclude that the analysis of a large number of incidents can support the quantification of underlying causes. Weak points, e.g. the occurrence of non-injury events, must be recognized pro-actively in order to prevent major accidents. In addition, Douglas et al. (2014) emphasize the importance of a proactive safety reporting culture, where near miss reporting is regarded as a key factor.

1.2.1 HS performance indicators

Hale (2009) states that the main purpose of safety indicators is to monitor the level of safety in a system to motivate action and to provide information for decision-makers regarding where and how to act. The primary purpose in measuring safety is to develop intervention strategies and to avoid future accidents. Recognizing signals before an accident occurs provides the potential for improving safety. Many organisations have sought to develop programs that identify and benefit from alerts, signals and prior indicators. (Grabowski et al., 2007a)

Safety is primarily the responsibility of the business and production management, rather than the duty of safety managers or of a dedicated safety organisation. The choice of indicators is crucial because the manager's attention is a limited resource. Unlike other major issues of company performance, HS is an intangible issue. Therefore, tangible and concrete goals are important although they cannot exactly reflect the overall HS sphere of required action. (Häkkinen, 2015) There is the danger that indicators could become barriers against attention being paid to other relevant safety issues (Kongsvik et al., 2010).

According to Leveson (2015), the characteristics of good leading indicators are that they are complete, consistent, effective, traceable, minimal, continually improving and unbiased. Another common criterion for indicator selection is SMART: specific, measurable, achievable, relevant and time-bound (Zwetsloot, 2013). It is important that safety should be made tangible and that incentives should be created for proactive, forward-looking and positive measures. In companies that have achieved major increases in their reporting of near-accidents and hazard observations, a clear decline in workplace injuries has been simultaneously achieved. Active reporting of near-accidents is also an indicator of a good safety culture, where people dare to talk about and report their own

failures without fear, and identification of a near-accident is a positive reminder that safeguards colleagues at the site and is a sign of management caring for their employees. (Häkkinen, 2015)

Besides the principal company's own success in safety performance, the overall success depends on the performance of the entire network, including that of the supplying companies. Therefore, in a shared workplace, performance needs to be measured (Koivupalo et al. 2015a), and this includes both the company's own personnel and also its contractors.

1.2.2 Leading and lagging indicators

HS indicators are often divided into leading and lagging indicators. Leading indicators are also referred to as pro-active, positive or predictive indicators (Podgórski, 2015). Lagging indicators are collected after losses have occurred and cost assessments have been made (Grabowski et al., 2007b). Leading indicators address the need to predict and act before an unwanted event (Hale, 2009; Hinze et al., 2013) and they measure aspects of the OHS management system (Sheehan et al., 2016). Furthermore, leading indicators should correlate with lagging indicators, and thereby provide proof for managers that they are indeed valid (Hale, 2009). Leading indicators show how well one is prepared, but the distinction is not always sharply defined. There is a lack of agreement on basic definitional issues concerning leading and lagging indicators (Sinelnikov et al., 2015; Harms-Ringdahl, 2009). For example, near miss incidents can be seen as either leading or lagging indicators (Hinze et al., 2013; Pasman and Rogers, 2014). Lagging indicators might also have the characteristics of a leading indicator in predicting another outcome or event (Dyreborg, 2009).

Any firm that truly embraces a zero injury philosophy will consider the use of measures other than the traditional lagging indicators of safety performance (Hinze et al., 2013). A growing number of safety professionals question the value of lagging indicators and argue that lagging indicators do not provide enough information or insight to effectively avoid future accidents (Grabowski et al., 2007b; Mengolinim and Debarberis, 2008; Hinze et al., 2013). The focus in recent research has therefore been on leading indicators, which can also be characterised as upstream, predictive, heading and positive indicators (Hinze, 2013). Leading indicators are valuable because they enable organisations to identify and correct deficiencies and to prevent or mitigate the worst effects from injuries or damage (Sheehan et al., 2016).

There is no need for a discussion about what is leading and what is lagging, but there is a need to develop and implement useful indicators which can provide early warnings about potential major accidents (Øien et al., 2011).

Reiman and Pietikäinen (2012) summarize that safety management needs a continuous focus on the lagging indicators of past outcomes, including deficiencies and incidents, but also on the leading indicators of current technical, organisational and human conditions and the leading indicators of technical, organisational and human functions that can drive safety forward. A number of carefully selected leading indicators will probably provide the best predictive results (Hinze et al., 2013).

Leading indicators are primarily focused at the individual level and perhaps at the departmental level in virtual organisations. Lagging indicators are broader in scope and generally focus on organisational measures. Lagging indicators are seldom focused on individual performance while leading indicators are most often focused on small units of analysis. (Grabowski et al., 2007a) Sinelnikov et al. (2015) arrived at a similar conclusion: corporate performance is mostly measured with lagging indicators, but at the site level the focus is more on leading metrics. There are two reasons for this: first, leading indicators are very process-specific (tied to certain functions or activities at individual sites); second, organisations may find it difficult to roll up site-level leading indicators to the corporate level, because sites differ in terms of size, location, operations, structure, culture, occupational HS procedures and many other characteristics that make them difficult to normalize and sometimes impossible to compare.

Koivupalo et al. (2015b), in a previous study, found that the case company had defined a wide range of HS indicators and that the sites reported them monthly as required. All sites used these required indicators, but they had also many local indicators. Some sites compared the relation between a lagging indicator (e.g. lost time injury frequency, [LTIFR]) with a leading indicator (e.g. hazard notice frequency). It was also discovered that although some local sites had determined their own targets for other HS indicators, there was no corporate level target for indicators other than the lost time injury frequency. The corporate HS standard determined the details for the HS report and the reporting conformed well to that standard.

Despite the challenges regarding definitions, Sinelnikov et al. (2015) concluded that there could be a desire to create and validate a standard index for leading indicators that would be used for benchmarking across organisations.

1.2.3 LTIFR and benchmarking indicators

Accident rates are one of the most commonly used independent measures of safety performance (Morrow et al., 2014). LTIFR is a commonly used indicator for HS performance monitoring, and it is defined as the number of lost time injuries per one million hours of work. The World Steel Association (WSA, 2016b) uses it as its main safety indicator.

> *A lost time injury is an injury due to an accident at work, where the injured person does not return to work on the next shift. (Kjellén, 2000)*

However, LTIFR has some deficiencies as an indicator. It is insensitive to the severity of the injuries, it is possible to manipulate the registration and classification of injuries, the use of alternative jobs (i.e. restricted work), and, for small companies, LTIFR is fluctuating and sensitive to changes (Kjellén, 2000). In addition, frequencies can be defined in many ways, e.g. per 200 000 labour hours, as OSHA defines it in the United States (Bureau of Labor Statistics [BLS], 2013). European Statistics on Accidents at Work (ESAW, 2013) defines separate incidence rates for fatal accidents and for accidents leading to more than three days of absence, and it defines the incidence rate as the number of accidents at work per 100 000 persons in employment. Morrow et al. (2014) conclude that in nuclear power operations, the safety accident rate is a measure of performance that is less relevant to the organisation's safety culture relative to other measures.

WSA members represent around 85% of world steel production (WSA, 2016a). WSA was chosen as the first benchmark because it represents the steel industry within which the case company operates. WSA uses LTIFR as its main safety indicator. WSA publishes a safety and health principles and definitions guidance book (WSA, 2013) for its member companies. It aims to encourage member companies to apply the principles and metrics to their organisation and to set a standard for the industry. WSA has defined the basic indicators for an annual safety data survey. The overall trend is that most WSA member companies have significantly improved their safety and health performance in recent years (WSA, 2014; WSA, 2016b).

In comparison, the key indicators for OGP (oil and gas producers) are the number of fatalities, fatal accident rate, number of lost work day cases and number of lost work days, total recordable injury rate, lost time injury frequency, number of restricted duty cases and restricted duty case days, and number of medical treatment cases. Even though LTIFR has been decreasing in this industry, in the 2013 data report it was stated that the severity of lost work day cases had increased. (OGP, 2016) OGP has been chosen as a second benchmark because OGP members represent a process industry, as is true of the case company.

A summary and comparison of the different HS definitions is presented in appendix 1. The indicators are substantially similar in definition.

2 MATERIAL AND METHODS

The empirical part of this study focuses on the numerical and measurable results of the organisation's occupational HS management. The study design is described in detail in Figure 1. The empirical study, as one part of the research process (Fig. 1), is qualitative. In this study, each industrial site is considered as a separate case. Cross-case synthesis was used to analyse the multiple cases. Each of the cases (N=8) was treated as a separate study. The goal was to give an in-depth review of the current state of HS performance. As qualitative material is analysed in this study, the study is descriptive in nature. (Yin, 2009)

The empirical part of this study focuses on the HS performance management practices of a global company producing stainless steel and high performance alloys. Production facilities cover all continents and the sites are located in China, Finland, Sweden, Germany, UK, Mexico, and the USA, with a global sales and service centre network. The case company has a long history, originating in the 1910s. During the last century, the company experienced numerous organisational changes. The organisation changed significantly towards the end of 2012 when several new sites joined the company. Some sites had previously been part of larger organisations and had been so for decades, whereas other sites were relatively new to the industry, but all were experiencing on-going changes. (Outokumpu, 2015b)

Table 1 shows a summary of the sites investigated, their location and the interviewees. Each interview was conducted in a different country although several came from the same continent (either Europe or the Americas). The total number of employees in the organisations in which interviews were conducted was about 8 750, which

represented about 75% of the whole company (the number of employees at the time when this study was conducted was about 11 700). The case study sites represent all the major sites that the company had during the time when this study was conducted.

Table 1. Investigated sites and representatives.

Site	Number of interviewees	Location	Number of employees	Method
A	3	Europe	540	Interview
B	1	Europe	2000	Interview
C	2	Europe	770	Interview
D	1	Europe	110	Interview
E	3	Americas	930	Interview
F	2	Europe	2850	Interview
G	1	Asia	450	Questionnaire
H	1	Americas	1100	Questionnaire
Summary	**14**		**8750**	

Semi structured interviews (see appendix 2) and e-mail questionnaires were sent to local safety managers during 2015. Additional participants were human resource specialists and other HS specialists. The interviewees (N=14) were chosen by the researcher based on their position in the sites. The main criterion was that the interviewee should know the HS reporting practices and especially the origin of the HS data in their sites. Due to language issues, data was collected from two sites using an e-mailed questionnaire. The questionnaire included the same questions as were used in the interviews.

Prior to the interviews, the questions were e-mailed to the interviewees. The goal was that they should prepare for the interview by knowing what content to expect. At the same time, the interviewees were made aware of the possibility of inviting other internal experts to attend the interview. Interviews were made in English, except for one that was made in Finnish. In that particular interview, the questions were still presented in English. Conversations were transcribed for analysis and the data was organised on the basis of each HS indicator. The interviews were conducted by using internal video conference equipment.

The first part of the empirical study provided information about the local indicators (RQ1). The second part of the empirical study (RQ2) was based on the analysis of the internal corporate material and its benchmarking to the external material (mainly to OHSAS 18001 and WSA). Internal corporate HS reporting standards, instructions and statistics were reviewed systematically.

A cross-sectional classification was set up to facilitate a systemic analysis of the transcribed data with a view to proposing the next steps towards advanced HS performance. Analysis was performed in two phases. First, the researcher read through the material and sketched different themes based on the research questions. The themes were based on the HS indicators and the data sources in use at the sites and on possible variations between the definitions. In addition, areas needing improvement were identified. In the second analysis, the researcher categorized the material according to the themes.

3 RESULTS

3.1 Local HS indicators (RQ1)

HS indicator requirements were listed against the corporate HS standards and instructions. The quantitative lagging HS indicators required were the number of fatalities, lost time incidents, non-lost time incidents and occupational diseases; total sick leave hours and sick leave hours due to injuries. The quantitative leading indicators required were the number of near misses, hazards, safety behavioural observations, other preventive safety actions and safety training hours. Short definitions of the indicators are summarized in appendix 3. In addition to the HS indicator reports, general data, i.e. the number of employees and working hours at the site, are collected monthly for frequency calculations. In addition to the HS indicator reporting, internal safety audits have been a common

company-wide proactive HS practice. Although audits also lead to statistical data, they did not fit the scope of this study as no continuous monthly data was available.

Most of the indicators were collected from both own personnel and contractors, except that the number of employees and Safety Behavioural Observations (SBOs) (LE3) notices came only from own personnel. Workplace accidents (fatalities, lost time injuries and non-lost time injuries) excluded commuting accidents.

Table 2 presents a comparison between the sites and the indicators. The summary row illustrates how well all the sites together are covering each indicator, i.e. the number of indicators covered completely according to the definition.

Table 2. HS indicator comparison between the sites (LA=lagging indicator, LE=leading indicator).

Site	LA1	LA2	LA3	LA4	LA5	LA6	LE1	LE2	LE3	LE4	LE5
A	✓	✓	×	✓	✓	✓	×	-	✓	×	-
B	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
C	✓	✓	×	✓	✓	✓	×	-	✓	×	✓
D	✓	✓	×	×	✓	✓	-	×	✓	-	×
E	✓	✓	×	✓	✓	✓	✓	✓	✓	-	✓
F	✓	✓	✓	-	✓	✓	×	-	✓	-	✓
G	✓	✓	✓	✓	✓	✓	-	✓	✓	-	✓
H	✓	✓	×	✓	×	✓	✓	×	×	-	✓
Summary	**8**	**8**	**3**	**6**	**7**	**8**	**3**	**3**	**7**	**0**	**6**

Explanations		
	✓	Covered according to the definition
	×	Partially covered
	-	Not covered at all

When focusing on leading (LE) and lagging (LA) indicators, the most precise indicators were LA1, LA2, LA5, LA6 and LE3. Fatal accident (LA1) is usually a clear situation, verified by a medical professional and thus understood well. Monitoring LTI (LA2) had a long history of use as an indicator in all the sites and, being based on long experience, it was well-defined. The only difficulty was in defining work-relatedness, for example in the case of previous health problems. One small anomaly was discovered in the reporting of total sick leave hours (LA5): as it covered more hours of absence than were required. However, the average length of the periods of absence varied even when the illness was quite similar in nature. The length of absence was based on a medical professional's evaluation, and this could lead to difficulties in comparing sickness absence data between sites.

Sick leave hours due to injuries (LA6) were reported as required, but there was some confusion in the case of LTI if the absence was not immediately after the incident or when the incident situation had other aspects that were not clear. The period of length of absence after LTI was usually definitive, but if, for example, the injured person had changed jobs at the same time, it was not always easy to determine the length. Although LA6 was reported according to the definition, the length of absence varied a lot between countries even though the injury was similar in nature (due to local legislation and workplace accident insurance policies). It should be taken into account that this causes difficulties in comparing data between sites and a statistical analysis that is based on the length of absence after injury is not completely comparable.

For SBOs (LE3) the corporate has its own standard, and this was followed closely. There was one misunderstanding regarding the definition, and some hazards were reported as SBOs. At the corporate level, this caused a decrease in the number of SBOs and an increase in the number of hazards, but the total number of leading indicators would still be the same.

In the case of non-LTIs (LA3), there was some confusion about which accidents should be included. Some sites included even the smallest cuts to fingers (first aid treated incidents) without a visit to the health care centre, but other sites required the visit to be to a health professional (for medical treatment or incident evaluation). Restrictive work cases were included either with LTIs or non-LTIs depending on whether there was a period of

absence or not. Some sites used restrictive work as an HS indicator, and they wanted to include it in the corporate reporting requirements. Not all sites used restrictive work.

The number of occupational diseases (LA4) was highly dependable on local legislation and it was difficult to get comparable data from the sites. In addition, it is common that occupational diseases develop over time, and all the sites did not have a long history with the case company. Half of the sites had reported occupational diseases over the years and half of the sites had not.

All sites recorded near misses (LE1) and / or hazards (LE2), but the difference between them was not unambiguous. The case company has defined near miss incidents as leading indicators, although something had very nearly happened. The case company categorizes near misses as leading indicators due to the requirement for in-depth investigation and actions, and it aims thereby to prevent incidents resulting in injuries or ill health. Furthermore, the division between hazards and near misses varied: some sites reported both, but some of them reported only one and not the other (i.e. hazards or near misses), although the incidents might be similar in nature. Some hazards were even included in the SBOs.

From the HS perspective, well-performing sites (with accident frequency targets achieved and a high leading indicator frequency) used many other leading indicators and measures. Near misses, hazards and SBOs did not include all the preventive actions taken in these sites and there were additional proactive safety actions as well. A number of other preventive actions (LE4) were created as HS indicators after the organisational change in 2012. The reason for that was the large number of preventive HS actions that were not included in any of the reporting categories and these needed to be included. Examples were H&S audits, walks, inspections and ideas. However, it was discovered that all sites did not report these although they performed them. This category was generally found to be difficult to understand.

Safety training hours (LE5) were calculated manually in some sites while other sites had automated systems. In two sites there was no reporting of training hours and safety systems.

Three sites used various additional indicators besides the corporate requirements, two of them had a few additional indicators and three of them used only the compulsory indicators. Some of the leading indicators were included in LE4, but not all. These HS indicators were: seriousness of workplace and commuting injuries, commuting injuries, restrictive work cases, absence days due to commuting injuries, open and completed actions, investigations and actions taken in time, risk assessments, safety rounds or walks, internal and external audits, actions following audits, contractor audits, contractor safety discussions, safety briefings, toolbox meetings, safety meetings, safety jobs from maintenance system, permits (e.g. permit to work), housekeeping index and safety cards.

3.2 Corporate HS performance (RQ2)

A comparison of LTIFR between the case company, WSA and OGP is presented in Figure 2. The case company's performance was weaker than that of the two global benchmarks, but it is approaching an equivalent level. For the WSA member companies, LTFIR has shown a decline from 4.8 to 1.2 (WSA, 2016b). LTIFR for oil and gas producers has been below 1 for almost a decade, coming down to 0.29 in 2015 (OGP, 2016). After the major organisational change in 2012, the case company's LTIFR increased. Despite this setback, the development since 2012 has been positive. Still, there is work to do to achieve the level of the benchmarks.

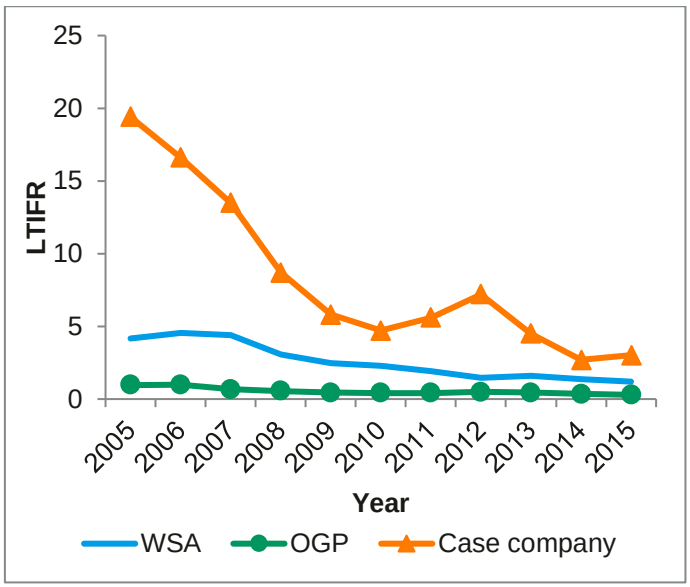

Fig. 2. LTIFR comparison (original data from WSA, 2016b; OGP, 2016 and case company's database).

3.3 Recommendations

The comments from the interviewees were mainly related to stricter reporting schedules, inadequate reporting software and a lack of clarity in HS indicator definitions. In addition, difficulties in responding to rapid and continuous organisational changes and to different national, international and corporate requirements were mentioned several times. Concern about too much focus on the lagging indicators was expressed during the interviews as well.

The conclusive aim of the study was to make recommendations on how to achieve a healthier and safer workplace by benchmarking and by comparing the current local and company-wide practices against external definitions and standards, literature and good practice. Proposals for the next steps are presented in Table 3.

Table 3. Proposals for the next steps.

Proposal	Detailed explanation
Greater depth in the corporate standards	- The standards need more precise definition to enable local sites to meet the requirements. The current version is adequate in common situations, but if something exceptional happens, it does not cover those circumstances. The most common exceptional situations should be identified and included in the standards. - Internal instruction at the sites should be completely compatible with and equivalent to the case company standards, and internal standards should be completely compatible with and equivalent to external requirements.
Indicator definitions and classification processes	- All incorrectly reported indicators should be corrected and the correct definition should be highlighted. This mostly concerns the correct breakdown of near misses, hazards and SBOs. Hazard and near miss must be defined unambiguously. - It needs to be clearly specified what accidents, besides lost time injuries, should be reported and how they are to be classified. Non-LTIs should be split into restrictive work, medically treated and first aid treated incidents. These indicators should be added to the reporting system and used as OGP (2016) does (e.g. total recordable injury rate). - Many sites report commuting injuries. This indicator should be added to the reporting system.
Follow-up processes and reporting systems	- Further follow-up is required on the reporting of occupational disease and safety training hours. - Other preventive safety actions were not reported by all sites although they conducted comparable actions. These should be clearly determined (e.g. a

	new account for actions, investigations, audits, risk assessments, safety walks, housekeeping index) for all the indicators, or else all sites should include them under other preventive safety actions. - There are additional leading indicators that are suitable for the whole company's HS performance monitoring. Reviews should be made of the indicators used locally and in external best practices. - The reporting system was mentioned several times when interviewees were asked about what needs to be developed. Reporting system must take into consideration different local requirements as well as corporate requirements. The reporting system should support the reporting, not complicate it.

4 DISCUSSION

External reporting requirements (GRI, 2013; WSA, 2013) and standards (ISO, 2010; OHSAS, 2007) define the framework and provide details for high level HS performance monitoring. Corporate HS indicators are quite similar to the OHSAS (2007) and WSA (2013) indicators. General sustainability and CSR reporting principles are also followed in sustainability reporting. These basic requirements form the framework for all HS reporting.

The case company has detailed requirements for HS reporting that are defined at the corporate level. At the local site level, there were even more detailed leading indicators, which support the results of Sinelnikov et al. (2015). In the case company, HS management is based on both preventive and corrective actions, especially at the local site level, and reflects its commitment to HS and to a proactive safety culture. By developing such a culture, behaviour and attitudes will eventually change as well. However, a corporate preventive safety culture has not yet become common at a profound level in the case company. Although HS indicators are being developed, they are not yet adequately adopted.

The case company has been encouraging its own employees and contractors to report hazards, but as yet, not all sites have a high reporting frequency. Also, there is not yet a clear understanding of the difference between hazards and near misses. As the active reporting of hazards and near misses reflects a good safety culture, it remains an important focus for future development for the case company. For benchmarking purposes, the lagging indicators have their place and value, but if an organisation seeks to develop a proactive safety culture then its focus should be on the leading indicators (compare Hinze at al., 2013; Bellamy et al., 2013; Douglas et al.; 2014; Morrow et al., 2014). Some adjustments are needed to the leading indicators; for example the next performance level could be achieved by splitting the 'other preventive safety action' category into a few separate indicators.

The quality of the preventive actions is the factor that has the most significant impact in bringing about genuine change in a safety culture and safety behaviour. The qualities of a well-constructed HS indicator have been adequately achieved by the case company (c.f. Zwetsloot, 2013; Leveson, 2015); however, it was noted that there is still a need to define some of the HS indicators more precisely to ensure consistency of application and to ensure that they are relevant. The indicators were found to be relevant and effective for the purposes of a line organisation. The movement is in the right direction, but at some sites reporting had developed too much as the responsibility of the HS department.

Despite the controversial opinions relating to exact definitions for leading and lagging, the difference has been easy to understand and put to practical use in the case company. Similarly, Øien et al. (2011) showed that the main goal was to get preventive reports despite the division between leading and lagging indicators.

This study revealed that there are small differences in the definitions of HS indicators within one company operating in one industrial sector. Requirements are set, for example, by the corporate, the government, the authorities and by associates. Another reason for the differences is historical, because several of the sites had not been part of the current company for long. When there are differences between the sites within one company, it is to be assumed that the differences are even larger between different industrial sectors and between geographical locations.

Although external reporting requirements and definitions differ and therefore hamper the work of benchmarking, OHSAS (2007), WSA (2013), OGP (2016) and the case company largely have similar definitions at the higher level. This study supports Sinelnikov et al.'s (2015) conclusion that there is a need for a standard index that could be used for benchmarking purposes. In order to enable a comparison between businesses, continents, countries and different sectors, general HS indicators should be identified and applied. Within a particular branch of the industry, it is easier to find more lagging and even some leading indicators for comparison. The wider the

scope, the more general the indicators are. In addition, local leading HS indicators, especially those suited to their environment, should be adopted more widely in local sites. These local HS indicators could reveal the weak signals and points that anticipate serious near misses and accidents. One possibility for helping the case company achieve its benchmarks would be to create a more uniform HS performance indicator selection for the leading indicators.

Despite the critique by Kjellén (2000), LTIFR is still the most widely used HS indicator for benchmarking purposes. However, even LTIFR is not always defined in the same way (e.g. working hours may be actual or theoretical, and it can be difficult to define what is work-related), and when comparisons of HS performance are made it is essential to define the requirements precisely. Even more important is to know what lies behind the numbers when benchmarking and comparing one industry or company to another. On the basis of this study it can be concluded that the case company, historically, had been performing poorly in comparison to the benchmarks, but in recent years it has been getting closer to them. Accidents causing absence in the case company as well as in the benchmarked companies have decreased significantly in recent years.

It must be considered that length of absence (total sickness absence and absence due to injuries) is not a good indicator for comparing the seriousness of accidents in a global environment because there are such big differences in local practices. One satisfactory solution for an internal comparison within an organisation is to use a standardized risk matrix, which is in fact used in the case company. With a risk matrix, the likelihood and seriousness of an incident can be more accurately evaluated.

Supporting the research results of Yorio and Watcher (2014), it was found that the frequency of all workplace accidents and illnesses (e.g. recordable cases) revealed more than just the frequency of lost time injuries. Therefore, it is suggested that this should become the main lagging indicator rather than LTI in the case company.

In the case company, the target and the challenge is to create a uniform safety culture for a shared workplace in a changing organisation. In this company, its global HS management practises are not yet formulated, but the development has started with several separate local practises that are moving towards one central global practise. In order to achieve a uniform safety culture, it is necessary to have uniform HS indicators so that ultimately all sites will be headed towards the same goal. At a general level, the corporate standard does define the indicators, but the standard is not sufficiently detailed to be accurately applicable in all sites. It was clear that more preventive actions are occurring in the sites than the current statistics reveal. There needs to be common definitions for these and the reporting needs to be more active.

4.1 Limitations, evaluation and future research

4.1.1 Limitations

The research findings can be generalised at some levels, for example to the manufacturing industry. With a similar set up, similar research could be performed and repeated. The study was conducted from the perspective of the case company, and a perspective from other parties would presumably reveal new and interesting dimensions. The experimental reliability was high, although the number of interviewees was small. Stable HS indicators enabled the researchers to assume that the interviewees would know and be aware of the HS indicators. However, as a benchmarking indicator, LTIFR causes uncertainty and the criticisms of it should be considered.

4.1.2 Future research proposals

This study suggests several interesting future research topics and internal development needs (recommendations), which would support the case study organisation with its continuous HS development. For example:

- How are HS targets included in the competence specifications and performance appraisals of managers and how do they affect them?
- Well-being at work is an essential part of HS at work, but it is excluded from this study. Koskela (2014) reviewed OH&S reporting as a part of CSR reporting in three companies from different business sectors and found that the companies mainly reported on occupational safety, with a range of subsections, whereas well-being at work was seldom reported on. Consideration could be given to how well-being at work could be effectively measured.
- Zohar (2010) integrates the safety climate and safety pyramid models. This idea of integration could be used in the case company to develop an integrated model for safety leadership and safety climate. This is particularly relevant when considering that safety climate perceptions are linked to employees' levels of job satisfaction, engagement and the objective turnover rate (Huang et al. 2016). Examples of safety

climate related indicators have been presented in the study by Sparer et al. (2016). Communication could be another future focus.

- The integration of lean management principles and HS management has been studied with encouraging results (Court et al., 2009; Nahmens and Ikuma, 2009; Rozenfeld et al., 2010). In this context, lean management is a more proactive approach than the more traditional one. Lean principles could support the future development of HS management in the case company.
- Hallowell et al. (2013) and Shea et al. (2016) identified proactive and leading HS indicators in their studies, and these could be reviewed when considering adjustments to the leading indicators used by the case company. An in-depth analysis of leading indicators and HS practices would be interesting for the case company. For example, a company-wide indicator for housekeeping and systematic positive feedback was missing.
- The prevention of commuting, home and leisure accidents (Yrjämä-Huikuri and Väyrynen, 2015) could be pursued in the next phase with a view to reducing total sickness absence and all lost time accidents.

5 CONCLUSIONS

Several HS indicators were identified from the literature and the standards. A common practise is to split these into leading and lagging indicators, as the case company has done. The corporate requires that there should be a balance between both types of HS indicators. In addition, some local HS indicators were used, especially those related to preventive actions.

The case company's HS performance was monitored through leading and lagging HS indicators in the main production sites. The balance between leading and lagging indicators was adequately achieved and the indicators were indicative of a good HS indicator construct. However, fine adjustments to the corporate HS reporting requirements (the internal standard) are needed and the reporting system requires improvements.

The case company's HS indicators and terminology were similar to the OHSAS 18001 standards, and the WSA and OGP indicators. General sustainability and CSR reporting principles were followed in the sustainability reporting. The case company has focused deeply on improvements in its HS sector in recent years: A decade ago, the case company was not even close to the benchmarks (OGP and WSA), but recently it has come much closer to them. However, the critique related to LTIFR as the main HS performance indicator must be taken into consideration. It is obvious that accidents causing absence in both the case company and in the benchmarked parties have decreased significantly. Although this might not represent overall HS performance, it does shows good progress in the follow up of one of the most stringent HS indicators.

It does not matter much if an indicator is called a leading or a lagging indicator in the daily working environment. The ultimate goal is to reduce occupational accidents and illnesses, and the focus must therefore be on actions that are leading, preventive, proactive, predictive and positive in nature. The different categories are something that can help when following up on the actions and monitoring HS performance. Official standardization of the main leading HS indicators would help to benchmark and to spread good practice within companies that want to invest in their personnel's HS.

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APPENDIX 1: Comparison between definitions

OHSAS 18001 (2007)	**WSA (2013)**	**OGP (2016)**	**Case company standard and instruction**
OH&S (occupational health and safety) performance	Safety and health performance	Safety performance, key performance indicator	Reporting health and safety statistics, safety key performance indicators
Reactive measures of performance			Lagging indicator

Proactive measures of performance			Leading indicator
Employee	Company employee	Company employee	Company employee / own personnel
Contractor	Contract employee (contractor)	Contractor employee	Contractor employee
Visitor	Visitor		Visitor
Ill health	Work-related illness	Illness	Occupational disease
Fatality	Fatality	Fatality, fatal accident	Fatality
	(Serious injuries are included in a yearly survey, but are not defined in definitions book)		Serious injury
Work-related activities	Work-related injury (work related / non-work related)	Work-related injury	Work-relatedness (work related / non-work related)
Incident (includes accident and near miss with no injuries), accident	Incident (with and without injury)	Incident (fatality, recordable injury or illness, physical or environmental damage)	Accident, injury, incident
	Lost time injury	Lost time injury	Lost time injury
	Injury with work restrictions	Restricted work day case	Restrictive work injury
	Minor injury		Minor or zero injury, non-LTI
		First aid case	First aid treated injury
	Medical treatment injury	Medical treatment case	Medically treated injury
Near miss	Near miss incident	Near miss	Near miss
Hazard, potential harm from injury or ill health	Safety deviation	Hazard	Hazard
	Hours worked	Hours worked	Hours worked
	Calculation for frequency rate	Frequency	Frequency rate calculations
Education, training	Training	Training	Training
	(Other preventive safety action is collected in the yearly survey, but not defined in definitions book)		Other preventive safety action (e.g. audit, walks, inspection)

APPENDIX 2: Interview questions

Questions for each indicator (LA1-LE5)

- How is the indicator defined, i.e. what does it include and what not?
- What is the initial source of the information (how the data ends up in the local system)?
- What is the local system?
- Who reports the information to the local system?
- What is the monthly deadline for local reporting?
- Who reports the data to the corporate system?

Local safety performance indicators

- In addition to the corporate requirement, what local HS indicators are used (e.g. in monthly reports)?
- Are these numbers included in the "other preventative safety actions" of the corporate reporting system?

Improvement needs

- Is there a need to remove or add any indicators?
- What are the main difficulties with HS reporting?
- What improvements do you wish to see?

APPENDIX 3: HS indicators

Lagging indicators			Leading indicators		
LA1	Number of fatalities	Death from a work-related accident as certified by a medical professional.	LE1	Number of near misses	Near miss is an unplanned event where someone or something interacts with a hazard but it does not result in injury or illness – it had the potential to do so. Near miss is a more serious situation than hazard (below).
LA2	Number of LTIs	Direct result of a work-related activity, where the injured party was absent from their next scheduled period (e.g. day) of working. Includes fatal accidents.	LE2	Number of hazards	Hazard is any situation or action that has a potential to cause harm (injury or ill health, environment or property damage).
LA3	Number of non-lost time injuries (non-LTI)	Workplace accident that is the direct result of work-related activities, where the injured party received treatment for the injury, but the injury didn't incur loss of work time, or not more than the shift in which it occurred. The injured person continues with their normal scheduled work. Restricted duties without absence are included in this category.	LE3	Number of Safety Behavioural Observation (SBO) notices	Safety based discussions between an auditor (typically the supervisor or manager) and the person being audited.
LA4	Number of occupational diseases	Occupational disease is any chronic ailment that occurs as a result of work or occupational activity, such as noise induced hearing loss, industrial dermatitis, occupational asthma, etc.	LE4	Number of other preventive safety actions	Near misses, hazards and SBOs do not include all preventive safety actions. These actions are included in 'other preventive safety actions'. Examples are H&S audits, walks, inspections or ideas.
LA5	Total sick leave hours	Number of total sick leave hours during the reporting period. Sickness absence includes sick leave hours certified by doctors, self-certified hours (if applicable) and sick leave hours due to injuries. Sickness absence excludes bereavement, maternity and paternity.	LE5	Safety training hours	Safety training hours to personnel is the sum of the hours of safety training received.
LA6	Sick leave hours due to injuries	number of sick leave hours as a consequence of injuries that have taken place during working hours at the work place			

REFERENCES

Bellamy, L.J., Mud, M., Manuel, H.J., Oh, J.I.H., 2013. Analysis of underlying causes of investigated loss of containment incidents in Dutch Seveso plants using the Storybuilder method. Journal of Loss Prevention in the Process Industries 26 (6), 1039-1059.

BLS (Bureau of Labor Statistics), 2013. How To Compute a Firm's Incidence Rate for Safety Management. http://www.bls.gov/iif/osheval.htm (9.10.2015).

Court, P.F., Pasquire, C.L., Gibb, A.G.F., 2009. A lean and agile construction system as a set of countermeasures to improve health safety and productivity in mechanical and electrical construction. Lean Construction Journal, 61–76.

Douglas, E., Cromie, S., Chiara Leva, M., Balfe, N., 2014. Modelling the Reporting Culture within a Modern Organisation. Chemical Engineering Transactions 36, 589-594.

Dyreborg, 2009. The causal relation between lead and lag indicators. Safety Science 47, 474-475.

ESAW (European Statistics on Accidents at Work), 2013. Summary methodology. Eurostat, Publications Office of the European Union. http://ec.europa.eu/eurostat/documents/3859598/5926181/KS-RA-12-102-EN.PDF/56cd35ba-1e8a-4af3-9f9a-b3c47611ff1c (9.10.2015).

GRI (Global Reporting Initiative), 2013. Reporting Principles and Standard Disclosures. Global Reporting Initiative, Amsterdam, Netherlands. https://www.globalreporting.org/resourcelibrary/GRIG4-Part1-Reporting-Principles-and-Standard-Disclosures.pdf (10.8.2015).

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

Grabowski, M., Ayyalasomayajula, P., Merrick, J., McCafferty, D., 2007 b. Accident Precursors and Safety Nets: Leading Indicators of Tanker Operations Safety. Maritime Policy and Management 34 (5), 405–425.

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

Hallowell, M., Hinze, J., Baud, K., and Wehle, A., 2013. Proactive Construction Safety Control: Measuring, Monitoring, and Responding to Safety Leading Indicators. Journal of Construction Engineering and Management 139 (10).

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

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

Huang, Y-H., Lee, J., McFadden, A.C., Murphy, L.A, Robertson, M.M., Cheung, J.H., Zohar, D., 2016. Beyond safety outcomes: An investigation of the impact of safety climate on job satisfaction, employee engagement and turnover using social exchange theory as the theoretical framework. Applied Ergonomics 55, 248-257.

Häkkinen, K., 2015. Safety Management – From Basic Understanding Towards Excellence. In Väyrynen, S., Häkkinen, K., Niskanen, T. (Eds.), Integrated Occupational Safety and Health Management Solutions and Industrial Cases. Springer, Switzerland.

ILO (International Labour Organization), 2009. Guidelines on occupational safety and health management systems, ILO-OSH 2001, second edition. International Labour Office, Switzerland.

ISO (International Organization for Standardization), 2010. ISO 26000: Guidance on Social Responsibility. ISO, Switzerland.

ISO (International Organization for Standardization), 2015. ISO 45001 - Occupational health and safety. http://www.iso.org/iso/iso45001 (2.7.2015).

Kauppila, O., Härkönen, J., Väyrynen, S., 2015. Integrated HSEQ management systems: Developments and trends. International Journal for Quality Research 9 (2), 231-242.

Kjellén, U., 2000. Prevention of Accidents Through Experience Feedback. Taylor & Francis, London.

Koivupalo, M., Junno, H., Väyrynen, S., 2015 a. Integrated management within a Finnish industrial network: Steel mill case of HSEQ Assessment Procedure. In: Väyrynen, S., Häkkinen, K., Niskanen, T. (Eds.). Integrated Occupational Safety and Health Management – Solutions and Industrial Cases. Springer, Switzerland.

Koivupalo, M., Sulasalmi, M., Rodrigo, P., Väyrynen, S., 2015 b. Health and safety management in a changing organisation: Case study global steel company. Safety Science 74, 128-139.

Kongsvik, t., Almklov, P., Fenstad, J., 2010. Organisational safety indicators: Some conceptual considerations and a supplementary qualitative approach. Safety Science 48 (10), 1402-1411.

Koskela, M., 2014. Occupational health and safety in corporate social responsibility reports. Safety Science 68, 294-308.

Le Coze, J.C., 2011. A study about changes and their impact on industrial safety. Safety Science Monitor 15 (2), 1-17.

Leveson, N., 2015. A systems approach to risk management through leading safety indicators. Reliability Engineering and System Safety 136, 17-34.

Mengolinim, A., Debarberis, L., 2008. Effectiveness evaluation methodology for safety processes to enhance organizational culture in hazardous installations. Journal of Hazardous Materials 155 (1-2), 243–252.

Morrow, S.L., Koves, G.K., Barnes, V.E., 2014. Exploring the relationship between safety culture and safety performance in U.S. nuclear power operations. Safety Science 69, 37-47.

Nahmens, I., Ikuma, L.H., 2009. An empirical examination of the relationship between construction and safety in the industrialized housing Industry. Lean Construction Journal, 1–12.

OGP (International Association of Oil and Gas Producers), 2016. Safety performance indicators – 2015 data. Report 2014s, OGP data series. http://www.iogp.org/pubs/2015s.pdf (19.10.2016).

OHSAS 18001:fi, 2007. Occupational health and safety management systems. Requirements. Finnish Standards Association, Helsinki.

Øien, K., Utne, I.B., Herrera, I.A., 2011. Building Safety indicators: Part 1 – Theoretical foundation. Safety Science 49 (2), 148-161.

Outokumpu, 2015 a. Sustainability report 2014. Outokumpu Oyj. https://www.outokumpu.com/SiteCollectionDocuments/Outokumpu_Sustainability_report2014.pdf (8.12.2015).

Outokumpu, 2015 b. Outokumpu - global leader in stainless steel. http://www.outokumpu.com/en/company/Pages/default.aspx (11.8.2015)

Pasman, H., Rogers, W., 2014. How can we use the information provided by process safety performance indicators? Possibilities and limitations. Journal of Loss Prevention in the Process Industries 30, 197-206.

Podgórski, D., 2015. Measuring operational performance of OSH management system – A demonstration of AHP-based selection of leading key performance indicators. Safety Science 73, 146-166.

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

Rozenfeld, O., Sacks, R., Rosenfeld, Y., Baum, H., 2010. Construction job safety analysis. Safety Science 48 (4), 491–498.

Shea, T., De Cieri, H., Donohue, R., Cooper, B., Sheehan, C., 2016. Leading indicators of occupational health and safety: An employee and workplace level validation study. Safety Science 85, 293-304.

Sheehan C., Donohue, R., Shea, T., Cooper, B., De Cieri, H., 2016. Leading and lagging indicators of occupational health and safety: The moderating role of safety leadership. Accident Analysis and Prevention 92, 130-138.

Sinelnikov, S., Inouye, J., Kerper, S., 2015. Using leading indicators to measure occupational health and safety performance. Safety Science 72, 240-248.

Sparer, E.H., Catalano, P.J., Herrick, R.F., Dennerlein J.T., 2016. Improving safety climate through a communication and recognition program for construction: a mixed methods study. Scandinavian Journal of Work, Environment & Health 42 (4), 329-37.

Taylor, J.B., 2010. Safety Culture: Assessing and Changing the Behaviour of Organisations. Gower Publishing Limited, England.

WSA (World Steel Association), 2013. Safety and Health Principles and Definitions – Guidance Book. World Steel Association.
http://www.worldsteel.org/dms/internetDocumentList/bookshop/Safety_health_principles_2013/document/Safety%20and%20Health%20Principles%202013.pdf (25.6.2015)

WSA (World Steel Association), 2014. Sustainable Steel - Policy and indicators 2014.
http://www.worldsteel.org/dms/internetDocumentList/bookshop/2014/Sustainable-indicators-2014/document/Sustainable%20indicators%202014.pdf (25.6.2015)

WSA (World Steel Association), 2016 a. Membership. http://www.worldsteel.org/about-us/membership.html (03.08.2016).

WSA (World Steel Association), 2016 b. Sustainability indicators.
http://www.worldsteel.org/statistics/Sustainability-indicators.html (19.10.2016).

Yin, R.K., 2009. Case Study Research: Design and Methods. 4th Edition. Sage Inc., Thousand Oaks, California, USA.

Yorio, P.L., Wachter, J.K., 2014. The impact of human performance focused safety and health management practiceson injury and illness rates: Do size and industry matter? Safety Science 62, 157-167.

Yrjämä-Huikuri, L., Väyrynen, S., 2015. The Total Risk of Lost-Time Accidents for Personnel of Two Large Employers in Finland – All Accidents Affecting Work: Home and Leisure, Commuting, and Work Injuries as Causes of Absence. In: Väyrynen, S., Häkkinen, K., Niskanen, T. (Eds.). Integrated Occupational Safety and Health Management – Solutions and Industrial Cases. Springer, Switzerland.

Zink, K.J., 2014. Designing sustainable work systems: The need for a systems approach. Applied Ergonomics 45 (1), 126-132.

Zohar, D., 2010. Thirty years of safety climate research: Reflections and future directions. Accident Analysis & Prevention 42 (5), 1517-1522.

Zwetsloot, G., 2013. Key performance indicators. OSHwiki, European Agency for Safety and Health at Work.
http://oshwiki.eu/wiki/Key_performance_indicators (27.10.2015).