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A framework for safety performance indicators: the case of the Swedish mining industry

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Abstract: Companies in the Swedish mining industry have introduced numerous safety practices to prevent accidents from occurring, prompting a need for the development of indicators and models focusing on the performance of these practices. The aim of this article is to develop a framework for safety performance indicators, based on safety practices from six companies. Through a study of policy documents and other relevant texts, key practices are described in terms of safety management, safety leadership, safety education, and worker safety engagement. These serve as the foundation for suggestions of indicators and associated measurements, as well as a framework for safety performance indicators. This includes taking important social dimensions into account as a means of increasing the sustainability of safety performance indicator development.

Keywords: mining; safety research; safety practices; safety performance; safety indicators; safety management; safety management system; accident prevention; risk management; international research.

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1 Introduction

Companies in the Swedish mining industry have introduced a number of measures to prevent accidents from occurring and increase safety in general (Sundström and Nygren, 2023). Over time, the lost time injury frequency rate (LTIFR) has also dropped significantly, from around 50 accidents per million working hours in the early 1980s to 6.0 in 2020 (Svemin, 2021). These safety practices have been introduced at various levels within the companies and have focused on organisational as well as technical solutions of various kinds. The practices can furthermore be connected to the introduction of new regulatory requirements for health and safety management in Sweden in recent decades focusing on risk assessment and proactive and corrective actions (Lööw and Nygren, 2019).

Overall, this has prompted a need for the development of new methods and tools to measure the safety performance within the companies, i.e., the effectiveness of the safety practices in question (Sundström and Nygren, 2023). From a historical perspective, focus has to a large extent been on analysing accident statistics when measuring safety performance or, in other words, safety in a more retrospective sense (Johansson and Johansson, 2008). As safety practices have become more proactive in nature, the development of new indicators and metrics have also become a priority area (Lööw and Nygren, 2019). Instead of focusing on measurements of outcomes, these types of indicators measure, for instance, the extent and functionality of implemented safety practices; they thus provide a picture of the safety performance within the company in a proactive sense. Indeed, as suggested by Haas and Yorio (2016), the performance management of a company's organised and proactive safety practices is an important area for further development given the essential role that safety management plays for reducing accidents in the mining industry.

The organised proactive safety measures in a given company can regularly be found described in various policy documents and written rules and guidelines (Sundström and Nygren, 2024). In effect, these documents function as means to control safety management in practice, stipulating what ought to be done, by whom and how the roles and responsibilities should be divided and distributed (Vinodkumar and Bhasi, 2010). There are numerous international standards available that can provide guidance as to what should be included in proactive safety management in the mining industry. Besides national regulations such as systematic work environment management in Sweden, the management system OHSAS 18001, developed by the British Standards Institute, has historically been utilised by mining companies (Haas and Yorio, 2016). Although the translation process from written policy to actual practice can be difficult at times, the stated and normative practices found in a company's internal documents are a good avenue for exploring what proactive safety measures are being prioritised and deemed especially important in the mining industry (see Lööw and Nygren, 2019).

While some studies have focused on the safety development in the Swedish mining industry (see, e.g., Blank et al., 1995; Lööw and Nygren, 2019; Sundström and Nygren, 2023), no studies have focused on the matter of indicators of safety performance. As such, there is space to study and categorise the proactive safety practices utilised in the industry in order to better understand their characteristics and possible role in safety performance indicator development. The purpose of this article is thus to describe a framework for safety performance indicators, based on examples of safety practices from six companies in the Swedish mining industry.

The article begins with an overview of important concepts and associated definitions with a focus on workplace safety, safety performance and safety performance indicators. Against the background of this literature review and based on analysis of documents from six companies detailing proactive safety practices, a framework for safety performance indicators is described. The article concludes with a discussion regarding the sustainability of a possible framework for safety performance indicators and the importance of including social dimensions when developing such a framework.

1.1 Workplace safety

Workplace safety can be defined as "an attribute of work systems reflecting the (low) likelihood of immediate or delayed physical harm – whether immediate or delayed – to persons, property, or the environment during the performance of work" (Beus et al., 2016). Although the definition includes the likelihood of damage to property and the environment, we will mainly focus on the personnel within an organisation, i.e., personal safety. This, in turn, can be placed in relation to the concept of process safety, i.e., the likelihood of damage occurring in industrial operations due to, for instance, fire or the release of toxic substances (Hopkins, 2009). There is a clear connection between these phenomena in the sense that deficiencies in process safety can have serious consequences for personal safety. Problems linked to personal safety, primarily the risk of sustaining an accident at work, however, is about more than just deficiencies in process safety. Common accidents in the mining industry can be linked to deficiencies in the organisation or unsafe actions on the part of the workers as well (Lenné et al., 2012; Patterson and Shappell, 2010).

A problem with the concept of safety, defined as an attribute of a work system which reflects a low probability of personal injury (i.e., a dynamic 'non-event'), is that it is difficult to operationalise in empirical studies. This has led to researchers suggesting that *safety-related behaviours* may form a basis for both studies of safety and for the development of measures aimed at increasing safety (Beus et al., 2016). In this regard, research on safety climate has made progress in the last 20 years. A study by Larsson-Tholén et al. (2013) within the Swedish construction industry, for example, has shown the importance of clear policies and routines, as well as an active leadership showing that safety is a priority area, for the safety behaviour among workers. Improving safety is thus a matter of changing the circumstances that individuals must relate to regarding how the organisation handles and prioritises safety-related issues. Expressed in social psychological terms, a good safety climate is then that a given work group, in their shared perceptions of policies and practice in relation to safety, perceives that safety is an area that is actually prioritised. In some safety culture research, which focuses on the elusive and deeper layers within an organisation of joint meaning-making and symbolism, safety behaviour has also been highlighted as a way of making safety as a phenomenon more concrete (Edwards et al., 2013). Indeed, both researchers and practitioners have argued that workplace safety practices cannot be fully understood without situating them within the broader concept of safety culture (Reiman and Rollenhagen, 2014; International Atomic Energy Agency, 1999). Safety culture refers to the shared values, attitudes and behaviours that shape how safety is prioritised and practiced throughout an organisation. It could thus be argued that it underpins the design, implementation and sustainability of proactive safety measures.

1.2 Safety performance indicators

Safety performance has been linked to safety behaviour in terms of a high safety performance being synonymous with individuals following rules and actively promoting safety (Griffin and Neal, 2000; Christian et al., 2009). However, safety performance can also be a concept addressing the safety situation in a broader meaning, often linked to outcomes in terms of LTIFR over time (Christian et al., 2009). From that perspective, high safety performance is synonymous with low accident rates. However, there are problems with making a connection between low accident rates and high safety performance. As Beus et al. (2016) point out, high accident rates are a clear sign that there are flaws in safety given that the probability of sustaining an injury at work can be said to be high. However, the opposite is not necessarily the case, i.e., low accident rates do not necessarily mean that the safety levels are high. It is possible that during a certain period, few accidents will occur while risks at the same time accumulate within an organisation that, when the often-complicated underlying factors for accidents coincide, can cause accidents to start occurring again. A period with few accidents can consequently be a matter of what Beus et al. call a 'state of limited freedom from harm', rather than high and reliable safety *per se*. With a starting point in a definition of safety in the vein of low probability of personal injury, measurements of accidents could thus actually be seen as highlighting the absence of safety within an organisation, i.e., 'un-safety' (Oswald, 2020). Consequently, safety performance needs to be linked to more aspects than just outcomes in a retrospective meaning; safety performance also relates to the extent and the quality of the proactive safety practices put in place to reduce the number of accidents and improve safety in general. This, in turn, makes it important for safety performance to be measured and examined from different perspectives, which is something that is the focus of research on *safety performance indicators*.

It is common for safety performance indicators to be divided into two main types: lagging indicators and leading indicators (Oswald et al., 2018). These indicators are retrospective (i.e., lagging) in relation to safety-related incidents and forward-looking (i.e., leading), demonstrating possible changes in future safety performance. An example of a lagging indicator is the number of accidents per 1,000,000 working hours. A leading indicator, on the other hand, focuses on the performance of working methods, systems and processes aimed at maintaining safety. It could, for example, focus on the frequency of safety-related activities carried out by managers, i.e., the extent of a proactive safety-related effort. In that sense, a high indicator value would show that the activities are carried out to the extent that they should and thus contribute to safety performance. Should the effort show a low indicator value, i.e., a low degree of activities being carried out, it can be seen as a risk in terms of maintaining safety performance (Lingard et al., 2017). In other words, such an indicator demonstrates the performance of an organisation regarding processes, protective barriers or behaviours that can prevent unwanted outcomes such as accidents from occurring (Dyreborg, 2009).

Lingard et al. (2017) use the so-called *bowtie model* to illustrate how the relationship between leading and lagging indicators has been viewed traditionally. According to the model, leading indicators can be placed on the left side of a possible safety-related incident while lagging indicators end up on the right, i.e., after an incident has occurred. However, a problem with the model is that it provides a simplified picture of the safety within an organisation. Safety-related incidents often have underlying factors that can be linked to the interaction between organisational, technical, and cultural factors (Reiman

and Rollenhagen, 2014). Consequently, the model does not necessarily provide a correct picture of the oftentimes complex causal relationships of the factors underpinning accidents. It can also be difficult to make a clear distinction between leading and lagging indicators in practice. Deficiencies in protective devices can, for example, be seen as a lagging indicator, i.e., a measurement of an outcome, but protective devices could also be seen as a barrier that has been put in place to ensure safety and thus function as a leading indicator (Lingard et al., 2017). According to Dyreborg (2009), there should also be a connection between different indicators in the sense that a high indicator value on the left side of the incident, as depicted in the bow-tie model, can be connected to a low indicator value on the right side, i.e., that there is a causal relationship between the different measurements. However, it is difficult to explain such connections given that the relationship between two variables may be influenced by a third unidentified variable (Haas and Yorio, 2016). In short, it is problematic to demonstrate causality between different indicators in practice.

1.3 Safety performance indicators in the mining industry

As mentioned in the introduction, companies in the Swedish mining industry have historically focused on mainly lagging indicators in the form of accident rates (Johansson and Johansson, 2008; Lööw and Nygren, 2019). This is also the case in the international mining industry, however there has been an increased focus on leading indicators from the early 2000s and onward (ICMM, 2012). Regarding leading indicators, it is according to ICMM important that they are easy to understand for responsible parties and that they are demonstrable in terms of showing an actual reduction in safety-related problems. They should also be adapted to existing management systems and be comparable to other important metrics within the organisation. ICMM emphasises that different sets of indicators may be required depending on the degree of maturity within a company. At a basic level, indicators should be developed aimed at ensuring that legal requirements for health and safety are upheld and addressed. It could, for instance, be a matter of the company developing and publishing a health and safety policy. Once these aspects are in place, the next level concerns efforts aimed at improving the work environment more directly. If we continue with the example of a health and safety policy: an indicator on this level would focus on the policy in question not only being published but also well-communicated within the company. At the third and final level of maturity, indicators should be introduced that focus on continuous learning regarding health and safety. An indicator at this level can focus on the number of opportunities that are provided for the employees to exchange experiences regarding safety in their daily work.

In one of the few research studies in the mining industry on safety performance indicators, Haas and Yorio (2016) interviewed nine managers and occupational health and safety specialists in the US mining industry to get their perspective on safety and its measurability. Based on the answers provided by the informants, the authors suggest an indicator framework focusing on interventions, organisational performance, and worker performance. Regarding worker performance, this can be measured via behavioural observations, evaluations of how well the work was performed, and by testing their knowledge on health and safety. For organisational performance, focus can be placed on root causes of accidents, risk analyses and audits. Interventions, finally, concern the specific actions that managers, supervisors and employees undertake in health and

safety-related issues, such as the number of behavioural observations or audits completed, or the amount and the type of safety training carried out. These indicators also include a mixture of quantitative and qualitative measurements, which according to the authors is preferable in an indicator framework. A quantitative measure (for example, the number of safety walks carried out) can show the extent of a safety-related effort, something that can then be supplemented with a qualitative investigation (e.g., interviews) of the same effort to clarify important procedural and contextual aspects that are difficult to measure and quantify in themselves.

As the above review of safety research and policy shows, there is no consensus on what, exactly, should be measured to highlight safety performance within a company. However, Reiman and Pietikäinen (2012) point out that safety indicators, leading as well as lagging, can be designed to be in line with prevailing perspectives among key personnel within a company on safety issues. This involves those who are responsible for developing policies and routines, as well as other individuals with knowledge of safety management and organisation. By extension, this also involves basing the indicators on the stated practices in the company as they are documented in various policies, written routines and other relevant texts. This can contribute to indicators being developed and adapted to the existing practices within the company, thus contributing to the usability of the indicators in question.

2 Methodology

2.1 Data collection

By contacting representatives from four mining companies and two contractors in late 2018 and early 2019, we received material focusing on three broad topics that had been specified in advance to provide a comprehensive picture of prevailing safety practices. The topics were: company-specific safety policies and safety strategies, compilations of descriptive statistics concerning accidents and leading safety indicators, and company-specific surveys, reports and other documents focusing on the work environment in general and workplace safety in particular. Sixty-six documents were received in total, mainly policy documents stipulating the companies' stated ambitions for safety development, but also guidelines, internal reports, communiqués and an assortment of other documents. What the documents had in common is that they focused on prevailing health and safety practices within the companies.

The variety of different types of documents studied in this article provides a more nuanced understanding of how the companies communicate in and through their documentation, as well as how they describe the organisation and implementation of different safety practices.

2.2 Analysis

The documents were imported into the qualitative data analysis program NVivo 14 for thematic coding and analysis (Gibbs, 2018). The process began with coding the material into short, descriptive sentences that highlighted the main characteristics of the safety practices as described in the documents. The coding was done on a semantic level (Braun and Clarke, 2006), i.e., on what was explicitly written regarding the safety practices in

question. These codes and associated extracts consisting of sentences or paragraphs were then collated into four themes highlighting the broader characteristics of the safety practices: safety management systems, safety leadership, safety education, and worker safety engagement. See Table 1 for an example of two extracts and associated codes that, among others, comprised the theme 'safety leadership'.

Table 1 Example of the coding process

Extract	*Code*	*Theme*
"Managers are responsible for safety issues that are directly affected by the decisions they make. The responsibility is to create a good work environment… and to inform the nearest senior manager when the resources [to do this] are not sufficient."	Manager responsibility for safety and a good work environment	Safety leadership
"Through visible and felt leadership, reporting and analysis of incidents, as well as exchange of good safety practices, a culture of inclusion can be promoted."	Visible leadership for safety development	

According to Törner (2011), the social dimensions of an organisation's safety practices are vital to highlight given the importance of aspects such as cooperation, empowerment of the employees, open communication, etc., for safety in the workplace, regardless of the particulars of a specific safety practice. In line with this, for each of the four categories (i.e., safety management systems, safety leadership, safety education, and worker safety engagement), key aspects relating to social dimensions were analysed and coded. The codes were then collated under three additional themes focusing on the following social dimensions as important for the sustainability of the safety practices: communication and collaboration, empowerment and responsibility, and inclusion.

3 Results

In the following section, four prioritised safety practices in the Swedish mining industry are described, followed by examples of indicators and associated measures that can be connected to these, as well as a framework for safety performance indicators.

3.1 Safety management systems

All the companies emphasise the important role that the regulatory requirement for health and safety management plays for safety at work, i.e., the employer's systematic approach to investigating, implementing and following up on the activities that have been implemented to prevent accidents and achieve a satisfactory work environment overall. In addition to the national regulatory requirements, the health and safety management system OHSAS 18001 is also described as an important proactive safety initiative. It should be pointed out that several of the companies had been certified according to ISO 45001, which is an international management system standard for health and safety, at the same time this study was carried out. Management systems can thus be seen as fundamental elements of proactive safety practices as they add a systematic approach to risk assessment and associated measures, as well as guidelines for how the roles and

responsibilities should be divided in these matters (Fernández-Muñiz et al., 2009). In international research, management systems are also common topics when occupational safety is being analysed and discussed. The specific type of management system that is in focus may vary between studies, but they are often based on the so-called 'plan-do-check-act' cycle, with a focus on continuously reviewing the conditions in the work environment (Haas and Yorio, 2016). The importance of including contractors working for larger client companies in safety assessments is also highlighted by authors such as Nygren et al. (2017). Management systems can, however, also be a collective term for all health and safety-related actions carried out within an organisation, including measures that go beyond the requirements and guidelines in standardised management systems such as OHSAS 18001 or ISO 45001 (Sundström and Nygren, 2024). When it comes to performance indicators, it is common that focus is placed on how the individual elements in the management system can be measured, as a way of checking that practices within the system are carried out to the extent that they should. As mentioned above, however, it is important to note that indicators should not solely focus on the management system. It is equally as important that there are indicators that highlight the organisation's performance on issues in a broader sense, for example the scope of safety training, as well as worker experiences of and performance in safety matters (Haas and Yorio, 2016). This brings us to the next category: safety leadership.

3.2 Safety leadership

A second area that is prioritised in the Swedish mining is leadership and the importance of managers and supervisors being role models for the workers in safety matters. In addition to visible safety leadership, clarity in roles and the distribution of responsibilities emerge as an important area, i.e., that formal leaders on different levels within a company take responsibility for safety-related issues and ensure that safety management is carried out to a sufficiently high extent. Gunningham and Sinclair (2014) emphasise that mines exhibiting a high safety performance are characterised by managers actively working to create formal and informal relationships with the workers, listening to their requests and needs regarding safety, and ensuring that the organisation supports middle managers in their work, i.e., the people who work in direct connection to the production itself. This is also supported by Ajith et al. (2020), Balogun et al. (2020) and Cui et al. (2013) showing that support from leaders is an important part of encouraging safe behaviours among the workers. Regarding specific leadership styles, Donovan et al. (2018) argue that transformational and authentic leadership can be beneficial for safety, i.e., that leaders actively encourage workers to communicate safety issues and are open and honest with their own opinions on these matters, which can contribute to joint sense-making among managers and personnel (Willmer, 2017). Yu and Li (2020) and Zhu et al. (2020) emphasise that leadership issues can be connected to the psychosocial work environment. By reviewing and managing stress factors at work, this can ultimately contribute to safer work environments. In addition to the aforementioned focus on creating relationships with workers built on active, clear and inclusive communication, it is important to develop clear goals within the company, as well as there being clear expectations regarding how work is to be carried out. On a basic level, it is a matter of communication between individual workers, as well as communication between managers and workers in general, as prerequisites for understanding which rules and routines that apply (Laurence, 2005). Furthermore, it is also important that a climate exists within the company that

encourages transparency and honesty regarding safety issues, as a way to increase focus on safety problems and their solutions (Casey and Krauss, 2013).

3.3 Safety education

A third area that is prioritised in the Swedish mining industry is educational initiatives of various kinds. This includes basic training in safety, as well as courses that focus on specific conditions in the mining industry. Beyond that there are also profession-specific training initiatives that vary depending on the work being performed and what role a person has in it the company. Authors such as Laurence (2005), Parker et al. (2017) and Ajith et al. (2020), emphasise that educational initiatives should be seen as a fundamental part of the efforts to increase safety within a company. In addition to safety issues being a fundamental part of the safety training for all employees, continuous re-education is equally important to introduce and systematise as part of the training programs (Lu et al., 2020). One way to increase the quality of the courses can be to focus on how a work group jointly handles safety-related issues, as a complement to individual competence development efforts. This would according to Ye et al. (2020) contribute to the development of a common view on safety issues within the company and that it is something that a work group has a responsibility for and must handle together. Bahn (2012) also recommends educational efforts that focus on specific safety-related issues, including operation-specific hazards, as a complement to more general safety training.

3.4 Worker safety engagement

As far as creating a picture of the workers' view on and experiences of safety-related issues at work, all companies in the present study use employee surveys of various kinds. These are often general in the sense that focus is placed on broader conditions in the work environments but can also focus on specific concepts, such as safety culture or safety climate. An example of a survey that has been used by Swedish mining companies is the Nordic Safety Climate Questionnaire (NOSACQ-50), developed by researchers from Sweden, Norway, Denmark, Finland and Iceland. The survey has been tested in various industries and in different languages and shows, according to Kines et al. (2011), that there are specific aspects of safety climate that can be investigated empirically. These include: management's safety commitment and safety competence, management's support and safety empowerment, management's fairness regarding safety, employees' safety commitment, employee priorities regarding safety and absence of risk acceptance, safety communication, learning and trust, and employee confidence of safety systems. Overall, safety climate measurements are about shedding light on a given workgroup's joint perceptions of how safety is handled and prioritised within an organisation. One reason for carrying out employee surveys is thus to create a picture of how safety issues are experienced in practice, but it is also about creating conditions for participation in safety-related matters by directly asking the workers about their perspectives and experiences (see Foster and Hoult, 2013; Bascompta et al., 2018). If the management of a company shows that it actively prioritises safety in practice, and is genuine in its ambition to make use of the workers' experiences via, for example, questionnaires, it can also contribute to strengthening the safety climate within the organisation. Furthermore, this can in and of itself contribute to employees actively participating in various

safety-related activities that the company organises (Griffin and Neal, 2000). However, there are also other ways to include employees' perspectives and increase commitment to safety. In addition to safety issues being prioritised during, for example, workplace meetings or daily pulse meetings, it can be a matter of organising occasions for the exchange of experiences between different personnel groups within a company, in order to spread know-how of safety efforts to different parts of the organisation. At least two of the companies in our study have events that fall under this specific category of worker engagement. Overall, when employees are involved in the processes of implementing, e.g., safety-related routines and practices in the workplace, this tends to lead to a reduction of risks and ultimately fewer work-related injuries (Laurence, 2005).

3.5 Indicators based on prioritised safety practices

Based on the prioritised safety practices in the Swedish mining industry, four categories with associated examples of performance measurements can be highlighted (see Table 2). To each individual category that describes a specific prioritised area we have included examples of measurements that can be used to highlight the performance in these areas. We furthermore suggest that measurements of the four categories can show a basic level of safety performance within a company in a proactive sense, in accordance with what is seen as important focus areas within the Swedish mining industry.

Table 2 Examples of safety performance indicators

Prioritised safety practices	*Example of performance measurement*
Safety management system	Number of conducted risk assessments.
	Number of actions taken by the employer to proactively ensure safety.
	Number of feedback communications to workers that have reported risks, incidents or accidents.
Safety leadership	Number of occasions where company executives have participated in safety walks.
	Number of occasions where company managers have participated in safety walks.
	Number of risks, incidents and accidents reported by managers and supervisors.
Safety education	Number of people who have undergone occupation-specific safety training.
	Number of people who have undergone training in first aid.
	Number of people who have undergone training in underground rescue chambers and escape routes.
Worker safety engagement	Number of respondents on safety surveys.
	Number of occasions for exchanging experiences regarding safety between different work groups or units.
	Number of reported risks and incidents per work group.

Regarding the performance measures, these can be adapted depending on the needs within a company of special metrics to, for example, connect the indicators to more overarching company safety goals. Which specific performance measurements should be included for each indicator category may also differ between companies depending on which elements are considered to have the highest priority. However, it is important to have as comprehensive performance measurements as possible for each prioritised safety practice.

3.6 Social dimensions of safety practices

There is often an assumption when measuring indicators, such as the number of risk assessments carried out, that this will provide an indication of the actual safety conditions in an organisation (Oswald, 2020). However, these measurements do not in and by themselves say anything about the actual quality of the safety-related efforts and associated practices. An example could be a safety walk where a group of people analyse different risks in the workplace with the help of a checklist but without further discussing the problems observed. This can be compared to another group that fills in the same checklist but also takes the time to discuss the various issues in detail. In a numerical measurement of these two safety rounds they will seemingly be equal in terms of performance, but in practice the second example is probably more beneficial for upholding safety in the sense that there were actually discussions held about safety issues.

This points to the importance of also focusing on the quality of the safety practices that can form the basis of indicators within a company, rather than only quantifying them and connecting the results to specific safety objectives. Below, we outline a number of common denominators that we see in the empirical material collected for this study. These are based on what the company documents underline as being necessary *social dimensions* for upholding efficient safety practices in their organisations.

The first area, *communication and collaboration*, is seen as an important part of different safety practices within the studied companies. Safety-related interventions of various kinds are said to be characterised by open communication and collaboration, regardless of what the intervention is focusing on in an instrumental sense. Overall, there is also a focus on, e.g., engagement and reflective conversations as being key issues when developing a safety culture. However, shared norms and values do not arise by themselves; company-wide communication and cooperation is often stated in the studied documents as being a requirement for, e.g., desired norms to be spread in the organisation. It can also be about promoting the desired culture and emphasising that it should permeate the entire organisation through signs and slogans in the workplace, as well as safety issues being permanent features at meetings and other gatherings.

A second theme that constitutes a common denominator among companies' safety practices is *empowerment and responsibility*. This includes the importance of developing a clear and formal distribution of roles and responsibilities among managers and supervisors, as well as the individual's personal responsibility for his or her own safety. Empowerment thus involves a clear mandate to actively engage in specific safety issues – a mandate that should be accompanied with the necessary resources to be able to perform the tasks in question. This can be linked to the regulations for health and safety management in Sweden, which state that employers must ensure that health and safety issues are included as a part of daily work practices, and that the associated tasks must be

distributed among the personnel in a clear way so that a satisfactory work environment can be achieved. However, it is not only about the implementation of the regulations themselves. It is alluded to, if not directly stated, in some of the company documents that empowerment is also about the responsibility that an individual perceives that he or she has, i.e., that there is a culture within the organisation that contributes to people feeling that they have the authority to act in a certain way in relation to safety. The matter of empowerment and responsibility can also be linked to training. As mentioned above, all the companies that participated in the study have implemented several training courses focusing on workplace safety. Furthermore, there are general health and safety training courses with the aim of ensuring basic knowledge of, among other things, safety issues. Here, too, an emphasis is commonly placed on the importance of personal responsibility for safety at work.

Finally, *inclusion* concerns how the safety practices are designed and adapted with the company personnel in mind. An example is accident investigation through a digital reporting system, which can enable people to follow up on the reports that have been filed. It is thus about developing systems that suit the users' needs. High user friendliness is considered to contribute to higher degrees of utilisation of important systems and technical solutions, as well as providing an experience that the individual can actively contribute to the safety within the company. However, inclusion can also be about the workers being able to understand why, for example, management introduces new safety rules and routines. In this case, focus is placed on the fact that the information that is spread within the company is designed to suit different target groups' needs.

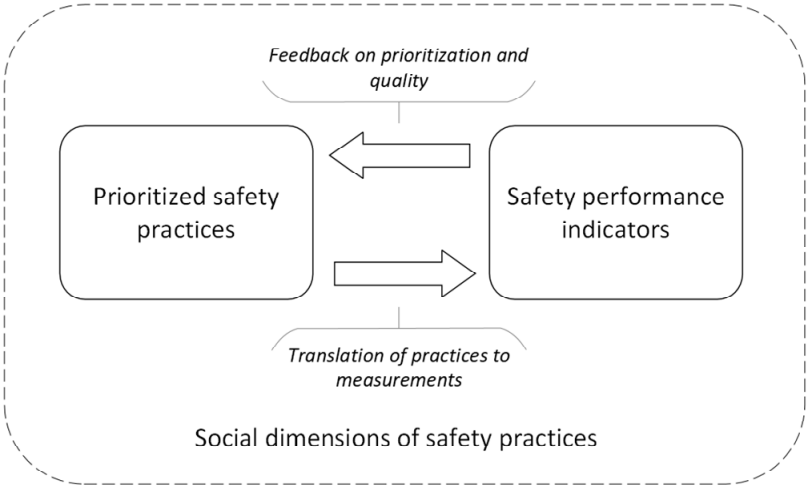
One way to highlight these social dimensions of safety practices is to include questions in employee surveys that focus on the workers' experiences of communication and collaboration, empowerment and responsibility, as well as inclusion, in relation to different safety practices. The results from these surveys could then be used as a basis for discussions about how well the prioritised safety practices take these social dimensions into account.

3.7 A framework for safety performance indicators

Having explored the safety practices of six companies in the Swedish mining industry, a framework of the interactions between the different aspects involved can be established. Prioritised safety practices relate to several elements of safety management, i.e., specific practices that the companies have chosen to focus on in order to improve safety. In this study, these practices have been shown to include safety management systems, safety leadership, safety education, and worker safety engagement. Safety performance indicators concern the metrics and measurements that can be developed to highlight the scope and thus the performance of the prioritised safety practices. They provide organisations with quantitative measurements of safety development efforts and can be used to identify areas in need of improvement. Safety practices and proactive indicators thus operate in a cycle, with efforts in prioritised practices being translated to measurements of safety performance which in turn highlight underutilised practices in need of improvement. However, as previously mentioned, a high number of implemented and executed safety practices do not per se indicate a safe organisation, similar to how a workplace cannot be considered 'safe' simply because of low accident rates. In order to provide more nuanced measurements, these two areas should be related to specific social dimensions that can be seen as quality-enhancing in the sense that they contribute to the

stability and added value of the prioritised safety practices. Qualitative analyses of safety performance indicators' social dimensions, e.g., the promotion of cooperation, the delegation of power and responsibility, and user friendliness, allow for more accurate assessments of the conditions for safe work. These assessments can serve as support for the design and implementation of prioritised safety practices, indicating which practices to focus on. A framework of the interactions between prioritised safety practices, safety performance indicators and the potential inclusions of social dimensions can thus be illustrated as in Figure 1. It describes the cyclical relationship between safety practices and indicators while emphasising the need for the permeation of social dimensions as a quality-enhancing measure.

Figure 1 Framework for safety performance indicators



However, while the examined mining company documentation suggests an awareness of social dimensions and their relation to the success of safety practices, they are not commonly included in efforts to measure safety performance. Safety performance indicators are instead, as mentioned previously, more commonly measured through quantitative means such as, e.g., the number of people undergoing safety education. The importance of social dimensions to the quality of an organisation's safety performance is a subject emphasised in literature by authors such as Törner (2011). They claim that leadership promoting social aspects such as cooperation, collective goals, empowerment of employees and open communication contribute to the development of a positive safety climate and act as tools for establishing trust between management and workforce. Trust, in turn, can serve to promote workers' motivations to contribute to the organisation's goals, for example by adopting safe behaviours. This is contingent, however, on whether management can properly communicate the importance of those goals and demonstrate a consistent prioritisation of safety. As the foundation for positive safety climates, the quality with which social dimensions are incorporated in the safety practices of a group or an organisation could serve as an important indicator of their potential performance. Through their advocating of communication, empowerment and inclusion of employees in their safety practices, the studied mining organisations have ample opportunity to apply social dimensions in such a manner in their safety performance indicators.

The added utility of implementing social dimensions into the process of safety performance indicators can be illustrated by comparing the framework to Reiman and Pietikäinen's (2012) system model for indicators. Social dimensions can be added to both drive indicators, i.e., measurements of prioritised activity fulfilment, and monitor indicators, i.e., measurements of safety performance capacity, in order to provide higher quality measurements that better represent reality. Including social elements as drive indicators could help steer organisations towards more inclusive and engaging safety development. Monitor indicators based on social interaction and activities are already something described by Reiman and Pietikäinen (2012). The scope could however be expanded to include evaluations of aspects such as whether safety practices or strategies would be likely to encounter resistance or low engagement from the employees.

4 Conclusions

In this study, the proposed framework for safety performance indicators focused specifically on the conditions and practices within the Swedish mining industry, as described in internal documents from six companies. However, a singular focus on safety practices and their measurability is not enough to guarantee quality safety management. It is also important to consider the social dimensions of safety as a means of enhancing the quality of the practices in question. The social dimensions should thus be deliberately prioritised when discussing, developing and implementing new proactive safety management strategies and indicator frameworks.

An important avenue for future research concerns how organisational risk factors and system-level complexity can be better integrated into frameworks for safety performance indicators. While proactive safety practices – such as leadership, education, and workers' engagement – are essential components of safety development, recent research has highlighted how deeper organisational conditions (e.g., lack of organisational clarity or ineffective control actions) may lead to an erosion of safety margins and ultimate a drift to failure (Komljenovic et al., 2017). At the same time, the increasing technological and organisational complexity of modern mining operations introduces emergent risks that are not easily captured through conventional indicators (Brocal et al., 2019; Dekker et al., 2011). Future studies should explore how safety indicators might reflect such situated complexity and how they can be used to monitor latent risks in everyday organisational functioning (Brocal et al., 2019). By doing so, indicator frameworks could move toward a more dynamic understanding of safety performance in high-risk industries such as mining.

Declarations

The authors declare no conflicts of interest.

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