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SAFETY AUDITING (4):
Development of Positive Performance Indicators

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Abstract

The paper describes and discusses the development of positive performance indicators and the warm acceptance of this novelty safety performance measure worldwide by industries in the United States of America, Europe and Australia. Special attention is paid to Australian, and particularly Western Australian experience, where mining and mineral processing industries derived numerous benefits in occupational safety and health from systematic applications of positive performance indicators.

Key Words

Development of positive performance indicators. Mining and mineral processing operations. International safety and health standards. Occupational safety and health.

Introduction

The previous three articles in this series have illustrated the advantages of the System Safety approach to accident prevention over the classical industrial safety approach. The use of classical industrial safety techniques, including the accident prevention strategies formulated on the basis of accident investigation or of various accident sequence models (Heinrich, 1980), routine safety inspections etc. have reached the limit of their effectiveness. A variety of measures used in classical industrial safety to evaluate and measure the safety performance are reactive, being calculated on the basis of accident consequences of the accidents we have not been able to prevent.

Examples quoted previously include lost time injuries, first aid injuries or medical treatment injuries, as well as restricted duty injuries. The System Safety approach focuses on the preventive measures, without waiting for occupational accidents to happen and for occupational diseases to develop. This is connected with the effort to develop predictive measures of occupational safety and health performance and related safety management techniques. One of these techniques, and a very powerful one, is safety auditing, i.e. auditing of the critical range of the accident prevention processes.

The first article in this series (Nedved, 2014) discussed the significance of safety auditing in the prevention of accidents and ill health at work. Major objectives, main elements and organisational aspects of safety auditing were discussed. Also, recent Western Australian experience in the development of safety auditing was described. The development of a safety auditing programme and a training programme for safety auditors developed by the Western Australian team and tested extensively throughout South East Asia, was outlined. The significance of well-prepared audit documents, including audit protocols and checklists, was explained.

The second article in this series (Nedved, 2015a) dealt in more detail with the development of audit protocols, rating systems and checklists for pre-audit surveys and for the actual safety audits. Such audit protocols guide and direct the safety auditors as to the observations that should be made and the questions to ask in order to effectively verify all the organisational aspects relevant to the occupational safety and health programme element under review by the safety audit.

The third paper in this series (Nedved, 2015b) described the development of safety audits for the purpose of company's self-assessment, i.e. the development of a self-audit system. Self-audits have been developed to enable the management in industrial organisations to regularly conduct consistent high quality assessment if occupational safety and health management systems and internal controls. Such self-assessment facilitates and verifies compliance with company and statutory requirements and objectives, and recognised best practices.

Development

During the last decade safety auditing has been established as a very powerful and proactive safety management tool, which is used to verify that the occupational safety and health management system is in place in the company and that the system is working effectively. This can be determined by establishing whether or not the relevant safety management activities and related outcomes and results conform to planned, written arrangements.

One of the key competencies, namely knowledge and experience in auditing methods and techniques, includes the competency of designing relevant audit protocols. Some examples of this have been outlined earlier in this series (Nedved, 2015a). A number of occupational safety and health audit systems and programmes have been in existence for many years. Some examples are the International Safety Rating Scheme; National Safety Council 5 Star programme; Du Pont Safety Management Programme; Victorian Safety MAP programme.

In the Introduction section of this paper (Nedved, 2015a), the advantages of proactive safety measure over the reactive ones (outcome measures) were outlined. There are further numerous limitations to reactive safety measures. Outcome measures can be influenced by a number of interfering factors, such as reward programmes that frequently lead to under-reporting of accidents and injuries, or, on the other hand, by the fear of being reprimanded or punished. Outcome measures have no diagnostic value to help understand or modify the contributory factors that produce unwanted outcomes -accidents and injuries. Whilst the traditional reactive measures of safety, the accident and injury records, measure the number of such events, they do not provide any indication of the programme effectiveness.

The effective occupational health strategy aimed at helping all those involved in the prevention of ill-health at work, should involve a partnership of those involved to work together towards common goals. This should involve the relevant government authorities and all industry, with the industry having to play the most important role. It is expected that the industry will put in place the systems, which will identify the widest range of occupational safety and health problems and establish priorities. It is necessary to apply resources where they are most effective. The new systems must include the provisions for staff training to ensure that ill health at work would be targeted continuously and the workers would apply their skills to protect them-selves against known hazards. The effectiveness of actions taken must be monitored, and inputs and outputs must be clearly measured. Instead of relying on the numbers of tool-box meeting*s*, ***we should measure improvements attributable to them.*** Using positive performance indicators is one of very effective strategies to achieve such goals.

Positive performance indicators

Positive performance indicators (PPIs) for occupational safety and health performance measurement should be seen as a method for assessing and measuring the organisational systems. This includes, for example, the accountability and responsibility of managers. Essentially, this means that we can establish a host of targets and measures aligned to what we want to measure as well as test strategic and operational targets.

PPIs must form an integral component of the organisation's program and they should be linked and supported by management systems. They are a proactive measure but be mindful that they are not the beginning or the end of the system.

It is important to remember that the use of PPIs is essentially a methodology and a tool to improve safety and health while providing outcomes that minimise risk for the organisation. PPIs must be linked to programs or strategies that have a high priority for the organisation, for example they should be:

- implementation oriented;
- results oriented, that is setting targets that are measurable and achievable;
- related top process, relevant to the workplace in question;
- measuring an increase or decrease of a particular factor, e.g. the ability to recognise achievements and identify opportunities for improvement and future planning; and
- assessing the effectiveness and application of a procedure.

It is recognised that in the first instance the collected data may be qualitative as against quantitative however, more importantly is the establishment of a framework for the systematic development of PPIs while at the same time providing an opportunity for the more effective use of the lag indicators such lost time injuries. PPIs and lag indicators can be used side by side to support the overall safety and health management of the organisation.

PPIs are workplace based and specific to the organisation. They are as a rule of thumb unable to measure legislative requirements or be used as a comparative measure against similar organisations.

Examples of PPIs

The following 5 examples of PPIs are based on the key objectives of Policy, Planning, Implementation, Measurement and evaluation and Management Review. (Criteria of the Australian & New Zealand Standards AS 4801/4804, 2001).

<u>Policy</u>

Does the organisational Occupational Safety and Health Policy include accountability, responsibility and authority statements aimed at relevant levels of management?
To have 100% of managers trained to Certificate IV in Safety within 12 months commencing?

<u>Planning</u>

Do managers pro-actively plan for occupational safety and health?
Are the plans linked to the organisational strategic and operational plan?

<u>Implementation</u>

What percentage of Executive Managers have been trained and can demonstrate a working knowledge of OHS legislation, principles and practices?
To have all requirements of the amended legislation implemented into current procedures within 12 months.

<u>Measurement and Evaluation</u>

At what organisational level are OH&S Performance Indicators reported?
Are all lost time injuries investigated as per the requirements of the organisational Policy? (This could be' for example that investigation and recommendations are made within the same working shift).

<u>Management Review</u>

How does the overall Occupational Safety & Health strategic plan or management plan operate? At what level of the organisation are managers held accountable for their actions or at what level of the organisation are plans and outcomes reported?

Advantages of PPIs

- Some of the advantages of PPIs are:
- They are relatively easy to establish;
- They can be easily understood;
- Able to be used to identify trends;
- They provide the opportunity to identify areas requiring additional resources; and
- They are proactive and positive in nature allowing the measurement of organisational process, safety systems or part safety systems and can also be used to measure resource based systems and strategic objectives.

Acceptance of Positive Performance Indicators Methodology

The warm acceptance of this novelty safety performance methodology has been widespread. In Australia it is being used by governmental bodies (e.g., Department of Employment and Industrial Relations 2005; NSW Government 2011), by private industries and by insurance companies (e.g., CCI Insurance 2014).

Positive Performance Indicators in Western Australian mining and mineral processing

In the Western Australian mining and mineral processing industries, the continuing reduction in the total number of lost time injuries over the last decades and the consequent improvement in the lost time injury frequency rate for most mining operations has eroded the importance of injury statistics as a measure of safety and health performance in the industry. The industry has long realised that injury statistics are at best only a rule of thumb indicator of injury trends and provide no meaningful direction for the implementation of innovative and progressive initiatives for the substantial reduction of workplace injuries (The Chamber of Minerals and Energy, 2004). The new initiatives have led to the development of the strategies for the identification of the major factors which, if addressed on a systematic basis, would facilitate a positive performance culture on mine sites. Major areas in which a positive performance culture has developed in the Western Australian mining industry are:

- Safety Policy
- Leadership and Management Commitment
- Culture
- Organisation for excellence in safety and health
- Line responsibility
- Incident management and follow up
- Supportive health and safety staff
- Safety activity effectiveness
- Safety audits
- Safety training
- Information management and communication
- Contractor management -major contractors
- Emergency prevention, preparedness, response and recovery

Conclusions

The reasons discussed above demonstrate beyond any doubt that the traditional reactive measures of safety, or out-comes, could not be used as reliable measures of occupational safety and health performance. Therefore, positive performance measures or proactive monitoring data should be fully utilised in the development of occupational safety and health management systems to assist industry in achieving further improvement in occupational safety and health.

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Examining the Relationship Between Safety Culture and Safety Climate and the Role Leading Safety Indicators Play in Enhancing Safety Performance in the Oil and Gas Industry

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Abstract

This study examined the relationship between safety culture, safety climate, and leading safety indicators in enhancing safety performance in the workplace. The research showed that an organisation's positive safety culture is believed to be important in improving safety performance. Achieving a positive safety culture takes time and relies on a top-down approach, with a visible commitment to safety by management. On the other hand, safety climate relies on a bottom-up perceptual approach, corresponding to individual values, attitudes, and perceptions regarding safety. No universally agreed method exists for establishing and correlating safety culture factors with leading safety indicators for the oil and gas industry, nor is there a generic set of safety indicators to cover all relevant aspects of a positive safety culture. However, it is possible to link the safety culture maturity model to a set of leading safety indicators so that management can act on the early warning signs.

Keywords: organisational culture; safety culture; safety climate; leading safety indicators.

Introduction

Every year more than 2.3 million workers lose their lives through work-related accidents and diseases. In addition, workers suffer 317 million occupational accidents each year - these are conservative estimates according to the International Labour Organisation (ILO) (2014). The oil and gas industry is not immune to these accidents. According to Platts (2015) 138 workers were killed on the job while extracting, producing or supporting oil and gas in 2012.

Oil and gas (O&G) usage has evolved over time and expanded and is now an integral part of today's global economy (Business Reference Services, 2013). Over the past two centuries, progress has become dependent on the energy derived from crude oil, natural gas, coal and nuclear power as well as from renewable sources such as wind, solar, and hydroelectric sources. Currently, O&G accounts for an estimated 61% of the world's energy consumption, despite effort to increase the use of alternative sources of energy. The total global energy demand in 2030 is projected to be 50-60 percent more than current levels from fossil fuels (Sankara, 2014). In short, the O&G industry is vital to many nations and is of prime importance to global economy and progress. O&G are likely to remain the leading energy sources for many years to come (Longwell, 2002).

Large scale projects in the O&G industry are therefore of prime importance to our society and therefore public expectations are assumed to be critical for the safe operation of such facilities (Hannevik, Lone, Bjørklund, Bjørkli, & Hoff, 2014). For this reason, throughout the world, efforts are made to regulate the O&G industry through the establishment of various government regulatory agencies such as the UK Health and Safety Executive (HSE), Norwegian Petroleum Safety Authority (PSA) and Australian National Offshore Petroleum and Environmental Management Authority (NOPSEMA) to name a few. The primary aim of these agencies is to ensure that the O&G industry is operated safely, responsibly and in the public interest. While regulations in each country differ, they are all more or less based on the principle that the operator must have, among other systems, a sound safety culture to safeguard workers, the environment and the facility (Griffin et al., 2014).

Despite decades of coordinated effort to improve safety in the O&G industry worldwide, accidents continue to regularly occur, e.g. in July 1988 Piper Alpha offshore gas platform that suffered an explosion and is regarded as the worst offshore oil disaster in the history of the UK. This incident claimed 167 lives and cost billions of dollars in property damage (Pate-Cornell, 1993). In September 1998, Esso Australia's gas plant at Longford in Victoria suffered a major fire. Two people were killed, eight were injured and the state's gas supply was severely affected for two weeks (Hopkins, 2000). In March 2005, a hydrocarbon vapour cloud explosion occurred at the BP's Texas City refinery in Texas City, killing 15 workers and injuring more than 180 others (U.S. Chemical Safety Board, 2007). In August 2009, the Montara wellhead platform drill rig off the northern coast of Western Australia suffered a wellhead accident, resulting in the uncontrolled discharge of oil and gas. This discharge is considered one of Australia's worst oil disasters (Environment News Services, 2013). A year later, in April 2010 the BP Deepwater Horizon in the Gulf of Mexico claimed eleven lives and is considered the largest, and perhaps the most expensive, accidental marine oil spill in the history of the petroleum industry (Cleveland, 2013).

Why are these disasters still occurring in an age of state-of-the-art occupational health and safety management systems coupled with behavioural-based safety programs, technologies, tools and training in most O&G organisations? While creating and sustaining a 'zero harm' workplace is a common goal for many companies, why does this goal still elude so many organisations? According to scholars, accident investigators, and safety practitioners a ‘negative’ safety culture may be a key causal factor in many tragic accidents (Cooper, 2002; Gadd, 2002; Glendon, Clarke, & Mckenna, 2006; Guldenmund, 2007; Human Engineering, 2005; Jin & Chen, 2013; Olive, O'Conner, & Mannan, 2006; Quan, Dongping, & Mohamed, 2011; Reason, 1997).

Accidents result in human, environmental and financial loss and cause pain and suffering, yet are highly preventable. The challenge that remains is how to make workplaces safer? This study aimed to:

1. Identify the essential characteristics or elements of a ‘positive’ safety culture.
2. 2. Provide a clear distinction between safety culture and safety climate and how these terms interact to create a culture favourable to safety.
3. Examine the relationship between a positive safety culture and leading safety indicators in improving safety performance.

Method

A systematic review of the literature was conducted. This was limited to full text English articles published between the years 1980 and 2015. Studies were identified through a search of the databases ProQuest and Science Direct together with web pages from Health Safety Executive (UK) and Safe Work Australia.

Initially, a search using ProQuest database with the phrase “safety culture‟ “AND” safety climate‟, “AND” “organisational culture‟ yielded 12,730 results. A refined search was then conducted limiting the results to those based on the topic of Professional Safety and peer reviewed scholarly journals published between the years 1980 and 2015 which yielded 53 results. A second search was conducted using Science Direct database. This yielded 15,409 results in total with keywords “safety culture‟ and “safety climate‟. The search was then refined to include Safety Science journals published between the years 1980 and 2015 and yielded 93 results of which 50 were related to safety climate and 43 were related to safety culture. A third search was conducted using Science Direct database. This yielded 16,211 results in total with keywords “safety culture‟ and “leading indicators‟. The search was then refined to include Safety Science journals published between the years 1980 and 2015 and yielded 99 results of which 28 were related to O&G industry.

Out of the total searched, 174 articles establishing a link between the review topics were considered. Some of the reviewed publications were published by the same collaboration of authors, although a different first author was used. For publications that had similar information only the most recent publication was included. Sixty nine of these publications are cited in this review. Thirty five of the cited publications are research studies, 10 are comprehensive literature reviews and 24 are commentaries/guides/ frameworks or books about safety climate or safety culture in workplaces.

Results

Safety Culture

The term ‘safety culture’ was first introduced after the 1986 Chernobyl accident by experts at the International Atomic Energy Agency (IAEA). IAEA experts analysed the accident and concluded that the incident could not just be attributed to human error, the technology, or even the socio-technical system, but to organisational and management factors which they labelled as ‘safety culture’ (Castro, Gracia, Peiro, Pietrantoni, & Hernandez, 2013).

In a review of 27 studies examining definitions, models and theoretical development of safety culture, only eight defined safety culture in more tangible ways. These definitions tend to reflect the view that safety culture is something an organisation ‘is’ rather than something an organisation ‘has’ (Choudhry, Fang, & Mohamed, 2007). Further, five key elements were identified as ‘common ingredients’ for a positive safety culture: management commitment, management involvement, employee empowerment, incentive structures and reporting culture (Dekker, 2006). Similarly, Reason (1997) identified four elements of organisational ‘cultures’ in combination including: a reporting culture, a just culture, a learning culture and a flexible culture.

The following definition of a safety culture was proposed by the Advisory Committee on the Safety of Nuclear Installation (1993) and adopted by the UK Health and Safety Commission (HSC):

> *The safety culture of an organisation is the product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation’s health and safety management* (cited in Fang & Wu, 2013, p. 139).

This definition captures management and organisational factors as well as attitudes, beliefs, perceptions and values that employees share in relation to safety (Mengolini & Debarberis, 2012).

Table 1 provides a list of the elements reported in the literature (35 elements from 9 publications) that are associated with a positive safety culture. There are many more variations to the number and characteristics of a positive safety culture, the majority of which revolve around the elements listed in table 1 (Cooper, 2002; Hale, 2000; Mohamed, 2003).

Table 1: Enabling conditions associated with a positive safety culture

Source	Elements of a 'positive' safety culture
Advisory Committee on the Safety of Nuclear Installation (1993)	• Individual and group values, • Attitudes, • Perceptions, • Competencies • Patterns of behaviour
Reason (1997)	• A reporting culture, • A just culture, • A learning culture • A flexible culture
INSAG (1999)	• A viable management system • A widely shared awareness of hazards • A widely shared behavioural norms and values.
Gadd (2002)	• Senior management commitment to safety • Realistic and flexible customs and practices for handling both well-defined and ill-defined hazards • Continuous organisational learning through practices such as feedback systems, monitoring and analysing • A care and concern for hazards which is shared across the workforce.
Cooper (2002)	• Psychological element (i.e. attitudes and perceptions) • Behavioural element (i.e. job related behavioural safety) • Situational element (i.e. organisation safety systems and audits).
Human Engineering (2005)	• Leadership • Two way communication • Employee involvement • Learning culture • Attitude towards blame (a just culture).
Hopkins (2006)	• An over-riding commitment to safety
Choudhry et al., (2007)	• The way people think and/or behave in relation to safety.
Dutch National Aerospace Laboratory (cited in Piers, Montijn, & Balk, 2009)	• Commitment • Behaviour • Awareness • Adaptability • Information • Justness.
Institution of Occupational Safety and Health (UK) (2014)	• Working practices and rules for effectively controlling hazards • A positive attitude towards risk management and compliance with the control processes • The capacity to learn from accidents, near misses and safety performance indicators and bring about continual improvement.

Safety Climate

Safety climate is used interchangeably and in conjunction with safety culture. Christian et al., defined safety climate as "shared perceptions of work environment characteristics as they pertain to safety matters that affect a group of individuals' (Christian, Wallance, Bradely, & Burke, 2009, p. 1106). A positive safety climate is said to relate to employees' perceptions of management safety values and commitment to safety (Flin, Mearns, O'Connor, & Bryden, 2000; Mohamed, 2002).

Guldenmund (2007, p. 722) argues that "safety climate and safety culture are not separate entities but rather different approaches towards the same goal of determining the importance of safety within an organisation". This was echoed by Fruhen and colleagues (2013) who confirm that the concept of culture and climate are acknowledged in the literature as having a considerable overlap. While both phrases can be used to describe the underlying safety attitude of an organisation, safety climate generally refers to the attitude the people in the organisation have towards safety (Olive et al., 2006).

Flin and colleagues describe safety climate as a "snapshot of the state of safety providing an indicator of the underlying safety culture of a work group, plant or organisation" (Flin et al., 2000, p. 178). By inference, safety climate changes more quickly and more readily than safety culture. Olive et al., (2006) point out that in the aftermath of a major accident, it is the climate of an organisation, rather than the culture, that will undergo immediate scrutiny and modification. Sidney Dekker (2006) echoed such an assertion and argues that safety climate is a more short term, changeable atmosphere of openness and learning that can result from a crisis such as a recent major incident. Consistent with literature, Table 2 provides a clear distinction between the two terms.

Table 2: Differences between safety culture and safety climate

Safety Culture	Safety climate
• Is an organisation level issue	• Is an individual level issue
• Refers to shared meaning about safety and collective commitment to safety	• Refers to psychological characteristics of employees (e.g. how a person feels, corresponding to the value, attitude and perception of each individual with regard to safety with an organisation)
• Concerned with the creation of a viable safety management system for effectively controlling hazards	• Concerned with employees' perceptions of management safety values and commitment to safety
• Widely shared awareness of hazards/risk	• Individuals awareness and perception of risk
• In the aftermath of a major accident, working practices and rules, competences and compliance, reporting and learning cultures will be systematically examined and under go long term modification.	• In the aftermath of a major accident, it is the individual values, attitudes, perceptions and patterns of behaviour that will undergo immediate scrutiny and modification.
• Widely shared behavioural norms and deep seeded values that does not change quickly	• Changes more quickly as it is superficial and more transient than safety culture
• Supportive environment.	• How an individual feels to be a member of an organisation.
• Over-riding management commitment to safety (i.e. assigning the highest priority to safety)	• Relies on personal commitment to safety (e.g. individual attitude to violations)
• A top-down organisational approach	• A bottom-up perceptual approach.
• Is a leading indicator of organisational culture	• Is a leading indicator of safety culture

Safety Indicators

According to Hale (2000) safety indicators are used for three different purposes: to monitor the level of safety in a system, to decide where and how to take action and to motivate those in a position to take the necessary action to take it.

The two types of safety indicators currently in use by the oil and gas industry are lagging and leading indicators. A lagging indicator is related to reactive monitoring and shows when a desired safety outcome has failed, or has not been achieved (Health and Safety Executive, 2006; Zwetsloot et al., 2013). The U.S. Centre for Chemical Process Safety (CCPS) defined lagging indicators as "a retrospective set of metrics that are based on incidents that meet the threshold of severity that should be reported as part of the industry-wide process safety metric" (CCPS, 2011, p. 4). Thus, lagging indicators are generally focused on organisational measures such as recordable injury rates, fatalities, days away from work, motor vehicle crashes, worker compensation claims and property damage costs to name a few (Grabowski, Ayyalasomayajula, Merrick, Harrald, & Roberts, 2007). In short, lagging indicators measure outcomes that have resulted from past actions and meet the industry threshold of severity.

The incident on the Deepwater Horizon Mobile Offshore Drilling Rig that was situated off the Louisiana coast of the United States of America is an example of safety practice that relied on lag indicators. On the 20th April 2010 BP Executives were on board this rig to congratulate the management staff on having seven years without recording a loss time injury (a lag indicator) when an explosion on the rig occurred that killed 9 platform workers, 2 engineers and resulted in an environmental pollution oil slick that covered 6,500 km2 (Bertolati, Hannelly, & Jansz, 2015). In the light of such incidents proactive measures or leading indicators that identify hazards, assess and control the risk before the arrival of the event or incident must be developed (Grabowski et al., 2007). Leading indicators are defined as "a forward looking set of metrics which indicate the performance of the key work processes, operating discipline, or layers of protection that prevent incidents" (CCPS, 2011, p. 4). Unlike lagging indicators, leading indicators require a routine systematic check that key actions or activities are undertaken as intended (Health and Safety Executive, 2006). In addition, leading indicators measure the inputs to the process that will affect future outcomes and monitor adverse conditions before harm or failure occurs. It is therefore plausible to suggest that leading indicators can help to control risks and prevent undesirable events.

Examples of leading safety indictors include: percentage of Permit to Work reviewed and controls found to meet requirements, percentage of safety critical training completed on time, safety audit recommendations closed on time, perceptions of management commitment to safety, number of leadership walkthrough per month. In short, leading safety indicators provide information on organisational safety performance earlier in the process and enable proactive corrective actions to be made before adverse events occur.

The review confirmed that there was evidence in the literature to suggest that leading safety indicators help improve future safety performance by promoting action to correct potential weakness without waiting for failure to occur. The main challenge however is in identifying the indicators that give management an opportunity to act upon the early warning signs in a timely manner (Hale, 2000).

Much work has been invested in trying to measure or predict safety by establishing safety indicators in the O&G industry (Attwood, Khan, & Veitch, 2006; Bergh, Hinna, Leka, & Jain, 2014; Cox & Cheyne, 2000; Griffin et al., 2014; Hannevik et al., 2014; Mearns, Flin, Gordon, & Fleming, 1998; Mearns & Yule, 2009; Pate-Cornell, 1993; Skalle, Aamodt, & Laumann, 2014; Skogdalen, Utne, & Vinnem, 2011; Wold & Laumann, 2014). Despite this effort, there is currently no universally agreed method of establishing leading safety indicators nor are there a generic set of leading safety indicators determined for the O&G industry (Skogdalen et al., 2011). This is perhaps due to the fact that no set of indicators remain relevant to an organisation indefinitely (ICMM, 2012).

In summary, the development of effective leading safety indicators assists in promoting a positive safety culture within an organisation. It creates a heightened awareness of emerging signs, signals and alerts and invites actions to be taken before the safety culture drifts to failure.

Relationship between safety culture and leading safety indicators

The Safety Culture Maturity Model (Fig. 1) depicts the relationship between safety culture maturity and levels of leading performance indicators.

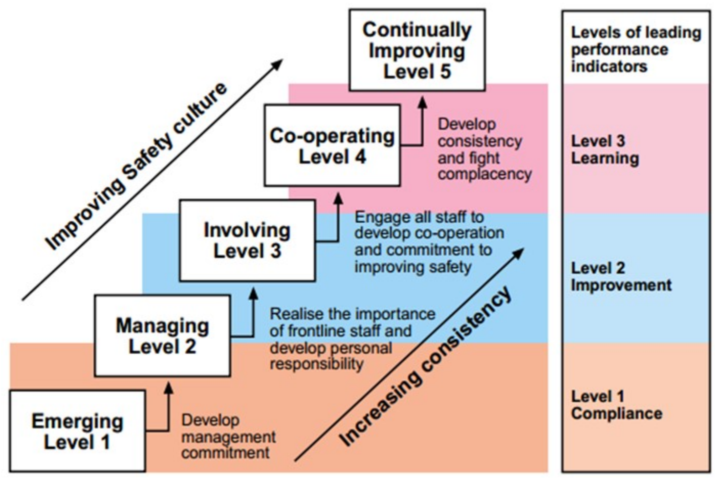

Figure 1: Safety Culture Maturity Model (Step Change in Safety, 2003, p. 6).

In this model, organisations progress through increasing levels of safety culture maturity in a continuous improvement process. At each level of maturity, the issues that are most important for improving performance and actions that will assist in moving to the next level of maturity are different (Step Change in Safety, 2003). The safety culture maturity model was supplemented with three levels of leading indicators:

Level 1 - Compliance: The leading indicators at this level tend to provide answers to the question: 'is the organisation implementing its management systems and complying with its requirements as stated in legislation'? This level can be thought of as a compliance culture and is equivalent to levels 1 to 2 in the safety culture maturity model. With the focus on compliance, a leading safety indicator can be common for different O&G companies within a country. This is because the same legal and regulatory requirements apply across the O&G industry for that particular country. For example, the Offshore Petroleum and Greenhouse Gas Storage Act 2006 (Office of Legislative Drafting and Publishing, 2009) is widely used in Australia as the basis for effective safety management systems of O&G facilities. Once the system in place is compliant with legal requirements, new level 2 indicators should be introduced if leading safety indicators are to continue to assist the improvement process.

Level 2 - Improvement: The leading indicators at this level tend to monitor the effectiveness of the company's management systems by indicating areas of strength and weakness of defences and may require improvements. This level can be considered as an improvement culture and is equivalent to levels 2 to 3 in the safety culture maturity model. Level 2 indicators are based on the areas of potential weakness with the greatest potential for improvement. These are likely to be selected by the leadership team and applied on a company wide basis. These indicators may focus on the effectiveness of the implementation of the Occupational Health and Safety Management Systems (Standards Australia, 2001). However, at this level there may be divergence between the indicators used by different companies as their areas of weakness and improvements required may differ.

Level 3 - Learning: At this level, continuous learning and improvement is the norm for all parts of the organisation. This level requires the empowerment of the workforce to identify issues and select where and how improvements can be made. This level can be considered as a learning culture and is equivalent to levels 4 to 5 in the safety culture maturity model. As the organisation's cultural maturity develops further and there is more engagement of all parts of the organisation in the improvement process, the areas with greatest opportunity for improvement at this Level 3 are more likely to vary from one company to the next and perhaps between work sites and workgroups. Each business area is likely to identify its own improvement actions and develop local leading safety indicators commensurate with its need to monitor safety performance. In short, at this level, there would be greater divergence in the level 3 leading indicators among companies and perhaps within work groups.

A list of leading safety indicators that were mentioned in the O&G literature was linked to the safety maturity model establishing a relationship between safety culture and leading safety indicators as shown in Figure 2 (Bergh et al., 2014; Filho, Andrade, & Marinho, 2010; Hassan & Khan, 2012; ICMM, 2012; Øien, Utne, & Herrera, 2011; Reiman & Pietikäinen, 2012; Skogdalen et al., 2011; Step Change in Safety, 2003).

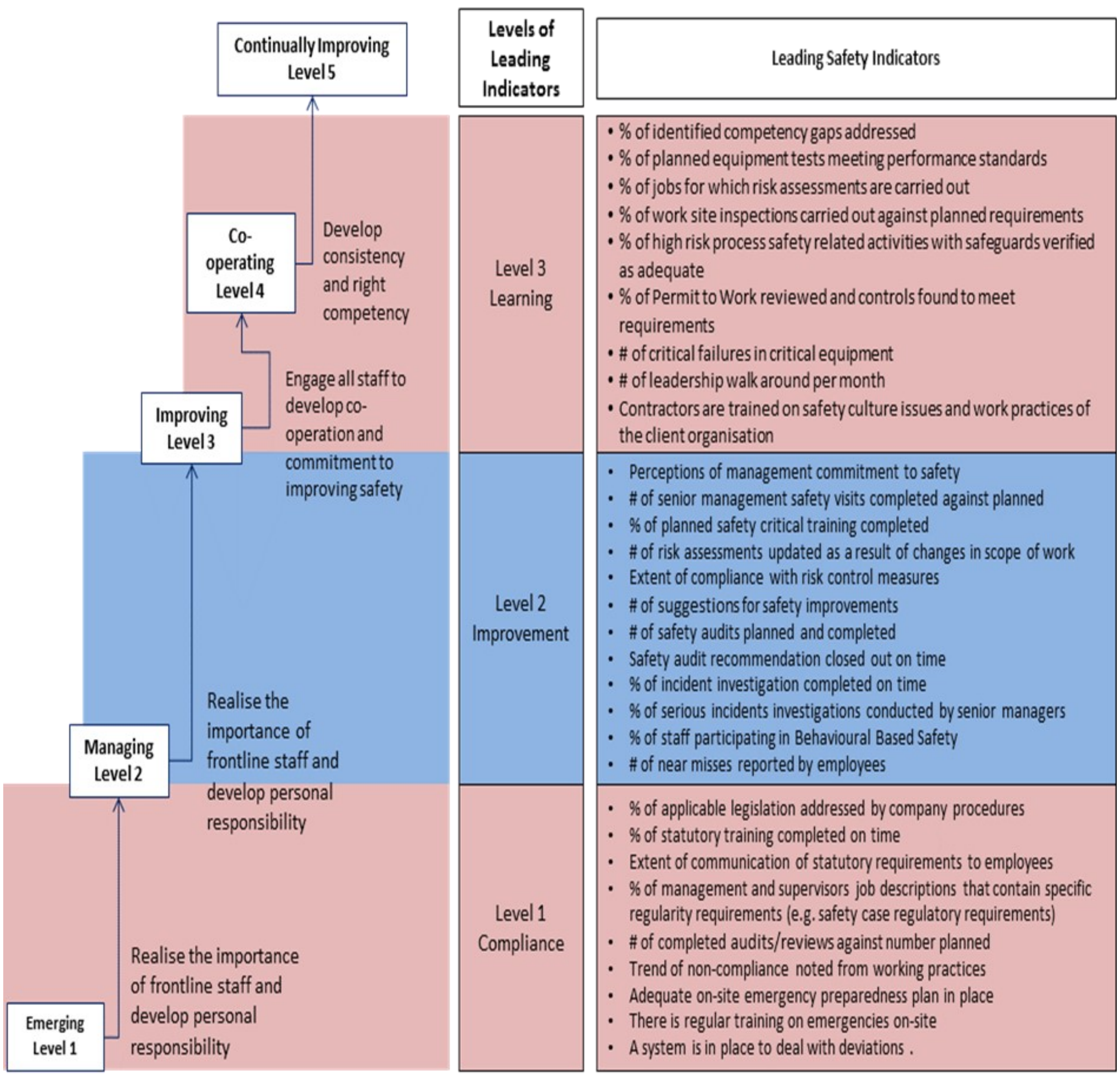

Figure 2: Examples of leading safety indicators linked to maturity levels

To conclude, Level 1 leading indicators are presumed to be less useful than Level 2 and 3 indicators. This is because Level 1 indicators are expressed as absolute e.g. either a company complies or does not comply with rules and regulations. However, at Level 2, as the safety culture takes root, the safety indicators peak and therefore their usefulness becomes less. At Level 3 indicators are fewer in nature but more concerned with strategic business issues that revolve around problem identification, continuous learning and responsiveness to emerging alerts and signals. The 74 day Montara oil and gas well leak and fire that occurred in the Timor Sea 200 km off the coast of Western Australia provides a case study example of where the use of leading indicators would have prevented a major accident from occurring as if the level one compliant indicator of a system in place to deal with deviation in Figure 2 and the level 3 leading indicators had been used the organisational, work process and equipment failures that were the cause of this accident would have been identified and appropriate risk control measures would have been implemented (Hunter, 2014).

Discussion

Introduction

This literature review was conducted with the aim of identifying the factors associated with a positive safety culture and safety climate, and examining the relationship between a safety culture and leading safety indicators in improving safety performance in the workplace. The findings related to each research objective are discussed below.

Elements of 'positive' safety culture

Developing a positive safety culture is a challenging task and without the data to guide the improvements it is easy to get lost (Biggs & Biggs, 2013; Burns, 2005; Cooper, 2002). When the phrase 'safety culture' was first introduced by IAEA, it referred to a very general matter implying that a good safety culture means assigning the highest priority to safety (INSAG, 1999). In an effort to explain the concept more completely, IAEA determined that a strong or positive safety culture is found in the association of three major factors: 1) a viable management system, 2) a widely shared awareness of hazards, and 3) widely shared behavioural norms and values. In contrast, a negative safety culture manifests itself in underdeveloped or inadequate management systems, with negative attitudes or disruptive informal social norms becoming predominant within an organisation (Verlini, nd). This explanation recognises that safety culture has two general components. The first is the necessary framework within an organisation and is the responsibility of the management hierarchy. The second is the attitude of staff at all levels in responding to and benefiting from the framework (Verlini, nd).

Despite the IAEAs best effort to define safety culture, ambiguity and confusion still surrounds the concept. Academics are divided on the issue, what it really means and how it can be achieved (Burns, 2005; Choudhry et al., 2007; Clarke, 2003; Flin et al., 2000; Guldenmund, 2000; Hopkins, 2006; Reason, 1997). Hopkins explains "for some writers, every organisation has a safety culture of some sort, which can be described as strong or weak, positive or negative. For other writers, only an organisation which has an over-riding commitment to safety can be said to have a safety culture. On this view, relatively few organisations have safety culture" (2006, p. 876). Sidney Dekker (2006, p. 171) put it more directly, "a safety culture is a culture that allows the boss to hear bad news".

Consistent with literature, elements of the safety culture, as reported in Table 1, can be categorised under one or more of the following themes:

- *Leadership commitment* – including visible management commitment to safety
- *Working practices and rules – A viable management system* for effectively controlling hazards
- *Two way communication* – including feedback loop
- *Employee involvement* – including realistic and flexible customs and practices for handling both well-defined and ill-defined hazards
- *Workforce attitudes* – safety performance depends on safe thinking and behavior
- *Compliance culture* – complying with all Occupational Health and Safety rules and legislation
- *Learning culture* – including continuous organisational learning through practices such as feedback systems, monitoring and analyzing
- *Just culture* – including trust between management and staff
- *Reporting culture* – including regularly reporting concerns about safety
- *Flexible culture* – decisions are made by the people best equipped to make them.

Distinction between safety culture and safety climate

One of the issues highlighted in the literature review was the lack of universal consensus regarding the terms safety culture and safety climate as both of these terms are often used interchangeably. Hopkins (2002, 2005) explains that part of the reason for this confusion is to do with language. He argues that the two terms have different linguistic consequences and as a result, the talk of safety climate and safety culture does not mean a climate or a culture favourable to safety.

Although many authors down play any significant distinction between safety 'culture' and safety 'climate' and often use the terms interchangeably, there is support in the literature to suggest that there are differences between the two terms. Safety culture and safety climate are two separate concepts each of which leads to a separate route. For example, Human Engineering (2005) argues that a safety culture is a characteristic of groups, not of individuals. In contrast safety climate identifies culture as an individual level issue. It sees climate as a matter of individual attitudes that are cultivated at work, but in the final analysis are characteristics of individuals, not the organisations to which they belong to.

The safety culture, on the other hand, refers to the commitment at all levels of an organisation to the creation of an effective safety management system in which safety is routinely practiced and improved as a matter of course within an organisation. It is therefore reasonable to suggest that the safety culture of an organisation is a long term objective and more to do with the creation of an effective safety management system and less to do with changing individual attitudes and behaviours.

In summary, it can be argued that safety culture of an organisation refers to the collective commitment at all levels to creation of an effective systems and rules and patterns of behaviours in which safety is valued, prioritised and routinely practiced and improved as a matter of course. Safety climate on the other hand, refers to psychological characteristics of employees i.e. how a person feels, corresponding to the value, attitude and perception of each individual (here and now) with regard to safety within an organisation.

The role of leading safety indicators in improving safety performance

A lack of effective leading indicators is probably the single biggest problem faced in occupational safety and health management today (Laitinen, Vuorinen, Simola, & Yrjänheikki, 2013). An important characteristic of leading indicators is the ability to guide actions to improve safety performance in the workplace.

Leading indicators can guide an organisation in prioritising risk areas with appropriate follow up measures and may be used as an exposure indicator for risk. For example, the results of a safety climate survey e.g. the Safety Climate Assessment Toolkit (see Cox & Cheyne, 2000) or an Offshore Safety Questionnaire (see Mearns et al., 1998) could serve as an exposure leading indicator for psychological risk in the workplace. The results from the exposure indicator are likely to motivate the appropriate people to take the necessary action should a relationship between psychological hazards and employee attitude be established.

Furthermore, throughout the literature, there is evidence to suggest that in the aftermath of most if not all catastrophic accidents, prior indicators, missed signals, and dismissed alerts were cited as prime causes of these incidents (Hopkins, 2006). Had the indicators been recognised and appropriately managed before the event accidents might have been averted. For example, the major findings of the BP Texas City refinery explosion in 2005 and Tesoro Anacortes refinery fire and explosion in 2010 was that both companies did not have in place effective process safety leading indicators (CSB, 2012; Gomez, 2012).

In summary, leading safety indicators have the potential to improve safety performance through the development of early warning signs, signals and alerts to motivate relevant people within an organisation to take action in a timely manner.

Relationship between leading safety indicators to safety culture

To progress towards a zero accident vision a new pathway is necessary to create a lasting change in safety culture. The International Council of Mining and Metals (ICMM) (2012) argues that leading indicators evolve through the life of an organisation depending on the organisation's level of maturity. The rationale for linking leading indicators to the maturity levels is that if an organisation attempts to implement a higher level leading indicator and it is not at the appropriate level of maturity, these measures may not be useful. Thus, as an organisation matures through the maturity ladder, leading safety indictors are likely to be refined to give accurate early warning signs and alert management of their potential outcomes.

It is also important to be mindful of the fact that no set of indicators remain relevant to an organisation indefinitely. Leading safety indicators are internally specific to a company as they are relevant to the prevailing level of maturity of that particular organisation or site at that given time. This particular point was one of the shortcomings of ANSI/API Recommended Practice (RP) 754 which was developed by CSB in 2010 that highlighted the need for and established obligations for the use of process safety indicators in the refinery and petrochemical industries (Gomez, 2012).

In short, leading indicators should be appropriate for each level of safety culture maturity levels of the relevant group or organisation. Being able to predict potentially emerging risk through leading safety indicators takes the 'luck' out of managing safety and keeps the organisation on path towards achieving a zero accident vision in the workplace. It is therefore imperative that the established leading indicators are reviewed and refined as the organisation matures through the safety culture maturity levels.

Unlike lagging indicators, leading indicators evolve throughout the life of an organisation, depending on the organisation's level of maturity. Biggs and Biggs (2013) argue that having consistent and reliable measures of safety performance is critical to the overall safety effort to quantify improvements gained in safety culture development. The challenge however is in correlating safety culture factors with leading safety indicators.

Recommendations and Conclusions

Recommendations

There are seven important recommendations drawn by the authors from this research:

- Building a safety culture is not enough to avert unwanted events. Supplementing the safety culture with a number of clear reliable leading safety indicators lend further support to the effort to achieve improved safety performance in the workplace.

- To enhance safety culture within an organisation, it is imperative to establish where in the safety maturity level the organisation sits and then establish a set of key measurable leading safety indicators to guide actions should a risk become apparent. A clear causal link between the established leading safety indicator and the outcome it is measuring must be established.

- In implementing a positive safety culture it is not necessary to effect personality change (e.g. employees' attitude). Rather, effort should be directed at what can be changed, e.g. working practices and rules, employee involvement and visible management commitment to safety.

- The definition of safety culture and safety climate should not be so important. The importance should be placed on identifying all the conditions or elements which play a role in safety and working on improving all of them individually or collectively.

- While the definition of safety culture and climate remain in dispute, safety climate could be used as an indicator of the overall safety culture.

- The classification of indicators as lagging or leading is not important. The importance is to capture information that can be acted upon to motivate relevant people within an organisation to take action in relation to enhancing occupational safety in a timely manner.

- The leading safety indicators compiled in Figure 2 are extracted from various qualitative and quantitative studies and are by no means exhaustive nor have they been validated. Therefore further research is required to establish validity, reliability and reproducibility of these indicators.

Conclusions

The authors consider that the safety culture of an organisation is widely believed to play an important part in improving safety performance within an organisation. However, pursuing a safety culture is not a straight forward process. There are obstacles to establishing and achieving a positive safety culture in the workplace. Competing business priorities, production and cost pressure, workload and time pressure and individual differences are just a few of these obstacles that are believed to negatively influence safety culture (Biggs & Biggs, 2013). The findings of this research contribute to advancing accident prevention knowledge and provide a tool to be used in the oil and gas industry by linking appropriate leading indicators for the oil and gas industry to the well-known safety culture maturity model (Figure 2) that can be used to improve the safety culture in this process industry.

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Workers Aged Twenty Years or Younger: Harassment of Young Workers in the Workforce

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Abstract

Young workers are often subjugated to workplace sexual harassment. Workplace sexual harassment can take on many forms and have numerous negative long-lasting repercussions on the victim. This article analyses the effects it can have on the victim and how Australian legislations deal with the problem.

Keywords

Young workers. Workplace. Sexual harassment. Effects. Legislation. Attitudes and perceptions.

Introduction

The Labour force in Australia is made up of both males and females. In the financial year of 2014-15, Australia had a participation rate of 64.9% this included workers aged 15 to 65 years of age (Australian Bureau of Statistics, 2015). Of that, the Labour force participation rate for young people was 67.5% for males and 66.3% for females (Australian Workforce and Productivity Agency, 2014). According to the Australian Bureau of Statistics, young workers are people aged 15 to 24 years old (Australian Workforce and Productivity Agency, 2014 & Australian Bureau of Statistics, 2013).

There is no age restriction for when children can commence paid employment in Tasmania, South Australia, Australian Capital Territory, Northern territory or in Tasmania to work. Once a person is 15 years old, they can work without a parent's permission (Fair Work Ombudsman, 2015).

In Western Australia, a person who is 15 years or older can work in paid employment with no restrictions. Below this age, employment restrictions are applied. Children less than 10 years old are not allowed to work in paid employment. With the permission of a parent, children aged 10 to 12 years are allowed to deliver newspapers or advertising material, but not during school hours. From 13 to 14 years, Western Australian children are also allowed to collect shopping trolleys and are allowed to work in a shop, as long as they have written permission from a parent, do not work during school hours and do not work before 6am or after 10pm (Department of Commerce, 2015). Young children can be particularly vulnerable to bullying or harassment as they may lack the maturity to defend their rights.

Harassment can come in many different forms. Types of harassments are: verbal, sexual, physical, personal and racial (Racial Discrimination Act 1975). This article will mainly focus on sexual harassment on young people in the workforce. Sexual harassment is a broad term, examples from previous case studies include: vulgar flirtatious comments, inappropriate touching and pinching, lewd gestures and explicit references to sexual acts (Kelly Pate Dwyer Denver Post, 2004 & Joyce, 2004).

Sexual harassment occurs in all industries, but of all the industries, sexual harassment of young workers most commonly occurs in the hospitality and retail industry (Kelly Pate Dwyer Denver Post, 2004 & Human Rights and Equal Opportunity Commission, 2003). The reason behind this is that these industries often have high turnover rates and low skill level requirements, hence making it relatively easy for young adults to start their first job in these industries (Von Bergen, 2005). In the United States of America, the hospitality industry is predominantly made up of young workers to the extent where they make up 44.6% of the industry (Von Bergen, 2005 & Kelly Pate Dwyer Denver Post, 2004) as compared to 18.4% in Australia (Australian Bureau of Statistics, 2012).

Methods

To investigate the topic of harassment of young workers in the workforce, a primary literature search was done. The two main journal databases that were used to search for literature was Curtin University's Proquest and Google Scholar. Other databases such as PubMed and Science Direct were used but no literature was used from them.

Using Proquest and Google Scholar, the initial keyword "harassment of workers" provided 247581 and 162000 results respectively. The number of provided literature was too high, thus the keyword "young" was added to the search. As a result, Proquest provided 102290 results. After gathering a number of articles from newspaper origin, the search was further refined by selecting articles of scholarly journal origin, of which only journals dated post 2000 were selected.

Another search on Google Scholar adding in the keyword "young" provided 106000 results. Of which only journals were selected. Interestingly, the majority of literature that provided sound information was from Proquest or referred back to the Proquest database.

To expand the literature search to include other forms of literature, the Fair Work Ombudsman, Fair Work Commission, Safe Work Australia and the Australian Bureau of Statistics were used to gather supporting literature and facts to further enhance the credibility of this literature review. Supporting legislation were also included. The Bureau of Labor Statistics was used to provide a comparison between Australia and the United States of America.

In total, 29 publications are included in this article. Included are 13 peer reviewed journal articles, 11 government publications, 2 newspaper articles, one fact sheet and 4 Laws.

Discussion

Why sexual harassment occurs among young people

Sexual harassment often and mostly occurs to young people for several reasons. The main reason for it occurring to young people is because it is easy to take advantage of young workers. Young workers, especially those straight out of high school or those whom have never had a job before lack the experience and as a result have nothing to fall back on. The majority of young people also lack information regarding their legal rights (Kelly Pate Dwyer Denver Post, 2004). Since young workers are new to the workplace, they are usually easily influenced (Von Bergen, 2005). Compounded with them being seen as the lowest rank in the workplace hierarchy. Young workers often feel intimidated and less likely to voice their opinions yet complain about their senior more experienced colleagues (Von Bergen, 2005 & Joyce, 2004).

Young workers due to their inexperience may not know what is acceptable or unacceptable behaviour regarding workplace practices (Kelly Pate Dwyer Denver Post, 2004). Very often, young workers do not recognize illegal and unacceptable harassments because these practices are often practiced in high schools and are not deemed sexual harassments. As a result, when these acts are committed to them in the workplaces, they do not recognize it as being illegal. For example: vulgar flirtatious comments (Kelly Pate Dwyer Denver Post, 2004). However, when young workers do recognize that sexual harassments has occurred onto them, they may weigh it against aspects of the job, such as networking and making new friends, staying on the manager's good books in a bid to gain more shifts, thus earning more money or keeping it to themselves so as to not appear as the new employee who frequently complains (Kelly Pate Dwyer Denver Post, 2004).

Another reason why sexual harassment frequently occurs to young workers is because older colleagues often take advantage of their mind set and mental maturity (Von Bergen, 2005). As people mature from adolescents to adulthood, they tend to question and challenge things around them and events that occur to them. However, when people are in their adolescent or young adult stage, they often do not challenge issues that oppose them. This issue is further exacerbated if young workers are trying to prove their independence and thus hide the sexual harassment in a bid to hold onto their newly fledge independence (Von Bergen, 2005).

A common problem young workers face in dealing with sexual harassment is that very often they do not know that they have the right to address the problem (Von Bergen, 2005). They commonly believe that due to them being the employee, the responsibility of addressing workplace sexual harassment lies with the manager and as a result, this increases their vulnerability to this problem (Von Bergen, 2005).
Psychologists and the Fair Work Ombudsman recommend that young workers understand the laws relating to workplace sexual harassment and their rights so as to better equip themselves to combat the problem (Joyce, 2004 & Fair Work Ombudsman, 2015).

Workplace sexual harassment happens particularly in the hospitality and retail industry. Aside from the high turn over rates and low skill level requirements, supervisors and managers in these two industries are often of similar age as the young workers being sexually harassed and are either not adequately trained or lack the experience to handle sexual harassment cases (Kelly Pate Dwyer Denver Post, 2004 & Von Bergen, 2005). In certain cases, workplace managers are the perpetrators. Examples range from inappropriate touching to sexually reprimanding and criticizing workers in public (Kelly Pate Dwyer Denver Post, 2004 & Kellner, McDonald & Waterhouse, 2011).

Effects of sexual harassment on victims

It is widely known that workplace sexual harassment affects the individual victim, however, sexual harassment also affects the family members, close friends and the inner circle of people surrounding the victim and those the victim confides to (Marican & Rahman, 2012).

Workplace sexual harassment causes calamitous short-term immediate effects and devastating long-term psychological effects (Marican & Rahman, 2012). As a result, this article will categorise the consequences into short-term and long-term effects. After the event occurs, victims often experience emotional distress (Kelly Pate Dwyer Denver Post, 2004) such as feeling embarrassed, alone or helpless (Von Bergen, 2005). Victims of workplace sexual harassment could also suffer from increased anxiety and fear. When a person experiences fear, the body reacts with either a flight response or a fight response (Suresh, Latha, Nair & Radhika, 2014). If the victim experiences a fight response rather than a flight response, the victim may encounter anger issues, such as having sudden bursts of anger or frustration for no particular reason or for problems which may be easily solved (Suresh et al. 2014). If the victim however reacts with a flight response, the victim many encounter various negative psychological problems associated with increased anxiety. The victim may experience panic attacks if the memory of the sexual harassment reoccurs or phobias of the environment where the event occurred. In the case of workplace sexual harassment, the victim may develop a phobia of the workplace or specific location where the incident took place (Signs and Symptoms, 2015 & Marican & Rahman, 2012). This in turn could cause the victim to develop workplace problems, which may ultimately result in the victim relocating to a different department or a completely different workplace (Malik, Malik, Qureshi & Atta, 2014).

If the victim chooses to remain in the same workplace where the incident occurred, they may experience a drop in overall confidence (Marican & Rahman, 2012). A fall in self-esteem often alters the outlook of a person to become negative. This in turn causes the victim to experience secondary effects such as increase self blame, weight loss and a decline in general physical and mental health (Malik et al. 2014).

Both outcomes are detrimental to the victim as it ultimately causes the person to have a negative change in personality.

The short-term effects mentioned above, combine with one another to cause the victim of workplace sexual harassment to suffer from long-term effects. In the workplace, these often relate to a fall in job efficiency and a rise in absenteeism (Sierra, Compton & Frias-Gutierrez, 2008). This then leads to increased employee stress, causing the surrounding employees to also become demoralized as they now have to deal with the counterproductive attitude and behaviour of the affected employee (Sierra et al. 2008 & Marican & Rahman, 2012). Overall, this negative downward spiral leads to a fall in workplace productivity (Sierra et al. 2008).

A study carried out by the United States armed forces found that young men who were sexually harassed in the workplace suffered psychological effects such as difficulty in mental maturity and family withdrawal (Sierra et al. 2008 & Langout, Bergman, Cortina, Fitzgerald, Drasgow & Williams, 2005). In the case of young workers who were students, sexual harassment often lead to emotional trauma, depression and anger management leading to counseling and a drop in their overall academic grades (Boles, 2015).

With all these examples on the effects of workplace sexual harassment, why do some victims, mostly women not report the incident? The reason for this is due to fear, embarrassment and uncertainty of their current employment (Marican & Rahman, 2012). Victims often weigh up the costs of reporting the incident. Often they are afraid that reporting the incident could jeopardise their career opportunities and advancement. This is especially so if the perpetrator is their manager or supervisor (Marican & Rahman, 2012).

Attitudes and perceptions of workers to sexual harassment

Recent studies have shown that women were more prone to becoming upset at events perceived to be sexual harassment as compared to men (Sears, Intrieri & Papini, 2011). This is especially so if the women is a young; under the age of 24 years old. (McCabe & Hardman, 2005 & Australian Human Rights Commission, 2012).

When comparing the attitudes and perceptions of sexual harassment between blue and white collared workers, it was shown that blue-collar workers experienced more workplace sexual harassment, were more tolerant towards it and perceived less behaviours as sexual harassment as compared to white-collared workers (McCabe & Hardman, 2005). However, both groups agreed and notably perceived more behaviours as sexual harassment if the victim was a female and the perpetrator was a male. Conversely, if the perpetrator was a female and the victim was a male, it was perceived that fewer actions were sexual harassment (McCabe & Hardman, 2005).

It is also recognised that there is a relationship between professions and gender ratio for female complaints in traditional male occupations (Maeder, Wiener & Winter, 2007). Women whose professions are in traditional male employment reveal and report greater workplace sexual harassments than women who are employed in traditional occupations. A known example occupation is tradeswoman (Maeder et al. 2007). Similarly, men who are employed in traditional women occupations such as administrative or service employees report greater rates of sexual harassments as compared to if they were employed in traditional male dominated jobs (Maeder et al. 2007).

Research has also shown a link between type of employment of the perceiver and the perception of sexual harassment. Men in traditional women dominated professions were the least likely to perceive sexual harassments followed by men in neutral occupations then men in traditional male dominated professions (Maeder et al. 2007).

However, workplace sexual harassment is still widely viewed as behaviour targeted to females by males (Kellner et al. 2011).

With all the research being done into workplace sexual harassments, a current gap still exists. The problem with most publications that report workplace sexual harassment is that they do not define or mention mild or moderate cases. Examples include: whistling, starring or repeated requests for going on dates with the opposite sex. Most publications focus on the extreme and severe cases, example: molestation or inappropriate lewd gestures (Maeder et al. 2007).

Workplace sexual harassment and OSH laws

Under Australian laws, workplace sexual harassment is deemed illegal and various Acts set out to address the problem. Acts mentioned in this article are grouped into Federal and State Acts. The Fair Work Australia Act 2009 is an example of a Federal Act. Under this Act, there are two governing bodies; the Fair Work Commission and the Fair Work Ombudsman (Fair Work Act 2009). The Fair Work Commission is Australia's national workplace tribunal and deals with disputes and bullying in relation to the Fair Work Act (Fair Work Commission, 2015). Bullying is defined as the repeated less favourable treatment of a person by others in the workplace that is considered unreasonable and inappropriate. As a result, workplace sexual harassment can be included in this definition set out by the Act. The Fair Work Ombudsman is tasked with investigating practices that oppose the Act (Fair Work Ombudsman, 2015). In the case of workplace sexual harassment, the victim would contact the Fair Work Ombudsman for investigation and if the matter cannot be resolved by conciliation, the matter would be brought before the Fair Work Commission for a tribunal hearing (Fair Work Commission, 2015 & Fair Work Ombudsman, 2015).

The Australian Human Rights Commission Act 1986 is another Federal Act that deals with workplace sexual harassment. The main method of problem solving is through conciliation (Australian Human Rights and Commission Act 1986). Workplace sexual harassment is covered under this Act by the definition of unlawful discrimination. Unlawful discrimination is defined as when someone or a group is treated less favourably than another person or group based on prejudice (Australian Human Rights and Commission Act 1986).

In Western Australia, the only Act regulating workplace sexual harassment is the Occupational Health and Safety Act 1984. This Act only applies to Western Australia because the State along with Victoria has not implemented the Model Work Health and Safety Act developed through Safe Work Australia with the other Commonwealth States and Territories for the National Work Health and Safety Act 2011; Harmonisation program (Safe Work Australia, 2011). Section 19, 20 and 26 of the Occupational Health and Safety Act 1984 relate to workplace sexual harassment. Section 19 states that an employer shall so far as reasonably practicable provide a workplace that is free of hazards (Occupational Safety and Health Act s.19). Section 20 states that an employee shall take reasonable care to ensure his or her own workplace safety, and circumvent the safety of others through any actions or omissions (Occupational Safety and Health Act s.20). The above two sections relate to workplace sexual harassment. Section 26 states that an employee may refuse to work where he or she has reasonable grounds to believe that continuing to work would expose him or her to imminent or serious harm to their health and safety (Occupational Safety and Health Act s.26). Breaches to section 19, 20 and 26 of the Act will result in charges of negligence and may result in legal criminal prosecutions (Occupational Safety and Health Act s.19A, s.20A & s.28A).

Conclusion

When workplace sexual harassment occurs, the victim often suffers from immediate short-term effects and experiences long-term consequential ramifications. Due to an increase in studying and understanding workplace sexual harassment over the past decades, it is now better understood how to combat the problem and thus the government has enacted various Acts as prevention measures. In certain Acts governing workplace sexual harassment, the onus is on the employer to ensure safe working environments and practices. However, this becomes difficult when the employers are the perpetrators. Workplace sexual harassment is not a new matter, this problem has been encountered for a long period of time. The practice needs to be eradicated to ensure the range of psychological and physical effects mentioned above do not hinder both individuals and the company. Nonetheless, researchers still need to address the common gaps in knowledge that many publications miss in order to effectively combat this heinous societal problem.

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Railway Developments and Safety in the MENA Region: A Selection

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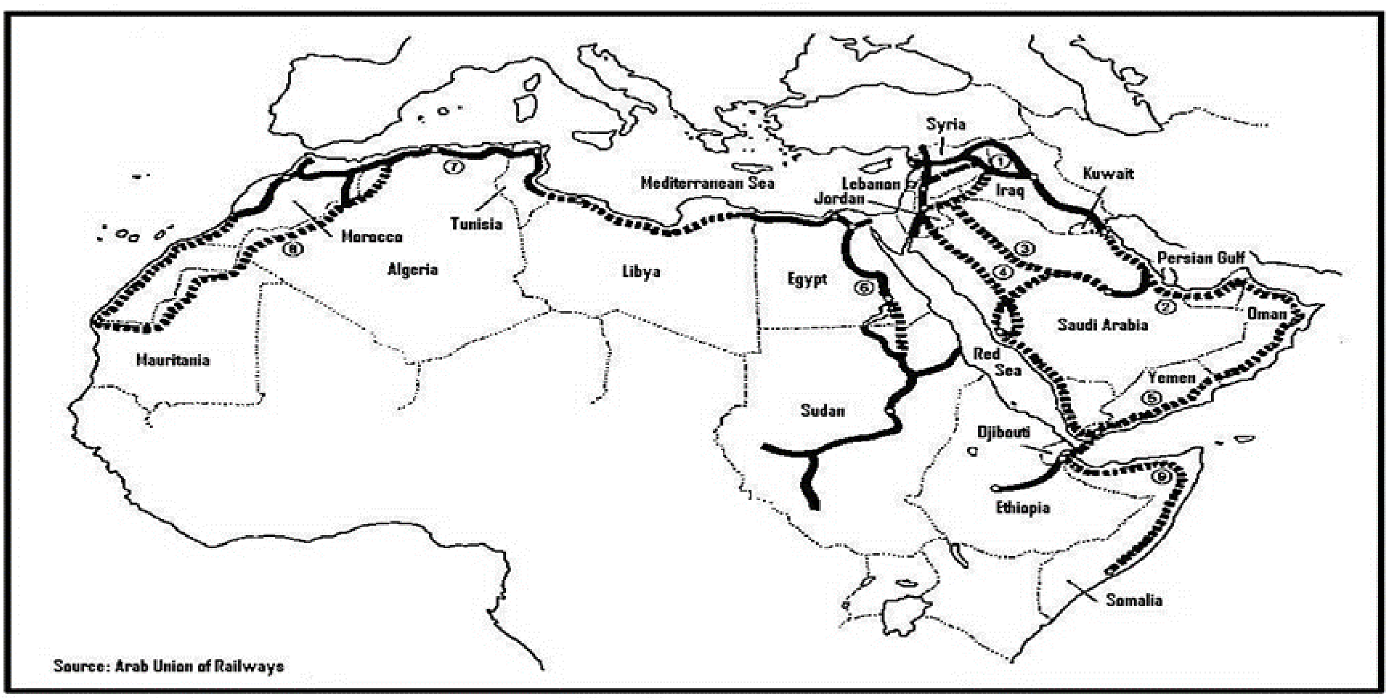
Abstract

In the Arabic-speaking MENA (Middle East and North Africa) region (Syria, Iraq, Lebanon, Jordan, the Palestine Territories, Saudi Arabia, Kuwait, Qatar, Bahrain, the United Arab Emirates (UAE), Oman, Yemen, Mauritania, Morocco, Algeria, Tunisia, Libya, Egypt, Sudan, Djibouti, Somalia, and the Comoros Islands), railway development projects are planned or underway, which make the region one of the fastest growing railway markets in the world. This article looks at a selection of railway developments in this region.

Railways in the MENA Region: A Concise History

The Arab-speaking MENA region, which comprises Syria, Iraq, Lebanon, Jordan, the Palestine Territories, Saudi Arabia, Kuwait, Qatar, Bahrain, the United Arab Emirates (UAE), Oman, Yemen, Mauritania, Morocco, Algeria, Tunisia, Libya, Egypt, Sudan, Djibouti, Somalia, and the Comoros Islands (see Map), covers an area of about 13.5 million km² and has a population of more than 300 million that share a broadly common culture, society and written language [Sabouni, 1997]. The first railway line in the MENA region was opened in Egypt, between Alexandria and Kafar Zayyat, in 1854 [Sabouni, 1997]. Subsequently, railway lines were built in other countries of the region among which, in the early 1900s, the important Hedjaz Railway axis, linking Medina in Saudi Arabia, via Amman in Jordan, with Damascus in Syria. At the moment, there are railway lines in 11 countries of the MENA region (Syria, Iraq, Lebanon (not functioning at the moment), Jordan, Saudi Arabia, Sudan, Egypt, Tunisia, Algeria, Morocco and Mauritania) with a length totalling less than 30,000 km. Existing railways (solid lines) and proposed rail links by the Arab Union of Railways (dashed lines) in MENA region are shown in Figure 1.

Figure 1. Existing railways (solid lines) and proposed rail links (dashed lines)
[Choueiri, 2010a; Choueiri, 2010b]



As the railway lines in the MENA region were mainly built during the colonial period to serve military and strategic purposes, and as distribution routes for products from the industries of the various colonising nations, they have different characteristics, depending on which country constructed them. For instance:

- the railway lines in the Middle East, which were originally built to serve the ruling powers of former times, i.e. the Ottoman Turks, the French and the British, are characterised by [Choueiri, 2010a]:
  - being limited in length and different with respect to track gauge, not only between neighbouring countries but also within the countries themselves;
  - serving national goals, in terms of their network layout;
  - allowing only low axle loads and design speeds;
  - accounting for only a small share of freight and passenger traffic volumes carried, as compared to other modes of transport.

Further, the railway lines in the Middle East, e.g. Syria, Lebanon, Jordan, Iraq and Saudi Arabia, have different technical characteristics, e.g. track gauge, rail weight, permissible axle loads, design speeds, depending, as noted earlier, on which country constructed them;

- the railway lines in North Africa are characterised by the fact that [Choueiri, 2010b]:
  - in a number of countries, they only serve a limited area. For instance, in Mauritania, there is only one railway line that runs from Zouwayrat, via Fderik, to Nouadhibou, which mainly serves the transport of iron ore from the mines at Zouwayrat to the port of Nouadhibou. In Morocco, Algeria and Tunisia, the railway lines mainly serve the areas located along the coast;
  - there is no railway line linking all the countries. For instance, the railway line in Mauritania is not linked to the railway network of Morocco. And the railway networks of Morocco, Algeria and Tunisia, which are linked to each other, are not linked to that of Egypt as there are no railway lines in Libya. Also, there is no rail link between Egypt and Sudan.

Also, the majority of railway lines in the MENA region feature single track and a very low traffic density, as compared to that in developed countries. In addition, the design speeds, maximum axle loads and loading gauges vary from country to country. Also, although the majority of the railway lines feature standard-gauge track, there are also other track gauges: e.g. 1,000 mm in Tunisia, Algeria and Iraq, 1,050 mm in Syria, Jordan and Lebanon, 1,055 mm in Algeria, and 1,067 mm in Sudan. This diversity of track gauges has rendered through traffic difficult, and even traffic between two adjoining countries in the region. Thus, there are no real rail links between the majority of the 11 countries of the MENA region that currently have railway lines (Syria, Iraq, Lebanon (not functioning at the moment), Jordan, Saudi Arabia, Sudan, Egypt, Tunisia, Algeria, Morocco and Mauritania). For instance, Saudi Arabia has two internal main routes in the eastern part of the country. Jordan has a railway line that runs to Damascus in Syria which, however, is not compatible due to the difference in track gauge. Even though Lebanon has railway links with Syria, there are no train services at the moment. In the case of Egypt, there is a rail link that runs to the border with Sudan, but a difference in track gauge makes crossing the border rather difficult. A connection with Libya was under construction, while rail links to Israel and the Palestine Territories are defunct [Choueiri, 2010a; Choueiri, 2010b].

Thus, generally speaking, most of the railways in the MENA region still operate at the standard to which they were originally constructed, and although some limited small-scale upgrading has occurred, the railway lines mostly carry low-axle load and low-speed traffic, and are largely under-capitalised, making them ill-suited to meet modern requirements. Also, in the century since sections of the Hedjaz Railway from Damascus to Medina were damaged during World War I, hardly any rail development has taken place in the region, because cheap fuel prices ensured that cars and trucks remained the favoured mode for passenger and freight transport and, thus, rail is the region's least developed mode of transport, with passenger and freight transport mostly being conducted by the road, air or sea mode of transport. For rail to play a significant role in passenger and freight transport in the region it should offer a high level of service, improved travel and transit times, reliability, security, as well as a good frequency of train services. Also, the railway infrastructure and rolling stock should be in a good state of repair.

However, there are signs that changes are taking place in the region, as many countries are now undertaking or planning large-scale railway development projects and, thus, railway development in the MENA region is now gaining ground, at least in Gulf Cooperation Council (GCC) countries.

Railway Development in the MENA Region is Gaining Ground

Generally speaking, the transportation sector in the MENA region is central to accelerating economic development through export led growth, creating jobs, and reducing vulnerability and exclusion, which could also benefit railway development in the region and vice versa. The most important factor is the region's strategy and commitment to becoming the next global transportation hub. The rationale behind this is the geographical position of the region, as it lies at the central point on the routes between Europe and Africa on one hand, and between Europe and Asia/Australia on the other. Furthermore, a big proportion of the world's population, including that of countries like India, is within close reach of the region. Riding on this natural geographical advantage, governments in the region have supported the development of the transportation sector by improving the regulatory frameworks, building infrastructure, and giving various incentives to market players. Another factor is the region's economic fundamentals and demographics, which represent a strong potential for transport companies within the region itself. Rising consumption creates demand for increased movement of goods, and thus freight transport within the region. At the same time, demand for passenger travel is expected to grow, as more people would be able to afford it. Thus, the development of the transportation sector not only depends on demand from outside the region, but also on demand from within the region. This is where development of the rail mode of transport is coming into being.

Railway development projects: a selection

In the MENA region, rail has now become a main focal point for the development of transportation infrastructure. Currently, a number of major railway projects are planned or under construction in this region, and which, once completed, should see a reduction in freight delivery times and road congestion, as well as a transformation of economic development and trade in the region [Feuilherade, 2013a].

Among the pan-regional railway development projects being considered, are two large-scale ones, i.e.:

- *a trans-Arab railway network:* the idea of the trans-Arab railway dates back to 1979, when a body to assess its viability was created. In 1992, two possible routes were suggested, i.e. one from Syria, via Jordan down to Saudi Arabia; and the other from Egypt across North Africa to Mauritania, see Figure 1. When accomplished, the network could be a practical alternative to short- and medium-haul freight and passenger flights. However, the project has still not progressed any further [“Trans-Arab railway,” 2009];
- *a GCC railway network:* this rail link, which will connect Saudi Arabia, Kuwait, Bahrain, Qatar, the United Arab Emirates and, eventually, Oman, was on the agenda of the six-nation Gulf Cooperation Council (GCC) summit that was held in December 2009 [Salama, 2013; “Gulf States to Set Up …,” 2013]. One of the major components of the project would be a 1,300 km railway line from the Saudi-Abu Dhabi border to Ras Al-Khaimah and Fujairah in Abu Dhabi. This project, designed to connect all the GCC member states, is in a more advanced stage of development. The network would stretch from Kuwait in the north to Oman in the south, see Figure 2 [“GCC Rail Projects …,” 2011

Figure 2. Existing railways (solid lines) and proposed rail links (dashed lines) [“GCC Rail Projects …,” 2011]

Value of railway projects in GCC is given in Table 1, see below [“GCC Rail Projects …,” 2011; “Qatar, Saudi Lead …,” 2011].

Table 1. Value of railway projects in GCC

States	Number of projects	Projects value (US$)	% of GCC projects by value
Saudi Arabia	23	25.6 billion	24%
Qatar	1	25 billion	23%
UAE	8	20.6 billion	20%
Kuwait	2	17 billion	16%
Oman	1	10 billion	9%
Bahrain	1	8 billion	8%
Total	36	106.2 billion	100%

It is scheduled that the route of the GCC train project starts from Kuwait via Dammam in the Kingdom of Saudi Arabia to the Kingdom of Bahrain through the proposed land bridge to be built parallel to the King Fahd land bridge, and from Dammam to the State of Qatar through Salwa. The GCC train would also link Qatar with Bahrain via the Qatar – Bahrain land bridge to be established between them, and from Saudi Arabia through Al Batha to the United Arab Emirates (Abu Dhabi - Al Ain) and then to end up in Oman across Sohar to Muscat. The total project length is approximately 2117 km, and the length of the track inside the Kingdom of Saudi Arabia totalling 663 km, see Table 2 [Saudi Railways Organization, 2014].

Table 2. Total length of the railway line in GCC in KM [Saudi Railways Organization, 2014]

States	The total length of the railway line in KM
Kuwait	145
Bahrain	36
Qatar	283
Oman	306
United Arab Emirates	684
Saudi Arabia	663
Total	**2117**

Table 3 shows the level of transport imported by all modes of transportation in the years 2004-2006, compared with the expected to be only transferred by train in 2016 [Saudi Railways Organization, 2014]. The achievement of these expectations will add to the basket of the Gulf incomes what is estimated of 400 million dollars as a result of the transfer of goods imported and exported via the train.

Table 3. Level of transport imported by all modes of transportation [Saudi Railways Organization, 2014]

States	Transfer rate for the period (2004-2006) by means of current transportation	Expected by train only in 2016
Kuwait	16.3	7.5
Bahrain	5.1	6.7
Qatar	6.6	4.3
Oman	1.8	2.8
United Arab Emirates	3.7	7.1
Saudi Arabia	3.9	1.6
Other Arab states	2.6	1
Total	**40**	**31.1**

Table 4 shows a comparison between the forecast of passenger transport by different means of transportation [Saudi Railways Organization, 2014].

Table 4. Passenger transport before and after Gulf railway network [Saudi Railways Organization, 2014]

***Unit**: one thousand passengers*

	Train	Car	Bus	Airplane	Total
Before the Operation of Gulf railway network	0	28.820	1.106	13.034	42.960
In the beginning of the Operation of Gulf railway network	3.308	27.425	989	11.670	43.392

Apart from pan-regional railway development projects being considered, countries in the region are individually undertaking various railway development initiatives. For instance:

- ***Saudi Arabia**,* where plans exist to spend billions of US dollars towards increasing its railway network by almost five times. Within the framework of the 30-year Saudi Railway Master Plan (2010-2040), a number of projects have been conceived, in order to provide vital rail links between different parts of the country, including the holy city of Mecca, embracing both passenger and freight transport. The Master Plan includes the Land Bridge project between Jeddah and Riyadh, and the Haramain High-Speed Rail Project that is to link Jeddah with Medina and Mecca. The 450 km long high-speed railway line, which is set to open in late 2014 or early 2015 and on which 35 electric high-speed trains will be operated at 300 km/h, would serve pilgrims travelling to the Holy Cities of Medina and Mecca, as well as people travelling to the new financial area, King Abdullah Economic City, in Jeddah, see Figure 3 [Feuilherade, 2013a].

Figure 3. Existing railways (solid lines) and proposed rail links (dashed lines) [Feuilherade, 2013a]

- ***Iraq**,* where the government is backing a 650 km long high-speed line between Baghdad and Basra, that would run via Karbala, Najaf, Moussayeb and Samawah and allow passenger train operation at speeds up to 250 km/h; Construction was envisaged over a 4-5 year period [Moore & Clarke, 2013].
- ***Jordan**,* where plans are in place to develop the National Rail Network in order to integrate it with other rail networks of neighbouring countries for efficient transport of passengers and freight throughout the region. The backbone of the project would be the construction of a 509 km north-south corridor, linking the Syrian Border to the Port of Aqaba, which was expected to be completed in 2017. Other phases of the project would see the development of links with Saudi Arabia and Iraq, providing assistance with the redevelopment of Iraq. The project would ultimately facilitate the linking of Turkey and Europe on the one hand and the countries of the Gulf Co-operation Council (GCC) on the other, to build a completely integrated transport network [Union for the Mediterranean, 2014].
- ***Morocco**,* where the construction of a 350 km high-speed railway line between Tangier and Casablanca, in partnership with France, is regarded as Morocco's most important transport project. The first project under this strategy consists of a dual-track line stretching along the Atlantic coast from Casablanca to the capital of Rabat, the growing industrial town of Kénitra, and on to Tangiers. The train will be built for a maximum capability of 350 km per hour, and operated in its initial stage at 320 km per hour. The potential economic benefits are considerable. The high-speed railway will reduce travel time between Casablanca and Tangiers, the country's top two industrial hubs, from nearly five hours to two hours and 10 minutes; travel between Tangiers and Rabat will be reduced to just 1.5 hours. Work was launched in 2010 on the first segment of this line, a 200-km stretch between Tangiers and Kénitra, which is slated to begin operation in 2016. Once fully operational, the high-speed railway will increase passenger traffic on this line from 2m to 8m people per year [Oxford Business Group, 2014].
- ***Algeria**,* where the government plans to modernize the network and electrify existing rail operations, as well as develop a 1,300km high speed east-west line that will run from Tunisia to Morocco, with branches connecting with major ports and cities. It should be noted that the rail network in Algeria is currently concentrated in the north of the country and comprises 3,660 km of standard gauge and 1,140 of narrow gauge [Feuilherade, 2013b].
- ***Tunisia**,* where construction of the first two lines of a high-speed railway network, valued at some USD 187 million, is scheduled to start mid-2014 and expected to be completed in 2018 [Feuilherade, 2013b].
- ***Libya**,* where the wait is on to see what will happen to the projects, i.e. the construction of more than 2,000 km of new railway lines, valued at some USD 12 billion, that were planned and have been stalled due to the political changes that took place in this country [Feuilherade, 2013b].
- ***Egypt**,* where, due to a mounting economic crisis, it is difficult to see how a proposed high-speed railway project, costing an estimated USD 3.5 billion, would attract either local or foreign investors. However, the European Union has allocated US$ 160 million towards the development of the transport sector, one third of which will fund construction of the third phase of the Cairo Metro. Grants totalling US$ 250 million from Kuwait and the Arab Fund for Eco-

nomic and Social Development will support electronic signalling projects on the Banha-Zagazig line north of Cairo. However, the railways in Egypt could do with further modernisation of its rolling stock and signalling systems [Feuilherade, 2013b].

Railway projects in cities: a selection

Besides the country or region-wide railway development projects that are planned or underway, there are also railway development projects in a number of cities in the MENA region, where private vehicles are currently the most preferred mode of land transport with, in some cases, car ownership being as high as in developed countries, resulting in a high level of traffic congestion, pollution and road fatality cases. Governments recognise that this is a problem and, therefore, also in cities, public transport is being encouraged through increased awareness and efforts to develop railways, public buses, and taxi corporations.

In some cities of the GCC countries, light rail transit and metro projects are planned or underway. For instance, in the UAE, where in Dubai a brand-new metro system was opened in September 2009 [Planetizen, 2009], a large-scale metro system is planned for Abu Dhabi [Latham & Watkins, 2013]. Also in Riyadh, the capital of Saudi Arabia, a 176 km six-line automated metro network is going to be built, which is scheduled to be completed in 2018 ["Riyadh Metro Construction …," 2013].

If all of the metropolitan railway projects currently planned go ahead, then by 2030, almost every major city in the GCC member states will have some form of metro or light rail transit network. Once completed, not only road congestion problems would benefit, but it would also benefit the macro-economic perspective, boost economic growth, diversify economies, boost inter-regional trade and enhance the possibility of major GCC cities of becoming international trade hubs. Although the extensive railroad developments have many benefits, there is still a need to improve road safety practices at level crossings.

Dangerous Road-User Behaviour at Level Crossings

The level crossing is the location where the railway line intersects the roadway and, thus, it is here where the train is confronted by users of other modes of transport, be it pedestrians, cyclists, motorbike riders, car and truck drivers, etc., each with their own form of, often unpredictable, traffic behaviour. It is here where the risk lies – when a train travels from A to B it has the right of way on its route. However, at level crossings, the behaviour of individual road users determines whether or not this right of way is impeded and, thus the safety at these locations.

Road users vary greatly in their traffic behaviour and also in their understanding of traffic safety issues. There is an increase in the number of people that partake in road traffic whilst under the influence of substances that impair traffic safety judgment, e.g. alcohol, drugs, medicines, etc. However, even without being under the influence of these substances, their traffic behaviour can show signs of irresponsibility when, at level crossings, they take enormous risks in erratically trying to get across whilst the train is already approaching.

- Warning signals at level crossings are in place for a reason – to warn people that a train is approaching and that one should exercise caution. However, many people seem to think that it is a starting signal to act irresponsibly, and to try and beat the train to who will be first to pass the level death, and then the person's body is not going anywhere at all, except to its last resting place.

If not ending in death, the accidents may result in severe injuries, both physical and psychological, with people often maimed for life. The psychological impact on all those involved is large, as the accidents do not affect only the person trespassing and the people on-board the train – not in the least the train driver, but also their loved ones. Train braking distance is related to the operating speed and weight of the train. However, whatever speed the train travels at, braking to avoid sudden "objects" on the track is hard for the train driver. He has to think on his feet and act quickly, in order to try and avert the worst. There is also a financial impact, as there is a cost burden on the healthcare system, as well as the fact that resulting traffic hindrances have their inherent costs. All this for the sake of people not wanting to wait for a few minutes at the level crossing – the possible consequences far outweigh the timesaving the trespasser thinks of making.

Today, there are various organisations that draw attention to safety awareness at level crossings. Since 2009, there has even been an annual "International Level Crossing Awareness Day (ILCAD)", which indicates that the importance of safety at level crossings is an issue that is not to be underestimated.

International Level Crossing Awareness Day (ILCAD)

On 3 June 2014, the 6th edition of ILCAD was launched in Lisbon, Portugal, under the auspices of the International Union of Railways (UIC) and REFER, the Portuguese rail infrastructure manager. On this day, using educational material and other activities, attention was drawn worldwide to safety awareness issues surrounding level crossings, as well as to the need for a change in road-user behaviour.

In a press release issued by UIC to mark ILCAD [UIC, 2014], UIC estimates that there are more than 600,000 level crossings around the world, and notes that, since 2009, it has coordinated the ILCAD initiative with support from organisations such as the Community of European Railway and Infrastructure Managers (CER), the European Rail Infrastructure Managers (EIM), the European Transport Safety Council (ETCS) and Operation Lifesaver.

The press release also presents some statistics from the "Safety Performance Report 2014", compiled by the European Railway Agency (ERA), which show that in 2012:

- there were some 114,000 level crossings in the European Union (EU);
- on average, each day, one person got killed and almost one person got seriously injured at level crossings in the EU;
- there were 573 serious accidents at level crossings in the EU, which resulted in 369 fatalities and 339 serious injuries;
- the number of fatalities represented 29% of all accidental deaths concerning railways, as against 1% of road fatalities – what may be considered a minor problem for the road sector, is a huge problem for the railway sector.

The press release then continues to note that:

- almost all accidents that take place at level crossings (at least in Europe) are caused by errors or deliberate misbehaviour by road users, including pedestrians, who do not respect traffic signs and signals, and that these people often live and work near level crossings;

crossing. Their lack of judgment and their irresponsible traffic behaviour often ends in collisions at level crossings can result in derailments, death or serious injury to railway staff and train passengers, and post-traumatic stress, as well as long, costly and awkward delays for both road and rail users, and expensive damage to the infrastructure and rolling stock;

- a train travelling at 90 km/h takes up to 1,200 m to stop, depending on the weight of the train, whilst a car travelling at 100 km/h takes up to 80 m to stop;
- a train can weigh between 130 to 6,000 t, depending on the type of train and the country in which it is operated (in comparison, in Europe, the average weight of a car is 1 t);
- using a level crossing is safe as long as users respect the Highway Code and traffic signals that are in effect.

The above, in essence, sums up why it is so very important to continue to draw attention to the issue of safety awareness at level crossings, and that it is important that the road and railway sector work together on this issue, as it affects them both. That there is one day a year on which, worldwide, one stands still at the issue of safety awareness at level crossings is, of course, great, but it would be far better if people stood still at level crossings **every** single day of the year!

CONCLUSIONS

After decades of more or less a standstill and the railway mode of transport in the region having been faced with fierce competition from other modes of transport, with passenger and freight transport mostly being conducted by the road, air or sea mode of transport, railway development has now come alive again in the MENA region. Governments in Arabic-speaking countries in the Middle East and North Africa are becoming increasingly aware of the importance of designing and building sustainable railway networks in the region. Although, at times, plans have to be put on a low burner as occurrences make it difficult to progress, the vision is there to establish railway lines in the region which, once completed, could provide efficient passenger and freight transport routes in the region, making the region again the middle ground between Asia, Europe and Africa, which could benefit trade and economic growth in the region. As all of these impressive developments occur, it is important to include safety in the design stage of rail transport and to educate road users on the importance of safety awareness at level crossings.

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Safety Culture to Gain Commitment for Good Occupational Health and Safety in the Workplace

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Abstract

Safety culture is the overall values, attitudes and behavior of an organisation and can be a difficult challenge to influence and change in a workplace. Although the Occupational Safety and Health Act 1984 contains occupational provisions, appropriate policies and procedures need to be implemented and followed in each workplace to shift safety culture in a positive manner. This article reviews published literature associated with factors that influence safety culture and the commitment for good occupational health and safety (OHS) in a workplace. This article considers the legal obligations of an employer and employee, what safety culture is and how it may positively change the workplace.

Keywords: Commitment to occupational safety and health. Safety culture. Organisational culture. Attitude. Employers. Employees. Occupational safety. Construction safety culture.

Introduction

The concept of 'safety culture' is relatively new to many industries and workplaces (Mohamed, 2003). There has been a surge in interest of this area as organisations aim to reduce the number of injuries or illness, accidents and disasters (Cooper, 2000). Safety culture entails positive behaviours, positive values and a unified commitment to occupational health and safety in the workplace, which results in increased employee satisfaction, reduced occupational injuries and reduced costs due to injuries (Guldenmund, 2000).

Safety culture is embedded within organisational culture and is defined as the values, attitudes, norms, beliefs, practices, policies and behaviours of safety within an organisation (Choudhry, Fang & Mohamed, 2007). It is recognised as a necessary precursor to improving safety in the workplace. Developing and maintaining a positive safety culture is an effective method of improving occupational health and safety management in a workplace (Vecchio-Sadus & Griffiths, 2004).

This paper explores what safety culture is, factors that influence safety culture and how it may be improved.

Methods

To investigate how a positive safety culture may influence commitment to good OHS. This review focused on applied research, published research and literature that addressed what safety culture is and the benefits of a positive safety culture in the workplace. The main question addressed by the review was "How can safety culture improve an organisation?" Further questions included "What is safety culture?" "What factors affect safety culture?" and "How can safety culture be improved?" In investigating these aspects of safety culture, this review will provide a method of gaining a commitment to good occupational, health and safety.

A search of five electronic databases was used to identify qualitative and quantitative peer-reviewed studies that were published in English from 1997 to 2014. The date restriction was implemented as a filter in the search databases. These databases included: HSELINE, NIOSHTIC, RIOSH, Proquest and Google scholar. Search terms were used to identify relevant studies and articles that answered the questions for the purpose of this review. Search terms used included: safety culture, commitment to OHS, organisational safety and benefits of safety culture. Useful peer reviewed studies included ones that used questionnaires, focus groups and behavioural observations to assess the quality and correlation of safety culture in a workplace. Initially, a search using Google Scholar database with the phrase "safety culture" AND "safety climate" AND "organisational culture" yielded 120,000 results. A filter for scholar journals published between the years of 1997 to 2014 was applied, refining the results to 18,600 journals. Twenty-two of these were used to conduct a literature review n the effect of safety culture of gaining a good commitment to OHS in the workplace.

Discussion

Benefits of a positive Safety Culture A positive safety culture possesses management commitment to OHS, genuine concern for the workforce, reciprocal trust and credibility throughout all levels of the organisation and employee empowerment (Luria & Rafaeli, 2008). Employer and employee behaviour and risk management is switched from reactive to proactive, when a positive safety culture exists in an organisation (O'Toole, 2002). Proactivity of OHS, results in finding and prioritising issues, such as hazard identification, risk assessment and applying relevant controls (Gong et al., 2012). This proactivity leads to the benefits of prevention and reduced number of injuries, illness and accidents in the workplace (Parker, Lawrie & Hudson, 2006). Reduction of injuries, illness and accidents is economically beneficial for the organisation and results in cost effectiveness and stronger shareholder value (Vredenburgh, 2002).

Factors that influence Safety *Culture*

There are many ways the safety culture of an organisation can be assessed. A measurement scale questionnaire of safety culture conducted by Sherif Mohamed (2002) encapsulated five broad aspects that affect safety culture, namely; management, safety systems, competence, work pressure and risk appreciation (Mohamed, 2002). This assessment found that management, safety systems and employee risk appreciation influenced the safety climate of construction sites, whereas work pressure and competence demonstrated limited influence on the safety culture (Mohamed, 2002). Improvement of procedures, systems, the physical set up of the working environment and overall health and safety management system of the organisation should be implemented (Young, 2014). These improvements will allow continuous advancement to safety and safety culture in the workplace (Mearns, Whitaker & Flin, 2003).

Management Involvement

Prior to implementing and advancing the safety culture, the organisation is required to possess a good OHS management system, which is compatible to the desired safety culture (Earnst, 1997). Positive commitment to safety by management has a strong influence on the safety culture of a workplace (Gracia et al., 2004). It is believed that through this commitment, management will lead by example and model employee's safety behaviours. In leading by example, management establish and reinforce positive norms and attitudes toward safety practices, resulting in creating a safe environment (Zohar, 2002).

Employee Empowerment

Employee contribution and empowerment in OHS is just as important as management involvement, when creating safety culture in a workplace (Griffiths, 2001). Employee empowerment results in proactivity, instead of reactivity and positive behaviours for OHS, resulting in better risk management and an overall decrease of illness, injury and property damage (Vecchio-Sadus & Griffiths, 2004).

Improving Safety Culture

Many studies have included suggestions on how to improve safety culture in an organisation (Leape, Berwick & Bates, 2002). Goal-setting has been suggested to be an effective method of improving safety culture if implemented correctly (Cox & Cheyne, 2000). The goal of achieving a 'safety culture' should be split into sub-goals that are attainable and directs the employees to ultimately the 'safety culture'.

Establishing a company wide safety culture from management to front-line workers, throughout all levels of the organisation has been demonstrated to positively influence the safety climate (Mohamed, 2002). A non- adversarial safety culture in combination with an open environment for exchanging safety ideas has been suggested as a method of improving the management arm of safety culture (Mohamed, 2002). Management should set norms and standards for safety and lead by example (Glendon & Stanton, 2000). Front line workers should actively be aware of the behaviour of themselves and colleagues (Michael et al., 2005). Furthermore, employees should be aware of a support system from management, where they feel safe to report unsafe behaviour and put suggestions forward (Michael et al., 2005).

Legislative requirements

The Occupational Safety and Health Act 1984 governs the legislative requirement of occupational safety and health in Western Australia. Although the legislation does not detail how a safe occupational environment should be achieved, it does outline the minimal requirements of occupational health and safety, and duty of care relationship between an employer and employee in the workplace. The Occupational Safety and Health Act 1984 section 19 states that the duty of an employer as; an employer shall, so far as is practicable, provide and maintain a working environment in which the employees of the employer are not exposed to hazards.

Section 20 of the act, states the duties of employees. An employee shall take reasonable care to a) ensure his or her own safety and health at work and b) avoid adversely affecting the safety or health of any other person through an act or omission at work.

If an organisation has a strong and positive safety culture, where employers and employees think and behave in a safe manner, the legislative requirements of both employers and employees will unlikely be breached (Lin & Mills, 2001).

Conclusion

This paper attempted to examine how safety culture may be used to gain commitment to good OHS and factors that may influence and determine the safety culture of an organisation. Peer reviewed articles, published journals and studies were reviewed for support and evidence of this paper. Studies found that management, employee empowerment and safety systems have a strong influence on safety culture in an organisation. Positive management, employee empowerment and efficient safety systems have the power to positively influence safety culture, as management are able to lead by example, employees are actively involved in hazard identification and risk assessment of their environment and there are proper support networks to facilitate their awareness for OHS. Although implementation and drive of safety culture may be difficult to obtain, organisations need to be constantly assessing; if the safety culture is working, requires change and effectively reduces the risk of injury and accidents. Once a positive safety culture is present throughout all levels of the organisation, it leads to reduced injuries, illness, accidents and costs.

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Mining Truck-Related Accidents: Multi-Objective Economic Optimization of Safety

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Abstract

Off-road-truck-related accidents are a major cause of considerable losses in the US surface mining industry. Though the rates of fatalities, permanent disabilities and other injuries have shown decreasing trends in the past decade, the associated lost lives and working days are far from a "zero work place accident policy" in this industry. After identification of the root cause(s) of off-road truck related accidents, the major task is to decide on the implementation of appropriate safety measures. In cases that there are several alternatives, an optimal decision should be taken in order to choose the most effective alternative(s) which incur minimum costs while achieving maximum improvements. The three major objectives are defined, in this study, as (i) maximization of loss prevention, (ii) minimization of costs, and (iii) maximization of reliability of safety measures. A multi-objective three-function-two-variable mathematical framework for optimization of the decision is proposed. The framework is examined in a generic mining situation to demonstrate its applicability. The genetic algorithm method was used to solve the multi-objective decision problem. The results identified the most effective safety measures and the optimal time interval that each one should be employed to achieve the best results.

Keywords: Genetic algorithm, Multi-objective optimization, Off-road-truck related accidents, Surface mining

1. Introduction

Off-road truck-related accidents are a major cause of fatalities, permanent disabilities, and other types of injuries in the US surface mining industry (Zhang et al., 2014; Zhang and Kecojevic, 2015). Analysis of the last 15 years (2000–2014) of Mine Accident, Injury and Illness Reports beginning with 1/1/2000 reveals occurrence of 169 records of severe accidents that affected 184 employees. This dataset comprised 121 fatalities and 63 permanent disabilities due to operating and/or working in the proximity of off-road trucks (Mine Safety and Health Administration [MSHA], 2014).

Most of the severe injuries were sustained while the employee was operating the off-road truck. In the 81 severe accidents (83 victims) that occurred while operating a truck, 69 employees sustained fatal injuries and 14 employees were permanently disabled. The four main causes of these accidents were: (i) losing control of the truck, (ii) berm/dump failure, (iii) unsafe/careless actions, and (iv) truck/component mechanical failure. In the category of "unsafe/careless actions," MSHA identified that the underlying root causes were either associated with poor safety training, management and enforcement with managerial causes, or failure of the employees to obey safety regulations (personal issues). In nearly all of the 34 accidents that occurred during the "maintenance/repair" activity, either the employees' failure to follow safety regulations or a component/equipment malfunction/failure caused severe injuries. A major cause of fatalities in this category was failure to block off/lockout the truck/bed. This was either due to the employees' unsafe actions or the mechanical malfunction of the equipment. In the category of "other," 39 employees were involved in 28 fatal accidents that resulted in 31 fatalities and 8 permanent disabilities. The main causes of this category were: (i) the operator(s) exited the cab while operating the equipment and (ii) unsafe/careless minor repairing attempts.

Considering the root causes of the historical accidents, the following major safety measures can be implemented to reduce severity and/or frequency of this type of accident in future operations:

1. operator training/skills improvement through both simulator-based and real-world training,
2. berm/dump slope stability analysis, monitoring, and enhancement,
3. enforcement of safe driving behavior,
4. implementation of proximity detection and automatic collision preventing systems, and
5. training and enforcement of safe maintenance, repair, and inspection practices.

Associated with each of the above safety measures are capital and operating costs that should meet the specified budget requirements. Thus the main objective is to minimize the total cost while achieving the highest level of loss prevention (i.e., minimizing the lost working days, fatalities, and disabilities) through optimal selection of safety measures. A secondary objective is to maximize the reliability of safety programs. Therefore, the optimization problem is a multi-objective one [i.e., one minimization function (costs), and two maximization functions (loss prevention and reliability)] subject to safety budget requirements per specified time interval (i.e., safety project duration).

Recently, Mishra and Khasnabis (2011) proposed an optimization procedure for optimal safety alternatives allocation to minimize accidents at urban intersections subject to budgetary constraints. Han et al. (2013) designed a multi-objective optimization framework for economic-safety-emission optimization of a hydrogen infrastructure using a fuzzy optimization programming. Aven and Hiriart (2013) formulated a basic model for economic safety analysis, considering different safety measures with different costs and loss prevention capabilities. El-Halwagi et al. (2013) proposed a mathematical model for multi-objective economic-safety optimization of bio-refineries. Martinez-

Gomez et al. (2014), similarly, proposed an economic-safety optimization framework for unit relocations in petrochemical plants.

Although recently many research studies have been devoted to the issue of multi-objective safety-economic concurrent optimizations in different studies (see e.g., Riauke and Bartlett, 2009; Torres-Echeverría et al., 2012; Hoffenson et al., 2014) yet, to the best of the authors' knowledge, no similar model has been proposed yet for the specific case of surface mining operations, and in particular, the off-road-related-accidents in the US surface mine industry. Thus, in the mining industry, there is no published robust procedure/framework for selecting optimal safety measures, among available alternatives, subject to budgetary constraints. Therefore, the contribution of this study is to propose a mathematical framework for this multi-objective optimization problem. A generic example of a surface mine is presented and solved with the genetic algorithm to demonstrate applicability of the methodology. However, this study is limited to prevention of off-road truck-related accidents in surface mining operations (including open pit, quarry and strip mining of coal, metal, and industrial minerals) in the United States.

2. Methodology

The optimization task is to choose optimal safety measures, among n alternatives, and to specify the implementation time of each one to obtain the minimum costs. Thus, the problem is a three-objective-two-variable optimization practice. The objectives are total costs (minimization), total gain (maximization), and cumulative reliability (maximization), and the two decision variables to be optimized are a binary {0, 1} associated with application of each safety measure, and the time interval it should be implemented. The major constraint is the safety budget requirements. The three objective functions and the multi-objective optimization framework are defined in the following sections.

2.1. Minimization functions

Assuming that there are n different alternatives to reduce/eliminate the losses due to off-road truck-related accidents (e.g., implementation of proximity detection), the cost minimization task is to minimize the total capital costs and operating costs as defined in Equation (1).

(1) $$C = \sum_{i=1}^{n} T_i \left(\frac{r \times CC_i}{1-(1+r)^{-T_i}} + OC_i \right) I_i$$

Where, C is the total cost of application of n safety approaches; T_i is the period of application of the ith approach; r is the discount rate; CC_i is the capital cost of the ith approach; OC_i is the operating/maintenance cost of the ith approach per year; and I_i is 1 if the ith approach will be used, otherwise 0. $\frac{r \times CC_i}{1-(1+r)^{-T_i}}$ is the annual equivalent of the CC_i;

In Equation (1), $\sum$ is the summation symbol, which means that all costs (associated with different safety alternatives) are summed. Since in general there are n different alternatives, the summation is performed over all alternatives (i.e., i = 1 to n). The first term inside the $\sum$ is $T_{i,}$, which accounts for the period of application of each safety alternative. For instance, if the first alternative (i.e., i= 1) will be used for 7 years (i.e., $T_1 = 7$) then the total annual costs should be considered for the whole 7 years. Therefore, T_i is multiplied by the next term in the parentheses. The next term in the parentheses is the summation of the annual discounted capital costs ($\frac{r \times CC_i}{1-(1+r)^{-T_i}}$) and annual operating costs (OC_i). Therefore, all (annual) costs associated with each alternative are calculated within the parentheses. Then these costs are multiplied by the alternative's application period (T_i) to calculate its whole-life costs. Finally, since the optimization task here is to decide on both the best alternatives and their application periods, a term I_i is multiplied by the calculated costs. For instance, if the first alternative is found to be inappropriate it will not be used and thus there should be no costs associated with it. In this case $I_1 = 0$ is multiplied by the sum of the first alternative's costs in order to eliminate its costs.

The capital costs are converted to equivalent annual payments using the discount rate and duration of implementation of the ith measure. The annual operating costs (i.e., maintenance, repair, inspection, parts, and consumables) are assumed to be fixed per the implementation interval. The second decision variable in Equation (1) is I_i, which takes a value of 1 if the ith safety measure will be employed, otherwise zero (Equation 2). Since in the case that the ith safety measure is not feasible to use, its corresponding application time must be zero (dependency of T and I), a relevant constraint is defined, as in Equation (3). The main constraint of the optimization task is to meet the available budget for the life of the safety project as is defined in Equation (4).

(2) $$I_i \in \{0,1\} \ \forall \, i = 1..n$$

Equation (2) constraints the optimization algorithm to takes either a zero or one value for the parameter I_i. This means that each candidate alternative is either (economically) appropriate or not. Therefore its associated I_i parameter should be either zero or one. The symbol $\forall$ in Equation (2) means that *for all* values of i , the I parameter is either zero or one.

Subject to:

(3) $$If\ I_i = 0\ then\ T_i = 0;\ else\ T_i \geq 1$$

(4) $$C \leq \text{Total safety budget for period } [0, \max(T_i)]$$

Equation (3) is a logical optimization constraint, which means that if a given alternative is not to be used ($I_i = 0$), then its application period (T_i) should be zero. Otherwise (*else*), if it is appropriate, then it should be used for at least one year ($T_i \geq 1$).

Equation (4) constraints the optimization algorithm with the total available safety budget for the application period. Therefore the total costs (defined in Equation 1) should not exceed the budget. Since there are different safety alternatives (i = 1 to n) with different application periods (T_i), the overall safety program period is set to the maximum of $T_i s$. For instance, if there are three alternatives with $T_1 = 5, T_2 = 3, \text{and } T_3 = 8 \text{ years,}$ then the total costs should not exceed the total available safety budget for 8 years ($\text{i.e.}, \max(T_i)$).

2.2. Maximization functions

The main goal of the implementation of safety measures is to reduce/eliminate the cumulative losses due to accidents. The equivalent annual monetized value (δC_i) is defined in Equation (5) to obtain the first maximization function. The third important objective is to maximize the cumulative reliability of the implemented measures as defined in Equation (6) subject to Equation (7).

(5) $$G = \sum_{i=1}^{n} T_i \times \delta C_i \times I_i \quad (5)$$

Where, G is the total loss prevention due to application of n safety approaches, and δC_i is the expected equivalent monetized annual loss prevention due to application of the i[th] approach.

In Equation 5, the ∑ symbol has the same meaning as in Equation (1). The objective here is to maximize the total gains associated with the application of n different alternatives. Therefore, the equivalent annual monetized value (δC_i) of each alternative is multiplied by its application period (T_i). Similar to Equation (1), I_i is a binary variable (0 and 1) that makes sure if a given alternative is not used there will not be any gains associated with that alternative (i.e., $I_i = 0$), otherwise $I_i = 1$.

Finally in Equation (6), R_i is defined as a reliability index (or performance index) of the i[th] safety alternative, and its values are bounded in the [0 , 1] range in Equation (7) for all ($\forall$) alternatives.

(6) $$R = \sum_{i=1}^{n} R_i \times I_i \quad (6)$$

(7) $$0 \le R_i \le 1 \ \forall\, i = 1..n \quad (7)$$

Where, R_i is the reliability index of the i[th] safety approach.

The decision variables are I_i and T_i, that is, given the associated costs, gains, and constraints of n safety measure alternatives, the question is that which one(s) should be implemented, and for how long?

3. Results and Discussions

Zhang et al. (2014) used fault tree analysis to investigate the root causes of 12 fatal off-road truck-related accidents in West Virginia coal mining operations during 1995–2011. The authors reported that poor maintenance and inadequate inspections were the two major root causes of these accidents, which resulted in a total of 13 fatalities. Other root causes of fatalities included lack of adequate training of operators and mechanical failures. Therefore, different safety measures (with different costs, gains, and reliabilities) can be implemented in a specific surface mine operation to mitigate off-road truck-related accidents in accordance to the major root causes. As discussed earlier, a trade-off between the costs and efficiency should be made in order to choose optimal alternative(s) (multi-objective optimization). Taking the major root causes into account a generic set of alternatives is suggested in Table 1.

Since in real world applications, the performances of different alternatives are not perfect, a reliability index is consider in Table 1. For instance, it is not expected that even a state-of-the-art proximity detection system prevents 100% of all possible collisions in a given mine site. Therefore, the total gains associated with that safety alternative should be penalized by a factor. This factor is defined as a reliability index and is maximized for all alternatives as in Equations (6-7). Similarly, one doesn't expect that safety training (the second alternative in Table 1) results in a perfect elimination of all the risks and accidents that are associated with human errors. Therefore, this alternative is also penalized via a reliability index, which is considered to be 95% in this example. Similarly, R_3 (the reliability index of the third alternative in Table 1) is assumed to be 0.90. It should be noted that, without loss of generality, the R_i s are assumptions of this example. The actual values for different alternatives should be identified from the statistics of past experiences with using them.

The first suggested safety alternative is the implementation of automatic proximity detection systems on and around the working areas of off-road trucks. These systems detect objects (including human and other machinery) approaching the "danger zone" of off-road trucks and warn the truck operator and/or idle the truck automatically. It is assumed that capital investment for the system is 2,000 money units (e.g., 1,000 USD) and its operating cost is 250 units/year. The life time of the system is assumed to be 10 years and the discount rate is 0.2 (see Equation 1). It is expected (from previous studies and/or experience from similar operations) that the system will result in an equivalent annual accident cost reduction of 300 units per year. Alternatively, this equivalent "gain" (see Equation 5) can be represented in the form of equivalent annual reduction in cumulative lost work days. Assuming that the system has a reliability index of 0.85, the two important questions are: (i) should this measure be employed, (ii) if yes, for how long?

Similarly, the attributes of the two other alternatives: training operators (either using simulators and/or real practices) and, strict law enforcements are presented in Table 1. Given the safety budget requirements, a decision maker needs to choose the optimal combination of the available alternatives and specify the implementation duration of each one. Therefore, this is not a trivial problem, particularly when the number of alternatives increases, which needs solving a multi-objective optimiza

	Capital investment	Operating/ Maintenance costs	Cost reduction (safety efficiency)	Reliability index
Alternative	US$1000	US$1000/year	US$1000/year	
Proximity detection	2000	250	300	0.85
Operator training	100	0	25	0.95
Law enforcement	10	10	10	0.90

Table 1. Generic example of three safety alternative

tion problem. In multi-objective or multi-criteria optimization problems, there are more than one objective function that are usually conflicting with each other (i.e., optimization of one function (minimization or maximization) deteriorates the optimality of other function(s)). For instance, minimization of costs tends to deteriorate maximization of gains. Thus, a "trade-off" should be considered between the optimal states of different objectives. In this case, instead of representing the optimal solution in the form of a single value (as it is in the case of single-objective optimization) the optimal solution is represented in the form of a "Pareto optimal frontier" that depicts the trade-offs between conflicting objective functions (Zitzler & Thiele, 1999). Evolutionary algorithms such as the genetic algorithm have been employed by many researchers to efficiently solve complex multi-objective problems (e.g., Busacca et al. 2001; Iakovou, 2001; Marseguerra et al. 2002 and 2005; Abido, 2006; Lambert et al. 2006; Zhao et al. 2007).

The NSGA-II algorithm (Deb et al., 2002) was employed, in this study, using the tool developed by Savić et al. (2011). Details of the algorithm and different solution tools are discussed extensively elsewhere, and hence are not addressed in this study (see: Li & Zhang, 2009; Murugan et al. 2009; Ameyaw et al. 2013). Figure 1 illustrates the result of Pareto optimal frontier comparing the cost and gain functions. Two distinct regions are recognized: (1) high cost and gain (upper right), and (2) low cost and gain (lower left).

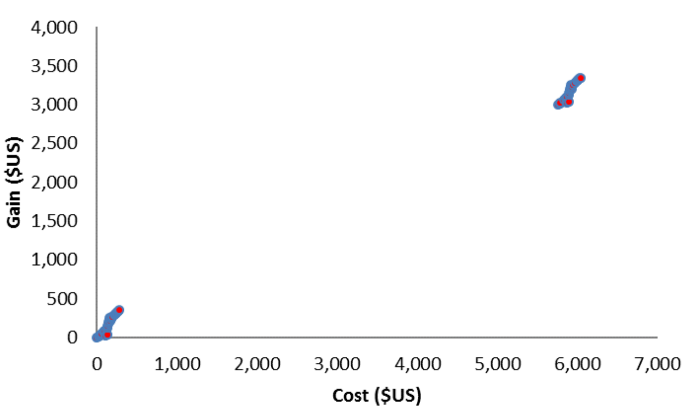

Figure 1. Pareto optimal front (cost vs. gain functions)

The optimal solutions in each region are magnified in Figures 2 and 3. Figure 2 illustrates the conflict ("non-dominance" state) between the gain and cost functions in the Pareto front. This means that it is not possible to decrease costs (increase gains) without decreasing gains (increasing costs). This can also be examined through inspecting the upward trend of the scatterplot of the cost-gain diagram (Figure 2). The red areas in Figure 2 depict either infeasible or sub-optimal solutions. The yellow areas show nearly a 1:1 relation between the cost and gain functions. On the other hand, the green area shows a considerable increase in gains by smaller changes in costs. Increasing the total project's safety costs from 120 to 160 units results in an increase in total gains from 100 to 260 units. Thus this region can be considered as an optimal choice in decision making. Apparently, in this range of costs, application of proximity detection system is not feasible, and hence the other two alternatives are considered. For instance if one assumes that the total safety project life is 10 years, one trade-off solution proposed by the algorithm (in the green area of Figure 2) is implementation of the second (operators training) and third (law enforcement) alternatives for 10 and 1 years, respectively. This program results in a loss prevention equivalent to 260 money units, and it costs 183 money units. The cumulative reliability index will be 1.85. The other 6 solutions in the green area have nearly the same ranges and result in similar trade-offs between the cost and gain functions.

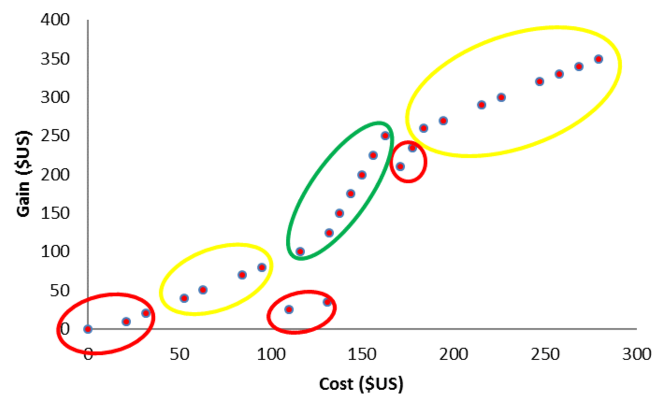

Figure 2. Pareto front region 1 (low cost-gain area)

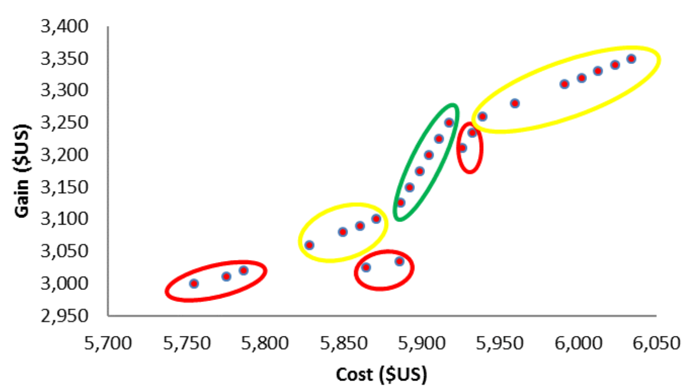

Figure 3. Pareto front region 2 (high cost-gain area)

Similarly, the infeasible/sub-optimal, acceptable, and best solution for the upper right region of Figure 1 (i.e., high cost-gain interval) are depicted in Figure 3. In the green area there are six solutions in the Pareto frontier that result in a sharp increase in gains by relatively smaller increases in costs. At this range of costs, obviously implementation of the first alternative (proximity detection) is proposed. For instance, implementation of the proximity detection for 10 years, along with the "operators training" option for 8 years (without implementation of the law enforcement option) results in 3,200 units of gain function, while the costs will be 5,905 units. The cumulative reliability index will be 1.8.

Comparison of Figures 2 and 3 reveals that the green areas could be the decision zones. Application of either case depends on the project size, budget limitation, and "gain" expectations. For instance, for a small scale surface mining operation with few off-road trucks (and hence small absolute annual accident losses) the first region is preferred. On the contrary, for a large surface operation with considerable budget available, where a considerable reduction in off-road-truck-related accident loss is expected/desirable, the second region is preferable.

4. Conclusions

An evolutionary multi-objective optimization based decision support system for the optimal economic selection of safety alternatives was proposed. The proposed multi-criteria mathematical framework was examined in the case of selection of optimal safety measures to mitigate/eliminate off-road-truck-related accidents in surface mining. A genetic algorithm based solution was employed to solve a generic example. Decision variables were optimally selected in the form of Pareto fronts. Development of this study through validation of the methodology in a real mining case, and incorporation of data variability (in form of a stochastic multi-objective optimization scheme) is expected to render a comprehensive decision aid in addressing the problem of off-road-truck-related fatalities, disabilities, and injuries. The major limitation of this study was lack of application of real world mining example(s) to examine and validate the methodology. The proposed generic example demonstrated the solution scheme in general, but the methodology's validation remains for the future studies. A second important limitation was lack of incorporation of data variability or randomness. Therefore, the framework was deterministic in nature and could not deal with data variability. Thus, development of a stochastic multi-objective optimization framework, for optimal safety measure selection and implementation in surface mines, remains as an interesting topic for future studies.

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World Safety Organization

Code of Ethics

Members of the WSO,
by virtue of their acceptance of membership
into the WSO,
are bound to the following Code of Ethics
regarding their activities
associated with the WSO:

Members must be responsible for
ethical and professional conduct in relationships
with clients, employers, associates, and the public.

Members must be responsible for professional competence
in performance of all their professional activities.

Members must be responsible
for the protection of professional interest,
reputation, and good name of any deserving WSO member
or member of other professional organization
involved in safety or associate disciplines.

Members must be dedicated to professional development
of new members in the safety profession
and associated disciplines.

Members must be responsible
for their complete sincerity in professional service
to the world.

Members must be responsible for continuing improvement
and development of professional competencies
in safety and associated disciplines.

Members must be responsible
for their professional efforts to support the WSO motto:

"Making Safety a Way of Life…Worldwide."

World Safety Organization

Statement of Purpose and Objective

WSO's purpose is to internationalize all safety fields, including occupational and environmental safety and health, accident prevention movement, etc., and to disseminate throughout the world the practices skills, arts, and technologies of safety and accident prevention.

WSO's objective is to protect people, property, resources, and the environment on local, regional, national, and international levels. WSO membership is open to all individuals and entities involved in the safety and accident prevention field, regardless of race, color, creed, ideology, religion, social status, sex, or political beliefs.

WSO is in Consultative Category II Status (Non-Governmental Organization-NGO) to the Economic and Social Council of the United Nations.

The WSO is a Not-for-Profit Corporation (Missouri, USA), non-sectarian, non-political movement dedicated to
"Making Safety a Way of Life…Worldwide."

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