# Incorporating Musculoskeletal Disorder Prevention into Organizations' Management Systems

by
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**Authors Declaration**

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final versions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

**Abstract**

Musculoskeletal disorders (MSD) – for example, low back pain or shoulder tendinitis -are prevalent disorders with significant economic burdens to organizations and personal costs to workers. The approaches to prevent these disorders are rarely linked to broader management system frameworks. The main purpose of this thesis was to explore possible practices, tools and avenues to incorporate MSD prevention activities into these broader management frameworks. The results of a scoping review study revealed that there was very little literature describing the integration of MSD risk assessment and prevention into management systems. This lack of information may isolate MSD prevention, leading to difficulties in preventing these disorders at an organizational level. As Participatory Ergonomics (PE) was seen to be an internationally recognized approach to prevent MSD prevention in workplaces, an assessment of its compatibility with the requirements of an Occupational Health and Safety Management System (OHSMS) standard (OHSAS 18001) was performed. It showed that irrespective of the strength of PE, it did not match well with common business processes and practices. However, it is expected that paying adequate attention to adopting management approaches and using the common language used in management system frameworks, could make MSD prevention activities more effective and sustainable.

Interviews with key informants - including health and safety managers, consultants, researchers, policy makers, and union representatives - revealed that using common language will result in more management buy-in and is the key to the success of MSD prevention activities. The key informants argued that MSD prevention will receive more attention and recognition through integration of prevention activities into organizational-wide approaches and tools. MSD prevention was suggested to be sold as an “innovation and competitive advantage” and as an

added value to the core business of the organization. The participants said that workers' participation should not been as "negotiation" and it could be achieved by linking prevention goals to current practices in organizations such as "management of change" and "user participation". In addition to this, training was argued to be a necessary component of prevention programs as well as management systems. The key informants strongly recommended that training for MSD prevention should contain hazard identification and risk assessment components. This study also revealed that "strategic positioning" and the use of common tools and language may result in effective training programs that would consequently improve H&S and MSD prevention in the workplace. The consistent message from key informants was that the incorporation of MSD prevention into a wider organizational approach avoids creating "silos" within organizations. This could ultimately give the same level of recognition to MSD prevention as other business drivers, resulting in more effective and sustainable prevention, improved performance, and a better corporate social responsibility image. This integration was said to be more useful and cost-effective for small businesses. Incorporating MSD hazard identification and assessment into current tools used by organizations such as Failure Mode and Effect Analysis (FMEA), was recommended as an effective approach to develop harmonized assessment tools.

The case studies showed that despite the existence of proactive OHSMS and ergonomics program in the case-study organizations, these two programs were separated, and this disconnect resulted in isolation of MSD prevention from the organizations' overall business structure. The case studies showed that initiatives led by middle management in engineering and quality departments resulted in better prevention of MSD; better management buy-in to invest in MSD

prevention; increased workers' participation; improved communication; and increased awareness.

Reviewing MSD hazard identification and risk assessment methods and exploring their possible integration into other assessment tools used by organizations to address other types of hazard, concluded that integration was feasible, in a few cases. This integration could create an opportunity to use harmonized hazard identification and assessment tools within management systems.

The thesis concluded that the current disconnect of MSD prevention activities from other management processes creates silos within organizations that result in poor sustainability, isolation, and less management buy-in for MSD prevention. Rather than creating stand-alone programs, the use of harmonized tools and an integrative approach should result in increased management support and improved effectiveness and sustainability of MSD prevention activities.

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**Dedication**

I dedicate my PhD thesis to my parents because of their endless love and support in the past 34 years.

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# CHAPTER I: Introduction

## 1. Background

Musculoskeletal Disorders (MSD) are the number one type of work-related lost-time claim injury reported to the Workplace Safety and Insurance Board (WSIB) in Ontario (OSHCO, 2006) as from 1996 - 2004, MSD accounted for 42% of all lost-time claims, 42% of all lost-time claim costs, and 50% of all lost-time days accepted by WSIB in Ontario. Several workplace risk factors have been identified for development of MSD (Bernard, 1997; NRC, 2001). Based upon these studies, many methods for the assessing of MSD risk factors have been developed and reviewed (e.g., Takala et al., 2010; Dempsey et al., 2005). These methods are complex and may not fit well into the approaches used by organizations to manage other risk factors. The high prevalence of MSD within workplaces may be partially due to the fact that MSD hazards are not being addressed as effectively as is possible. This could be as a result of a disconnection of MSD prevention activities from broader management frameworks such as Occupational Health and Safety Management Systems (OHSMS), Quality Management Systems (QMS) or Integrated Management System (IMS). Management system frameworks and other project driven methodologies such as Six Sigma demand everyone in the organization collect, analyze and display information in a consistent manner. The disconnect means that information concerning MSD hazards may not be “on-the-table” and so may not receive adequate attention.

## 2. Overall Objectives

This research project was conducted with intention to explore possible practices and avenues to incorporate MSD prevention activities into broader management frameworks such as OHSMS. This integration and harmonization of tools and approaches would possibly allow MSD hazard information to be analyzed and presented in a form that is consistent with other information used in the organization. In addition, this will result in improved prevention of MSD ***in practice***; this

would help avoid health and safety, and especially MSD prevention, becoming a "sidecar" function (Neumann & Dul, 2005).

## 3. Specific Objectives

The specific objectives of this thesis are to:

- Identify and summarize available evidence on embedding the prevention of MSD within OHSMS and thus integrating this specific aspect of prevention into an organization's management system. (Chapter 2).
- Assess the compatibility of participatory ergonomics programs with the elements of occupational health and safety management systems (Chapter 3).
- Explore key informants' experiences, perceptions and perspectives on prevention of MSD and its link to three main elements of management systems including management commitment, training, and worker participation (Chapter 4).
- Explore key informants perspectives on, perceptions of, and experiences with the integration of MSD prevention into management systems (Chapter 5).
- Document the techniques and approaches used by companies in the manufacturing sector to address MSD hazards and how they do or do not integrate these into their H&S or management systems (Chapter 6).
- Explore workers' involvement in addressing health, safety and MSD hazards within companies' current practices and approaches (Chapter 6).
- Explore the possible integration of well-recognized MSD hazard identification, risk assessment and evaluation tools into well-established tools used by organizations to address other occupational hazards (Chapter 7).

To achieve these objectives a qualitative methodological approach was used and several techniques and analytical approaches were applied including a scoping review of literature, semi-structured interviews, key informants interviews, document and records analysis, workplace site visits, content analysis and thematic analysis.

The results of this thesis are presented in eight chapters. The current chapter is followed by six other chapters (Chapter II-VII) that will present the findings of five research studies. Finally, Chapter VII will discuss the contribution and implication of the findings of this thesis.

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# CHAPTER II: Prevention of Musculoskeletal Disorders within Management Systems: A Scoping Review of Practices, Approaches, and Techniques

## 1. Introduction

Musculoskeletal disorders (MSD) represent a large proportion of work-related disabilities in most countries (NRC, 2001). MSD have a substantial work-related component and a consistent set of workplace risk factors including forces exerted, the postures required, the time history of the mechanical exposure, vibration, cold, contact stress, and a range of psychosocial factors (Bernard, 1997; NRC, 2001). MSD negatively impact the worker, firm, and the economy by increased discomfort, pain, disability, and medical costs, as well as decreased productivity and employee morale (Martin et al., 2003; Morse, 1999). Hence, as a result of these adverse effects, the prevention of these disorders should be high priority.

It is the responsibility of organizations to provide safe working conditions through anticipation, identification, assessment, and control of a wide range of hazards in the workplace. If these activities are performed within some organizational level framework, it may be considered a "management system". More formally, a management system is defined as a framework of individual processes, procedures, and resources to ensure achievement of certain objectives effectively and efficiently (Karapetrovic & Willborn, 1998). Three key internal management systems are: Environmental Management Systems (EMS), Quality Management Systems (QMS), and Occupational Health and Safety Management Systems (OHSMS). Several standards and guidelines have been developed over the years to guide organizations in implementing these management systems, for instance, Occupational Health and Safety Assessment Series (OHSAS 18001), BS 8800, International Labour Organization guidelines, Health and Safety Executive guide (HSE, 2007), QMS standard (ISO 9001) developed by International Organization for Standardization (ISO), and EMS standard (ISO 14001). OHSAS 18001 is a framework developed to provide a recognizable health and safety management system. This framework includes elements aiming to improve health and safety systematically.

Often organizations integrate above management systems together to increase efficiency and reduce costs. This model is known as an Integrated Management System (IMS). These management system frameworks are typically based on the Plan-Do-Check-Act (PDCA) model (Deming, 1986) of continuous improvement.

The IEA 2000 definition of ergonomics was adopted in this paper, which includes physical, cognitive, and work organizational factors (IEA, 2000). In the literature, ergonomics appears to be frequently used as a synonym for MSD prevention. Therefore, where applicable, it will be clarified which meaning has been used by different authors. Participative Ergonomics (PE) practices are commonly presented as a desirable approach for the prevention of MSD (Noro & Imada, 1991). Ergonomics programs for the prevention of MSD vary in complexity, but most of those reported in the literature appear to be set up in isolation from management system frameworks (Yazdani et al., forthcoming). PE programs typically have their own separate set of policies and procedures with elements such as management commitment and training (e.g. NIOSH, 1997), but the relationship to other management processes is not described. It is unclear why this general disconnection from prevention of MSD activities exists in the first place and then, what are the possible challenges and barriers that could obstruct the integration of MSD prevention into existing broader management systems.

The purpose of this study was therefore to both identify and summarize available evidences on embedding the prevention of MSD within OHSMS and thus integrating this specific aspect of prevention into an organization's management system.

## 2. Methods

The nature and extent of the literature on the topic and was not clear therefore a scoping review was performed. As defined by Mays, Roberts, & Popay (2001), a scoping review is a literature

review methodology that maps the key concepts to examine research questions and evidence. This could be done through a stand-alone project where researchers aim to address a complex research area, or an area that has not been comprehensively reviewed before (Mays, Roberts, & Popay, 2001; Arksey and O'Malley, 2005). It follows a methodology that is equivalent to qualitative analysis of literature. Scoping reviews not only itemize and summarize the existing findings on a topic, but also facilitate in-depth understanding of how those findings relate to each other and to the research question (Poth and Ross, 2009). For the purpose of this paper a framework by Arksey & O'Malley (2005) was used. The authors identified four different reasons to conduct a scoping review, including a) to examine the extent, range, and nature of research activity; b) to determine the value of undertaking a full systematic review; c) to summarize and disseminate research findings, and d) to identify gaps in the existing research literature. Reasons a) and d) matched the aims of this paper.

### 2.1. Scoping review process

The process used in this review was similar to those outlined by Arksey & O'Malley (2005) and consists of the following steps: 1) the research questions were clearly identified; 2) the inclusion and exclusion criteria were described; 3) search schemes were defined; 4) the literature search was conducted; 5) relevant studies were selected; 6) the evidence was extracted, and data were tabulated, and 7) the results of the review were summarized.

#### 2.1.1. Research question

What is known about preventing MSD within OHSMS and other management systems and how can these MSD prevention activities be integrated into an organization's management system?

### 2.1.2. Literature search outline

The search strategy combined two sets of keywords using the Boolean operator “AND”, while an “OR” strategy was used to combine the keywords within each group. In addition, the reference lists of documents were manually searched, in case they met the inclusion criteria. The first set of keywords was focused on the following terms: musculoskeletal disorders (MSD), ergonomics, low back pain, cumulative trauma disorders (CTD), upper extremities, repetitive strain injuries (RSI), musculoskeletal injuries (MSI), and injury prevention. The following keywords were used as the second set for management systems: occupational health and safety management system, health and safety management system, integrated management system, quality management system, total quality management system, risk assessment, and risk management. The keywords were searched in the titles, abstracts, and topics of documents. A title and abstract that contain one term from each group of keywords were considered to be eligible for this review.

### 2.1.3. Literature search

Electronic databases that were searched for relevant documents included MEDLINE, EMBASE, Compendex, Web of Science, PsycINFO, Ergonomic Abstracts, and 44 other databases using the ProQuest search platform. These databases include a wide range of journals in the fields of health, business, management, and science. The databases were searched for English language studies.

### 2.1.4. Inclusion and exclusion criteria

This paper included peer reviewed journal articles and conference papers aiming to describe injury prevention practices and approaches within any management system frameworks, such as

OHSMS, QMS, and IMS. Papers published until February 2012 were included. The search was updated on April 2014 to extract the most recent literature. Both qualitative and quantitative studies were included. This review excluded studies that lacked information about integration of prevention into management system using assessment techniques, strategies and approaches. Also, articles not written in English were excluded.

### 2.1.5. Document relevance review

One reviewer screened the title and abstract of each article. If the reviewer could not make a decision on relevancy of articles, an additional reviewer was asked to repeat the process. Those articles determined to meet the inclusion criteria were retrieved. Then, the articles were reviewed by pairs of reviewers independently to make a decision on the retention of the article. The decision for each paper was made by reaching consensus.

### 2.1.6. Data extraction and synthesis of information

Pairs of reviewers extracted data from articles on context, type of risk assessment techniques, strategies, techniques within management systems, and any authors' comments or recommendations related to MSD prevention within a management system. A thematic synthesis technique was used to combine the findings. This approach has been used to identify important or recurrent themes, and to summarize findings under thematic headings (Thomas & Harden, 2008).

## 3. Results

The literature search resulted in 718 citations after removing duplicates. Finally, 21 studies met the relevance criteria. Five main themes were identified from the thematic synthesis: 1) IMS and Occupational Health & Safety (OHS); 2) Workers' involvement or participatory approaches

within IMS; 3) IMS and MSD prevention; 4) Risk assessment tools within management systems, and 5) Continuous improvement and MSD prevention.

### 3.1. Theme 1: IMS and OHS

The literature supported the integration of different management systems, and this was recommended as an essential approach to address different risk factors within workplaces (Labodova, 2004; Shen and Walker, 2001). With respect to feasibility and scope, as described in case studies by Labodova (2004), the IMS approach can be implemented in companies with or without a systematic management system and in any kind of company regardless of size and sector, including those of small and medium size. This can be achieved by providing proper training (Labodova, 2004).

Integration of OHS into management systems was suggested as an important and essential approach for organizations to improve health and safety and performance (Shen and Walker, 2001; Badri, Gbodossou and Nedeau, 2012; Hare et al., 2006, Saurin, 2008, Lingard et al., 2009; Matias and Coelho, 2002). A case study conducted by Shen and Walker (2001) on the integration of quality, environment, and OHSMS in a construction project highlighted the importance of an integrated approach in addressing different risk factors in the planning and design phases of a construction project. Badri and colleagues (2012) argued that implementing standards such as QMS Standard (ISO 9000) alone may not necessarily lead to a higher level of organizational OHS performance, and that OHS issues have been overlooked in these types of standards. They suggested that additional approaches are needed to integrate OHS into management systems. The authors also concluded that there was lack of systematic integration of OHS in management systems despite the improvements in their legislations and structures

(Badri, Gbodossou and Nedeau, 2012). As reported by Hare et al. (2006) and Saurin (2008) the best results will be achieved when OHS is integrated during the planning phase of project. In addition, Lingard et al. (2009) proposed the life-cycle approach, which indicates how the integration of the OHS into all aspects of decision-making by clients could significantly improve the performance of constructional projects, and therefore enhance the prevention of injuries.

### 3.2. Theme 2: Workers' involvement/participatory approaches within IMS

Participation and involvement of workers is a key feature of any management system. They are also necessary in the implementation of changes within an organization. The literature supports systematic participation of workers in activities within IMS. Badri and colleagues (2012) reported that the systematic integration of OHS risk management into project management can increase employees' participation and this leads to transfer of knowledge, including the description of responsibilities and increased employees' involvement (Badri, Gbodossou & Nedeau 2012). Activities in organizations, such as those in the construction sector, are usually organized and performed using a project management approach. Furthermore, a participatory approach for the identification and assessment of risks has been suggested, involving several stakeholders such as project manager, team members, risk management team, experts, end users, stakeholders, risk analysis specialists, and even customers, and has been strongly encouraged to achieve most promising outcomes (Hare et al., 2006).

A model client framework suggested various processes for client involvement in multiple aspects of OHS programs, including the planning, design, procurement, construction, and completing stage of a construction project (Lingard et al., 2009). This model identifies client

behaviors. It has been implemented by the Australian government to create a positive OHS culture in construction projects. As reported by Lingard et al. (2009), it consists of three main elements: a) the Federal Safety Commissioner's OHS Principles with 8 principles: developing a safety culture, leadership and commitment, developing cooperative relations, promoting OHS in planning and design, consulting and communicating OHS information to project stakeholders, managing OHS risks and hazards, maintaining effective OHS measures across the project lifecycle, monitoring and evaluating OHS performance; b) the project process map, and c) supporting tools and resources.

In a case study conducted by Cohen, supervisor and manager were ultimately accountable to implement and follow-up with corrective actions (Cohen, 1997). They declared that their integrated approach, particularly with worker involvement, significantly reduced RSI severity. The program was reported to be a part of the company's management system. However, the authors didn't mention the implementation of any systematic risk management strategy with a continual improvement approach.

### 3.3. Theme 3: IMS and MSD prevention

Prevention of MSD was noted to be rarely incorporated into companies' management systems (Caroly et al., 2010). When considering MSD prevention and ergonomics activities within OHSMS and IMS, Matias and Coelho (2002) proposed that the benefits of incorporating different management systems could be enhanced by the integration of ergonomics into these management systems. Lewandowski (2000) highlighted the importance of integrating ergonomics as a general concept into a total quality management system. He suggested that to achieve the effects of constant improvement in OHS and quality, ergonomics must be

considered in management processes. Theoretical work has also identified the incorporation of ergonomics aspects into design as a useful prevention strategy (Imbeau et al., 2001). Munck-Ulfsfält et al. (2003) suggested that ergonomics is not a separate entity, but a strategy. The authors suggested that the involvement of managers and other employees in ergonomic work was much easier when they saw the link with the KLE strategy. KLE in Swedish stands for Quality, Delivery Precision, and Economy (Munck-Ulfsfält et al., 2003). The KLE strategy introduced quality as a priority and that everything should be done properly from the beginning. The authors argued that employing ergonomics in work position, job stages, ways of stacking and sorting materials, equipment, and work technique would automatically lead to better product quality. The authors used the term "ergonomics" in its broader sense, but the consequences of poor ergonomics at work such as injury (including MSD), cost, and absenteeism were addressed (Munck-Ulfsfält et al., 2003). In addition, Caroly et al. (2010) suggested that the integration of quality, ergonomics, productivity, and safety depends on a policy based on integration and involvement of all stakeholders. A collective approach was also promoted to enhance the assessment of actions and tackle operational problems (Caroly et al., 2010).

Lee (2005) speculated as to why the promotion of ergonomics has not had more success. One of the main reasons he advances is that instead of promoting the discipline's methods as "everybody's tool", ergonomists have kept the tools to themselves. Another reason proposed is the lack of an effective way to use ergonomics in management systems. Common objectives of ergonomics and quality, health and safety management systems as well as other effects of ergonomics in productivity and quality argue for its integration.

Most of the case studies have been published in conference proceedings, but the literature is still

not conclusive on organizations' experiences with these techniques. The following three studies presented three different strategies to prevent MSD. The first example was the integration of ergonomics into an overall QMS. Cocianni and Williamson (2008) presented a methodology for the practical involvement of ergonomics in mobile pumping and coiled tubing equipment and operations as a part of an overall QMS. Implementing this multi-step methodology was reported to have resulted in positive outcomes. The authors concluded that ergonomics must be included as an integral part of the design of new equipment. They suggested that engineered solutions to design oilfield equipment, including ergonomics, would contribute to the overall QMS of an oilfield services company. However, the authors did not provide more information about how the integration of this method to QMS has been accomplished. The authors used the term "ergonomics" in its broader sense, but the prevention of injuries was also discussed as a consequence of poor ergonomics in the workplace. The second example described the development of a stand-alone program (Murphy and Mitchell 2002). This multi-component approach formed a continuous process and was designed for the health care sector. This method had a systematic approach that could be integrated into a management system, however, the authors aimed to develop a self-sustainable program rather than an integrated approach. The third example described integrating MSD prevention into the general management structure of a company. Cohen (1997) described a program developed by an electronic manufacturer in California, USA. The program was implemented by four different sub-committees working under a larger committee and was managed through the company's management structure. The program was said to be successful.

### 3.4. Theme 4: Risk assessment tools within management systems

The risk management process in all management systems is similar. It involves: a) hazard identification; b) risk assessment and analysis; and c) determining the control actions. Our analysis suggests that the literature is very small on the topic of management systems and MSD, and it was unclear how the integration of MSD risk assessment could be achieved with different risk assessment approaches commonly employed for assessing other types of risk factors. However, some authors suggested various approaches. A risk matrix developed by Labodova (2004) was based on a common scale of financial acceptability to compare levels in different areas (quality, environmental, health and safety) in the IMS and was the result of top management decisions. The risk matrix is noted to be an element of the risk analysis based approach which described to be the combination of risk analysis and PDCA approach. Shen and Walker (2001) suggested a mechanism to integrate risk management process. The mechanism is similar to risk assessment process outlined in management system frameworks and includes: a) baseline assessment of risk factors and strategy planning to overcome these risks; b) identification and assessment of risks; and c) control of risk. The authors argued that since this process is similar for quality, health & safety, and environmental issues, the risk management process can be integrated. They reported that this method enhanced workers' involvement and increased their awareness of integration of these systems. It was also suggested that the integration could be achieved by using different methods and tools, but this was not elaborated on further.

Tixier and colleagues (2002) conducted a review of 62 risk analysis methodologies which were used to manage risks. They grouped risk assessment methodologies into three different phases, including: a) identification to identify workplace hazards; b) evaluation to assess risk factors;

and c) hierarchisation to prioritize risk factors, often based on their severity and frequency. The authors described these methodologies based on three main themes: a) types of methods (deterministic, probabilistic, qualitative, and quantitative); b) types of input data (i.e., plans or diagrams, substances, probability and frequency, and policy and management); c) types of output data such as management actions, lists of errors and hazards, probabilities related to error and accident frequency, and hierarchisation related to level of the risk. Authors noted that all risk assessment methodologies may not necessarily contain these three phases, and that these phases are important in management of risk in any systematic approach to control health and safety risk factors in the workplace. They concluded that taking all risks into account is challenging. Authors suggested the disconnection of human risk factor analyses from classical methods. They reported that this might be due to the complexity of human risk analysis. Their review suggested that there was no unique method to accomplish all risk analyses, and a combinatory methodology should be applied (Tixier et al., 2002). The review didn't address the implementation of these methodologies within a management system. However, most of the methodologies described can be used within any management system and have been widely used to address health, safety, environment, and quality risk factors. This review could assist health and safety specialists to select the appropriate risk assessment to use within IMS, but it is silent on how this integration could be done.

With respect to MSD prevention, Matias and Coelho (2002) argued that integration of MSD prevention into management systems requires harmonized tools, approaches, and concepts to match other methods used in management systems. To do so, it is necessary to acknowledge that there are specific techniques and approaches that organizations use to manage quality and other aspects of health, safety and environment. Lee (2005) suggested that it is important to

make ergonomics an “everyday tool” in workplaces and in design departments. The author used the term “ergonomics” in its wider definition.

There is a lack of information on tools and methods that could be used for integration of MSD prevention into management system frameworks. A promising exception was Shephard et al. (2003) who developed an Ergonomic Failure Mode and Effects Analysis (E-FMEA). FMEA has been widely used by quality, and health and safety practitioners worldwide to assess different types of risk factors. This is one of the rare attempts identified in this search that provided a detailed description of a way to harmonize ergonomic assessments with common risk assessment methods.

### 3.5. Theme 5: Continuous improvement and MSD prevention

As continuous improvement is the main feature of any management system, integration of any prevention activities within an organization’s management system can benefit from this. However, only few studies discussed this phenomenon with respect to integration of MSD prevention activities into organizations’ management systems. Caroly et al. (2010) examined how a “safety and production logic” approach could be integrated into a “continuous improvement” system for the sustainable prevention of MSD. The authors tried to address the ways that companies overcame MSD problems through management, based on what they called a dual logic of safety and production. As defined by them, the continuous improvement process initially aims to control production costs and quality by optimizing information, physical flow and products. Management system standard frameworks use this approach based on the PDCA model to continuously improve quality, health and safety, environment, and production. The authors proposed that implementing continuous improvement creates the opportunity to link

production management and prevention management. They also suggested that the integration of quality, ergonomics, productivity, and safety depends on policies, involvement of all stakeholders, and a collective approach that encourages assessment of actions and dealing with operational problems (Caroly et al., 2010). Such integration has been reported to result in continuous improvement and better and sustainable prevention of injuries. Badri and colleagues (2012) reported that attempts were underway to integrate OHS through timely intervention within a framework of continuous improvement.

A different approach was taken by Nastasia, Toulouse and Imbeau (2006) who performed a study to integrate ergonomics into continuous improvement methodologies such as Kaizen. This Japanese inspired approach aims to help businesses make low-cost changes with the assistance of a multidisciplinary team within the organization. They highlighted the importance of addressing MSD and OHS problems in a productive and efficient process. However, they found it difficult to integrate OHS into Kaizen. Authors concluded that accounting for the company's culture and context could facilitate this integration, and the success of integration might be closely related to the culture of the enterprise. The authors also noted that the integration of ergonomics was influenced by: a) the workers' involvement in the improvement process, and b) the company experience with continuous improvement. In a related study, Nunes and Machado (2007) emphasized on the importance of merging ergonomics principles into Lean manufacturing. They suggested that using computer-based tools such as Ergonomic CAD applications and Data Dependent System (DDS) might help to improve the identification of the MSD risk factors in the workplace. The authors did not report how these tools could be used in parallel with other hazard identification methods.

## 4. Discussion

A major theme in the review was workers' involvement or participatory approaches within IMS. PE as an approach frequently advocated for MSD prevention. The term appears to have originated with Noro and Kogi in 1983 (Motamedzade et al., 2003). Early literature promoted it simply as a good way to get ergonomics implemented (Noro and Imada, 1991). In a similar vein, PE has been described as "practical ergonomics", a way to improve problem solving (Kuorinka, 1997). Many PE approaches have since been reported in the literature over the last three decades (Nagamachi, 1995; Kuorinka, 1997; Laing et al., 2005; Driessen et al., 2010), with several taxonomies proposed (Haims and Carayon, 1998; Cole et al., 2009). However, there is no general definition of the term PE (Haines and Wilson, 1998), and mention of the relationship of PE activities to management systems is rare.

A main feature of the PE approach is an "ergonomics" team. This may consist of an employee representative, manager, and technical person such as an ergonomist or health and safety personnel (Rivilis et al., 2006). Ideally, this approach actively involves workers in managing their work activities to decrease exposure to psychological, physical, and/or work organizational risk factors for MSD (Westgaard, 1999; Wilson and Haines, 1997). Risk assessment, later stages of solution generation or interventions, and the process of implementation were shown to be enhanced by using a PE approach. Nagamachi (1995) reported that PE promoted the workers' acceptance of interventions, because they had participated in the redesign and the reforming of their organization. Rivilis and colleagues noted that partial to moderate evidence existed that PE interventions had a positive impact on health outcomes in some cases (Rivilis et al., 2006).

Another theme identified in the review was the prevention of MSD within management systems. As Caroly et al. (2010) noted, the integration of MSD into management systems would

result in better prevention within a continuous improvement approach. Others supporting this idea included Lewandowski (2000) and Matias and Coelho (2002). As brought up by (Hendrick and Kleiner, 2002) and Lee (2005), micro-ergonomics approaches (vs. macro-ergonomics approaches) only addressed MSD prevention at the department level and didn't promote ergonomics as a part of "everybody's tool". This may be why promotion of ergonomics has not had more success. It was suggested that this integration might also contribute to the overall QMS (Cocianni & Williamson, 2008). More benefits can be achieved by integrating MSD prevention into design process (Imbeau et al., 2001; Hendrick & Kleiner, 2002). Studies of the sources of workplace risk factors have shown that critical decisions made during the design of products, facilities, and work routines all contribute to the eventual presence of MSD hazards in those workplaces (e.g. Neumann, 2012; Neumann et al., 2006, Neumann and Wells, 2008). From a design science perspective, changes to a design become progressively more difficult and expensive to make as the design process proceeds (e.g. Neumann, 2004).

The further theme involved hazard identification and assessment. As hazard identification and risk assessment are crucial and are required in management systems, using comparable assessment techniques for all types of hazards appears to be challenging (Fera and Macchiaroli, 2010; Tixier et al., 2002). Methods introduced in Tixier et al. (2002) would potentially be used to analyze different types of risk factors. Beside this, ISO 31010 was published in 2009 to introduce general guidance on the implementation of risk management across many industries and types of systems. This standard focused on management of risk within organizations and can be used for all risk categories such as quality, environment, health and safety. Techniques such as HAZard and OPerability (HAZOP), Layer of Protection Analysis (LOPA), and Failure Mode and Effects Analysis (FMEA) are examples of techniques described by ISO 31010 that

have been widely used by health and safety as well as quality practitioners. Although ISO 31010 introduced many qualitative and quantitative tools that could be used to assess workplace risk factors, integrating MSD prevention into FMEA (Shephard et al., 2003) and CAD software (Chaffin, 2005) were the only attempts to describe the integration of MSD prevention into risk assessment approaches used by other disciplines. The report by Lin et al. (2012) attempted to integrate human factors into FMEA. This approach took ergonomic assessment methods directly to the people who (engineers) arguably should be using them by incorporating them directly into their tools and methods.

Hazard identification and risk assessment are also prominent in ergonomics programs for the prevention of MSD. Although there is general consensus on the necessity for this element, there appears to be few general tools and a multitude of specific methods are described in the ergonomics literature to identify and assess MSD hazards (Fallentin et al., 2001; Dempsey et al., 2005; Takala et al., 2010). An issue relevant to training brought up in Fallentin et al's (2001) and Takala et al's (2010) reviews was the lack of information on the education and training required to use any of these methods effectively. They noted that the majority of the tools were not particularly user friendly, and that most of them targeted highly skilled workers, specialists, and experts. This would tend to make the proposed tools more difficult to use in most organizations' risk assessment processes.

The research question grew out of the notion that integration of MSD prevention into OHSM could be desirable. The effectiveness of an OHSMS itself in improving health and safety performance is a pre-requisite to pursuing this goal. Robson et al. (2007) conducted a systematic review study on the effectiveness of mandatory and voluntary OHSMS interventions. They found that OHSMS interventions were, generally effective in managing health and safety

related issues. However, they were concerned that studies in the literature had a number of methodological limitations. Nonetheless, as described above, attempts to integrate MSD prevention into management systems appear to be beneficial for preventing injuries (Caroly et al., 2010; Lewandowski, 2000; Matias and Coelho, 2002; Lee, 2005). For instance, Bunn et al. (2001) reported a 24% decrease in illness or injury frequency, and a 34% decrease in lost-time case rate over three years as a result of voluntary OHSMS. Likewise, research by Yassi (1998) and Alsop & LeCouteur (1999) indicated a 25% and 52% drop in premium rate of workers' compensation cost respectively. In addition, the literature suggested that the successful implementation of OHSMS can be done in medium and small sized enterprises as well as in large organizations and can result in safer work environments (Arocena and Nunez, 2010). The study had a number of limitations. It is possible that the studies describing the integration of MSD prevention into management systems used different terminology and were therefore excluded from this review. However, the authors employed multiple search terms commonly used in the MSD prevention literature. In addition, the type of risk factors was not restricted in the search terms. Most of the papers focused on MSD physical risk factors, and none of the papers discussed psychosocial risk factors for MSD prevention or the integration of approaches and techniques to address these risk factors within a management system framework. Also, organizations may not publish details of their approaches to integrate MSD prevention activities into their management system in the peer-reviewed literature. We might not have therefore located information on the topic through the literature search approach described. The literature searched was not irrelevant however, as in our experience many professional ergonomists use this literature to help inform their practice of MSD prevention. A different approach would be required to access the information located within organizations.

The number of published studies found in this review was small. However, there was support for integrating MSD prevention into OHSMS and IMS. Such a practice may not only promote health and safety in general, but more importantly, have the potential to improve the prevention of MSD. This integration would help avoid OHS and MSD prevention becoming a "sidecar" function (Neumann and Dul, 2010), thus reducing the effectiveness of MSD prevention activities.

## 5. Conclusion

There was little information on the integration of MSD prevention into management systems in the peer-reviewed literature. The small literature did however indicate that incorporating MSD prevention into organizational level approaches could improve production in addition to preserving workers' health in workplaces. The high prevalence of MSD within workplaces may be due to the fact that MSD hazards are not being addressed as effectively as they should be, because MSD hazard assessment and risk prevention are partially outside of the main management processes. For these reasons, information concerning MSD hazards may not be "on-the-table", and thus, may not receive adequate attention. Bringing ergonomics as a means of preventing MSD into organizations' management systems appears to be highly desirable. Based on the scoping review of the limited literature available, it seems that a full systematic review is possible. The findings of this review argue for further research to integrate MSD prevention into management systems and to evaluate the effectiveness of the approach.

# CHAPTER III: How Compatible are Participatory Ergonomics Programs with Occupational Health and Safety Management Systems?

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## 1. Introduction:

Employers have a duty to anticipate, assess, and control a wide range of hazards in order to protect the health and safety of their workers. Many organizations have a business framework that they use to structure their prevention activities. If formalized, it could be considered an occupational health and safety management system (OHSMS). Musculoskeletal disorders (MSD) are a major cause of pain, disability, and costs to workers, employers, and society. It might be expected that MSD prevention activities would draw on methods and approaches like the OHSMS. A scoping review (Chapter II), however, found there was little information on how MSD prevention activities might be implemented within an OHSMS. Instead, MSD prevention was often described in terms of implementing a stand-alone ergonomics program, often a participatory ergonomics (PE) program. It was unclear what challenges and barriers might exist when integrating MSD prevention into an OHSMS.

There is evidence of the effectiveness of both approaches. Robson and colleagues (2007) conducted a systematic review of the effectiveness of mandatory and voluntary OHSMS interventions. They found that OHSMS interventions, in general, were effective in managing health and safety related issues. With respect to the effectiveness of PE programs, the systematic review of Rivilis and colleagues (2008) concluded there was partial-to-moderate evidence that PE interventions have a positive impact on musculoskeletal symptoms, reducing injuries and workers' compensation claims, and a reduction in lost days from work or sickness absence.

As part of a larger project on MSD prevention within management systems, the scoping review study (Chapter II) found little information on how MSD prevention might fit into an OHSMS. Given this absence of information, the goal of this study was to assess the compatibility of elements described in well-cited PE program literature – representing common practice in PE – with the requirements of an OHSMS. Specifically, this paper addresses the question: What are the similarities and differences

between an OHSMS framework and PE?

### 1.1. Occupational health and safety management system

An OHSMS is a formalized framework for organizations to manage the health and safety of workers (Rivilis et al., 2008). A variety of OHSMS frameworks and guidelines have been developed [eg, the Occupational Health and Safety Assessment Series (OHSAS 18001), British Standard (BS 8800), International Labor Organization guidelines (ILO, 2001)]. OHSAS 18001 was developed in response to demands from organizations to assess their management systems against a recognizable OHSMS standard. Some countries, like Canada, have developed management system standards for occupational health and safety (OHS) that closely parallel the frameworks described above (CSA, Z1000-6). In Europe, the "OSH Framework Directive" (European Council Directive 89/391/EEC of June 1989, cited 2014) was developed to introduce measures to encourage improvements in the safety and health of workers at work. The Directive contains basic obligations for employers and workers to ensure the health and safety of workers. The directive includes general principles of prevention such as evaluating risks, adapting the work to the individual, adapting to technical progress, developing a coherent overall prevention policy, and prioritizing collective protective measures (European Council Directive 89/391/EEC of June 1989, cited 2014). This framework has been implemented in some European countries such as Sweden.

The main characteristics of proactive OHS management systems that distinguish them from traditional OHS programs are their ability to be integrated into an organization's other systems, such as quality management, and the incorporation continuous improvement elements (Robson et al., 2007). Such management systems are generally based on the Plan-Do-Check-Act model (Deming, 1986) of continuous improvement.

### 1.2. Participatory ergonomics

PE is an approach frequently advocated for MSD prevention and has been described simply as "practical ergonomics" or a way to improve problem solving. A myriad of PE approaches have been reported in the literature under multiple taxonomies (Vink et al., 1995; Bohr, Evanoff, & Wolf, 1997; Wilson & Haines, 1997; St-Vincent et al., 1997; Haims & Carayon, 1998; Haslam, 2002; Malchaire, 2004; Laing et al., 2005; Cole et al; 2009). The term "ergonomics program" or "participative ergonomics program" is often used synonymously with MSD prevention. Unless quoting from papers, the specific term, MSD prevention, will be used. It is however noted that participation in ergonomics activities has been reported as an approach in the design process and health and safety activities, as well as in prevention in general. This paper is restricted to health and safety activities only.

## 2. Methods

In order to assess the compatibility of PE programs with OHSMS, it is necessary to describe each approach explicitly. For this purpose, OHSAS 18001 was selected as it represents an internationally recognized, well-practiced approach to the management of health and safety in organizations.

### 2.1.Explicit definition of PE programs

A universally accepted definition of PE is not known. Programs or processes are frequently described whereby cross-functional teams, with representation from stakeholders (eg, workers, management, and engineers) are recruited, trained in ergonomics, perform observations and analyses, and then suggest solutions. However, details and components differ considerably in the literature. Rather than selecting just one of the many definitions, a composite definition based upon the most frequently cited PE papers in the literature was developed. Publications included in a recent systematic review conducted

by Van Eerd et al. (2010) were reviewed. Van Eerd and colleagues (2010) sought literature that addressed context, barriers, and facilitators to the implementation of PE interventions in the workplace (Van Eerd et al., 2010). They systematically searched multiple electronic databases including MEDLINE, EMBASE, CINHAL, Business Source Premier, Risk Abstracts, CCINFOWeb, Ergonomics Abstracts Online, Scopus, ProQuest Digital Dissertations, Foreign Doctoral Dissertation, Index to Theses (Great Britain and Ireland), IDEAS and Canadian Institute for Scientific Information catalogue, Conference Papers Index, ISI Proceedings, PapersFirst, and ProceedingsFirst. They also searched relevant conference proceedings and reference lists. The authors included PE approaches that had attempted to improve workers' health by changing work processes, work tools and equipment, and/or work and workplace organizations. Fifty-two documents (33 peer reviewed and 19 gray literature) met their review criteria (Van Eerd et al., 2010). The authors used a large number of search terms in four broad areas including participation, ergonomics, intervention, and health outcome. The full list of search terms is available in Van Eerd et al. (2010). The selected papers were from multiple jurisdictions, but mainly Europe, Canada and the US.

Then, Web of Science citation report tool was used to determine the total number of citations and average citations per year of each paper. This was performed in August 2012 and updated in October 2013. Papers with ≥10 citations since publication and an average citation rate of ≥1 citations per year were designated as "well-cited" and used as the basis for an inclusive definition of PE.

### 2.2.Framework for comparing OHSMS and PE

For OHSAS 18001, a verbatim description of each element of an OHSMS was created from the document for short clauses. For longer clauses, the main ideas were summarized. These elements provided the headings by which the PE papers were analyzed. Two researchers read each well-cited

paper on PE that met our inclusion criteria. Any text in each paper that was related to the elements of OHSAS 18001 was transcribed verbatim into an Excel spreadsheet. A content analysis approach was used to analyze the data extracted from the PE articles. Themes within each element were identified and papers contributing to that theme were noted. Topics related to the establishment and management of PE programs that did not fit into the OHSAS 18001 elements were also noted.

## 3. Results

Of the 52 articles reviewed by Van Eerd et al. (2010), 20 articles met the criteria for selection as a well-cited article (table 1). A total of 21 elements were identified within OHSAS 18001 (table 2). The results are presented according to these OHSMS elements.

### 3.1.Scope

This element describes the scope of the OHSMS: enabling an organization to control its OHS risks and improve OHS performance. An OHSMS is intended to be applicable to any organization and address OHS issues. The PE programs described in well-cited articles were generally implemented at a department level within workplaces, but there was no information about the possibility of implementing a PE program within the entire workplace.

One article suggested that the scope of the "project" was identified after discussion of a number of trades and job tasks on the construction site (Hess et al., 2004). The purpose described was to address a specific issue, within a specific workstation or department by a group of researchers, and with the participation of different stakeholders within organizations. There are other examples of this type of strategy in the literature (Vink et al., 1995; Laing et al., 2005; Halpern & Dawson, 1997; Wilson, 1995; Vink, Urlings, & van der Molen., 1997; Rosecrance & Cook, 2000; Laitinen, Saari, & Kuusela., 1997). Interestingly, only one paper implemented an "in-house continuous improvement" PE program

in a public service agency (Haims & Carayon, 1998). This could be considered as the sole attempt to enable an organization to control MSD risk factors within a continuous improvement framework.

**Table 1. The total citations and average citations per year for the selected participatory ergonomics papers [a].**

| Study | Year | Jurisdiction | Industry [b] | Total Citation | Average Citations/year |
|---|---|---|---|---|---|
| Vink et al | 1995 | Netherlands | Public Administration | **40** | **2.11** |
| Wilson | 1995 | UK | Manufacturing | **26** | **1.37** |
| Westlander | 1995 | Sweden | Wholesale Trade, Public Administration | **18** | **0.95** |
| Bohr et al | 1997 | USA | Health Care and Social Assistance | **31** | **1.82** |
| Halpern & Dawson | 1997 | Western USA | Manufacturing | **30** | **1.76** |
| Vink et al | 1997 | Netherlands | Construction | **21** | **1.24** |
| Laitinen et al | 1997 | Finland | Manufacturing | **19** | **1.22** |
| Haims & Carayon | 1998 | Wisconsin, USA | Public Administration | **38** | **2.38** |
| Rosecrance & Cook | 2000 | USA | Manufacturing, Information and Cultural Industries | **26** | **1.86** |
| Loisel et al | 2001 | Quebec, Canada | Manufacturing, Health Care and Social Assistance, Other Services (except Public Administration) | **56** | **4.31** |
| de Looze et al | 2001 | Netherlands | Manufacturing | **25** | **1.92** |
| de Jong & Vink | 2002 | Netherlands | Construction | **34** | **2.83** |
| Anema et al | 2003 | Netherlands | Manufacturing, Health Care and Social Assistance, Accommodation and food Services, Other Services (except Public Administration) | **39** | **3.55** |
| Hess et al | 2004 | NR | Not Reported | **24** | **2.40** |
| Laing et al | 2005 | Ontario, Canada | Manufacturing | **29** | **2.89** |
| Lavoie-Tremblay | 2005 | Quebec, Canada | Construction, Health Care and Social Assistance | **22** | **2.44** |
| van der Molen | 2005 | Netherlands | Construction | **19** | **2.11** |
| Polanyi | 2005 | Ontario, Canada | Information and Cultural Industries | **11** | **1.22** |
| Rivilis et al | 2006 | Ontario, Canada | Other Services (except Public Administration) | **24** | **3.00** |
| Burgess-Limerick et al | 2007 | Australia | Mining and Oil and Gas Extraction | **10** | **1.43** |

[a] The total number of citations and the average citations per year of each paper were obtained from the Web of Science citation report tool in August 2012, updated in October 2013.
[b] The industry type was extracted from a table presented by Van Eerd et al. (2010).

**Table 2. Descriptions of elements of occupational health and safety management system based on the Occupational Health and Safety Assessment Series (OHSAS 18001). [OHS=occupational health & safety; OHSMS=occupational health and safety management system.]**

| OHSAS Clause number | OHSMS elements | Description |
|---|---|---|
| 1 | Scope | The scope is enabling an organization of any size and sector to control its OHS risks and improves its OHS performance. |
| 4.1 | OHSMS requirements-General | The organization shall establish, document, implement, maintain and continually improve an OHSMS. |
| 4.2 | OHSMS requirements- OHS Policy | The organization's top management shall define and authorize the organization's OHS policy and outline specific necessities for the organization's policy. |
| 4.3.1 | Hazard identification, risk assessment and determining controls | The organization shall establish, implement and maintain a procedure(s) for the ongoing hazard identification, risk assessment, and determining of necessary controls. |
| 4.3.2 | Legal and other requirements | The organization shall establish, implement and maintain an up to date procedure(s) for identifying the legal and other OHS requirements that are applicable to it. |
| 4.3.3 | Objectives and programme(s) | The organization shall establish, implement and maintain documented and measurable OHS objectives, at relevant functions and levels within the organizations. |
| 4.4.1 | Resources, roles, responsibility, accountability, and authority | Top management shall take ultimate responsibility for OHSMS and demonstrate its commitment by ensuring available resources, defining roles, allocating responsibilities and accountabilities, and delegating authorities. |
| 4.4.2 | Competence, training and awareness | The organization shall ensure that any person(s) under its control performing tasks that can impact OHS are competent on the basis of appropriate education, training or experience. |
| 4.4.3.1 | Communication | The organization shall establish, implement and maintain a procedure(s) for communication with relevant parties with regards to its H&S hazards and OHSMS. |
| 4.4.3.2 | Participation and consultation | Appropriate involvement of workers in risk assessment and determining of controls, accident investigation, development and review of OHS policies and objectives shall be established, implemented and maintained by necessary procedure(s). |
| 4.4.4 | Documentation | The OHSAS 18001 suggests a set of documentation including policy, objectives, description of the scope of the OHSMS, main elements of the OHSMS, and OHSMS records. |
| 4.4.5 | Control of documents | OHSMS documents need to be controlled by establishing, implementing and maintaining required procedure(s). |
| 4.4.6 | Operational control | Then the organization shall implement and maintain operational controls for those activities, controls related to purchased goods and equipment, controls related to contractors, etc. |
| 4.4.7 | Emergency preparedness and response | A procedure(s) to address potential emergency situations and respond to such situations shall be established, implemented and maintained. |
| 4.5.1 | Performance measurement and monitoring | OHS performance shall be monitored, measured, and shall provide for quantitative and qualitative measures, monitoring the organization's OHS objectives, and effectiveness of controls, proactive measures of performance. |
| 4.5.2 | Evaluation of compliance | Compliance with applicable legal and other subscribed requirements shall be periodically evaluated and the organization shall establish, implement and maintain a procedure(s) for this matter. |
| 4.5.3.1 | Incident investigation | The organization shall establish, implement and maintain a procedure(s) to record, investigate and analyze incidents in order to determine OHS deficiencies and other causal factors. |
| 4.5.3.2 | Non-conformity, corrective action and preventive action | In order to deal with actual and potential non-conformity (ies) and for taking corrective action and prevention action, the organization shall establish, implement and maintain a procedure(s). |
| 4.5.4 | Control of records | In order to demonstrate conformity to its OHSMS and OHSAS 18001 requirements, the records shall be established and maintained. |
| 4.5.5 | Internal audit | The organization shall ensure internal audits of the OHSMS are conducted at planned intervals with respect to specific criteria. |
| 4.6 | Management review | Top management shall review the organization's OHSMS, at planned intervals, to ensure its continuing suitability, adequacy and effectiveness. |

### 3.2. OHSMS requirements (general)

None of the papers addressed this element. There were no recommendations regarding how organizations could maintain, and, more importantly, continuously improve their MSD prevention activities. There was no indication of requirements to be followed and the only indication of continuous improvement, as one of the main requirements of OHSMS, was seen in the article (Haims & Carayon, 1998) noted in the previous section.

### 3.3. OHSMS requirements (OHS policy)

With respect to policy, only one paper reported that the company's health, safety and environment manager drafted the "Ergonomic Policy", which was then revised by the joint labor-management committee (Polanyi et al., 2005).

### 3.4. Hazard identification, risk assessment, and determining controls

This element was extensively described in most of the PE papers. Authors used one, or a combination of techniques. Table 3 summarizes the techniques and approaches reported in the well-cited papers to identify and control MSD risk factors.

### 3.5. Objectives and program(s)

Few of the papers partially addressed objectives, while apparently, in most of the PE papers, researchers determined the objective before the start of the project (Bohr, Evanoff, & Wolf, 1997). The objectives could be determined by having a group of stakeholders from different departments identify areas that require ergonomic improvement (Laing et al., 2005; Loisel et al., 2001), define a mission statement (Laing et al., 2005), followed by setting a timetable and appointing a person to oversee the

**Table 3. Hazard identification, risk assessment and determining controls.**

| Study | Year | Hazard ID | Prioritization of risks and control actions | Determining controls |
|---|---|---|---|---|
| Vink et al | 1995 | Questionnaires<br>Checklists<br>Observation<br>WEBA-analysis for the most performed jobs and those with largest problems | Not Reported | Not Reported |
| Wilson | 1995 | Questionnaires<br>Observation of work task<br>Direct observation<br>Production records<br>Archive analysis on sickness<br>RULA<br>Body part discomfort technique<br>Rating scales | Costs<br>Technical feasibility | Brainstorming meetings with workers and supervisors<br>Cost consideration through discussion of control actions with management |
| Westlander | 1995 | Not Reported | Not Reported | Cost consideration prior to discussion of control actions with management<br>Categorizing proposed improvement into two groups: “expense-free” and “expense-incurring”. |
| Bohr et al | 1997 | Basic level of technical information | Not Reported | Not Reported |
| Halpern & Dawson | 1997 | Video taping<br>OSHA 200 logs<br>Compensation claims | Not Reported | Control strategies were translated into process improvement plans and prototype workstation mock-ups |
| Vink et al | 1997 | Checklists | The degree of hazard (smallest vs largest | Feedback provided by workers and experts<br>Solution rating process |
| Laitinen et al | 1997 | Checklists<br>Observation | Not Reported | Not Reported |
| Haims & Carayon | 1998 | Ergonomics Coordinator Survey | Severity of the ergonomic problems | Not Reported |
| Rosecrance & Cook | 2000 | Questionnaires<br>Observation<br>OSHA 200 logs<br>Self-reported symptom survey<br>Job factors surveys<br>Several other qualitative and quantitative tools | Mechanism driven by number of injuries for prioritization | Ergonomic process and involvement of workers<br>Implementing “quick fixes” without a detailed analysis<br>For implementing more complex solutions, a more formal process is required that can guarantee appropriate resources for implementation |
| Loisel et al | 2001 | Meeting with stakeholders<br>Observation<br>Video taping<br>Interviewing workers and other stakeholders | Not Reported | Suggestions for improvement for hazardous tasks be made by an ergonomist |
| de Looze et al | 2001 | Meeting with stakeholders<br>Work condition survey in pre-intervention stage | Not Reported | Meetings with stakeholders |
| de Jong & Vink | 2002 | Questionnaires<br>Interviewing workers and other stakeholders<br>Previous analysis and risk inventories | Questionnaire | Solution sessions with the use of videotapes and slides<br>Contribution to productivity increase<br>Contribution to health problems<br>Consequence for company<br>Availability |
| Anema et al | 2003 | Checklists<br>Observation of work task<br>Direct observation<br>Interviewing workers and other stakeholders | Frequency and severity of each problem<br>Feasibility and solving capability | Brainstorming meetings with workers and supervisors |
| Hess et al | 2004 | Meeting with stakeholders<br>Focus group<br>Technical measures | Not Reported | Meetings with stakeholders<br>Focus group |
| Laing et al | 2005 | NIOSH load lifting equation<br>Snook and Ciriello manual material handling table<br>Survey on psychosocial factors<br>Basic physical demand analysis<br>Pain, symptom survey | Not Reported | Not Reported |
| Lavoie-Tremblay | 2005 | Questionnaires<br>Focus group<br>Anonymous comments collected in a box | Team meetings | Meetings with stakeholders |
| van der Molen | 2005 | Meeting with stakeholders | Not Reported | Meetings with stakeholders |
| Polanyi | 2005 | Not Reported | Not Reported | Not Reported |
| Rivilis et al | 2006 | Not Reported | Not Reported | Not Reported |
| Burgess-Limerick et al | 2007 | Simplified version of Manual Tasks Risk Assessment tool measure | Hierarchy of controls strategies | Risk control evaluation |

*Described a risk management cycle which is very similar with OHSAS 18001 approach including hazard identification, risk assessment; risk control and evaluation followed by hierarchy of controls strategies as an underlying principle.

follow-up. As reported in well-cited PE papers, proposed solutions should then be presented to the employer for final review and acceptance (Loisel et al., 2001). In one paper, a "commitment contract" was used to indicate the objectives and time frame of the action plans (Lavoie-Tremblay et al., 2005). Similarly, another paper indicated that stakeholders should come to agreement on details about responsibilities and timelines, and then an ergonomist should contact the employer to arrange the implementation (Anema et al., 2003). One paper used a "product sheet" and an "ideas' book", followed by a meeting with management and health and safety specialists to determine the objectives (de Jong & Vink, 2002). Another paper suggested the company's health, safety and environment manager draft the objectives which the joint labor-management committee would then revise (Polanyi et al., 2005). The reviewed articles implied that PE is a project- or intervention-based, relatively short-term process, and may not include continuous improvement.

### 3.6. Resources, roles, responsibility, accountability, and authority

This element of OHSMS was partially addressed in many of the well-cited papers. The most common statement was that management commitment is required for the program to be effective (Burgess-Limerick et al., 2007). With respect to resources, it was suggested that appropriate and adequate resources should be supplied to implement the PE program (Bohr, Evanoff, & Wolf, 1997; Laing et al., 2005) and that financial commitment should be sought from the organization's chairman (van der Molen et al., 2005). It was also noted that an initial budget was given by management, followed by additional resources allocated by top management upon reviewing a progress report of improvement plans (Halpern & Dawson, 1997).

It was suggested that the president of the company (de Jong & Vink, 2002) or a management representative appointed by top management (Halpern & Dawson, 1997) should lead the program or

that an ergonomist should seek responsible parties for adjustment in the workplace (Anema et al., 2003). A commitment contract (Lavoie-Tremblay et al., 2005) or agreement (Laing et al., 2005, Loisel et al., 2001) was used to determine the roles and responsibilities of different stakeholders in the PE program, and involvement of individuals was voluntary (Rivilis et al., 2006). It was reported that working hours and personnel resources were made available after senior management became interested in the project (Westlander et al., 1995). It was also reported that the company's health, safety and environment manager drafted responsibilities which the joint labor-management committee then revised (Polanyi et al., 2005).

### 3.7. Competence, training and awareness

Training was regarded as a key element of PE approaches. One paper stated that training should focus on the development of effective skills for working as a group (Bohr, Evanoff, & Wolf, 1997). The duration of training in PE programs varied from a single training session (Bohr, Evanoff, & Wolf, 1997; Laitinen, Saari, & Kuusela., 1997) to two sessions (Loisel et al., 2001, Westlander et al., 1995), from 20 hours of training (Rosecrance and Cook, 2000) to a series of training sessions (Laing et al., 2005, Burgess-Limerick et al., 2007; Rivilis et al., 2006). The training was conducted through seminars (Halpern & Dawson, 1997; Laitinen, Saari, & Kuusela., 1997), workshops (Burgess-Limerick et al., 2007; Westlander et al., 1995), or during what was termed the "main meeting" (Vink, Urlings, & van der Molen., 1997). The training could then be followed by awareness education for other employees (Halpern & Dawson, 1997). Polanyi et al. (2005) reported that the comprehensive education and training program was conducted as part of a "Stop Repetitive Strain Injury (RSI)" program and was reviewed on a regular basis.

With respect to training content, authors indicated this included: an overview of ergonomics

terminology (Bohr, Evanoff, & Wolf, 1997), MSD risk factors and task analysis processes (Bohr, Evanoff, & Wolf, 1997; Polanyi et al., 2005; Burgess-Limerick et al., 2007), use of techniques and a PE program description (Laing et al., 2005), physical work demand and remedies to control it (van der Molen et al., 2005), the PE process (Loisel et al., 2001, Anema et al., 2003) theory and methods (Anema et al., 2003), mechanism of injury associated with manual tasks (Burgess-Limerick et al., 2007), technical ergonomics for analysis and design committees (Halpern & Dawson, 1997), the importance of hierarchy of controls and general strategies for eliminating and controlling manual tasks injury risk (Bohr, Evanoff, & Wolf, 1997), and information about the PE project to increase awareness thereof (Vink, Urlings, & van der Molen., 1997). However, authors indicated neither how they measured the effectiveness of training provided nor how the training could be sustainable and effective.

### 3.8. Participation and consultation

OHSAS 18001 specifies one of the main elements of an OHSMS is the appropriate involvement of workers in risk assessment and determination of controls, accident investigation, and the development and review of OHS policies and objectives.

With respect to this element, most of the well-cited PE papers discussed their approach of seeking employees' involvement and participation in the ergonomics improvement activities with respect to MSD prevention. Laing et al. (2005) suggested that the involvement of employees is greatly helped by their participation in "ergonomic change teams". Lavoie-Tremblay et al. (2005) suggested that a work team (consisting of different stakeholders) should be set to ensure commitment within the department and the institution. Loisel et al. (2001) indicated that in their approach, the injured worker, employer and union representative were deeply involved in the redesign process. They noted that being injured

should not prevent workers from participating in the work groups (Loisel et al., 2001). Van der Molen et al. (2005) reported that different stakeholders from within an organization and an ergonomics consultant participated in their PE project.

As suggested by some authors, workers could select improvements if they received appropriate training and instruction (Vink et al., 1995) and the participation of trained workers could be achieved by contacting them (Haims & Carayon, 1998). Different stakeholders within an organization could be actively involved in the PE program and have different roles in working groups such as management, worker, health and safety executive, and member of the steering or ad hoc groups that could be involved at different stages of the program (Haims & Carayon, 1998, Wilson, 1995). As described by one of the papers, a group evaluated the improvement ideas suggested by employees and then positively evaluated ideas were added to an "idea's book" (de Jong & Vink, 2002).

Involvement of employees in one study was facilitated by providing information about the project, the outcomes and their likely effects, and then they were asked if they agreed with the changes (De Looze et al., 2001). In another approach it was reported that all employees were involved by completing checklists, developing suggestions for implementation, testing improvements, and giving their preference (Vink, Urlings, & van der Molen., 1997). However, the authors suggested that the steering committee should decide on the feasibility of proposed improvements, by considering costs and benefits before asking employees for their preference (Vink, Urlings, & van der Molen., 1997). In another study, ergonomic meetings were suggested where employees could participate in the PE process (Rosecrance and Cook, 2000). A further study involved employees by having them to complete questionnaires and then seeking their involvement in interventions (Rivilis et al., 2006). It was also noted that one organization encouraged employees' participation by paying overtime for those attending meetings (Burgess-Limerick et al., 2007).

### 3.9. Documentation

The OHSAS 18001 framework provides a list of documentation including policy, objectives, and a description of the scope, main elements, and records that should be available through an OHSMS. Only one paper addressed documentation, where the authors stated that methods of documentation should be provided (Bohr, Evanoff, & Wolf, 1997).

### 3.10. Performance measurement and monitoring

Most of the papers addressed this element. Authors used a variety of techniques to measure the effectiveness of changes (table 4).

### 3.11. Incident investigation

The OHSAS 18001 framework requires that the organization shall establish, implement and maintain a procedure(s) to record, investigate, and analyze incidents in order to determine OHS deficiencies and other causal factors. Only two authors mentioned a mechanism for incident investigation. One reported that methods for calculating job and department level injury incidence and severity rates were introduced (Laing et al., 2005). In addition, a pain survey was introduced. The other collected occupational histories and past histories of MSD of injured workers, descriptions of job tasks, workers' workplace medical files, and description of any past work accidents (Loisel et al., 2001).

### 3.12. Non-conformity, corrective action, and preventive action

According to OHSAS 18001, in order to deal with actual and potential non-conformity(ies) and to take corrective action and prevention action, the organization shall establish, implement, and maintain a procedure(s).

**Table 4. Performance measurement and monitoring**

| Study | Year | Tools |
|---|---|---|
| Vink et al | 1995 | Questionnaires<br>Observational techniques<br>Process evaluation techniques |
| Wilson | 1995 | Not Reported |
| Westlander | 1995 | Questionnaires<br>Interviewing steering committee members and other stakeholders<br>Document (minutes and directives) analysis |
| Bohr et al | 1997 | Survey<br>Team effectiveness indicator<br>- Number of identified problems<br>- Number of solutions that were implemented successfully |
| Halpern & Dawson | 1997 | Not Reported |
| Vink et al | 1997 | Questionnaires |
| Laitinen et al | 1997 | Weekly feedback observation by team |
| Haims & Carayon | 1998 | Research diary |
| Rosecrance & Cook | 2000 | Questionnaires<br>Employees feedback<br>Productivity<br>Committee productivity and participations' feedback<br>Errors and accident rates<br>Employee morale and job satisfaction<br>Quality<br>Illness and injury rates<br>Absenteeism |
| Loisel et al | 2001 | Survey |
| de Looze et al | 2001 | Questionnaires<br>Productivity<br>Interviewing employees |
| de Jong & Vink | 2002 | Questionnaires<br>Interviewing steering committee members and other stakeholders |
| Anema et al | 2003 | Not Reported |
| Hess et al | 2004 | Employees feedback<br>Lumbar Motion Monitor |
| Laing et al | 2005 | Worker perception via "one minute survey"<br>Biomechanical modeling<br>Electromyography<br>Accelerometry<br>Expert opinion of the research group<br>Questionnaires |
| Lavoie-Tremblay | 2005 | Questionnaires |
| van der Molen | 2005 | Specific measurement indicator |
| Polanyi | 2005 | Not Reported |
| Rivilis et al | 2006 | Questionnaires |
| Burgess-Limerick et al | 2007 | Not Reported |

Haims and Carayon (1998) stated that in order to educate workers on solution implementation, the ergonomist should provide information and instruction to workers about the new approach. The supervisors were also informed of the ways that they could encourage and guide the worker in new work situations. Using a similar approach, Vink, Urlings, & van der Molen (1997) reported that

instructional videos were developed, including working methods with reduced physical workload, and employees were informed about new situations. Halpern and Dawson (1997) describe a coordinated effort to translate the intervention and abatement strategies into production design changes: while the maintenance department was implementing changes, the engineering department was incorporating them into its new products and new manufacturing sites (Halpern & Dawson, 1997). Both Laing et al. (2005) and Rosecrance and Cook (2000) had the ergonomic committee test the solutions prior to full-scale implementation. Westlander et al. (1995) stated that the intervention had been scheduled after pre-intervention analysis. The short-term intervention was implemented for current problems, followed by long-term intervention for future problems.

### 3.13. Management review

According to OHSAS 18001, an organization's top management shall review the OHSMS at planned intervals to ensure its continuing suitability, adequacy, and effectiveness.

Only two of the papers mentioned a mechanism for management review. One noted that information directed to middle management and feedback about using ergonomic measures directed towards employees could strengthen the commitment, communication, and support for incorporating the new policy to use ergonomic measures within the company (van der Molen et al., 2005). Another reported that "Breakthrough Thinking" methodology was used to establish purpose, goals, program structure, and plans for the future, one year after the initiation of an Ergonomic Coordinator program (Haims & Carayon, 1998).

### 3.14. Elements not reported

Eight elements of OHSMS based on the OHSAS 18001 framework went unmentioned in the well-

cited PE papers: (i) legal and other requirements; (ii) communication; (iii) control of documents; (iv) operational control; (v) emergency preparedness and response; (vi) evaluation of compliance; (vii) control of records; and (vii) internal audit. A summary of the presence of elements of OHSAS 18001 in the PE articles is shown in table 5. This study did not find concepts within the PE papers that were not addressed in OHSAS 18001's elements.

**Table 5a**. Presence of Occupational Health and Safety Assessment Series (OHSAS 18001) elements in participatory ergonomics articles. [OHS=Occupational health & safety; OHSMS=occupational health and safety management system.]

| Study | Year | Scope | OHSMS General | OHS Policy | Hazard identification, risk assessment & determining controls | Legal and other requirements | Objectives and Programme(s) | Resources, roles, responsibility, accountability and authority |
|---|---|---|---|---|---|---|---|---|
| Vink et al | 1995 | X | | | X | | | |
| Wilson | 1995 | X | | | X | | | |
| Westlander | 1995 | | | | X | | | X |
| Bohr et al | 1997 | | | | X | | X | X |
| Halpern & Dawson | 1997 | X | | | X | | | X |
| Vink et al | 1997 | X | | | X | | | |
| Laitinen et al | 1997 | X | | | X | | | |
| Haims & Carayon, | 1998 | X | X | | X | | | |
| Rosecrance & Cook | 2000 | X | | | X | | | |
| Loisel et al | 2001 | | | | X | | X | X |
| de Looze et al | 2001 | | | | X | | | |
| de Jong & Vink, | 2002 | | | | X | | X | X |
| Anema et al | 2003 | | | | X | | X | X |
| Hess et al | 2004 | X | | | X | | | |
| Laing et al | 2005 | X | | | X | | X | X |
| Lavoie-Tremblay | 2005 | | | | X | | X | X |
| Van der Molen | 2005 | | | | X | | | X |
| Polanyi | 2005 | | | X | | | X | X |
| Rivilis et al | 2006 | | | | | | | X |
| Burgess-Limerick et al | 2007 | | | | X | | | X |

**Table 5b**. Presence of Occupational Health and Safety Assessment Series (OHSAS 18001) elements in participatory ergonomics articles. [OHS=Occupational health & safety; OHSMS=occupational health and safety management system.]

| Authors | Year | Competence, training and awareness | Communication | Participation and consultation | Documentation | Control of documents | Operational control | Emergency response |
|---|---|---|---|---|---|---|---|---|
| Vink et al | 1995 | | | X | | | | |
| Wilson | 1995 | | | X | | | | |
| Westlander | 1995 | X | | | | | | |
| Bohr et al | 1997 | X | | | X | | | |
| Halpern & Dawson | 1997 | X | | | | | | |
| Vink et al | 1997 | X | | X | | | | |
| Laitinen et al | 1997 | X | | | | | | |
| Haims & Carayon, | 1998 | | | X | | | | |
| Rosecrance & Cook | 2000 | X | | X | | | | |
| Loisel et al | 2001 | X | | X | | | | |
| de Looze et al | 2001 | | | X | | | | |
| de Jong & Vink, | 2002 | | | X | | | | |
| Anema et al | 2003 | X | | | | | | |
| Hess et al | 2004 | | | | | | | |
| Laing et al | 2005 | X | | X | | | | |
| Lavoie-Tremblay | 2005 | | | X | | | | |
| Van der Molen | 2005 | X | | X | | | | |
| Polanyi | 2005 | X | | | | | | |
| Rivilis et al | 2006 | X | | X | | | | |
| Burgess-Limerick et al | 2007 | X | | X | | | | |

**Table 5c**. Presence of Occupational Health and Safety Assessment Series (OHSAS 18001) elements in participatory ergonomics articles. [OHS=Occupational health & safety; OHSMS=occupational health and safety management system.]

| Authors | Year | Performance measurement and monitoring | Evaluation of compliance | Incident investigation | Non-conformity, corrective action and preventive action | Control of records | Internal audit | Management review |
|---|---|---|---|---|---|---|---|---|
| Vink et al | 1995 | X | | | | | | |
| Wilson | 1995 | | | | | | | |
| Westlander | 1995 | X | | | X | | | |
| Bohr et al | 1997 | X | | | | | | |
| Halpern & Dawson | 1997 | | | | X | | | |
| Vink et al | 1997 | X | | | X | | | |
| Laitinen et al | 1997 | X | | | | | | |
| Haims & Carayon, | 1998 | X | | | X | | | X |
| Rosecrance & Cook | 2000 | X | | | X | | | |
| Loisel et al | 2001 | X | | X | | | | |
| de Looze et al | 2001 | X | | | | | | |
| de Jong & Vink, | 2002 | | | | | | | |
| Anema et al | 2003 | | | | | | | |
| Hess et al | 2004 | X | | | | | | |
| Laing et al | 2005 | X | | X | X | | | |
| Lavoie-Tremblay | 2005 | X | | | | | | |
| Van der Molen | 2005 | X | | | | | | X |
| Polanyi | 2005 | | | | | | | |
| Rivilis et al | 2006 | X | | | | | | |
| Burgess-Limerick et al | 2007 | | | | | | | |

## 4. Discussion

The PE papers described approaches for improving workplace ergonomics, but they were actually aimed at preventing MSD, except for Laitinen et al. (1997), which was an ergonomic development program that was implemented in conjunction with a housekeeping program. In addition, as Loisel et al. (2001) described in their study, the PE program was implemented in a rehabilitation rather than prevention context. However, the authors argued that the implementation of PE resulted in increasing the awareness of back-pain risk factors in the workplace, which can potentially impact primary prevention. The PE program was implemented at organizational level, involving multiple stakeholders within an organization, to modify the work demands and improve work tasks of workers with back injuries, and hence is worthy of inclusion in this analysis. In their study, before subject recruitment, employer and union representatives of several workplaces received PE training and then workers with back pain were recruited and an ergonomist met them first at the clinic. These are examples of the diverse use of the PE approach.

Of the 21 elements of the OHSAS 18001 framework, although silent on eight, the PE literature did however provide a substantial amount of detail on five of the elements: (i) hazard identification, risk assessment and determining controls; (ii) resources, roles, responsibility, accountability, and authority; (iii) competence, training and awareness; (iv) participation and consultation; and (v) performance measurement and monitoring. However, the authors used many different approaches to address these elements. The findings of this study suggest that, irrespective of the strength of PE, it does not match business processes and practices. Analysis of the content of well-cited PE articles suggests that the implementation of PE programs has not been reported or written about in a fashion that facilitates easy integration into an organization’s management system because of the structure and language differences. PE appears to be regarded as a stand-alone program to solve a specific problem or sets of

problems.

It is worth noting that even when the PE literature addressed the management system elements, the vocabulary that was employed in the PE literature often differed from that used in a management system framework. For instance, one of the main elements of OHSAS 18001 describes how organizations should determine measurable objectives and targets. Also, the input and output requirements and data should be outlined precisely. However, few of the authors mentioned this element and the description was limited to using terms such as**"** commitment contract" (28) or "stakeholder agreement" on an existing problem (Anema et al., 2003). The process and language introduced in OHSAS 18001 suggests a more systematic approach that enables continuous improvement. In addition, OHSMS elements can be easily integrated into other management system practices and approaches, such as environment or quality. PE approaches described appear to lack these capabilities, or it could be said that the authors did not describe how prevention activities using PE methodology could be integrated into an organization's broader management system.

The approaches used by Laing et al. (2005), which were based upon the Participatory Ergonomics Implementation Blueprint developed by Wells et al. (2001), and the program reported by Loisel et al. (2001), were examples of approaches that were most similar to the OHSAS 18001 framework. Haims and Carayon (1998) were the only authors to describe a continuous improvement approach (for the PE process), which is one of the main features of any management system. Zink (1996) made a distinction between "selective" and "continuous improvement" participation: using participatory practices for specific organizational projects, such as implementing new technology, refers to selective participation. For continuous improvement, the authors suggested the use of participatory practices in an attempt to achieve continuous improvement within an organization (Haims & Carayon, 1998; Zink, 1996). It is worth noting that Kaizen and Six-sigma also encourage a participatory approach and are

well-practiced and popular approaches used by organizations across different sectors to solve specific problems.

With respect to sustainability, it was reported that the research team provided expertise, time, and effort as resources to the project, and they created "an ergonomics library" (Haims & Carayon, 1998). It was suggested that outside experts should leave the organization with an internal program in place that would be capable of addressing future problems (Haims & Carayon, 1998). Haims and Carayon (1998) stated that in order to ensure suitability, the Ergonomic Coordinator program be evaluated and continuous improvement was planned in their PE program. In addition, Liang et al. (2005) reported that following the withdrawal of the research team, a plant- or union-based ergonomics champion might enhance Ergonomic Change Teams sustainability. However, Bohr, Evanoff, & Wolf (1997) and Burgess-Limerick et al. (2007) reported some signs of sustainability in their implanted PE program. As the PE literature seems to have been written by researchers for researchers, there was only a moderate amount of detail about how to implement and structure a PE program within a target organization.

It could be argued that research publication did not allow detail of implementation as needed by practitioners. This could potentially make PE difficult to implement successfully by practitioners and organizations.

The literature showed that the scope of the PE programs described was usually limited to a departmental or similar level. As such, PE could be considered similar to other improvement processes such as Six-Sigma. The Six-Sigma approach, though, emphasizes "measurement" whereas in the PE literature, a qualitative approach is frequently employed. In addition, Six-Sigma can be used widely within an organization to address multiple issues, in contrast to PE, which has a much narrower application, often only for MSD prevention. More generally, the PE literature seldom referred to

methods or systems used in other areas of a company (eg, quality), organizational change, process improvement (eg, Six-Sigma or Kaizen) or other engineering approaches. Introducing ideas from related well-regarded business and engineering processes has the potential to strengthen MSD prevention. Similarly, introducing MSD prevention into business and engineering processes and methodologies also has the potential to improve MSD prevention, especially hazard identification and control. For example, it has been shown that it is feasible to integrate PE approaches into Kaizen events as conducted in the Lean Manufacturing tradition (Nastasia, Toulouse, & Imbeau, 2006).

PE articles did not typically comment on the sustainability of their approach and its continuous improvement capability. As might be expected, researchers or an outside party conducted the majority of studies found in the well-cited PE literature, and these were usually of short-to-moderate duration. It could be speculated that making future improvements would require the return of the researchers to the organization. Consequently, the sustainability of these programs is usually unknown. Management system frameworks, such as OHSAS 18001 by virtue of its continuous improvement nature and compatibility with business processes, tend to lead to sustainable prevention activities (Lo et al., 2014). Therefore, in order to achieve a sustainable and effective approach to prevention of MSD using a PE approach, more integration into management system frameworks using a continuous improvement method may be useful. PE can be used in a process-oriented organization but its integration into other processes within an organization has not been reported, and it therefore seems unlikely to achieve sustainable prevention. Hence, it may remain a parallel process that will require resources to keep it alive on an ongoing basis. This may make PE too costly for an organization that is trying to streamline its processes, which may mean that PE is seen as an outlier that could be eliminated.

Burgess-Limerick et al. (2007) noted that the greatest progress towards becoming self-sufficient was

seen in a company where the PE program was adopted within the company's "site standard", and program sustainability was therefore less likely to be affected by personnel changes. The natural fit of OHSMS with the normal way of doing business makes this an excellent opportunity to bring health and safety and MSD prevention to the table. This could occur by harmonizing concepts and terminologies for MSD hazard assessment with those commonly used in OHSMS or similar management system approaches.

Recently, there have been a few attempts by researchers to develop new PE frameworks such as development of Stay@Work by Driessen et al. (2010). The authors suggested that despite the positive feedback about the PE program and training using their framework, the implementation of the prioritized ergonomics changes (measures) was lower than expected.

The findings of this study are restricted by relying only on the peer-reviewed and grey literature identified by Van Eerd et al. (2010). PE approaches developed by individual companies and consultancies may have different characteristics. However, 20 papers were selected from multiple countries that were well-cited (table 1). The study sought only English language papers but the selected papers represent many different countries including the USA, Canada, Australia, and multiple European countries. Our definition of OHSMS was based on a single framework, OHSAS 18001; nevertheless, other frameworks such as BS 8800, International Labour Organization guidelines (ILO, 2001) or CSA-Z1000 are very similar.

A number of the PE programs have been implemented within research studies. Constraints that might have been introduced by this method include shortened timelines for obtaining pre-post measures, a lack of consideration of the sustainability beyond the study duration or the provision of substantial outside consulting, and facilitation resources by the research team. This may have affected the form of PE program from that which might be seen in organizations outside of a research study.

## 5. Concluding remarks

Both PE and OHSMS frameworks have evidence of success in addressing workplace hazards. Importantly, this study did not find any conflict between these approaches. This suggests that MSD prevention activities and approaches such as PE could be beneficially integrated into existing management structures. This approach would supply PE's absent elements. Therefore, it can be concluded that paying attention to and adopting management approaches as well as the language used in management system frameworks could make MSD prevention activities using PE more effective and sustainable.

# CHAPTER IV: Management Commitment, Training, and Worker Participation: An Interview Study of Key Informants' Perspectives on Key Elements of Management Systems and Musculoskeletal Disorder Prevention Programs

## 1. Introduction

Musculoskeletal disorders (MSD) related to work have a high personal, firm and societal burden. It is a challenge for organizations to prevent them. This study explored key informants' perspectives on MSD prevention approaches and the feasibility and desirability of integrating MSD prevention into a management system framework. Possible methods and approaches to achieve this integration were also explored. Key informants include experienced consultants, managers, researchers, union representatives, and policy makers who were actively involved in the area of health, safety, and MSD prevention. This paper focuses on three main elements of any management system framework: management commitment, worker participation, and training and education.

Management commitment is a key factor in the implementation and performance of intervention and prevention programs (Mooren et al., 2014; Koppelaar et al., 2013; Korunka et al., 2010; Cole & Brown, 1996; Hallowell & Colhoun, 2011; Dixon, Theberge, & Cole, 2009; Morag, 2007; Flin, 2003; Milgate, Innes, & Loughlin, 2002). Some characteristics of effective management commitment include active involvement, proactive actions, "manifestation of those attitudes in the form of operational policies and informal actions which contribute to safer workplaces" (Geldart et al., 2010, page 569), prioritization (especially when facing a conflict), "visible demonstration through action" (Milgate, Innes, & Loughlin, 2002), and allocation of financial resources (Koppelaar et al., 2013; Flin, 2003; Milgate, Innes, & Loughlin, 2002). Employees' perceptions of management commitment to safety is important as it is a significant predictor of future injury outcomes (Huang, 2012a; Huang, 2012b), is associated with lower injury rates (Rundmo, 1994), and increased compliance to health and safety routines (Torp & Grogaard, 2009). Worker participation is another vital factor required for prevention programs

to be successful (Mooren et al., 2014; Hallowell & Colhoun, 2011; Geldart et al., 2010; Morag, 2007; Rivilis, 2006; Milgate, Innes, & Loughlin, 2002; Eaton & Nocerino, 2000; Faville, 1996). It has been recommended that workers should be involved in the identification of problems and hazards as well as in the development of solutions (Faville, 1996; Cole & Brown, 1996). Thoughts about providing incentives as a means of gaining worker participation are mixed; however, its association with low injury rates was reported (Geldart et al., 2010). In addition, training was suggested to be essential for successful implementation and prevention programs (Mooren et al., 2014; Korunka et al., 2010; Milgate, Innes, & Loughlin, 2002; Faville, 1996; Cole & Brown, 1996). It has also been recommended that managers, supervisors, and employees participate in training (Faville, 1996; Korunka et al., 2010). In addition to this, Gillen (2004) also suggested that there is a need for safety and ergonomics training to be included in the educational system.

As part of a larger research project, the purpose of this study was to better understand the key informants' experiences, perceptions, and perspectives on prevention of MSD and their links to three main elements of management systems: management commitment, training, and worker participation.

## 2. The study

A key informant is an individual that can be called as an expert source of information (Marshal, 1996). As the key informant's interview has a very specific purpose, it involved identifying individuals who are knowledgeable about the topics of this study and with substantial work experience in the area of work and health. The key informant's interview involved gathering needed information, ideas, thoughts, and insights on a specific subject or topic of interest through interviewing a group of experts (Kumar, 1989). This

qualitative technique provides an opportunity to receive information directly from knowledgeable experts (Kumar, 1989) that can be used as a standalone research technique or in conjunction with other qualitative methods (Marshal, 1996). This technique also provides an opportunity to obtain high quality data in a short period of time (Marshal, 1996) and enables researchers to generate reliable suggestions and recommendations (Kumar, 10998). Considering the purpose of this study, the key informants' technique was seen to be an appropriate methodology and therefore was used to conduct this study.

### 2.1. Recruitment

For this study, 31 key informants were drawn from four groups; consultants, managers, researchers, organized labour and policy makers. Personal contacts and a snowball technique were used to recruit the key informants. The formal invitation to participate in the study was sent to each individual. When required, a follow-up email or phone call (usually two weeks after the initial contact) was used to recruit the participants. Recruitment and interviews were conducted from September 2013 to August 2014.

### 2.2. Protocol

All interviewees read and signed a consent form approved by the University of Waterloo Research Ethics Board. The consent form explained the aim of the study and how resulting data would be used. The interviews were asked for their consent to be interviewed, to have the interview recorded, and to have anonymous quotations from the interview used in research output. All of the interviewees agreed to be audio recorded except one. Consequently, the interviewer took notes from the participant who did not

agreed to be audio recorded. All interviewees were assured that only members of the research team would have access to their responses and that they were free to withdraw from the study at any point. The interview protocol was sent to the interviewee approximately one week prior to the scheduled interview.

Most interviews were conducted by telephone, although a few took place in person. The language of the interviews was in English, however, one of the interviews was conducted in French. Since the interviewee could not speak in English, a member of research team whose first language is French accompanied the interviewer and provided live translation. Most of the interviews lasted 45-60 minutes except two that lasted 35 minutes. The interview in French took about 150 minutes. The interview protocols for each group of participants were developed by a group of researchers with diverse research and education background. The initial protocol was pilot tested to ensure the appropriateness of questions and to improve interview protocols. Feedback from the pilot was used to modify and finalize interview protocols. In addition, feedback received from the research team, upon completing the first five interviews was used to review and finalize the interview protocol and improve the quality of the interviews. The final interview protocol used in this study is provided in Appendix A.

The interviews were digitally recorded and then transcribed verbatim by a professional transcriber and were checked against the tapes for accuracy by the investigator. The transcript was sent to each interviewee for their review and final comments. The interviewees were given two weeks to review the transcripts and finalize their responses. A few of the participants used this opportunity to provide further comments to clarify their positions and improve their responses. The final interviewee-reviewed transcripts were

used for analysis.

### 2.3. Data analysis

A qualitative data analysis software package (NVIVO$^{TM}$ Version 10.0) was used to store, organize and help analyze the data. A thematic analysis approach (Braun & Clarke, 2006) was used to code and analyze the data. As described by Braun & Clarke (2006) thematic analysis is characterized as being flexible theoretically and it can accommodate a variety of theoretical approaches. . This flexibility is seen to allow the approach to be applied within a range of theoretical and epistemological perspectives (Braun & Clarke, 2006). In this study, thematic analysis was used as an essentialist or realistic method to report participants' experiences, meanings, and reality. The guide developed by (Braun & Clarke, 2006) to conduct a thematic analysis was used by the researcher to analyze the interview data in this study. This includes the following steps:

a) Each interview transcript was read by two readers to better understand the nature of data and in order to familiarizing the investigator with the data.
b) Two independent coders initially coded the interview transcripts using a coding template to capture responses relevant to each topic, and at the same time generating new codes that identified underlying messages. The initial coding reflects participants' direct experiences, thoughts and assumptions.
c) The inter-coder consistency was determined. Two coders met in person to discuss the coded transcripts and to make sure that the coders are in agreement.
d) The initial codes were then sorted into potential themes. Then all relevant coded data were organized within the identified themes.

e) The potential themes were reviewed and finalized in order to avoid duplicate themes and to identify missing themes.

f) The identified themes were revisited by the researcher to refine the specifics of each theme and define the themes.

g) The final analysis of selected extracts was undertaken and was used to summarize the findings of this study and produce the report.

All interviews being completed prior to analyzing the data. To maintain the confidentiality of participants, each key informant is referred to using an alpha-numeric identification code. All managers are referred to with an "M", consultants with a "C", researchers with an "R", policy makers with a "P", and union representatives with a "U". Each person within these groups was given a unique number (e.g., "01", "02", "03", etc.).

### 3. Findings

In total, 23 individuals agreed to participate in this study. This included seven consultants from Health and Safety (H&S), ergonomics, management systems, five senior H&S managers, five senior researchers in the area of H&S, ergonomics, and management, three representatives from organized labour (unions), and three policy makers from policy-making organizations. The participants were located in the Canadian provinces of Ontario, Quebec, and British Columbia, United States of America, and the Netherlands. The following topics of interest guided the interview and used to present the findings of this study.

### 3.1. Management Commitment

Participants engaged in discussion with the interviewer on definitions, the importance of management commitment to implement prevention activities, and improving MSD prevention and the role of management. They were also asked to describe good practice to achieve management support and commitment.

#### 3.1.1. Definition:

Key informants were asked to describe management commitment in the area of H&S and MSD prevention. To do this, the participants were asked to define management commitment from their own perspective. The majority of participants defined management commitment as: the commitment and support provided by senior management through allocation of human and financial resources. The informants suggested that the commitment must be "consistent" to overcome H&S challenges in the organization. As several consultants described, prioritizing production over H&S and injury prevention is a problem that organization often face. Therefore, management commitment towards injury prevention becomes more challenging and meaningful when it comes to "competing priorities". Management commitment was said to be "pretty complicated" for H&S and MSD prevention. An H&S manager suggested that application of the organization's values towards H&S must be consistent. Another H&S manager in the health care sector believed that this needs a "global approach" and the commitment should come from all managerial levels (M-01). He argued that H&S and MSD prevention is not only a job for human resources (HR) but all levels of management should be involved and that commitment must come from top to down. This perspective was also

supported by a union representative, when he suggested that both middle and upper management should be committed to preventing MSD. Another union representative argued that the commitment to prevent MSD in workplaces should come from top management. The participants, consistently, suggested that the commitment towards MSD prevention should be in place from the very beginning and during the design stage.

A consultant defined management commitment using an example from the manufacturing sector. He used an example to share his experience of success in an organization with management support and commitment. He stated that:

> If the production manager is on board, then it does make everything smoother. Then they're able to allocate time from workers, foreman[s], managers, [and] maintenance. If they recognize the importance of the intervention, which I guess is a form of support, and if they're giving people's time and money, then that's certainly a kind of support. So I'm thinking of company A, it's a very large international company. I had done a lot of work with their local plant. I would say the local senior management strongly supported ergonomics and would show that by making sure workers were involved in any changes or decisions. [Also] making sure an ergonomist was brought in, making sure time was available for meetings and for talking through issues, for writing reports, for implementing solutions and trying solutions. So certainly I've had better success implanting ergonomics in companies where that kind of support is demonstrated (C-02).

Another consultant discussed the idea of accountability versus acting with integrity. He said:

> I think probably something that people say a lot is accountability. But I believe that needs to be based on acting with integrity. It's one thing to assign responsibility and accountability to someone and hold them to that, but those have failure points, and that means that they're not acting [the same] when nobody is watching. To me, that is sort of the definition of integrity [and that means] doing the right thing even when nobody's watching. Taking that as a part of [the] core value specifically in health and safety (C-04).

Prioritizing MSD prevention over other organizational issues and the management perspective on that came out in our interview with a senior policy maker. He argued:

> We as a system are committed to looking at how MSD prevention fits into the overall picture and understand how we would prioritize that against some of the other things that are out there. So I always think of things in terms of resource allocation, are we putting enough, too much, too little into a particular area? And in MSD prevention I think about two things: how does our commitment to that compare to the problems that are related to MSD and problems we're trying to address? And how effective can our measures be, is the other side of that commitment as well (P-01).

A union representative defined management commitment as having management as a leader in promoting prevention activities. He stated that:

> Management commitment is both the identification of things that will potentially lead to the MSD, but also recognizing when injuries are happening and taking corrective actions as well and having the actual management taking the lead in the promotion of these activities (U-03).

An interviewee from the researchers' group summarized the definition of management commitment reflecting on above perspectives. He stated that: "…to qualify what we mean by commitment, I guess it's whether they're providing the resources, adjusting incentives, removing barriers and just really giving positive encouragement for development in whatever the direction of the intervention is" (R-01).

### 3.1.2. The importance of management commitment to implement prevention activities

The interviewees were asked to provide their opinion, based on their experiences, of the importance of management commitment to implementing any intervention to prevent workplace injuries, including MSD. The majority of the participants confirmed that this is

an essential and very crucial factor to implementing any changes in organizations. The participants believed that this is a "primary factor" (C-01) and the "foundational piece" (C-03). According to a researcher, the success of any intervention to prevent workplace injuries is dependent on the commitment of different levels of management. He provided an example to support the importance of this issue:

> We've done a couple of participatory ergonomics projects from the bottom up and I think workers are able to identify potential interventions, but actually implanting them in a workplace is extremely complex and difficult and I think without active management and enthusiastic management support and commitment, it's just not going to happen (R-02).

A consultant also supported this position when he argued that the success of any prevention program depends on commitment and support provided by management. He stated that: "Without management commitment and support, the intervention or the program or prevention strategy would never work; it would not be sustainable (C-03)." Other key informants also highlighted the issue of sustainability and discussed the importance of buy-in from management and its impact on sustainability. A consultant stated that:

> If it's really going to be sustainable it has to be ingrained into the business drivers that are going to impact the manager. So again, if [top management] sees it as: 'I have all of these other duties and requirements in my job, and then on top of that you're talking about a health and safety initiative?'… Whether they see that as a system or they see that as a program, if it's perceived that way then our chance of success in sustainability is going to be very much jeopardized (C-01).

Another consultant (C-12) noted the impact of management commitment on workplace safety culture. He suggested that if management is committed to provide a safe workplace

and shows this commitment to employees, then this could improve employees' perspectives towards prevention activities and make them more responsible. An H&S manager (M-05) also believed that "management commitment drives the culture of the organization" and what the top management demonstrates, gets attention by the organization.

An H&S manager discussed management commitment and its impacts on performance. He stated that "…you can have a functioning, maybe even a legally compliant system, but you can't have an excellent or a high performing system if you don't have senior management commitment (M-05)." This clearly suggests the significance of this element of the management system in achieving the organizations' goals and strategic targets. Another perspective, introduced by a policy maker, discussed management commitment as a "platform" that drives the success of prevention activities. He argued that:

> …[management commitment] is the platform on which everything is built. If there's no management commitment it's not going to work. So management commitment makes certain positions accountable for providing a healthy and safe workplace. Without management commitment it's a hollow exercise, it's just in window dressing, nothing meaningful happens because nobody's held accountable or there's monitoring to make sure that the corporation is on the right path (P-01).

This perspective was similar to a perspective suggested by a union representative who emphasized on the fact that management should commit to introduce H&S as a part of the "organization's ultimate business plan" (U-01) and this needs to be documented and communicated.

### 3.1.3. Improving prevention of MSD and management

Key informants' were asked to provide their perspectives on the actions that need to be taken at management level to better prevent MSD in the workplace. Most of the participants said that, "training and education" is a key fundamental principle that needs to be provided to top management to help them in making educated decisions. Increasing awareness and "open communication" with management about H&S in general and MSD prevention in particular were suggested solutions to get management involvement. As suggested by a consultant (C-01), the prevention of MSD could be enhanced by improving decision-making processes at managerial level. He suggested that, as practitioners, we are still very focused on treating symptoms and this needs to be changed. A number of key informants reported that management should be involved in planning the intervention. As stated by a consultant (C-03), both senior and middle management need to be involved in overseeing the implementation and setting indicators to evaluate intervention programs. Another perspective was tying H&S in general and MSD prevention in particular, to performance evaluation of management.

As it has been mentioned, providing training to management was said to be an important step towards achieving better prevention of MSD in the workplace. A consultant argued that H&S and ergonomics training should be provided as a part of the education that they receive in their post-secondary education. He stated that: **"**What needs to be done at a management level to achieve better prevention, I say, include better training, better sense of position or better understanding of the whole health and safety issues regarding ergonomics during the training [they] get at the University level (C-04)."

An H&S manager provided a success story to support how strategic decision making in allocating financial resources by management can be effective. He stated that:

> One of the things that we've done in our organization for high risk issues, we have established a separate capital budget so that I've got this much that I put away across my company for equipment improvements and buildings and all that kind of stuff, and then I've got this much that I've dedicated to over the course of the next 5 or 10 years, address these kinds of issues. And that's been very successful for us (M-05).

Return on investment was introduced by a policy maker where he suggested that prevention of MSD can be improved where management is convinced on "return on investment" by making workplace healthier and safer. This position was also supported by a union representative where he said: "… [Management should] understand that there is, of course, a trade-off between what you've spent on making the workplace safe and the trade-off of the actual value that the company puts on injuring someone (U-03)." A policy maker believed that the prevention of MSD could be improved if senior management, who is ultimately the responsible person in the workplace to promote H&S, encourages a participatory process in the workplace thereby making everyone responsible about H&S. He suggested that this can be achieved by "…empowering people, getting their input, and getting their involvement because unless there is buy-in from people it's not going to succeed (P-01)." It is always a challenge when senior management should make strategic decisions (considering limitations) that may discourage employees to participate. A policy maker highlighted that by stating that: "…there are times [that] the senior management may disagree with something but then [he/she should] give rationale why that's not a practical solution or why that approach is not being taken, rather than just ignoring or saying that won't work (P-01)."

The need for knowledge translation at the management level was suggested in the interview with a researcher. She believed that researchers need to have some agreement about the improvement strategies and have a consistent message in language that management understands and see that there is a consistent message from researchers about MSD. A union representative argued that management should consider MSD prevention beyond the legal obligation of the organization. He suggested that better prevention of MSD might be achieved if management is trained on proactive prevention programs and if they are aware of their actual role and responsibility in organization with respect to H&S.

### 3.1.4. Good practices to achieve management support and commitment

It is often a challenge to get management support and commitment for health and safety. The key informants were asked to provide their suggestions based on their experiences in getting management onboard and achieving their support and commitment towards implementation of prevention strategies. Three ideas were commonly mentioned. First, educate both top and middle management and increase their awareness. This was supported by most of the participants, as they believed that senior management lacks enough knowledge on the importance and the potential impacts of these costly disorders. Second, demonstrate how investing in MSD prevention could improve productivity. H&S managers and consultants believed that this is the most encouraging way of achieving management support to overcome MSD problems in the workplace. They suggested that prevention activities should be tied to productivity measurement. Third, develop business cases to show how cost-effective and efficient the investment on H&S and MSD prevention is. An idea of developing a business case was mentioned in the interview with a union reprehensive where he suggested that in order to get management buy in, we need

to show the business case where everybody wins. He argued that: "You have to remember that the law is nothing more than the minimum standard. They (companies) will go way beyond the minimum standard if there's a business case (U-03)." This was supported by a consultant who suggested that presenting a business case to senior leadership is crucial to get management's attention. He said we need to, "… ensure that they [senior leadership] understand what is to be gained in terms of the net benefits, but also what are those costs that the employer is spending on a reactionary system where appropriate prevention strategies are not in place (C-03)." It was also suggested by a researcher that management should be convinced that the core business of the organization can benefit from implementing an intervention to reduce MSD. She argued that this benefit doesn't necessarily need to be direct financial benefits but it can also be related to clients. She stated that: "… if you can show how preventing MSD, in the employees, can also benefit the clients they're serving, then you're going to get more buy in (R-01)." The following paragraphs describe other emerging ideas.

An H&S manager suggested that there is a research gap (in i.e., diagnosis, treatment, prevention, and return to work) in this area and information is lacking on good practices. He suggested that provincial and national wide strategies are needed to address these issues. This participant argued that senior managers don't understand the issue, the scope of it, and the implication of the problem and stated that:

> Far too many managers have given up on being able to manage this [MSD] because of how prevalent non-occupational factors are and the fact that even when non-occupational factors account for like 90% or more of conditions, they still end up having to manage this and the resulting impacts on the organization [are] loss of productivity, extra costs, [and] those kinds of things (M-05)."

As policy maker suggested: a) getting better data on the significance of the problem, and b) measuring the effectiveness of proposed intervention could be an effective way of acceptance from management. He highlighted that:

> There is the misconception in senior management. [Management thinks that] it is about comfort I think that has to be taken away. That's why like we are talking about MSD prevention, rather than the term ergonomics, which is far more encompassing (P-01).

He elaborated his perspective further by providing an interesting observation and an example:

> There is the misconception even from the TV commercials which show something very fancy and say that's ergonomically designed, then immediately people's minds go to something very fancy when you talk about ergonomics. But if you keep the focus on disease, musculoskeletal disorders prevention, so that is injury prevention, everybody can understand that (P-01).

Another participant from the policy maker group said that the integration of H&S into a management system is a good and proven practice to achieve sustainable management support. He argued that:

> There has to be an integration of the health and safety management system, into the actual business outcomes. It has to be incorporated and an integral part or the business planning cycle, which it, in my experience, tends not to be. It tends to be a separate activity that happens and that is reported on, not part of a holistic business planning cycle process. And I think that that's where we need to move toward it (P-03).

A researcher believed that improving work conditions is about giving added value to the core business of the organization and the core view of the management of the organization. He suggested that we need to show that with linking work conditions for

H&S to topics in management then we become the partner of management to achieve its goals. He noted that ergonomics, in general, needs to be "sold" in terms of "innovation and competitive advantage". He stated that:

> What I sell is that I say every organization needs to innovate to be competitive. So, innovation is an ongoing process and in my view on innovation, which is also generally broadly accepted, is that innovation is not only about getting new ideas from outside the organization to innovate, innovate products or innovate processes, but it is also about how internally within the organization the ideas come up for renewal, for innovation. And those internal ideas, they can come from the employees in the organization… [then I argue that] there's one condition for [that]: … working environment is stimulating people to come up with these ideas. So these people [need] help in order to come up with the ideas for innovation that are good for your company (R-05).

Key informants' experiences and ideas about best practices to achieve management support and commitment towards H&S and MSD prevention could potentially be suitable to bold H&S and MSD prevention as organizational issues that can be addressed by appropriate support and commitment of senior and middle management.

### 3.2. Workers' Participation

The key informants were asked to share their perspective on where and when workers should be involved in a change process to address MSD problems in the workplace. In addition, the key informants' perspectives on the importance of worker participation on the success of prevention activities were sought. Moreover, they were asked to provide a few examples where workers' involvement resulted in successful prevention of workplace injuries. Finally, they were to share their perspectives and experiences on how an organization can encourage its employees to participate in prevention activities

effectively. The following sections present the findings of this study based on the interview data.

### 3.2.1. Level of involvement

The level of workers' involvement and participation in H&S and prevention activities influences the success of any prevention activity. This is important since it could significantly impact an organization's strategy and prevention activities. It was a consensus across groups that workers should be involved from the very beginning (in the conceptual design stage) of implementing any program or changes to the very end, ensuring that the worker's voice and opinion are being heard. It was noted that workers' involvement is very crucial to implement any changes in the organization and without workers' involvement, the success of any prevention program is unlikely. As a consultant described it, workers' participation should be built into their "hiring orientation materials (C-05)." He gave an example of how this could be useful:

> There you [as an employee] can start to set expectations that you [as an employee] are a contributor to the job improvement process. You [as an employee] own the job improvement process for yourself and your workstation, but also for the safety of others around you and your fellow colleagues (C-05).

The participant suggested that workers, as an end user group, need to be involved in designing new equipment or new layouts. It was also suggested that workers should be involved in production planning and change management processes. An H&S manager gave an interesting perspective by arguing that we should not see workers' participation as "negotiation". He suggested that workers involvement in conceptual design, design stage, commissioning stage, and verification stage is crucial and that would impact H&S,

quality, and productivity. He stated that: "… [Workers' participation] not only can reduce risk of MSD, [but] you can [also] improve quality and productivity (M-05)." Other key informants including H&S managers and union representatives also supported this perspective.

One participant proposed that involvement of participants be limited to the decision-making stage only. However, a few others opposed this idea as they believed this was too late. A policy maker stated that:

> To me it's too late if you're just getting them involved at the decision making stage because the investment by senior management, or by whomever has been working on it, up until that point and then somebody throws up a road block at the decision making point, it comes to a screeching halt. There's going to be resentment, there's going to be resistance and that's not an effective process (P-03).

He argued that although the participation of employees in all processes is ideal, it might not be always practical. A researcher suggested that getting workers' perspectives early, before purchasing new equipment and before installation and use, is very important. Union representatives had a stronger position on this topic and argued that workers are the key role player and need to be involved because of their comprehensive understanding of their job. One stated that:

> An engineer could draft what an assembly line should look like or process should look like, but it's the individual workers who actually understand the dynamics of where they're working. To me, I'd bring them in at the very start of the project rather than in the middle (U-01).

Another suggested that if employees were not involved then we would have less "buy-in". He suggested that:

> If you involve them then they feel valued and they may not fear the change that you're trying to implement. You can come with the best of intentions, all you want to do is [to] make the [work]place safer, but if you don't tell people what they're going to do, then they're going to reject it in advance just because they were never asked, they were never brought into the process (U-03).

### 3.2.2. The impact of worker participation on the effectiveness of MSD prevention

The perspective of the key informants on the impact of workers' participation on an effective MSD prevention strategy was very consistent. It was said to be a crucial step to make the implementation of prevention activities successful, effective and sustainable. In the interview with a consultant, he said that if workers are not involved we may choose a "wrong solution" that may not be practically possible to be used by workers. This would significantly impact the success of the implementation of workplace changes. It was also noted that we need to actively seek workers' input and even if their suggestions and solutions are not practical, they need to be encouraged. Therefore, workers would feel that they had been, at least, consulted and that may help the effectiveness of changes implemented. A policy maker stated that: "… when they [workers] are listened to, they feel part of the process and they follow the correct work practices (P-01)." According to one of the key informants, workers participation would create a culture within an organization that would allow employees to raise their concerns and bring forward their ideas. He argued that: "You have to have that culture in order to be able to mobilize your work force and your workplace (P-03)." This perspective was supported by most of the key informants including a union representative who stated that:

> Encouraging worker participation and having that atmosphere where workers feel like they can come to their managers, their front line managers and report the problems, without fear of reprisal or ridicule, it's just going to lead to a better and safer workplace (U-03).

An interview with a researcher led to an interesting perspective. The idea of integrating prevention activities using a participatory approach into an organization's management system and structure was suggested as being essential. The interviewee argued that:

> …here's a lot of workers' participation going on in any organization and we should link there. For example, a lot of implementation of [information technology] IT systems or implementation of other technical renewals, it's well known in the literature, in the management and technology literature as well, in order to implement new changes you need commitment from users of those systems. So that's not called participatory ergonomics or things like that. That's called management of change. It's a whole big area in management, also in management literature, about how to implement changes, how to manage changes and user participation is always part of it. It's called user participation. So we are there. I mean, it's there. But we must link it again, not as we have a special program for injury prevention (R-05).

The interviewee believed that linking our prevention activities into current practices such as "management of change" and "user participation" would ultimately lead to an effective prevention of workplace injuries.

### 3.2.3. Success stories on workers' participation

The participants were asked to provide examples and success stories where workers' participation on MSD prevention activities was successful. Key informants provided examples of multiple numbers of cases where workers' inputs led to reduction of injuries or better prevention of workplace injuries. For instance: a) using a participatory approach to improve patient lifting that resulted in a reduction of back injuries in a hospital; b) improving behaviors among health care workers by engaging them on prevention activities; and c) improving lighting as a result of workers' participation in the process and removing potential barriers upon consultation with workers during the "trial" stage.

Participation of workers in organization-wide approaches was mentioned in a few of the interviews. An example of such an approach was the participation of workers in "3-P methodology" (Pre-Production Planning). The participant suggested that workers' involvement in this approach could benefit organizations in many aspects, including MSD prevention. The participant stated that:

> [3-P mythology] provides three key gate opportunities where the operators and a cross functional group can be brought in and they can analyze the new product design, they can analyze the new equipment and layout that's going to be proposed and then also sort of the third event would be where they're looking at the immediate setup of their workstations (C-06).

The participant provided an example where implementing changes without workers involvement resulted in failure. He stated that: "We've had the experience of putting in what we thought was great technology and having it completely ignored. The patients' lift is an example. In some nursing divisions they ended up just gathering dust or being expensive coat racks (C-06)." He then provided an example where, in the same organization, workers' involvement made a difference. He said, "In other divisions where the managers got behind it and the workers got into it, they were used quite a bit. And so you can provide technology, but if it's not used it's not doing any good (C-06)."

### 3.2.4. Encouraging effective and sustainable participation of workers in prevention activities

The participants were asked to share their experiences on how organizations can encourage workers to participate in prevention activities. Key informants suggested a variety of approaches and some disagreements were also seen between managers and consultants. Consultants were in a favour of providing incentives for workers to

participate in prevention activities; however, H&S managers had mixed feelings about it and half were in favour of such an approach and the other half opposed it.

An H&S manager suggested that an integrated approach using the "E3" approach (Economy, Energy and Environment) was seen to be an effective way to encourage employees to participate in any organizational approaches, not only for H&S but for other issues too. He argued that:

> …the same tools for health and safety, productivity, and whatever [need to be used]. One of these tools is the E3. So pretty much everyone fills out an E3 every day and some of them are presented to the plant manager and sometimes they're presented by the unionized workers. They had a problem, they worked on it and they found a solution.... But workers are involved everywhere. So that's the mindset here…It's impossible to make or do E3 alone [it needs active participation of workers]…(M-04).

Another H&S manager raised a good point. He argued that "union workers" might think that they will be blamed for not implementing a "good solution". He stated that workers might also think that they can't criticize changes that they have been a part of it. This is not true, he said: "You could be part of a solution and maybe when you did the solution maybe some information was lacking in your risk analysis. A year later, yeah for sure, things change [and you can criticize those solutions] (M-02)." Therefore, if workers believe in this, then they would be encouraged to actively participate in prevention activities.

In order to encourage effective and sustainable participation of employees in prevention activities, the following ideas were proposed by key informants: embedding some questions related to workers' participation in the hiring interview process, advertising and communicating success stories, promoting participation as empowerment, providing

appropriate tools that do not require extensive knowledge, a suggestion box, increasing awareness, making mandatory participation a policy, requiring everyone to participate in at least two improvement processes per year, using measurable approaches to quantity the degree of participation, follow-up with employees and provide them with regular updates on the status of proposed solutions, building trust between management and employees, implementing the Kaizen approach, instant reward for an idea, promoting a robust internal responsibility system, involving employees in H&S and ergonomics audits, involving employees in the decision making process that directly impacts their own daily work, communicating the impracticality of possible proposed changes, showing management commitment towards MSD prevention, promoting participation by unions, educating employees on the consequences of MSD and their impacts on quality of life, and empowering the role of employees by explaining their roles on productivity and making them aware that they are the assets for the organization.

### 3.3. Training and education

The key informants were asked to provide their perspective and opinion on the following topics of interest including content of training programs and the characteristics of effective training programs for MSD prevention. .

#### 3.3.1. Content of training programs

There was a clear agreement between key informants that training materials should contain hazard identification and risk assessment components. This was strongly supported by every single participant. In addition, they suggested that two types of training were essential including: a) general training, and b) job-specific training. The key

informants'' perspectives on the content of MSD prevention training programs varied when it came to including "anatomy". About half of interviewees were in favour of having anatomy modules in training sessions while the other half opposed it.

According to key informants, training programs for MSD prevention should be embedded to other approaches used by an organization. The participants suggested "5-WHY", "8-D (Eight Disciplines of Problem Solving", and "Fishbone Diagram" approaches as tools that could be used as a global approach in the organizations and, therefore, training on using these tools should be provided. This would help employees to identify problems and provide solutions to solve these problems. A participant suggested that policy makers, specifically in Ontario, should encourage health and safety associations to work together on developing a cross-sectorial general training program to streamline activities. He acknowledged that some sector-specific training program might also be needed.

The interviewees suggested the following components as possible useful contents for MSD prevention training programs: fundamental basic ergonomic practices from elementary schools to more advanced ergonomic practices at the university level, office ergonomics modules, practical problem solving materials, training on how the physical demand translates into a risk, basic risk assessment tools, training on hierarchy of controls, training on ergonomic design criteria, early symptom investigation training, injury and illness management training, risk based training, ergonomic principles training, and information on how to mitigate risk factors.

### 3.3.2. Effective training program for MSD prevention

Key informants consistently believed that training programs could be effective if they were integrated into an organization's overall training program. Frequent training sessions

and follow-ups were said to be necessary to make MSD prevention training effective. Participants discussed that training programs should be “continuous” and “on going” to be effective and their effectiveness should be measured periodically.

Some of the participants believed that online training could be useful while some believed that it is not effective. Others, like a policy maker, believed that we could have both ways of training. He argued that: “… a blended approach [is needed] so there can be some online e-learning, but then I think it’s important to also have some practical training as well to complement what you can learn from the e-learning (P-03).” Other ideas have emerged in this study that recommend approaches to make an MSD prevention training program effective. For instance, as suggested by a policy maker, for the training to be effective, a common language should be used. The participant indicated that: “I think creating that common language that people understand, identifying what those risks are, ensuring that people are aware of the preventative measures and having that integrated approach, integrated in the sense that you can have multiple modalities of learning (P-03).”

A researcher noted that the effectiveness of training depends on the employer’s perspective on it. He argued that training should be seen as a “communication channel” or “workers empowerment”. He stated that: “[Training] has to be linked to some workers’ empowerment or communication channel where they have the ability to point out situations that are dangerous to someone who’s in a position to fix them (R-02).” He also suggested that training should improve employees’ attitudes towards MSD prevention so that “doing it right” becomes a part of the production process and that H&S, in general, should not be seen as an external “add-on”. He argued that: “... If occupational health and

safety is not seen as some sort of external add-on but as an integral part of doing the job, then I think that encourages better behaviour (R-02).” He concluded that an integrated approach that ties MSD prevention to other processes would increase the effectiveness of training programs for MSD prevention. Other key informants supported this perspective where they suggested that MSD training programs could be effective by “strategic positioning” and using common tools with which employees are familiar.

A union representative raised a more fundamental perspective when he argued that training without an approach to encourage workers participation is not effective. He argued that: “If you don’t have a system in place at the workplace that allows workers to voice their concerns without being reprimanded or without being black-balled or without the fear of not getting a promotion, training doesn’t mean anything (U-01).”

## 4. Discussion:

It appears that there is a consistent understanding of management commitment definitions across different role players in the arena of H&S and it is reported to be consistent commitment of senior management to provide financial and human resources towards H&S. Literature supported this where many authors suggested allocation of financial resources as one of the main characteristics of effective management commitment (Koppelaar et al., 2013; Flin, 2003; Milgate, Innes, & Loughlin, 2002). Having management commit to H&S and MSD prevention was reported to be more challenging when it comes to competing priorities. There was a consistent message across key informants that all levels of management have a role in this process and the commitment towards H&S and MSD prevention must be a priority. The participants believed that management should act as a leader in promoting prevention activities and this committed

leadership drives the culture of the organization to be more responsible about H&S and MSD prevention. The findings of this study suggest that management commitment is a key factor in the implementation of any workplace interventions. The perspectives of the key informants were consistent with the scientific literature (Mooren et al., 2014; Koppelaar et al., 2013; Korunka et al., 2010; Cole & Brown, 1996; Hallowell & Colhoun, 2011; Dixon, Theberge, & Cole, 2009; Morag, 2007; Flin, 2003; Milgate, Innes, & Loughlin, 2002). Management commitment and support towards H&S and MSD prevention was reported to result in the sustainability of prevention programs as well as the performance of the organization. The consistent message by key informants that stands out, on the importance of management, was that management should be committed to consider H&S, in general, as a part of "organization's ultimate business plan". However, the key informants also suggested that management needs to be trained and aware of the consequences of H&S issues including MSD.

It was highlighted that management often gets on board when there is a case made for "return on investment" and a common language is used with which management is familiar. This suggests that in practice, management is more likely to be on board when there is a justification on the benefits of investment in MSD prevention and that can be achieved using tools and language that is common across organization. Key informants suggested that linking MSD prevention to productivity and developing business cases could positively get management attention directed towards MSD prevention. The need for provincial and national wide strategies to obtain management support for H&S was also suggested. However, this requires multiple stakeholders including organized labour, business owners, policy makers, and researchers to work together to design a strategy that

could possibly encourage management to pay attention to MSD prevention activities. The integration of H&S into an organization's management structure was said to be an effective way to get sustainable management commitment. It was noted that ergonomics needs to be "sold" in terms of "innovation and competitive advantage" and that we need to show that improving H&S would add value to the core business of the organization. This was consistent with the results of scoping review study (Chapter II).

The involvement of workers was suggested to be from the very early stages of design to the very end as a user in the operation stage. This is consistent with academic literature where multiple authors argued that involvement of workers should not be limited in identification of problems and hazards but also in the development of solutions (Faville, 1996; Cole & Brown, 1996). Key informants believed that this participation is crucial in order to implement any changes in any workplace settings and that the success of any prevention program depends on the level of workers' involvement. This idea is strongly supported by several scholars (Mooren et al., 2014; Hallowell & Colhoun, 2011; Geldart et al., 2010; Morag, 2007; Rivilis, 2006; Milgate, Innes, & Loughlin, 2002; Eaton & Nocerino, 2000; Faville, 1996). However, it was highlighted that workers' participation should not be seen as "negotiation". It was recommended that prevention activities using participatory approaches should be integrated into a broader management system within an organization and this could be achieved by linking current prevention practices in organizations such as "management of change" and "user participation". The results of Chapter III of this thesis supported this where the participatory ergonomics program was suggested to be advanced with integration to a broader management frameworks (Chapter III). The participation of workers in organization-wide practices that embedded H&S into

them have been recommended to be very effective. For instance, "3-P methodology" was suggested to be a good tool that could promote workers' participation in prevention activities. To encourage workers to participate in prevention activities, some of the key informants suggested providing incentives to workers could be useful but some opposed it, especially H&S managers. An H&S manager reported "E3" as an effective methodology to encourage workers' participation.

As training has been argued, by key informants, to be an important element of any management system and of any prevention activities (Mooren et al., 2014; Korunka et al., 2010; Milgate, Innes, & Loughlin, 2002; Faville, 1996; Cole & Brown, 1996), there was strong agreement between key informants that training material should contain information about hazard identification and risk assessment. The job-specific training was also suggested to be necessary to achieve the best results. It was noted that there is no consensus agreement between key informants on whether to include "anatomy" in training material. Several components (described in section 3.3.1) were suggested to be included in MSD prevention training programs. Similar to management commitment and workers participation, key informants argued that training programs for MSD prevention should be integrated to training for organization-wide approaches and techniques such as "5-WHY", "8-D", and fishbone diagrams". Eight Disciplines of Problem Solving (8-D) was also reported to be effective to encourage workers participation and to implement a successful training program. For MSD training programs to be effective, key informants argued that training should be continuous and on-going and frequent follow-up is necessary. Key informants have different opinion about online training and a disagreement was noted on the effectiveness of this type of training. It was suggested that "strategic positioning" and

using common tools might result in effective training program that would consequently improve H&S in the workplace.

## 5. Conclusion

The consistent message communicated by the key informants was the importance of using common language that senior and middle management are familiar with and integrating MSD prevention activities into organizations' management structures. The key informants suggested several approaches to achieve management commitment to and support for H&S and MSD prevention. These approaches include educating management and increasing their awareness on the importance of MSD problems, demonstrating how investment in MSD prevention could improve productivity, and developing business cases to compliment the cost-effectiveness of the investment on H&S and MSD prevention. In addition, incorporating MSD prevention activities into organizational-wide tools such as E3 methodology, 5-WHY, Fishbone diagrams, 3-P methodology, and 8-D. This study concludes that there is strong support and a consensus among key informants that MSD prevention needs to be integrated to a broader management framework and organizational-wide tools and approaches to receive more attention and buy-in from management.

# CHAPTER V: Prevention of Musculoskeletal Disorders within Management Systems: A Qualitative Study of Key Informants' Perspectives

## 1. Introduction

The integration of MSD prevention into wider organizational approaches such as an organization's management system and continuous improvement approaches should result in better prevention of MSD (Caroly et al., 2010; Lewandowski, 2000; and Matias, & Coelho, 2002). MSD prevention was reported to benefit from integration into Occupational Health and Safety Management Systems (OHSMS) (Chapter II), Quality Management Systems (QMS) (Cocianni & Williamson, 2008), and design process (Imbeau et al., 2001; Hendrick & Kleiner, 2002), and this may result in promoting ergonomics, in general, as a part of "everybody's tool" (Lee, 2005). Despite a small peer-reviewed literature on the integration of MSD prevention into management systems, the literature supported this incorporation and suggested that it could potentially improve production as well as preserving workers' health in workplaces (Chapter I).

The literature also showed that participatory ergonomics (PE) processes and language don't match business practices and processes well (Chapter II). However, as suggested in Chapter II, MSD prevention approaches such as PE could be integrated into existing management structures to benefit from resources available through the management systems, as there was no inherent conflict between the two. In addition to this, MSD risk assessment tools and techniques seem to be partially outside of main management process due to their complexity. This may result in MSD prevention not being "on-the-table" and it may not receive enough attention (Chapter II).

Due to the small literature on the topic, this study was conducted to explore key informants' perspectives on, perceptions of, and experiences with the integration of MSD prevention into management systems.

## 2. The study

As described in Chapter IV, 31 key informants were invited to participate in this study and 23 individuals accepted the invitation. The key informants participating in this study included: seven H&S consultants, five H&S managers, five researchers, and five policy makers and labour representatives. Semi-structured interviews were conducted by phone or in person during September 2013 to August 2014. The interviews were transcribed and uploaded to a qualitative computer software package (NVIVO$^{TM}$ Version 10.0) and a thematic analysis approach (Braun & Clarke, 2006) was used to code and analyze the data. For a complete description of the methodology, please see the methods section in Chapter IV. The final interview protocol used in this study is provided in Appendix A.

## 3. Findings

The following topics were explored and 23 participants who agreed to participate in the project provided their perspectives with respect to these topics.

### 3.1. Differences between MSD risk factors and other OHS risks

To better understand the possibility of integration of MSD prevention activities into other business practices, the participants were asked whether there was some inherent difference between MSD risk factors and other risks at work. Such a difference could keep MSD prevention activities separate from other H&S prevention activities.

The first difference was said to be “visibility”. Participants discussed how risk factors and outcomes of other H&S risks are visible, compared to the risks and outcomes of physical demands at work. The participants suggested that this makes MSD difficult to prevent and therefore hard to get management buy-in. Participants noted however that this is similar to

some other occupational diseases and psychological hazards because their effects are not rapidly apparent, nor visible. A consultant argued that invisibility of causes and effects could create a cultural barrier that may significantly impact the prevention of MSD in the workplace. He stated that, "there's always that sense of "how real is it?" and how much of it is still in the stigma of somebody just looking to make their job easy because they're lazy?(C-01)" The participant also discussed another cultural aspect of the problem where he stated,

> When I joined health and safety 25 years ago, generally the perception was that musculoskeletal injuries were really because today's work force is weaker, not as resilient, not willing to put up with sort of the "this is part of the job" stuff. And in many cases we had to build that legitimacy, to say that this is just as important, just as relevant, and just as real as the laceration, broken bones and other injuries that are more visible (C-01).

Participants also discussed differences in "mechanism of injury", "recurrence of MSD", "assessment", and "control" of risk factors. The importance of "confounding factors" for MSD was also raised as an important difference. Participants discussed this because seeing immediate impact for MSD prevention activities may not be possible; convincing management to invest in prevention of these costly disorders may not be an easy job.
One participant said that there are some similarities and some differences between workplace issues. He argued that there are some differences between slips, falls and MSD, but he didn't see much difference with "industrial hygiene" risk factors such as noise.
It was also argued that despite the above differences, MSD and other H&S problems are conceptually similar. This perspective was supported by others, including a policy maker and a researcher, who also argued that MSD in many aspects are similar to occupational diseases. The researcher stated, "…just like as we've seen with asbestos and carcinogen,

it's harder to get employers to spend money today to prevent something that might or not happen in 20 years (R-02)". Participants noted however that most of industrial hygiene risk factors are directly measurable and quantifiable, while this may not be as easy for MSD risk factors. An H&S manager stated that, "H&S specialists, have standards with regulators, with laws behind it, which we don't have [for ergonomics] (M-02)."

Some of the participants discussed the "behavioral-cultural" aspects of MSD, for instance, hazard recognition and safe performance of jobs. The participants argued that these behavioral and cultural issues make MSD prevention more complex. A perspective raised by some participants discussed the complexity of individual responses to the same MSD risk factors. A policy maker stated that "there's always that skepticism, I think, from an employer standpoint as to what part of that person's physiology is contributing to this vs. the work that's contributing to it? (P-03)". The work-relatedness and non-work-relatedness causes of MSD was also discussed where some of the participants were concerned with justifying the contribution of external factors, including activities at home, leisure time, and aging. This perspective was rejected by a union representative where he argued that he doesn't see any differences globally. He stated, "I think that when it comes to musculoskeletal, it encompasses a lot of different conditions. So I do think that somewhere in there that there is a lifestyle component to it (U-01)". The participant reinforced his perspective by providing an example:

> So the example I use when I go to meetings is this: If five workers are working in a room and there's an exposure and it causes say a respiratory condition, the first thing that employer does is go look at the venting system to eliminate that hazard, to make sure that hazard isn't there. So when it comes to MSD, you have five people working in the

> same area. One person develops a condition. Why do you only go and modify that one person's workstation? Shouldn't you be looking at modifying all of them as a cohort? But you would do that for occupational disease. Why don't you do it for MSD? (U-01)

Another interesting perspective by a union representative sees MSD as a "process related" issue. The participant noted that:

> MSD seem to be process related and process is constantly changing. Your facility doesn't change, well it does a little, but it doesn't change as much as process can. As soon as they change a process, all your good work that you've done [for MSD prevention] in the last few years can just disappear overnight. (U-02)

In short, despite the above differences, participants agreed that managing prevention activities and determining strategies to implement prevention activities should remain consistent for different types of H&S issues. An H&S manager emphasized the importance of integration of prevention activities by stating that, "the dream with H&S specialists is to create the checklists that will include MSD risk factors. And these checklists do not exist (M-02)". A union representative supported this by arguing that:

> The process itself shouldn't be any different under a [health and] safety management system, but I can definitely see how the ability to get information into the system may be limited and because of whatever factors are going on in the workplace. (U-03)

### 3.2. Incorporation of MSD prevention into company-wide approaches

The key informants were asked to argue how they position MSD prevention within an organization's framework, and their perspectives on incorporating MSD prevention activities into a broader framework were then explored. A consistent message with strong support from the key informants, across different groups, was that MSD prevention

activities must be incorporated into broader approaches within an organization in order to receive enough attention and avoid creating "silos" that may result in failure and confusion.

As a consultant discussed, the prevention activities will be effective if the same level of interest and recognition is given to MSD prevention as the other business drivers. The concept of integration was said to be an effective way of achieving this and it could be achieved by creating linkages between different business drivers. The participant said that he would take this even further and stated:

> [I go] to the point, where the health and safety program no longer exists and neither does the quality program or the environmental program. What we end up with at the end of the day is really this is how we manage our business and it's ultimately when we can take into consideration that when equipment and the processes are introduced to our workplace, we have a seamless conversation about where the risks are [and look for] opportunities and challenges aside. (C-01)

An example provided by a participant linked MSD prevention to quality errors and problems using tools within a quality management system (i.e., ISO 9001). In addition, it was also discussed that the continuous improvement of prevention activities could be achieved through this integration. The participant stated that, "To be on the proactive side, how it [MSD prevention] fits into your purchasing standards and your procurement standards? How does it fit into workstation design for the future? (C-01)"

As emphasized by a researcher, MSD prevention should be part of an organization's OHSMS framework and should not be implemented as an "add-on program". The participant stated that:

> I think it has to be fully integrated and the problem is if it's kept as a side issue and not integrated, then the metrics and the activities and the

> oversight just don't happen or they happen for a short period of time and then go away. So it has to be up on the same safety dashboard, the same monitoring, and the same level of importance as other health and safety risks (C-02).

An emerging idea that MSD prevention needs to be seen as a benefit to organizations was emphasized in interviews with the key informants. One discussed that the integration of MSD prevention activities can potentially raise the profile for several aspects of organizational concerns, including worker injuries and worker performance. This was suggested to be seen with respect to production goals and quality objectives. The participants discussed potential opportunities gained from this incorporation and that it could improve "corporate social responsibility" by having a healthy workplace and the idea of "workers growing rather than being deteriorated". The integration was suggested to be required in all activities including "operating procedures", "organization policy and procedures" and "training". The participants, however, suggested that overall business planning cycle should include MSD prevention and it should be an equal component of the system. This perspective was supported by other key informants as well and some stated that this becomes more important where organizations go through employee or process transitions because it would help ensure that the prevention activities were sustainable and not dependent on specific individuals. Another participant also said that for MSD prevention to be sustainable, it needs to be integrated into other organization-wide approaches. He provided an example from a health care setting. He stated that:

> When we're approaching patients, when we are care planning and documenting how we're going to care for those patients, the example of integration would be including those proper and safe client handling procedures associated with moving or immobilizing that patient. So I truly believe that in order to sustain the intervention that it needs to be integrated to other practices (C-03).

Participants also identified specific approaches to facilitate integration. One participant noted that MSD prevention could benefit from integration into ISO/TS16949 (quality management system) in auto manufacturing. They argued that MSD prevention needs to be integrated into the overall Plan-Do-Check-Act framework and continuous improvement approaches. This becomes more important during financial crisis or when organizations have cut budgets due to financial pressures. According to one of the participants, incorporating prevention activities into wider approaches, such as quality and even environmental management systems, could ensure that the prevention activities are still on the table, even during financial crises because it is embedded into a broader process. This perspective was supported by most of the participants and it was suggested that MSD prevention could also be integrated beneficially into approaches such as Kaizen, Six Sigma, and other continuous improvement practices. A consultant supported this by elaborating more using an example. He argued that:

> We train engineers on the continuous improvement; we say [that] we don't want to make you an ergonomist. You're doing your job, you're doing a great job, and your company is paying you for that. We just want to give you different type of [view], like sunglasses with a tint inside it. When you look at the same thing you're going to make your decisions, you're going to have a few ergonomics issues or maybe some elements that are going to gather your attention. So it's a great thing to put that in a company-wide approach, to have a standardized approach (C-04).

Despite the strong support for integration, one of participants argued that MSD prevention needs to be its own entity as well. He stated that, "Although it needs to be a part of the larger OHSMS, it needs its own entity or identity within that system to have that level of focus and that level of rigor around it (P-03)." The participant elaborated further,

indicating that, “I think the danger to me in incorporating MSD into a broader system is that it waters it down.”

One of the participants emphasized the importance of tying H&S in general to the quality of production and productivity and argued that this can be used to get management’s attention and support for H&S. An H&S manager discussed that the idea of integration is even more useful and cost effective for small businesses because they don’t need to hire multiple people, but with integration they can streamline activities and save in employment and operational costs.

### 3.3. Tools and approaches for integration

The participants were asked about their experience and perception on using more general risk assessment techniques or tools and incorporating MSD prevention into other organizational-wide tools through OHSMS or QMS. A participant argued that any integration would only be successful if the organization has some level of readiness. He argued that:

> There needs to be certain fundamental elements in place in order to go down the path of integrating through an OHSMS. So the things that we’ve observed that organizations needed to have, was a functional internal responsibility system. So ensuring that the employer, the supervisor, the workers, and the joint health and safety committee was at least functioning effectively and aware of their roles and responsibilities (C-03).

With respect to organization-wide approaches that MSD prevention activities could be integrated into, OHSAS 18001, CSA Z1000 standard series, PDCA model, and business process improvement tools and approaches such as Lean and Six-Sigma were suggested. A researcher admitted that some organizations may have an ineffective management

system and this may be due to poor implementation which may have negative consequences. Therefore, integration of MSD prevention into those approaches may not necessarily be successful. She argued that:

> Some people believe that integrating OHS in Lean was not effective but they never described what tools have been used, how they integrated them. Maybe the way that they integrate OHS to Lean was not good. Some organizations have less successful Lean, and therefore, the integration doesn't work. So, it depends on the system in place. The implementation is a strategic choice and it is not only culture of the organization that is important. How organizations position themselves in the market. How they have decided their strategic level. Understanding the company's strategy is important to understand the organization's management approach (R-04).

It was suggested that H&S in general and MSD prevention in particular should be introduced into the organization's overall objectives and appropriate translation should be made to link prevention activities to other language used to describe the overall objective of the organization. This could also be done through alignment of H&S objectives to those of the company, an H&S manager said. A participant suggested that MSD prevention could benefit from tools already in place in an organization, since different stakeholders have been using those tools daily for different processes. It was discussed that some may argue that some of these tools may not be optimal, but a participant believed that it is better to use a non-optimal tool if it can ensure the sustainability rather than not doing it. A researcher, however, suggested the use of "outcome metrics" rather than using "risk-based metrics". He suggested the use of performance metrics and workers' compensation claims to relate MSD problems to cost. He then argued that:

> It would sure be great when we get to the point that we can more readily look at jobs and give an approximate quantitative risk of what's the likelihood of injury in someone doing that job, and if you just did

> these changes, you could lower the risk by 20%. You know, the way we can do with some chemical exposures (R-02).

A consistent message was to use simple tools and techniques that are being used in organizations for other types of hazards. For instance, participants suggested using "Kamishibai" and "Ishikawa" for H&S issues in order to incorporate prevention activities into Lean management. These are problem solving tools within Lean. One participant also suggested that daily safety audits can be done and to use an "accountability board" to report on safety issues. This is a tool within Lean management and the participant reported that he uses this tool to address H&S issues in the workplace to incorporate them into Lean management. In addition to these, "process flow charts", Failure Mode and Effects Analysis (FMEA), decision making tools, and Job Safety Analysis (JSA) were recommended to be appropriate tools to be used for integration of prevention activities, due to their broadness and popularity in workplaces. Using the same risk matrix for all types of hazards was also introduced as an approach that could be considered. It was suggested that using risk assessment tools that calculate severity, frequency, and likelihood for MSD prevention is an ideal way that may potentially facilitate incorporation of MSD risk assessment into many of the tools used within organizations. It was argued that using an approach that could categorize risk factors into green, yellow, and red categories (like tools used within OHSMS and QMS) would help to gain management buy-in because of their familiarity. A consultant stated that, "If I show the manager, I used whatever checklist and I say the risk is in red [category]. End of discussion. He's going to understand [it and say]: it's red, [so] I need to do something (C-01)." On the other hand, ergonomic observational tools such as Quick Exposure Check (QEC) and Rapid Upper Limb Assessment (RULA) were recommended to be appropriate tools to be integrated

into other tools within an organization. A consultant characterized appropriate tools as being “quantifiable, repeatable and reliable, and measureable (C-06).”

## 4. Discussion

Possible differences between MSD hazards and other H&S hazards are thought to be one of the reasons for disconnection of MSD prevention activities from organizations’ management systems, compared to H&S management activities. Key informants reported that the lack of visibility of MSD risk factors and outcomes compared to other H&S issues, such as slips, falls, and chemical agents, is one of the main differences between these two types of risk factors. The lack of visibility of MSD risk factors becomes more challenging when it comes to psychosocial risk factors of MSD. The key informants also discussed how mechanism of MSD injuries differs from acute accidents or some of the occupational disease, and this potentially causes a huge challenge to get management support for investing in prevention of injuries that may not have immediate impact on injury statistics. In addition to this, the key informants noted that unlike industrial hygiene risk factors that are directly quantifiable and measurable, some of the MSD risk factors are hard to measure. This was speculated to be due to lack of research and practices in developing appropriate and reliable tools, or because of the inherently complex interactions involved (for example forces, postures and repetitions). That being said, tools such as the Threshold Limit Value (TLV) for Hand Activity Level (HAL) and the lifting TLV for low-back risk, have been developed by recognized organizations such as the American Conference of Governmental Industrial Hygienists (Latko et al.,1997; Marras, & Hamrick, 2006 ).

Behavioral-cultural aspects of MSD, the magnitude of complexity, and differences in individual responses (physiological and physical) to MSD risk factors, and issues around work-relatedness and non-work-relatedness causes of injuries were listed by key informants as potential differences between MSD and industrial hygiene risk factors. However, key informants believed that a consistent organizational-wide prevention strategy and approach needs to be implemented at the organization level to deal with different types of hazards. This was consistent with previous research where authors suggested integration of MSD prevention into problem solving approaches such as Kaizen (Nastasia, Toulouse, & Imbeau, 2006) as well as QMS (Lewandowski, 2000) and other approaches (Munck-Ulfsfält et al., 2003).

The key informants that participated in this research supported the idea of integration of MSD prevention activities into a broader organizational-wide framework, and they argued that this would avoid creating silos within organizations. The participants suggested that this integration could ultimately give the same level of recognition to MSD prevention as other business drivers, resulting in effective prevention. More explicitly, the key informants suggested that MSD prevention activities should be incorporated into organizations' OHSMS rather than implemented as an add-on program. The integration was suggested to positively impact the sustainability of prevention activities and the participants believed that this integration would raise the profile for several organizational concerns, including performance and the corporate social responsibility image. It was also suggested that MSD prevention could benefit from incorporation into approaches such as QMS, and continuous improvement approaches including Six-Sigma and Kaizen. Interestingly, this integration was said to be very useful and cost-effective for small

businesses. The key informants' perspective on this topic and suggesting the use of an integrative approach is consistent with the result of the scoping review study (Chapter II). This suggests that development of an interactive model is needed and is encouraged not only by researchers but also other stakeholders in the arena of H&S and injury prevention. As mentioned in the results section, the participants suggested that MSD prevention should ideally be introduced into an organization's overall business objectives, and to do so, an appropriate common language should be used. Employing tools currently used by organizations to deal with other business drivers was recommended as being an effective way of doing this. Explicitly, tools within Lean management such as Kamishibai, Ishikawa (fish bone diagram), and an "accountability board" were suggested as being suitable and popular tools that could be used to incorporate MSD prevention into Lean. Kamishibai is a Japanese mini-audit tool that provides visual outputs to be used within Lean management systems (Koch et al., 2012). Key informants also said that MSD risk assessment could benefit from incorporation into organizational-wide tools, such as FMEA, JSA, decision making tools, and process flow charts. This is consistent with findings from the scoping review study (Chapter II). The use of a consistent risk matrix for all types of hazards was also suggested as a possible approach. In addition, tools such as QEC and RULA were suggested to be used within organizational-wide tools to facilitate the integration. An appropriate risk assessment tool was suggested to be quantifiable, repeatable, reliable, and measurable.

## 5. Conclusion

The integration of MSD prevention into an organizational-wide approach was strongly supported by the key informants. The researchers, consultants, H&S managers, policy

makers, and union representatives that participated in this study suggested that MSD prevention activities could be beneficially integrated into OHSMS, QMS, and Lean approaches. This avoids creating silos within organizations and therefore results in better recognition of MSD prevention by stakeholders within organizations. Incorporating MSD hazard identification and assessment into tools such as FMEA, JSA, decision making tools, and Kamishibai and Ishakawa (for Lean) was suggested to improve this recognition.

# CHAPTER VI: Incorporation of Musculoskeletal Disorders Prevention into Organizations' Management Systems: Case Studies

## 1. Introduction

There are a multiple approaches, techniques and programs at the departmental and organizational levels to prevent occupational injuries and workplace accidents. Implementing prevention strategies using systematic frameworks are being practiced in order to improve the Health and Safety (H&S) of employees. Such frameworks being used at the organizational level are classified as "management systems". A management system is the framework of individual processes, procedures and resources joined to ensure achievement of certain objectives effectively and efficiently (Karapetrovic, & Willborn, 1998). To facilitate this, Occupational Health and Safety Management System (OHSMS) standards and guidelines, such as OHSAS 18001 and CSA-Z1000 have been developed. These systems are designed to be generic and applicable to organizations regardless of size, area of business, profit or not-for-profit orientation, and type of manufacturing or service process used (Karapetrovic, & Willborn, 1998). The concept of an OHSMS is now well known and has been adopted in many countries (Saksvik, & Quinlan, 2003). The main characteristic of this proactive management system that distinguishes it from traditional Occupational Health and Safety (OHS) programs is an ability to be integrated into other systems and to incorporate elements of continuous improvement (Robson et al., 2007). Generally, these frameworks aim to improve the health and safety of employees and prevent occupational injuries and disease while managing H&S risk factors in a systematic manner.

Although some of the approaches used to address MSD hazards have some elements in common with companies' management systems that address other risk factors - including quality and H&S risk factors - there is a lack of evidence on integrating MSD prevention and, specifically, MSD hazard identification and risk assessment into OHSMS. The result of the scoping review (Chapter II) suggested that the techniques to address MSD hazards are quite different to

techniques listed by the International Organization for Standardization (ISO) or used by companies to address other risk factors (health, safety and quality) within their management systems. This could result in MSD prevention becoming a "sidecar" function (Neumann, & Dul, 2005) that cannot be managed with company-wide tools at an organizational level. In addition, the review of literature noted that there is a research gap concerning the MSD prevention within companies' management systems.

In order to understand how MSD prevention fits into current management systems, a multiple case study was conducted (Yin, 1994; Dul, & Hak, 2008). This phase of the project explored current approaches and techniques used by companies to address general H&S hazards compared to methods used for MSD hazards. In addition, the roles of each participant with respect to H&S in general and MSD prevention in particular were explored.

Actor-network theory (Latour, 1987; Callon, & Latour, 1992) was used as a basis for the interview portion of the data analysis. This part of the study explored the role of different key actors within each organization in H&S in general and MSD prevention in particular. This theory provides a framework for explaining how actor networks get formed, for example, by identifying who pursues MSD prevention in a complex network in which other actors pursue other agendas, such as quality and H&S, and how they go about it. This framework was used to better understand the roles of different actors and their relations to each other.

The objectives of this study were to a) document the techniques and approaches used by companies in the manufacturing sector to address MSD hazards and how they do or do not integrate these into their H&S or management systems; and, b) explore workers' involvement in addressing these hazards. The purpose of this study is not to evaluate the effectiveness of the case study companies' OHSMS and MSD prevention approaches. Instead, it is to describe their

approaches as they have been implemented and operated.

## 2. Methods

To achieve the objectives of this study, two plants were recruited from a multi-plant corporation in the manufacturing sector. This phase of the project documented how the two case companies managed H&S within their OHSMS or other management systems, and how they addressed MSD hazards within these frameworks. A qualitative approach was utilized to achieve this including an interview study, document and records analysis, and workplace site visits and observations. These multiple approaches allowed a better understanding of how companies address MSD hazards within their management system in practice.

### 2.1.Selection and recruitment of organizations

The choice of the manufacturing sector was partially based upon the professional experience of the research team with this sector and access to workplace partners in Ontario. In addition, manufacturing companies likely face a wide range of challenges in addressing MSD hazards and even have different ways and approaches to address MSD hazards within their organizations.

The study of current approaches to prevent workplace injuries and management of H&S in different organizations within the manufacturing sector may lead to a better understanding of the current practices within this sector. In order to recruit organizations, a corporation with multiple plants was selected and two medium sized plants that are independent from each other were targeted for recruitment. The corporation was recruited using personal contacts.

After getting approval from the corporation's management, a recruitment package was sent to the H&S (or equivalent) managers of the organizations who is known as the "organization's

representative" in this thesis. The recruitment package consisted of a project summary, statement that the project was approved by the Office of Research Ethics at the University of Waterloo, interview justification and a consent form. Throughout several in-person meetings and phone calls, the representatives from the corporation and two of its plants agreed to participate in this research project. In one of the plants, the project coordinator had to meet with the plant manager to get his agreement to conduct the project. A memorandum of agreement was developed with the anticipated roles and responsibilities of all parties involved in the project, and were approved by both the corporation and the research team.

### 2.2.Selection and recruitment of individuals within organizations

The individuals within each plant were recruited through the organization's representative. An information package was sent to each individual and his or her agreement to participate in the study was obtained using the consent form. The choice of participants was informed by the personal expertise of the research team and actor-network-theory.

### 2.3.Interviewing participants

The interview protocols (Appendix B) were developed and mock interviews were conducted to test the feasibility of interviews and time required for each interview. Through sets of semi-structured interviews, we explored the plants' strategies to manage H&S hazards and MSD hazards. We also documented the plants' approaches to incorporate MSD prevention into their management system approaches. The interviews were designed to see whether there were special strategies for MSD hazards; what the participants' roles and responsibilities with respect to H&S and MSD issues were; what the level and nature of workers' participation was; what resources

were needed; and to solicit ideas of improvement.

Semi-structured interviews were conducted in person. Interviews took place at a location convenient for each interviewee and in a private location (i.e. a room located in the plant with a closed door) where interviewees felt comfortable. All interviewees read the information letter and signed the consent form, which explained the aim of the study and how resulting data would be used. They were asked for their consent to be interviewed, to have the interview recorded, and to have anonymous quotations from the interview used in any research output. Each participant was assured that his or her responses would be viewed only by members of the research team and, in particular, would not be shared with other individuals in his or her organization and that he or she was free to withdraw from the study at any point.

The language of the interview was in English. The interviews lasted between 45-60 minutes. All of the participants agreed to be audio recorded. The interviews were digitally recorded and then transcribed verbatim by a professional transcriber and were checked against the audio recording for accuracy by the investigator.

A qualitative computer software package (NVIVO$^{TM}$ Version 10.0) was used to help store, organize and analyze the data. Similar to the Key Informants study (Chapters IV and V) a thematic analysis approach (Braun, & Clarke, 2006) was used to code and analyze the data. The six phases of analysis outlined by Braun, & Clarke (2006) was used to guide the analysis of data (refer to Chapter IV for more details).

### 2.4.Document and record analysis

The plant representative provided the documents and records related to the OHSMS, where

possible. The documents and records were analyzed in order to gain a better understanding of the processes involved in managing H&S and MSD hazards within each plant. The organization's representative provided access to other necessary documents and records. The study of documents and records was conducted after the conclusion of interviews within each plant. This was done purposefully to help the investigator identify relevant documents and records to be requested from the plant representatives. Where possible, OHSMS or other management systems' documentation selected for analysis included: a) the H&S policy and objectives; b) description of the main elements of the system and their interactions; and, c) documents and records deemed necessary by the organization to ensure effective planning, operation, and control of processes that relate to the management of quality, H&S, and MSD hazards. Documents related to prevention of MSD, such as MSD hazard identification, assessment, and control were studied. In order to better understand the plants' approaches to address H&S and MSD hazards, the review of documents was conducted in collaboration with the organization's representative in each plant.

A content analysis approach was used in the analysis of the data from the documents and records. The results of the documents and records analysis, in conjunction with interview data, was used to better understand the organization's approaches and strategies to address MSD hazards within their H&S and overall management system.

### 2.5.Workplace site visits

The third part of this study was workplace site visits in order to better understand the workplace and the types of work performed. This provided the opportunity to get a better sense of the type of hazards within the organization and the organization's approaches to dealing with them.

Random work areas were observed to study the extent and nature of any changes implemented to improve them. Informal face-to-face conversations with workers were held in both plants to explore workers' involvement in prevention activities. In addition, extensive field notes were taken following each site visit, which were used to better understand the organizations' process to manage H&S and MSD issues in participating organizations.

## 3. Findings

The results consist of the analysis of the interviews, the document and record analysis, and the workplace site visits. Six topics were explored, including: roles and responsibilities, management commitment, worker participation, management of OHS, MSD prevention approaches, and ideas to improve current approaches.

In this Chapter, the word ergonomics is used in its H&S application as MSD prevention. To maintain anonymity, the participants were categorized into two main groups, administration and production. In addition, as only a few of the participants were female, to maintain the anonymity and confidentiality of the participants, all of the participants were referred to as she or her, as appropriate.

The following sections present the findings in plants A and B separately, followed by a general discussion and conclusion. Where possible, similarities and differences in perspective of different participants or approaches use by the two plants were noted.

### 3.1.Plant A

This manufacturing plant has about 500 employees, is a part of the participating corporation and is located in Ontario. The plant had an H&S management system framework that has been audited periodically by the corporate H&S department. However, ergonomics or MSD

prevention activities were not addressed within this framework. The plant did not have any stand-alone or integrated ergonomic program. Participants (10 individuals) interviewed included: the labour co-chair of the Joint H&S Committee (JHSC), H&S coordinator (management co-chair of the JHSC), Human Resources (HR) manager, maintenance manager, production engineer, production manager, production supervisor, quality manager, and two workers (an operator and a team leader). These participants represented workplace parties involved in health, safety, and production.

### 3.1.1. Roles and responsibilities

The participants were asked to describe their primary roles in the organization as well as their roles in management of H&S, if any. In addition, they were asked to describe their roles, if any, with respect to MSD prevention. Table 1 summarizes the roles of the participants with respect to the above functions.

A participant from the production group reported that everyone should have some sort of responsibility with respect to H&S, but in this plant the approach to H&S was more reactive than proactive. She stated:

> If they [workers] find something during their daily operations or if we decide to do a project [on safety] that we're working on, they're involved in that project.

This approach was seen to be the nature of some activities with respect to H&S and the analysis of documents and records showed that the roles and responsibilities of employees with respect to H&S were not well defined and not communicated to employees. The interview data showed no evidence that different participants had clear responsibilities or roles with respect to MSD prevention. A participant from the administration group reported that MSD related concerns

were addressed through a case-by-case basis approach and through requests made by production workers or injury claims. Another participant from production stated:

> We haven't actually had any ergonomic type initiatives in this facility. Previous divisions that I've been in, obviously, I've been a lot more involved in ergonomics. We've had an ergonomics committee. But in this particular division there's been nothing. And I've been here for about … years now.

In contrast, another participant argued that the quality department has some responsibilities with respect to ergonomics. She described her department's involvement in MSD prevention activities as limited to preventing these disorders among quality department employees. She said:

> Our only involvement is basically if we're introducing an inspection or a gauge, we try to make sure it is light first of all and the moment of inspection is not that you have too much of repetitive tasks, which can potentially cause a short-term or long-term injury. So, we try to work with our continuous improvement team while designing cell layout or redesigning the layout, we need to make sure the body postures are taken care of, there's no bending happening, our gauges are light, [and] there is enough lighting, this kind of stuff.

It is noted that these activities were not a part of the organization's overall H&S process and the document and record analysis did not find any evidence of these activities. This participant led some initiatives, mainly due to her understanding of ergonomic problems and their impacts on quality inspection. She seemed to be embedding ergonomics, so as to prevent MSD injuries, into a continuous improvement process.

Although the interview data and document and record analysis revealed no evidence that this workplace assigned responsibilities to its employees with respect to MSD prevention, the plant had a document that outlined the roles and responsibilities of employer, supervisor, and worker in health, safety and environment. Informal conversations with production workers and workplace site visit observations revealed that the workers were not fully aware of their roles and

responsibilities with respect to H&S in general. Their roles and responsibilities seemed to be limited to wearing Personal Protective Equipment (PPE) rather than participation in proactive measures to address H&S and MSD hazards. It was observed that the majority of employees in this plant believed that H&S was the responsibility of an H&S coordinator only.

### 3.1.2. Management commitment

Participants were first asked to define management commitment from their own perspective. Participants consistently defined management commitment as not only the provision of human and financial resources necessary for H&S, but also involvement of management in problem solving. A participant from the production group stated that this support and commitment should come from the top of the organization. She commented:

> That [management commitment] means it's a priority from the top of the organization, not just the general manager but also from the corporate level, from the VPs [vice presidents] and presidents, that it's a priority, and not just when there's an issue. Because that's typically what happens, I'll see over my 20 years, a lot of things come and different initiatives that come in over time, that's been a priority but then it's kind of the flavour of the day. So the ergonomics committee [that will be in place] can't be a flavour of the day for senior management. They need to get involved at some level and make sure that the organization is participating in the program.

## Table1. The primary role of different participants in plant A and their roles with respect to H&S

| Participants | Group | Primary role in the organization | Role with respect to H&S |
|---|---|---|---|
| H&S Coordinator (Management co-chair of JHSC) | Administration | ▪ Management co-chair of JHSC<br>▪ H&S coordinator | ▪ Managing and maintaining programs related to H&S based on corporate frameworks and requirements |
| HR Manager | Administration | ▪ Responsible for HR related programs in the facility (recruitment, training, performance management, employee relations, H&S) | ▪ H&S is structured under HR and will be managed by HR manager<br>▪ Managing H&S coordinator |
| Labour co-chair of JHSC | Administration | ▪ Production operator | ▪ Certified co-chair for JHSC<br>▪ Participate in JHSC meetings<br>▪ Involved in a number of projects (emergency services) and complaints or investigations<br>▪ Assisting H&S coordinator with safety related fixes in the workplace<br>▪ Current role more focused on safety |
| Maintenance Manager | Production | ▪ Ensures all equipment is working properly by performing preventative and corrective maintenance<br>▪ In charge of 50 employees who work across four shifts<br>▪ Follows work orders requested by anyone in the facility, which are prioritized<br>▪ Conducts feasibility review of orders when needed | ▪ Ensures employees under supervision are following H&S rules (i.e., Lock out tag out, and use proper tools) |
| Production Engineer | Production | ▪ Manufacturing engineering (develop process)<br>▪ Directing and leading engineering processes<br>▪ Purchasing<br>▪ Reporting directly to general manager | ▪ Safety compliance<br>▪ Workplace inspection<br>▪ Ensuring machines and equipment are OHS act & CSA standard compliant (including CSA Z432-machine guarding standard)<br>▪ When implementing improvement/change, consult with operators, supervisor, and get expense approved. Sometimes will get maintenance department involved to implement changes, or an external contractor might be involved |
| Production Manager | Production | ▪ Responsible for production in a specific area of the plant<br>▪ Managing tooling department, shift supervisors, production workers etc. | ▪ Making sure that safety requirements are in place<br>▪ Workers' safety and machinery safety |
| Production Supervisor | Production | ▪ Senior manufacturing supervisor<br>▪ Day to day production requirements, overtime requirements, manning requirements, and scheduling<br>▪ Responsible for supervisor, team leaders | ▪ Member of JHSC committee<br>▪ Accommodate workers with modified duties<br>▪ Operators inform team leaders, who will fix simple H&S problems or notify production supervisor |
| Quality Manager | Production | ▪ Ensures systems are in place to protect customers & the facility<br>▪ Support production<br>▪ Ensuring customer satisfaction and preventing customer line downs by removing non-conforming products<br>▪ Managing 11 employees | ▪ Ensuring employees in department follow H&S rules (wearing PPE, ensuring outside contractors have WSIB insurance and wear PPE, have liability insurance, and follow 5S methodology) |
| Worker 1 (an operator) | Production | ▪ Technician<br>▪ Take care of coolers<br>▪ Maintenance of machines | ▪ Communicate to H&S coordinator about possible H&S issues<br>▪ Look into the results of testing of oils and coolant to ensure they don't cause skin reactions |
| Worker 2 (team leader) | Production | ▪ Team leader in production line<br>▪ Supervising 21 operators | ▪ Daily inspection of shop floors to make sure they are clean and dry (no oil leaks)<br>▪ Daily inspection of light curtains and other safety features of production line<br>▪ Immediate communication with maintenance about light curtain failures or other safety issues such as oil leaks<br>▪ Where needed, communicate with Lean coordinator and engineers to solve H&S issues |

Another participant from the production group stated that managers needed to show their support and commitment by taking the lead in promoting or even enforcing how the company operates with respect to H&S and take responsibility for H&S and ergonomics. She argued that, from her perspective, management commitment means "commitment to shop floor" and getting involved in problem solving with workers on the shop floor. This perspective was supported and further elaborated upon by another participant who argued that commitment from management builds trust among workers.

Participants consistently suggested that management commitment is essential for improving H&S at the workplace. Another participant in the production group suggested that:

> It [management commitment] is number one. If the management doesn't have the commitment, then it will not happen. Nothing is going to happen. What is there will take 10 years instead of one month, because you don't have the support.

In addition, another participant argued that the "sustainability" of any procedure, including preventive maintenance and H&S, is dependent on management commitment. She noted that the process would be sustainable if the management is committed, reviews the process, and evaluates the effectiveness of the process.

Another participant from the production group said that management could show its support and commitment by attending JHSC meetings. She elaborated her position by saying:

> [if a manager attends JHSC meetings) ... all the questions that we may have and all the questions that have not been answered, we just give it to [the manager] and we can have a chance to ask him why is this too late or why is this problem not solved? … Attending those meetings, they will get it from the guys who are like me on the floor who are seeing it directly and telling them this is what I've seen. So what are you doing to help us? So that is a very good idea that they should try as much as possible to be coming to those employee safety meetings. That is where I think everything starts and how they're going to deal with it.

This perspective was strongly supported by other participants. Document and record analysis showed that the general manager participated in the JHSC infrequently, but his attendance resulted in speeding up the implementation of action items of the JHSC. A participant from the production group argued that the general manager of this plant had limited flexibility to allocate resources (financial and human resources) and showing his support with respect to H&S, and this would put the plant manager in a tough situation. She suggested that the commitment should come from the corporate level in companies with a corporate structure. Another participant suggested that to implement any intervention to reduce H&S problems, allocating financial resources usually depended on providing cost-effective solutions and this needed to be documented and justified to the top management. This was supported by another participant, where she had the same perspective but from a broader point of view. She suggested that in companies with a corporate structure, if the plant is not making a profit, then the corporate headquarters might not invest in that plant and this put the plant's general manager in a very tough situation in terms of allocating resources for H&S and ergonomics. She described the scenario below:

> If a division like this one in particular is losing money, the commitment from corporate to invest capital in this plant is generally very low, very low. The thought process that typically takes place if you're losing money, we're not investing in you until you turn it around... You know, sometimes you need to invest in order for things to get better…And a lot of the items that would come out of the ergonomics program would come out of your day to day operating expenses, which obviously would affect him [general manager] because he's got to show at the end of the month a profit or loss. So it makes it tough on him if he doesn't have the support…I'll say him as the general manager, if he doesn't have support from corporate and VPs to spend that money…held accountable for a loss that's due to well we've done all these improvements, ergonomics-wise. At the end of the day, I don't want to say they don't care about it, but they need to be sensitive to that issue. So he's in a tough position, because if I'm going to go spend $50,000, you're already losing $300,000 a month, you're going to put another $50,000 loss on top of

> that due to some ergonomics improvement…didn't help your bottom line. It may help the people on the floor long-term because now they don't have issues, but that's a tough sell for him.

A participant from the production group offered a perspective that would reflect on a previous comment. She argued that spending resources on H&S should not be seen as expenses but "investment". She stated:

> In manufacturing it's something that you have to make an effort at because it's [H&S] an expense. But you need to treat it as an investment. It's an investment to the safety of your employees; it's an investment to the longevity of your business. And that's how we have to treat that kind of thing. If you treat it as an expense, then it's always a battle. It's not just here, it's everywhere.

Interestingly, one of the participants from the administration group questioned whether safety was the first priority to which management should commit. She argued that the ultimate goal and responsibility of every manager in this plant was to protect workers' safety. However, this may not happen in reality when it comes to competing priorities. She explained:

> If you spoke with every manager in this place I have no question that they would feel that ergonomics is very important and the protecting of our people is probably our paramount responsibilities as managers while we're here. But realistically that's not quite how it translates to the floor. So it's not that the managers don't care, [but] it just doesn't seem to be everybody's top priority at the end of the day … we talk about safety first … [but] it kind of a bit of a running joke within sort of the HR, H&S group in [corporate name] that you know, you sort of go to these conferences and everybody is like safety first, safety first, and everybody kind of has a little chuckle because we all know production is first. You don't have products, safety doesn't mean anything right. And that's kind of sad for an organization as big as [corporate name], to say that … it is reality [but]… like I said, it's not for any manager not caring. It's just simply the way this industry tends to run unfortunately.

The overall perspective of most of the participants on current management commitment, in this plant, was positive and they argued that this commitment had been improving for H&S. The

participants noted that they needed the same level of commitment for MSD prevention, which was not evident.

It was also noted that the facility received H&S inspections every six months and the general manager was responsible for cooperating with these audits. A participant from the administration group reported that these audits would reflect management performance and were conducted as part of the corporate overall audit process. The corporate headquarters conducted a separate audit for ergonomics. The results of the documents and records analysis, however, indicated that this plant received a poor score for their ergonomic program due to not implementing the corporate ergonomics program. The participant also suggested that implementing the ergonomic program was a mandate of the corporate head office and not a direct decision by the plant manager. She said:

> ...up until recently general managers have not given that time, money and resources to that [ergonomic] program. Fortunately, a little while back one of the guys actually up at the corporate office said ok you guys, [you] need to get this done.

The interviews and document and record analysis revealed that corporate headquarters provided an online internal platform to share knowledge and best practices with all of its plants. These resources are available to all plants at no cost. In addition, companies could communicate and learn from each other by sharing their success stories and using each other's resources. The informal conversation with workers during the walk through site visits suggested that the plant had an open door policy where workers felt that they have been able to discuss their problems in face-to-face meetings with the plant's general manager. However, the commitment of the general manager to provide a safe workplace seemed to be reactive and dependent mainly on workers' complaints.

### 3.1.3. Worker participation

The consistent message of participants in this plant was the importance of encouraging workers' participation in all aspects of the workplace decision-making process. However, one of the participants from the production group warned that workers' feedback needed to be considered with caution due to the possible unfamiliarity of workers with regulatory requirements. Another participant from the same group argued that workers' involvement could increase workers' knowledge and awareness in achieving the organization's goals and targets. She stated:

> Times have changed over the years. 30 years ago, yeah, it was always a management decision. That's it; you just did it. You didn't know why you were doing it; you just did it because the boss said to do it. Now you have to have everybody involved. And the more that comes off the floor, the stronger you can be with that, because they're going to understand exactly what we're trying to achieve here. As far as ergonomics and safety, risk assessments, quality, productivity, all in one, the more they understand, the more they know what we're looking for, the better off we are.

A participant from the production group said that the management team had not supported the participation of workers in H&S very much. She reported that this had been a problem even for JHSC members where the supervisor/management did not allow members of the JHSC to participate in monthly meetings that required only two hours per month. This indicated that although the management saw the benefit of involving workers in H&S activities, they were unwilling to give them the time away from production to participate in H&S related activities. The results of document and record analysis also supported this, where evidence that workers had proactively participated in H&S initiatives was rare.

The participants were asked to provide their suggestions on how the organization could ensure effective and sustainable participation of employees in prevention activities. Several ideas were proposed. These included: a) the general manager making participation a priority; b)

acknowledging workers' ideas and communicating their inputs on positive outcomes; c) providing incentives to participate; d) creating improvement teams consisting of workers; e) increasing awareness through consistent training; f) face-to-face communication; and, g) including H&S in daily review meetings.

A participant from the production group said that using the existing approach in the organization for quality and other business drivers could potentially increase workers' willingness and motivation to participate in H&S. She stated:

> We have five different meetings with all the employees. Staff and hourly employees go to it. There's a business update, an HR update, a quality update. So if you want to make it effective, do the same practice and then people understand it…when people start seeing it, they'll get more involved. If we do it properly [and] if you implement and do it properly and don't just try and take a big paint brush and paint ergonomics on the wall, have specific projects that show effect, people will buy in and you show that in the meeting so then people understand that the company takes it seriously.

Another participant shared her past experience in another company where production workers participated in "improvement teams". She described how workers were involved:

> Well, where I came from, I was senior supervisor, 30 years in that plant. I had 32 teams off the floor and we had a meeting, one hour every single week. They were taken right off the floor. Here we don't do that because of time. But you know how much you can get out of that hour? … There's just so many things you get. So I'll have the lead facilitator. So I had 32 teams, 36 facilitators and once a month I'd meet with them to make sure that they were on track. It's for suggestions, ideas, improvements, it's for quality, for safety, it's for everything… Then that spreads through the plant and everybody gets on board with that. We made so many improvements over there, so much, and most of it all came from the floor.

The analysis of documents and records suggests that the plant did not have any systematic and formal approach to encourage workers' participation in prevention activities. However, there were some records of involving workers on a case-by-case basis in improvement initiatives to

increase lighting (in the quality department) or reducing safety hazards on the production line. For instance, one of the participants from the production group stated:

> We had an operator, got him involved, he brought up a question, I said no problem. I said you're now part of a team. So we took our process engineer, our plant engineer, our maintenance supervisor, and the production supervisor with this operator went to the machines and now today there's a contractor coming in to redesign lighting specifically for the operators to make their job easier.

Although one of the participants from the administration group reported that workers were involved in the risk assessment process, another participant from this group reported that she was not aware of any involvement of workers in risk assessment process. Instead, as further elaborated on by the two of participants from both the production and administration groups, this involvement in hazard identification and risk assessment was limited to receiving complaints from workers and not necessarily involving them in solution generation and implementation. Another participant said that she had been consulted on some occasions but she was not involved in the risk assessment process. The analysis of documents and records indicates that although there was a process in place to involve workers in hazard identification and risk assessment, in reality this did not take place systematically. The workplace observation revealed that the H&S coordinator had provided a communication sheet containing information on H&S hazards and required PPE for a few workstations.

The overall understanding of this plant's approach for workers' participation was that workers were not involved in H&S activities proactively. Instead, the approach was more reactive and on some occasions case-by-case and as a result of individuals' complaints. The plant had resources and support from its headquarters to proactively engage their workers in H&S and MSD

prevention activities, but the resolution and commitment seemed to be lacking due to poor implementation and management of H&S and MSD prevention activities.

### 3.1.4. Organization's approach to managing H&S

The results of documents and records analysis and interview data showed that this plant had implemented the corporate office's OHSMS audit model and was periodically audited by headquarters. According to one of the participants from the administration group, the entire corporation used Ontario's Workplace Safety and Insurance Board's (WSIB) audit program called the "Workwell Program". The analysis of documents and records suggests that the plant also implemented ISO/TS 16949 that aimed at development of a quality management system. ISO/TS 16949 provides specific requirements for the development of a quality management system and continual improvement and it is a frequently-practiced approach in the automotive industry. The organization has several H&S procedures that reflected the requirements of corporate headquarters' OHSMS. The plant's OHSMS was not linked to or incorporated into ISO/TS 16949.

Despite having procedures and policies in place for managing H&S, it appeared that the implementation of OHSMS was being done to meet the headquarters' requirements rather than implementing an organizational-wide management system that involved several stakeholders in the plant. The implementation of OHSMS seemed to be limited to the H&S coordinator. The plant had three main objectives for the year that are planned, documented, and monitored. However, these objectives were not communicated to employees and the interviews and informal conversations with workers suggest that most, if not all, of the employees were unaware of the existence of these objectives. The interview data suggested that there had been some improvement since the implementation of the OHSMS, such as decreasing the risks for slips and

falls, forklift accidents, and installing lifting devices. However, a participant from the production group believed that the approach that the plant was taking for H&S was more “reactionary” and not “systematic”.

With respect to addressing H&S and MSD concerns in the design stage, a couple of participants reported that they were unaware of any formal processes to address these issues in the design stage. However, another participant recalled that in another plant where she had worked previously, ergonomic assessments were required to be performed in the design stage. This indicates poor implementation or at least selective implementation of policies and procedures in this plant, despite the existence of headquarters’ support.

The participants were asked to identify (from their perspective) the main H&S and MSD problems in this plant. They reported minor injuries such as bruises and cuts, slips and trips, oil leaks from machines, lack of H&S awareness, safety culture, sub-contractors’ safety problems, fumes as a result of melting aluminum, repetitive motion, workload, frequent bending, lifting, back pain, shoulder pain, stress, and lack of management involvement, to be the main H&S and ergonomics problems in this plant.

Plant A had a procedure in place for hazard identification, risk assessment, and control for H&S and environmental risk factors. The process was well designed and the risk factors were supposed to be prioritized into four categories (immediate, high, moderate, and low) based on their risk number. The procedure described the roles and responsibilities of the stakeholders involved in risk assessment process including: the H&S coordinator, program managers/engineering, managers, supervisors, team leaders, JHSC, and employees. However, the document analysis indicated that the involvement of stakeholders in the risk assessment process was limited. The interview data supported this observation. In response to a question about her

familiarity with H&S risk assessment tools and her involvement one of the participants, a member of the JHSC, , stated that: “I’m aware of them but I’ve not been involved in them as of yet.”

One of the participants from the administration group said that the H&S risk assessment was being reviewed every year. The review process allows the management to reflect on recent incidents and the introduction of new processes or machinery. The risk assessment process was seen to be less participatory and the H&S coordinator mostly conducted the assessment. However, participants such as the maintenance manager and production manager were consulted in the solution generation process and were involved when an action item was assigned to them. One of the participants stated that she had never participated in formal risk assessment process and had never attended a JHSC meeting. A participant from the production group did not believe that the current approach for solution generation and problem solving (e.g. inspections) was efficient. She said:

> It’s not efficient then. Everybody is doing workplace inspection but that’s all, it’s only to comply with the rules I think. I don’t feel it’s for the purpose of fixing the problem.

A participant stated that they have been using “5-WHY” methodology not only for quality error problems but also for incident investigation. This is an example of how the plant incorporated H&S into other organizational-wide practices.

### 3.1.5. MSD prevention approaches

Plant A had not implemented any proactive programs to prevent MSD. However, the general manager of the plant recently accepted the mandate from headquarters to implement a formal, auditable ergonomic program. The participants were interviewed and related documents and

records were analyzed to explore the plant's current approach to address MSD hazards and how the organization manages to eliminate or minimize these hazards.

One of the participants from the administration group commented that MSD was a "hidden component" and was one of the main concerns of the plant. She stated:

> …not that we ignore the people that are there, but it's [MSD] just inherently one of those things that you kind of forget about it until it slaps you in the face and somebody comes down with something in their joint or something that you do and it's like oh, I forgot about that. So I would say that is a hidden one for sure.

The participants consistently reported that they were unaware of any formal risk assessment or any approach that the organization had with respect to ergonomics or MSD prevention. The participants suggested that addressing MSD hazards and ergonomic concerns could help the organization achieve its goals and objectives. One of the participants from the production group believed that this would ultimately reduce time off, increase job performance, reduce fatigue, improve quality, and overall safety. Another participant provided an example to emphasize how implementing an ergonomic program to address MSD hazards would result in improving quality of the products and improve customer satisfaction. She stated:

> The quality goal for the plant is we are mandated to improve 30% every year. So if I had 10 issues last year, I've got to have 7 issues this year. A lot of the issues [are] visual escapes. So if we have a good ergonomics program that means that operators are basically not uneasy at their job, the repetitive motion is not causing them pain, the gauges we provide them are not causing them uneasy or pain again. Then obviously, they'll focus more on visual inspection and that will result in better customer satisfaction.

A participant from the administration group supported this when she reported that ergonomics related problems, including heavy loads, have caused several quality issues resulting in customer dissatisfaction and complaints.

The analysis of documents and records showed that despite the absence of a proactive prevention approach, the plant had reactively responded to some of the MSD complaints reported by its workers. In one case, the plant was required to meet ergonomic requirements mandated by a client, which was said to be an ergonomic assessment. According to one of the participants, this assessment resulted in installing a lift assist and this was the only time that she was involved in a formal ergonomic assessment.

### 3.1.6. Participants' ideas to improve current approaches

Participants in Plant A were asked to provide recommendations on how to improve current practices and approaches in addressing H&S and MSD hazards. Ideas for improvement varied between different participants and multiple ideas were proposed. One noted that the current inspection process created a list of action items for which the maintenance department was mainly responsible. She mentioned that most of these action items were not practically possible to implement; only 20% of action items are practically doable. She said that the current risk assessment approach could be improved by engaging everybody. She felt that the maintenance department must be involved in the solution generation and decision making stages. In addition, she pointed out that the maintenance manager had never been invited to attend the JHSC and that she needs to be invited to attend the JHSC meetings. Another participant recommended that the current approach could be improved by placing more emphasis on general H&S awareness, awareness of job-related hazards, and having the management be actively involved in the shop

floor activities. A participant from production group believed that meetings with the general manager and using focus groups for H&S were needed to improve current approaches.

With respect to MSD prevention, one of the participants in the production group stated that current practices should be improved by incorporating ergonomic risk assessment into current H&S risk assessment process. She stated:

> Right now the only thing that we have to include in the risk assessment and have complete hazard identification for the facility is ergonomic risk assessment. As soon as we have that point done, we can have real hazard identification, including everything in the facility.

Incorporation of ergonomics into the organization's management structure was thought to be essential. Another participant from the production group pointed out that using tools such as Failure Mode and Effect Analysis (FMEA) to address ergonomic hazards could result in better recognition and understanding of MSD hazards due to the popularity and broad application of FMEA. She commented: "You can apply FEMA to any process, whether you're walking, whether you're talking, whether you're manufacturing, or H&S." Current approaches to address H&S and MSD were said to be improved through consistent involvement of leadership and proper training of members of the JHSC. A participant from the production group noted that:

> From what I've seen in the past, obviously leadership would have to be involved consistently, not just in and out if you're having monthly meetings, one month you're there, one month you're not or whatever. Secondly, I would make sure that you do a fairly, I'm not going to say rigorous selection process, but the people that are on the committee need to be properly trained. … Because you can train somebody, I've seen in the past where you can train people say from the floor, and this is nothing against people from the floor, but you provide them a bunch of information, it gets misused…it creates a lot of work unnecessarily because they don't understand how to properly utilize the information that they're given. So I think making sure you have the right people on the [JHSC] committee and proper training.

In short, participants consistently suggested that the current approach to address health and safety and MSD prevention could be improved by more training, management involvement, and a more integrative approach using tools such as FMEA.

### 3.2.Plant B

This plant has approximately 250 employees and, similar to plant A, is located in Ontario. The plant had a formal Environmental Health and Safety (EHS) management system framework as well as an ergonomic program. Several participants (eight individuals) in this plant were interviewed. Participants included: the engineering program coordinator, H&S coordinator, design engineer, HR manager, maintenance supervisor, quality manager, and two workers (a production worker and a team leader). These individuals represent all the individuals involved in health, safety, and production. The following themes were extracted from the interviews.

#### 3.2.1. Roles and responsibilities

Similar to the first plant, the participants were asked to describe, in their own words, their primary roles in the organization and in the management of H&S. Table 2 summarizes the participants' self-described primary role in the organization and their roles in management of H&S and MSD prevention. The plant had two formal procedures outlining roles and responsibilities of stakeholders in EHS and the ergonomics program. However, it appeared that most of the participants were not fully aware of their roles and responsibilities with respect to H&S and ergonomics.

A participant from the administration group admitted that she was less engaged in the ergonomic program compared to H&S, although she was trained to perform ergonomic risk assessments. She stated:

> I would say I'm maybe a little more removed than with the H&S side because [the engineering program coordinator) is quite strong in the function of sort of heading up the ergonomics committee. So I do sit on the ergonomics committee, I'm not considered the champion, but I am involved in the committee. I'm trained to do ergonomic risk assessments and really just support the committee.

She stated that she supported the H&S coordinator in obtaining an adequate budget to perform necessary changes. The costs related to some of the JHSC action items such as training would be approved directly by her, which could expedite the process. She described her financial authority as follows:

> I have signing authority up to $1,000. And our plant manager has signing authority up to $5,000. After that then typically we'll take it to our general manager. So I'll assess and say ok, within my power this makes sense, ok I sign off. If I'm looking at something that's maybe $2,000 I'll either go directly to my general manager and get approval, unless he's not available I'll go directly to the plant manager because he has $5,000 signing authority.

A participant from the production group reported that to address an H&S concern, workers needed to contact the H&S coordinator and, for ergonomic related issues, they had to contact the engineering program manager. The plant had two separate committees to deal with H&S and MSD hazards, including the JHSC and the ergonomics committee.

The results of document and record analysis showed that despite ergonomics being positioned under H&S and HR, there were two completely different procedures outlining the roles and responsibilities of participants with respect to H&S and ergonomics. It is not clear why the

organization has not attempted to merge these procedures. The walkthrough observation and informal conversations with workers suggested that most employees see the H&S coordinator and engineering program manager as the only one responsible for H&S and MSD prevention activities. One of the participants from the administration group said that the employees should be more aware of their responsibilities with respect to H&S and MSD prevention. She stated: "…[we are] trying to change the culture so that they [employees] have a little more awareness of their responsibilities as being safe workers as well, that it's not always somebody else's job."

### 3.2.2. Management commitment

The analysis of interview data indicates that there was a consistent understanding of the definition of management commitment in this plant. The participants defined management commitment as commitment by the senior leadership (general manager) to allocate necessary financial and human resources to manage H&S and ergonomic issues, encourage participation of employees in H&S activities, drive H&S and ergonomics, bring awareness, and be an active support to provide a safe workplace.

The participants had consistent perspectives on the importance of management commitment in implementing changes to improve H&S. The participants in this plant suggested that without management's active involvement and approval, implementing any changes was very difficult and almost impossible. One member of the production group suggested that this support should come from all levels of management and the leadership team. This became very challenging when the cost of changes exceeded more than $1,000 because the changes that cost over this amount needed the general manager's approval.

**Table 2. The primary role of different participants in plant B and their roles with respect to health and safety**

| Participants | Group | Primary role in the organization | Role with respect to H&S |
|---|---|---|---|
| Engineering Program Manager | Administration | ▪ Project management<br>▪ ISO/TS 16949 lead auditor<br>▪ Environmental management system internal auditor<br>▪ Coordinate Key Measurement/Process Indicator meetings<br>▪ Update technical specification and engineering standards | ▪ Ergonomic coordinator<br>▪ Run ergonomics meetings<br>▪ "Ergonomics expert" for the plant<br>▪ Implement and maintain ergonomic program |
| H&S Coordinator | Administration | ▪ In charge of ensuring the plant is compliant with H&S and environmental legal requirements and standards<br>▪ Provide management with feedback and updates on regulatory changes<br>▪ Follow up on incidents<br>▪ JHSC committee chair<br>▪ Workplace Inspections | ▪ Make sure that operators are performing tasks in a safe manner to ensure their well-being and prevent injury |
| HR Manager | Administration | ▪ Sufficient staffing and training<br>▪ Deal with compensation issues, benefits, surveys, human rights issues, employee complaints<br>▪ Oversee EHS<br>▪ Supervise receptionist, EHS coordinator, HR coordinator, and the employee advocate | ▪ Member of ergonomics committee<br>▪ Support JHSC and ergonomic committees<br>▪ Some financial approvals, or seeks financial approval from plant manager or general manager for EHS fixes |
| Maintenance Supervisor | Production | ▪ Coordinate work between millwrights and electricians<br>▪ Report to maintenance supervisor, in charge of all millwrights and electricians on all shifts | ▪ Ensure all equipment operates in safe manner and complies with CSA & company H&S guidelines<br>▪ Work with ergonomic committee to implement required changes<br>▪ Being accessible to production workers to forward their concerns to ergonomics committee/ H&S |
| Design Engineer | Production | ▪ Design new products and required tools | ▪ Occasionally a part of team conducting ergonomic assessments<br>▪ Consider ergonomic guidelines for each product including tooling and equipment during design stage |
| Quality Manager | Production | ▪ Ensure quality system is in place that meets customer demands and fills corporation guidelines<br>▪ Deal with quality based complaints internally and externally including quality of incoming components | ▪ Ensure when fixtures are placed they meet ergonomic guidelines for operator use by testing and recruiting the ergonomic coordinator to do an assessment |
| Production Worker | Production | ▪ Shop floor operator | ▪ Member of ergonomic committee<br>▪ Represent other operators in ergonomic committee<br>▪ Help to solve problems |
| Team Leader | Production | ▪ Ensure that operators follow standardized work procedures | ▪ Ensure operators wear PPE<br>▪ Inform H&S coordinator and/or ergonomic coordinator of operator concerns<br>▪ Make sure that operators bring their concern to team leader, if not addressed, then supervisor, then HR or open door process to employee advocate |

One of the participants shared the perspective that managers should commit to make everybody accountable when it comes to H&S and MSD prevention. Another participant explained how the management team had a significant role in getting employees involved in H&S activities by showing commitment to H&S. She stated:

> Because if you don't have the buy in from your management team, you're not going to get the buy in from the people on the floor. Because the people on the floor look to your management team as the role model. They're the ones that I may or may not look up to, but they're the ones that are supposed to be setting the example... If they're not providing a good example for the employees, then you can't expect the employees to do what you want them to do. So if you're not going to follow the rules as managers, then you can't expect your employees to follow the rules. So, if they're [managers] not committed, you can't expect your employees to be committed.

The participants were asked to comment on the current level of management commitment and support (in this plant) for H&S in general, and MSD prevention in particular. In general, despite a few concerns, the participants had positive experiences with management commitment to address H&S and MSD issues. However, one of the participants from the administration group highlighted that lack of involvement by some of the managers had resulted in some challenges. She stated:

> I would say the management is maybe a little fragmented would be the word I would use. We have certain managers who seem quite committed and push a lot. We have others that are completely not involved, which it then becomes one or two person's kind of show, and that makes it a challenge for those areas and those departments.

A participant from the production group raised an interesting concern. She asked how management commitment could be measured. What metrics could be used to evaluate management commitment? She stated:

> To compare quality and ergonomics, in ergonomics, in terms of commitment…I can't put a number but I'm trying to think of where I could see any visual differences between the two, where the one is being allowed more room for error or given more to do this. I don't see anything that I can measure in those areas.

Another participant noted that the current situation could be improved by bringing back the ergonomics survey and suggestion boxes that used to be helpful in obtaining management buy-in. Headquarters conducted these surveys every quarter. She also argued that the management support was not as it had to be and more support was needed for MSD prevention activities. In addition, increasing management awareness about H&S issues and concerns was said to result in better commitment. Another challenge mentioned by her was that the general manager of this plant was responsible for three other plants, which limited her time to be actively involved in H&S activities. Another participant from the administration group mentioned that the general manager needed to be more involved in H&S in general. She stated:

> Other than when we review it at our management reviews and things like that, I don't really see a lot of involvement. So, I think by even just physically attending meetings or physically bringing up issues that are noticed on the plant floor would resonate well with the rest of the organization.

Informal conversations with production workers and the analysis of the interview data revealed that this plant had an open door policy where workers could approach the management freely to discuss their H&S concerns. However, this approach could be considered as a reactive approach that may not necessarily show that the management is committed to addressing H&S issues proactively.

### 3.2.3. Worker participation

In contrast to a perspective by a participant from the production group who suggested that workers should be less involved in design, all of the other participants believed that workers should be involved consistently from the very beginning, from the design stage to the implementation and to the installation and operation stages. A participant argued that workers should be involved from the planning stage. She argued that if they were just involved when the equipment was being installed, good results may not be seen. She stated that, "later down the road when equipment hits the floor might just be a little too late because at that time it becomes reactive." The participants noted that workers could be involved effectively in H&S and MSD prevention activities with appropriate training. A participant from the production group used an example to show how getting employees' feedback and employees' participation resulted in reducing MSD risk factors for back pain. She stated:

> So, we made an ergonomic group and we explained that we have a new line. So, we get together and went on the floor, they asked what do you think we should do? So, a few employees they come up with an idea, so we need a lifter with rollers to make it easier for the driver and easier for the operator. So we have only one. Because they decided to do one just to make sure it works. And you know what, it works.

Despite positive perspectives on the importance of workers' involvement in H&S and MSD prevention activities, one of the participants felt that the participation of employees was not always constant. However, it seemed that for other business drivers, such as quality, several practices were in place to ensure employees' feedback and participation. This was seen as useful in order to overcome quality problems. For instance, one of the participants said that, for quality problems, often a "cross functional team" would be formed and involved several participants in the problem solving process. This was said to be an effective way to get employees to participate

in correcting and preventing quality problems. A similar process was suggested to be implemented for H&S and MSD prevention activities.

The participants in this plant suggested the following ways to promote employees' participation in H&S and MSD prevention activities: increasing awareness by training; conducting ergonomic surveys; a suggestion box; continuous communication with employees; rating management performance by their performance in H&S; providing incentives and rewards for changes that are suggested and accepted to be implemented; team work; H&S workshops; and posting H&S and MSD prevention bulletins on the cafeteria board.

The document and record analysis showed that this plant had mandatory monthly employee meetings. These meetings aimed to provide opportunities for employees to discuss organizational issues with the management team and to promote worker-management relations. Quality, production, maintenance, and HR issues were discussed in these meetings. However, H&S and MSD related issues were rarely mentioned. As one of the participants from the production group said, ergonomics (MSD prevention) should be promoted in these meetings by providing some training and discussions. She stated:

> Bring it [MSD prevention] up in the employee meetings. Even if it's just five minutes, at least it's something that's out there, a slide show, a clip, little clip of techniques maybe. Maybe one month you have techniques on lifting… It would be helpful. Even like a little slide show or a little clip or video of safe and proper handling, ways of bending, lifting stuff. Sometimes they do. I think maybe once a year they'll have it and that will probably be in the H&S, but that does have to do with ergonomics as well, right.

The interview data and the analysis of documents and records revealed that employees' training was limited to training production operators on how to work on their workstation or with the newly installed machine or process. One of the participants suggested that the employees might

be trained once a year on MSD related issues in employee meetings and this could be limited to general problems such as how to lift a box or handle the tools. The participants believed that the general training, in monthly meetings, should go beyond work-related tasks and reflect on employees' day-to-day life as well. One of the participants commented:

> It's wintertime now, so shovelling snow. You could have a clip of or a picture of an improper way of shovelling snow and then the effects of what could happen, and then a picture or clip of the proper way of shovelling snow and the effects of what's not going to happen and how they would feel a lot better as opposed to feeling tired and sore and broken after doing it the wrong way. Just stuff like that where it will just kind of help in getting people thinking oh yeah, that's true.

The documents, records and interviews also revealed that employees were not formally involved in the systematic risk assessment process and that their involvement was mainly limited to their complaints and, more recently, if new equipment was being installed in their workstation.

### 3.2.4. Plant B's approach to managing H&S

To better understand the type of H&S problems in this plant, participants were asked to describe the most challenging H&S issues that existed in plant B. They reported several H&S and ergonomic issues including: repetitive motions, excessive weight lifting, pinching on the hand, hand related injuries such as cuts and bruises, not using personal protective equipment (especially hearing protection), and back pain and shoulder pain. It appeared that low back pain was one of the main types of injuries in the workplace despite the implementation of an ergonomics program that aims to address MSD risk factors proactively. A couple of participants argued that this could be a result of not using the lifting devices available to employees. According to one of the participants,

> In this facility we tend to have more minor types of injuries. But I have noticed some back injuries. Typical lifting type associated injuries. Either not lifting properly or not asking for assistance to lift or specifically not using lifting devices. We have a lot of lifting devices and sometimes the operators choose not to do it. Be it may be they feel the pressure to produce parts or it's maybe cumbersome, I'm not 100% sure.

A participant from the production group shared her opinion and provided some examples of when necessary changes were made to improve ergonomics but were not used by workers. For instance, she said: "we installed a lift table to go up and down to prevent flexing of the back. And I go pass by and the person is not lifting at the table. He does not want to use the lever. So he bent down." She suggested that having more enforcement to follow requirements and to use assisting devices could potentially improve H&S in this plant. In addition, she suggested that more training on safe lifting and bending could be very beneficial to improve workers' postures while performing their tasks.

The plant had partially integrated H&S (based on the Workwell program) with its environment management system (certified ISO 14001). This partial integration was limited to certain documents such as policy, management review, and internal audit. In addition, since this plant had ISO/TS 16949 systems, some of the documents such as "document and record controls" were used for the H&S and the environmental management systems. As reported by one of the participants, plant B participated in several programs led by the corporate head office. This included the implementation of an OHSMS, external audits by headquarters, and internal audits. Despite some integration of H&S and the environment management system, the integration was very limited and it was separated from the ISO/TS 16949 system. The participants reported that the current approach works to manage H&S issues in the workplace, but there were some areas that needed more attention. This plant seems to have had several approaches in place for H&S,

ergonomics, quality, etc. These approaches were not linked and integrated as much as expected. The plant had separate committees for H&S and ergonomics as well as for quality. As suggested by the participant, the company could benefit from an integrated management system framework and save time and resources through a user-friendly overall management framework that streamlined activities.

The analysis of documents and records showed that the plant had a formal risk assessment process that was used to identify the H&S hazards and assess them based on three criteria including: frequency, severity, and probability. The risk number was then determined by adding up these items, with the final risk number being used to prioritize the risks. Then necessary action items would be developed, appropriate timelines would be determined, and responsibilities would be assigned to relevant stakeholders. However, the document and record analysis and the interview data showed that the prioritization was not always based on the risk number, but could be due to management decisions. In addition, it was not clear how H&S risks were being prioritized compared to other business drivers, such as quality and environment. The interview data suggested that only a few of the JHSC members were heavily involved in the risk assessment process, whereas other employees were not actively involved.

The interview data and documents and records indicated that the headquarters evaluated the plant's EHS and ergonomics performance. The plant also received surprise inspections from headquarters. The results of surprise inspections were said to be listed as action items for the plant (in company's action list system) and the plant is given 30 days to address the concerns raised in the surprise inspection. In addition, the plant had a list of measurable action plans that would determine underperforming divisions. The H&S coordinator maintained this system for EHS and the engineering program manager for ergonomics. One of the participants reported that

the plant benefited from resources and supports (i.e. technical and legal supports) provided by the headquarters. She stated:

> If [we] have questions or concerns or something like that and we can't really get an answer somewhere here or we can't find any information, we can always go to them [headquarters] and ask them. They also provide us updates for any legal changes that may be coming. They share best practices. So, if they see something good that's happening at another plant, we have a best practices section on our intranet that we can go to and we can see oh, that's kind of neat. We can maybe implement something similar to that here. They also provide us with some templates for different procedures and policies and stuff…if we have an incident and the Ministry of Labour gets involved, they will come here and provide support and make sure that legally that we're not doing anything that we're not supposed to, providing legal support as well for us.

The plant used a framework called "Advanced Product Quality Planning (APQP)" for design and re-design of production lines. The program is a framework of processes, procedures, tools, and techniques and it is similar to the concept of Design for Six Sigma (DFSS). The APQP framework is mainly used in the automotive industry to design and develop products or new processes. A participant from administration group reported that the plant had just recently started to see H&S in the APQP process and suggested that this could potentially incorporate H&S in design.

The plant had an incentive program through a suggestion box and it was a part of the project initiative and the continuous improvement program. This was not limited to H&S but could include ergonomics, quality, and any workplace improvement ideas. On the other hand, according to a participant from the administration group, H&S was a part of annual performance reviews and, for instance, failure to use personal protective equipment would negatively impact employees' performance reviews.

### 3.2.5. MSD prevention approaches

Plant B had implemented an ergonomic program that was led by the engineering program manager. The program had seven main elements: establish, analyze, prioritize, implement, follow-up, measure, and communicate. Headquarters designed this program and it had been implemented in many of the plants owned by the corporation. In addition, the documents and records showed that the organization had an internal responsibility system that provided a support infrastructure for the ergonomics program.

The roles and responsibilities of the employees in the ergonomics program were clearly defined and documented. However, these roles and responsibilities were defined by headquarters and had not been fully customized for this plant. In addition, the interview data suggested that these responsibilities had not been communicated effectively to employees. The plant had an ergonomics committee to drive the improvement process and consisted of representatives from operators, maintenance, engineering, and the H&S coordinator. The records indicated that the meetings were held on a bi-weekly basis.

The ergonomics program required all employees to participate in training sessions. Headquarters mainly conducted these training sessions, except for operators and supervisors who were trained internally. The training matrix showed that the training should be updated every three years for all employees.

The documents and records also indicate that the plant had implemented a proactive risk management system to address MSD risk factors in the design stage. The headquarters provided two tools for its plant to be used in the design stage to identify ergonomics (MSD) risk factors. These tools included an ergonomics design checklist and “Jack” Human Modeling and

Simulation Software (used in instances when it is difficult to visualize a complex job process and identify potential risk factors). As a part of the ergonomics program, the engineering program manager gathered information on injury data, workers' suggestions and complaints, job details, workplace hazards, etc. The plant had access to several analysis tools including Ergonomics Risk Analysis (ERA), NIOSH Lifting Equation, Snook Push/Pull/Carry Tables, RULA, and the Strain Index. The plant was required to use an appropriate risk analysis technique or, if needed, more than one risk analysis technique. Headquarters outlined numerical scores for each tool and the corresponding risk rating to categorize risk factors into low risk, moderate risk, high risk, and very high risk. Consequently, the plant was required to use the hierarchy of controls to identify effective controls. The interview data suggested that the engineering program manager, a design engineer, and the H&S manager conducted the risk assessment. The involvement of other stakeholders was not so clear. One of the participants reported that the maintenance department's involvement was limited to the stage where they needed to implement control actions, and not in the assessment phase. Despite the occasional involvement of a team leader in the risk assessment process, the involvement of workers was also limited to providing feedback to the ergonomics committee and to reporting existing problems, rather than formal involvement in risk assessment and problem solving processes. Interestingly, the plant had been asked to provide a "cost-benefit analysis" for some improvement projects. One of the participants from the administration group admitted that this was sometimes challenging and required the involvement of other stakeholders and access to other resources, such as quality deficit data.

A participant from the production group reported that the company used an integrative approach to eliminating MSD hazards in the design stage. The documents and records and the interview data suggested that the plant had integrated MSD prevention into the APQP framework, and

completing the ergonomic checklist is now a mandatory part of the APQP process. This was reported to have had a significant impact on integration of ergonomics into the design process.

### 3.2.6. Participants' ideas to improve current approaches

The interview participants believed that integration of MSD prevention into other aspects of the company management system, such as quality, would lead to successful prevention of these disorders in this plant. A participant from the administration group said that the integration of MSD prevention into quality was needed because it could save the company money and resources. As she commented,

> Automotive business is a very demanding business and to demand such a thing it's not really going to take so much resources and it's right on to the point. But to create something aside, it's going to take resources, right. And you know how reluctant [companies are?]…After 2008 there's not so much willingness to expend so much resources. So you have to always think resources wise. So if you want to implement something like that, you have to always do it including the job that you're doing, it will be easy.

She suggested that using tools such as FMEA could make this possible because of its broad application and popularity. Another participant from this group supported the idea of integration by stating that it would provide an opportunity to get more individuals involved in prevention activities. She stated:

> The more individuals you have accountable for it [MSD prevention], the more attention it's going to get and the more successful it will be. If it's in its own little area and nobody really pays attention to it except every couple weeks at an ergonomics meeting, it's harder to drive. But everybody is accountable, be it your quality areas, be it materials, if everybody has a stake in it, it makes a big difference

The participants also suggested that the current approach could be improved by more reviews and risk assessment at the design stage because this could save time and costs during the

implementation and operation stages. In addition, more awareness and training would be needed to improve current approaches to address H&S and MSD hazards.

## 4. Discussion

The analysis of participants' interviews, documents and records, and the walkthrough site visits for two manufacturing plants owned by a corporation in Ontario shed some light on the implementation and functioning of plants' OHSMS and MSD prevention programs. This paper documented the case companies' approaches to address H&S and MSD prevention activities within their company's management framework.

The participants in both plants have certain responsibilities and roles in the organization and activities to address H&S and MSD hazards were viewed as an add-on responsibility. Despite the existence of procedures describing the roles and responsibilities of stakeholders in both plants, these procedures were not well communicated to the employees and it seemed that the participants were not fully aware of their responsibilities with respect to addressing H&S hazards. Although both organizations claimed to have a functioning OHSMS where stakeholders' responsibilities are clearly defined and monitored, the results of this study suggests that the participants in both plants generally believe that H&S is the responsibility of the H&S coordinator. In the second plant, where the company had implemented an ergonomics program to address MSD hazards, the engineering program manager that led the ergonomics program was seen to be responsible for dealing with MSD hazards. The results of this study suggest that in plant A, no one is taking the responsibility to address MSD hazards in the plant proactively. The application of actor network theory suggests that despite the existence of an approach that defines the roles and responsibilities of stakeholders with respect to H&S and MSD prevention,

the function of H&S and the ergonomics program is very reliant on the H&S coordinators and ergonomics program manager. This suggests that the network is center based, with the above individuals being seen as responsible for the implementation and operation of these programs in both plants. Other stakeholders' roles seem to be complementary, on a case-by-case basis, reactive, and not systematic.

The participants in both plants defined management commitment as the commitment by the senior leadership to allocating necessary resources (both financial and human) for addressing H&S hazards in the workplace. This definition provided on the allocation of financial resources is supported by several scholars (Koppelaar et al., 2013; Flin, 2003; Milgate, Innes, & Loughlin, 2002). Participants' consistent message was that management should not only provide support but also engage in prevention and problem solving activities. This was also identified by Geldart et al. (2010) where they suggested that active involvement of management is essential for effective management commitment to H&S. The importance of management commitment in building trust and culture in the workplace was well supported in both plants. As identified by Milgate, Innes, & Loughlin (2002), visible demonstration through management actions would lead to an effective management commitment. The sustainability of any prevention activities was said to be dependent on management commitment. This perspective was also shared by the participants in the key informants study (Chapter IV). As indicated in other research, management commitment is an essential factor for implementation and performance of any prevention activities (Mooren et al., 2014; Koppelaar et al., 2013; Korunka et al., 2010; Cole & Brown, 1996; Hallowell & Colhoun, 2011; Dixon, Theberge, & Cole, 2009; Morag, 2007; Flin, 2003; Milgate, Innes, & Loughlin, 2002). It was stated that management should consider H&S as an investment not as an expense. It was also suggested that a tool to measure management

commitment could be useful in order to evaluate management support in addressing H&S and MSD prevention. However, the results of this study indicate that despite the existence of a framework to achieve management commitment towards proactive measures to deal with H&S problems, commitment seemed to be more reactive. The plants' management commitment towards H&S and MSD prevention when it comes to competing priorities, such as production, was said to be not very positive. This concern was also raised by participants in the key informants study (Chapter IV). Similar to the key informants study (Chapter IV), participants in this study believed that the commitment should come from all levels of management and that management should be trained in H&S and MSD prevention.

The importance of workers' participation to the success of prevention programs was supported by the participants from both plants, in this study, in the key informants study (Chapter IV) and in the scientific literature (Mooren et al., 2014; Hallowell & Colhoun, 2011; Geldart et al., 2010; Morag, 2007; Rivilis, 2006; Milgate, Innes, & Loughlin, 2002; Eaton & Nocerino, 2000; Faville, 1996). Most participants believed that workers should be involved from the very beginning and from the design stage. This is consistent with the results of the key informants' study where participants said that the involvement of workers should be from the design stage to the final stage of the operation (Chapter IV). However, this case study showed that workers' involvement in prevention activities was reactive, in a case-by-case fashion, and was not systematic and proactive. The literature indicated that workers should be actively involved in risk management process and solution development (Faville, 1996; Cole & Brown, 1996), but in this study, the involvement of workers in hazard identification and risk assessment in both plants was limited and not systematic. It was suggested that using "cross-functional teams" (improvement teams), currently used to solve quality problems, could practically and effectively engage workers in

addressing H&S and MSD hazards proactively. This was consistent with findings in Chapter IV, where the key informants suggested using a broader framework and approach to incorporate workers' participation in prevention activities. Participants in both plants believed that continuous communication with employees and making participation in H&S as a priority by management could potentially encourage effective and sustainable participation of workers in H&S. Similar to the key informants study (Chapter IV) some participants argued that providing incentives might be necessary to encourage workers' participation.

The interview data and documents and records revealed that both plants had implemented an OHSMS based on WSIB's Workwell audit program. This was a head office requirement. The plants received periodic internal audits as well as external audits by the corporate head office. The interviews revealed that deciding to implement the Workwell program over other internationally recognized OHSMS frameworks such as OHSAS 18001 could be due to the recommendation and resources provided by the head office. The program was mainly implemented and maintained by the H&S coordinator in both plants. Although the corporation mandates a proactive approach to dealing with H&S hazards in its plants, the results of this study suggest that management of OHS in the plants was more reactive rather than proactive. This could be due to poor implementation of an OHSMS and lack of management strategy and/or management commitment towards H&S. Both plants had systematic risk management procedures but the risk management was mainly implemented and maintained by the H&S coordinator. Other stakeholders were not actively involved. Despite having a broader management framework, e.g. ISO/TS 16949 in both plants, H&S was rarely integrated into this framework. On one occasion in plant B, H&S hazards and MSD hazards were addressed in the design stage using the APQP tool. Some participants reported that they had tried to incorporate

H&S into broader approaches and tools. This resulted in addressing H&S hazards more effectively. In addition, the head office provided a number of resources, training materials, and technical supports, but these resources seemed not to be used effectively. Plant A did not implement any MSD prevention or ergonomics program. MSD hazards had not been assessed systematically and it was reported that MSD hazards were being dealt with upon receiving complaints from the shop floor. Plant B, however, had implemented a proactive prevention program called an ergonomics program. The implementation of this program resulted in addressing MSD hazards better in this plant and consequently improved quality on some occasions. The program was separated from the plant's OHSMS and was not integrated into a broader management framework.

The findings of this study may not be transferable to other organizations. However, the purpose of this research was not to transfer the findings of this research or comment on the transferability, because different organizations have different approaches to addressing H&S and MSD prevention. However, documents and records analysis and interviews with other participants were conducted, when necessary, to more fully explore the topics. Despite the full collaboration of the workplace parties, the results are limited to those documents and records that were provided to the research team. Despite using the actor-network theory to recruit the participants and understand the role of each actor in the network, the necessity of maintaining the confidentiality of the participants limited the value of using this theory in the presentation of the data. However, this theory was used to better understand the roles of different actors and stakeholders to manage H&S and MSD prevention activities in the case study plants. Finally, this study did not aim to evaluate the case study plants' approach to manage H&S and MSD prevention activities. Instead the purpose of this work was to describe plants' approaches to

manage H&S and MSD prevention activities and explore participants' perspectives and ideas on studied topics. Therefore, the results of this study are presented in a more descriptive fashion.

## 5. Conclusion

This study provided an insight into the management of H&S and MSD hazards in two plants in the manufacturing sector. The results suggest that the improper implementation of OHSMS and MSD prevention activities may result in a less successful approach to address H&S in organizations. Strong management commitment and effective worker participation were seen as essential and crucial in order to implement any changes in their organizations. Incorporating prevention activities into broader management system frameworks and using tools such as APQP, FMEA, and 5-WHY methodology were thought to be essential for success. Furthermore, using business cases and linking MSD hazards to other business drivers such as quality costs was said and seen to be useful to attract management attention to persuade them to invest in MSD prevention activities. More case study research is needed to document organizations' best practices to address H&S and MSD hazards within management frameworks. In addition, further research is needed to develop approaches to incorporate MSD hazard identification and assessment into tools used within other business drivers such as FMEA and other well-known methodologies.

# CHAPTER VII: Harmonized Tools and Techniques to Identify, Assess, and Evaluate Musculoskeletal Disorder Hazards within Management Systems: Review of Current Practices and Integration Possibilities

## 1. Introduction

The ergonomics literature reports many assessment tools specific to Musculoskeletal Disorders (MSD). Checklist tools predominate at the screening level, observations of postures and repetition are seen at the observation level, and tools that collect data and create scores are commonly seen at the analysis level, whilst technical methods such as electromyography and motion capture may be used by experts. Hazard identification tools are typically screening tools, worker reports or injury records, whilst risk assessment tools will come mainly from one of the other levels. Reviews of Takala et al. (2010); Dempsey, McGorry, & Maynard (2005); and Neumann (2006), give a fuller description of these and other MSD relevant tools, including full references.

Observational Biomechanical Assessment (OBA) techniques are widely used to evaluate physical workload at the workplace (Takala et al., 2010). However, these techniques are typically neither compatible nor linked to methods used company-wide for many purposes, e.g. Failure Modes and Effects Analysis (FMEA). As noted by Fallentin et al. (2001) and Takala et al. (2010), the majority of the tools used for MSD prevention purposes are not particularly user friendly, and most of them target highly skilled workers, specialists, and experts as users. This would tend to make these tools difficult to use in most organizations' risk management processes.

In addition, as the results of the scoping review (Chapter II) concluded, the high prevalence of MSD may partially be due to not addressing MSD hazards as effectively as they might be. This could be because MSD hazard identification and risk assessment techniques are partially outside the main management processes. Therefore, information concerning MSD hazards may not be "on-the-table", and thus, may not receive adequate attention. Bringing ergonomics as means of preventing MSD into organizations' management systems appears to be highly desirable. Hence,

the information concerning MSD hazards would ideally be addressed employing tools used in other areas of the organization.

Organizations have multiple methods available to address risk factors found in quality, health and safety, environment, etc. A wide range of Risk Analysis Methodologies (RAM) are recommended by the International Standard Organization through ISO 31010 (Risk management – Risk assessment techniques focuses on risk assessment) and in the review by Tixier et al. (2002). Interestingly, there is no information in these documents on how these techniques could be used by organizations to assess MSD hazards. In fact, there is no mention of any MSD hazard identification and assessment tools in the documents. Lack of common tools and language could be a barrier for the integration of MSD prevention activities into a companywide approach or management system (Chapter II, III, IV, V, and VI).

Therefore, the purpose of this study was to explore the possible integration of well-recognized MSD hazard identification, risk assessment and evaluation tools into well-established tools used by organizations to address other risks. Potentially, this will bring MSD prevention onto-the-table and integrate it into a broader approach. This would help avoid health and safety, and especially MSD prevention, becoming a "sidecar" function (Neumann & Dul, 2005).

## 2. Methods

The study consisted of four main steps. The first step was to review the Observational Biomechanical Assessments (OBAs) tools studied by Takala et al. (2010) and Dempsey, McGorry, & Maynard (2005). The second step was to review the Risk Analysis Methodologies (RAMs) studied by Tixier et al. (2002). Thirdly, the framework used by Tixier et al. (2002) was used to categorize OBAs with the goal of documenting their common features that make them

appropriate for integration. Fourthly, the common structures and features of OBAs and RAMs were assessed to recommend opportunities for integration (Figure 1).

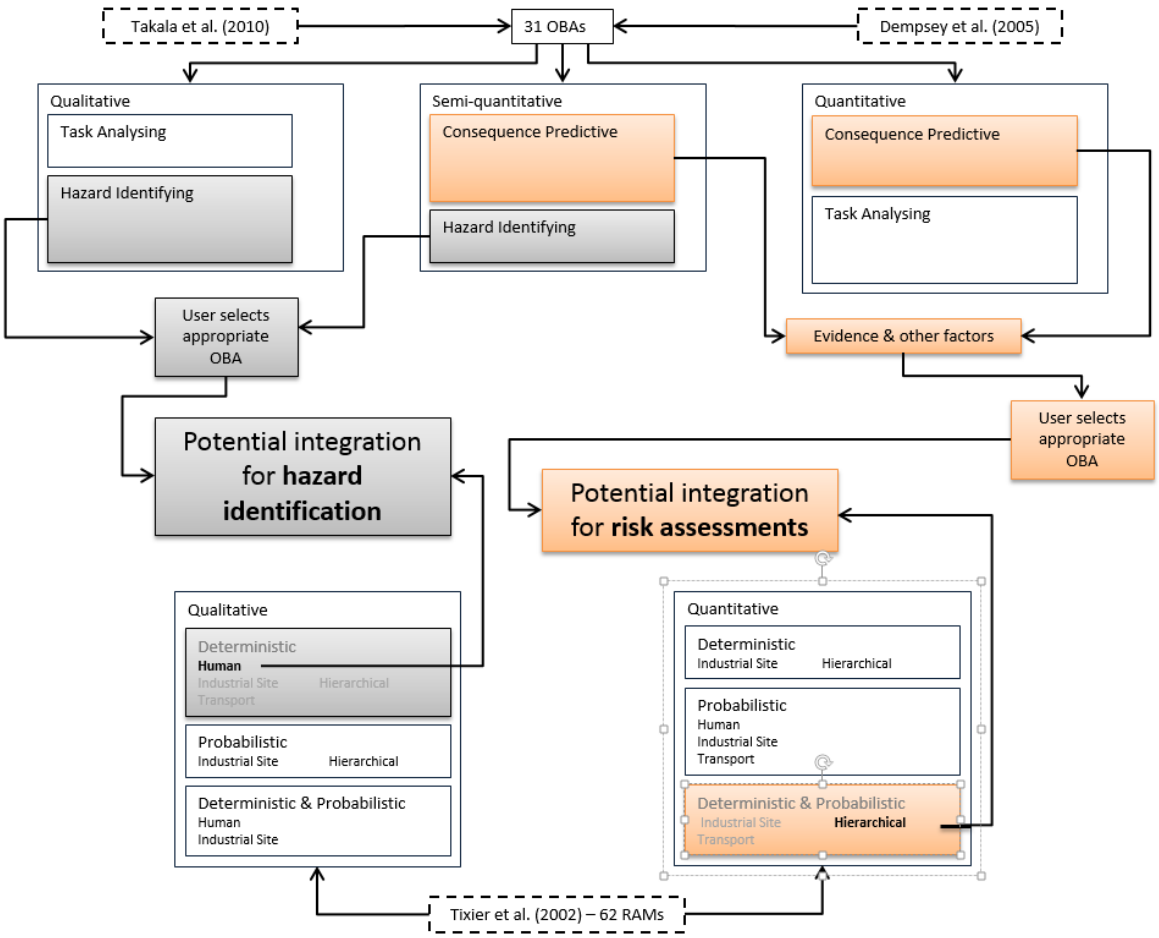


**Figure 1. Review process**

## 2.1. Review of OBAs

Choosing an appropriate and user-friendly technique to evaluate occupational physical workload has always been a challenge for stakeholders within an organization. There are a large number of observational methods to evaluate physical workloads, but there is no single technique that is appropriate for all situations (Takala et al., 2010). In order to identify and evaluate published

observational methods to assess biomechanical exposures in workplaces, Takala et al. (2010) conducted a systematic review of the literature. The authors identified 30 observational techniques, presented in Table 1. The authors reviewed these techniques using a framework describing target exposure, metrics, observation strategy, mode of recording, validity and repeatability of observational methods, association with MSD, strengths, limitations, decision rules, and potential users (Takala et al., 2010). Techniques were included in the review if the human locomotor system was the target of the observation, if the procedure described was allowing replication, and if the systematic observation of tasks was the principal exposure assessment tool. In addition, only methods that were publically available were included, while methods not developed for visual observation were excluded (Takala et al., 2010).

Dempsey, McGorry, & Maynard (2005) studied seven OBAs that are also reviewed by Takala et al. (2010) and two that are not: the Job Content Questionnaire (Karasek et al., 1998) and the Liberty Mutual Manual Material Handling Tables (Snook & Ciriello, 1991). The job content questionnaire is a psychosocial assessment and was therefore excluded from this paper. A total of 31 OBAs were therefore included in this study. A content analysis approach, informed by the framework of Tixier et al., (2002) was used to extract information from the studies into chart form, including: OBAs name, reference(s), inputs, outputs, mechanism, and other types of data.

### 2.2. Review of RAMs

Tixier and colleagues (2002) identified and reviewed 62 risk analysis methods that include three main phases of risk analysis (identification, evaluation, and hierarchisation phase). These risk analysis techniques are listed in Table 4. The authors stated that there is not an exclusive and unique method suited for all types of risk factors. They also recognized that the human factors

risk analysis is complex and often disconnected with classical risk analysis (Tixier et al., 2002). The risk analysis techniques were reviewed to determine whether and how tools aiming at MSD hazard identification and assessment could be incorporated into them. To do so, the RAMs were reviewed and information provided by Tixier et al. (2002) summarized in a spreadsheet.

### 2.3. Framework to study OBAs

To accomplish the objectives of this study, OBAs were classified using the framework that Tixier et al. (2002) had classified RAMs. This allowed for a better understanding of what OBAs and RAMs have in common, which might facilitate the integration of these tools (Tables 1-3). The modified framework presented by Tixier et al. (2002) was developed and used to better fit the characteristics OBAs. Therefore, each OBA was reviewed and categorized in groups using the framework.

### 2.4. Integration assessment

Tixier et al. (2002) main findings were summarized into one chart so that RAMs' characteristics could be succinctly displayed and analyzed. They defined qualitative as non-numerical and quantitative as numerical (Table 4). They stated that "…deterministic methods take into consideration the products, the equipment and the quantification of consequences for various targets such as people, environment and equipment…" and "…probabilistic methods are based on the probability or frequency of hazardous situation apparitions or on the occurrence of potential accident." (Tixier et al., 2002). These charts were then used to describe OBAs' characteristics and to provide recommendations for users to identify appropriate assessment

tools. Further, potential integration of OBAs into RAMs for the prevention of MSD were discussed and suggested.

## 3. Results and discussion

The following three sections will discuss the review findings and classification overview. Then, possible integration of OBAs and RAMs will be presented and discussed. The graphical diagram presented in Figure 2 shows the review process and number of tools in each category.

### 3.1. OBA's classification

Table 1 presents the classification of OBA tools reviewed in this paper based on the framework described by Tixier and colleagues (2002). Therefore, the OBAs were classified into six categories, three main purpose or subject groups, eight input types (with 38 subtypes), and five output types (with 8 subtypes). Each of the OBAs is described by the number code in Table 1. The following sections will discuss the OBAs classification.

#### 3.1.1 OBAs' purposes

The primary focus of each method was taken from Takala et al. (2010): a) general workload; b) upper-limb activities; and c) manual material handling (Table 1). Some tools with multiple purposes were categorized in more than one group. These classifications are necessary to understand the purpose of each OBA and what they could accomplish. The formatting of the number code represents one of the three previously listed classifications: normal formatting refers to a general workload method, upper-limb activities are represented with an underlined number, and manual material handling methods are represented with a number followed by an

asterisk. These categorizations show that the majority of the OBA tools were designed to identify and assess general workload.

### 3.1.2 Method categories

The OBAs were then classified according to their mechanism and outputs. Three main categories were used to classify OBAs: a) qualitative techniques: defined as an assessment with non-numerical output; b) semi-quantitative techniques: have a predetermined numerical output coupled with an output classification; and c) quantitative techniques: have a numerical output along with guidelines. The results show that the majority of OBAs are in the semi-quantitative and quantitative categories. This makes these tools appropriate for risk assessment and evaluation. Those categorized in the qualitative group are mainly suitable for hazard identification purposes because of their inability to provide a quantitative measure of the risks. According to Table 1, the majority of OBAs that aim to evaluate general workload and manual material handling are semi-quantitative and quantitative. The tools categorized in the semi-quantitative category provide numeric data as well as suggestions for required actions, while the quantitative assessments provide numeric data and risk parameters.

The OBAs' outputs were further subdivided into three groups: a) consequence predictive OBAs that evaluate potential consequences associated with exposure to a hazard while performing a task; b) task analyzing OBAs which document task characteristics; and c) hazard identifying OBAs that determine whether a hazard is present without further indication of the severity of any potential outcome. As can be seen from Table 1, the majority of tools are consequence predictive. These tools are suitable for risk evaluation that involves consequence prediction and risk rating.

### 3.1.3. Types of input data

The type of input data was a further factor considered. The observational techniques were categorized according to seven input classes used by Tixier et al. (2002), along with an additional input class, frequency and duration that was appropriate for MSD techniques. The input data classification was: plans and diagrams; process and reactions; products; frequency and duration; management; environment; texts and historical knowledge and worker (demographic). The definitions of these input classes were modified slightly to satisfy the particular characteristics of OBAs. The following presents that categorization of OBAs according to their input requirements. A summary of the results is presented in table 2.

- *Plans and diagrams:* About 40% of OBA techniques use the plans and diagrams as input. These tools require one or more of the following data as input. These include workplace/workstation design and characteristics, body and work positioning, and tools dimension and measurements. Table 2 presents the summary findings of this classification. This shows that the majority of the tools that use plans and diagrams as input are either qualitative or quantitative and categorized as hazard identification tools.
- *Process and reactions:* The results of this review suggest that almost all of the OBAs use process and reaction data as input. This includes external force, force type, workload, posture, support, perceived exertion, movement, contact forces, precision requirements, and vibration. These tools might use one or more than one of the above inputs for hazard identification, task analysis, and to predict the consequences of hazards. These tools are mainly consequence predictive and categorized as either semi-quantitative or quantitative. The results presented in Table 2 shows that most OBA techniques used more than one type of process and reaction input data.

- *Products:* The results show that almost 70% of OBAs use product data as input. This means that OBAs use the data related to objects or products being handled, and/or aids used to handle objects to evaluate the MSD hazards. These data include the weight, the shape (asymmetry, coupling), tools usage, glove usage, grip type and forces, and co-workers' support (team handling). These OBAs use more than one of the above-mentioned product data. Only two of the OBAs use team handling as an input and eight of the OBAs use grip force and/or grip type as an input.
- *Frequency and duration:* Almost all of the OBAs use task-time parameters data as input to evaluate MSD hazards: task frequency, duration, exposure time, and recovery time. About half of these tools are consequence predictive tools and either semi-quantitative or quantitative. Only five of the OBAs use recovery time data as an input (Table 2).
- *Management:* Nine of the OBAs consider data related to task characteristics that are directly related to managerial factors or work organization (Table 2). The results of this review suggest that six of these tools are consequence predictive and either semi-quantitative or quantitative. Despite the main purpose of these OBAs being the assessment of physical hazards, four of the OBAs use input data related to psychosocial or psychological factors. Other management related input data include information with respect to work pace, work organization, co-worker support, participation, task control, and training. Only one of the OBAs uses data on co-worker support.
- *Environment:* Only 35% of OBAs consider physical work environmental factors for preforming tasks. These factors include vibration, noise, site temperature, air movement, surface coupling, walking surface, visual conditions, lighting, predictability of task, and

working space. Most of the OBAs that include physical work environment data are qualitative and mainly hazard identification tools (Table 2).

- *Standards and historical knowledge:* Six of the OBAs use input data related to current standards and regulations, and historical task knowledge. These tools are mainly aimed at addressing manual material handling in the workplace.
- *Worker (demographic-historical):* As can be seen from the title, this type of input data considers an individual's demographic characteristics, including age and sex as well as an individual's historical data, including experience, previous injury data, and reports of aches and/or pains (in general health). Five of the OBAs require this type of input data and two of these OBAs are consequence predictive, while three of them are hazard-identifying tools.

### 3.1.4 Types of output data

Type of output data enables the user to evaluate the MSD consequences of hazards qualitatively or quantitatively. This information could result in better integration of OBAs into RAMs. The types of output data for OBAs vary from recommended actions to distribution of task characteristics. In this review, the classification used by Tixier et al. (2002) was slightly modified and applied to categorize OBAs to better address the specific attribute of OBAS.

## Table 1(a). Classification of Observational Biomechanical Assessment Tools using Tixier et al., (2002) framework

| | #[a] | Qualitative | # | Semi-quantitative | # | Quantitative |
|---|---|---|---|---|---|---|
| Consequence predictive | | | 8 | OWAS: Ovako working posture assessment system (Karhu,et.al., 1977) | 21 | Strain index (Moore, & Garg, 1995) |
| | | | 9 | AET: Arbeitswissenschaftliches erhebungsverfahren zur tätigkeitsanalyse - ergonomic job analysis procedure (Rohmert, 1985) | 22 | OCRA: Occupational repetitive actions (Occhipinti, et al., 1998) |
| | | | 10 | ARBAN: Ergonomic analysis ERGAN, formerly (Holzmann, 1982) | 23* | NIOSH lifting equation US National Institute of Occupational Safety and Health (Waters, Putz-Anderson, Garg, & Fine, 1993) |
| | | | 11 | REBA: Rapid entire body assessment (Hignett, & McAtamney, 2000) | 24* | ManTRA: Manual tasks risk assessment (Burgess-Limerick, Egeskov, Straker, & Pollock, 2000) |
| | | | 12 | QEC: Quick exposure check (David et al., 2008) | 3* | Hazard Zone Checklist Washington State ergonomic checklists- (Washington State Dept. of Labor and Industries, 2003) |
| | | | 13 | VIDAR: Video- och datorbaserad arbetsanalys - a video and computer-based method for ergonomic | | |
| | | | 14 | LUBA: Postural loading on the upper-body assessment (Kee, & Karwowski, 2001) | | |
| | | | 15 | RULA: Rapid upper-limb assessment (McAtamney, & Corlett, 1993) | | |
| | | | 16 | ACGIH HAL: The American Conference of Governmental Industrial Hygienists threshold limit value for hand activity level (Latko et al.,,1997) | | |
| | | | 17* | Arbouw guidelines on physical workload (Arbouw Foundation, 1997) | | |
| | | | 18* | MAC: Manual handling assessment charts (Monnington et al., 2002) | | |

[a] Each OBA is referred to by a number.

Each number is formatted to represent method subject classification
n = General workload  n = Upper-limb activities  n* = Manual material handling

## Table 1(b). Classification of Observational Biomechanical Assessment Tools using Tixier et al., (2002) framework

| | #[a] | Qualitative | # | Semi-quantitative | # | Quantitative |
|---|---|---|---|---|---|---|
| Task analysing | 1 | Posture targeting (Corlett, eta al., 1979) | | | 25 | TRAC: Task recording and analysis on computer (Frings-Dresen, & Kuijer,1995) |
| | | | | | 26 | PEO: Portable ergonomic observation (Fransson-Hall, Gloria, Kilbom, Winkel, Karlqvist, & Wiktorin,1995) |
| | | | | | 27 | HARBO: Hands relative to the body H (Wiktorin, Mortimer, Ekenvall, Kilbom, & Hjelm,1995) |
| | | | | | 28 | PATH Posture, activity, tools, and handling (Buchholz, Paquet, Punnett, Lee, & Moir, 1996) |
| | | | | | 29 | Chung's postural workload evaluation system (Chung, Lee, & Kee, 2005) |
| | | | | | 30 | Stetson's checklist for the analysis of hand and wrist (Stetson, Keyserling, Silverstein, & Leonard, 1991) |
| | | | | | 31* | BackEST: Back-exposure sampling tool (Village, Trask, Luong, Chow, Johnson, Koehoorn, & Teschke, 2009) |
| Hazard Identifying | 2 | PLIBEL: Plan för identifiering av belastningsfaktorer– a method assigned for the identification of ergonomics hazards (Kemmlert,1995) | 19* | ACGIH lifting threshold limit value for low-back risk (Marras, & Hamrick, 2006) | | |
| | 3 | Washington State ergonomic checklists (Washington State Dept. of Labor and Industries, 2003) | 20* | Liberty Mutual Manual Materials Handling Tables (Snook, & Ciriello, 1991) | | |
| | 4 | HSE Health and Safety Executive upper-limb risk assessment method (Graves, Way, Riley, Lawton, & Morris, 2004) | | | | |
| | 5 | Keyserling's cumulative trauma checklist-caution zone (Keyserling, Stetson, Silverstein, & Brouwer, 1993) | | | | |
| | 6 | Ketola's upper-limb expert tool (Ketola, Toivonen, & Viikari-Juntura, 2001) | | | | |
| | 7* | New Zealand code of practice for manual handling (Department of Labour Te Tar Mahi, 2001) | | | | |

[a] Each OBA is referred to by a number.

Each number is formatted to represent method subject classification
n = General workload  n = Upper-limb activities  n* = Manual material handling

The following describes the results of this classification and Table 3 presents the summary.

- *Management:* More than half of OBAs provide outputs to guide management to intervene and develop solutions.
- *List:* Almost half of the OBAs generate a list of hazards and predicted workload level. These tools were qualitative or semi-quantitative, which suggests that these tools provide a quick understanding of the types of hazards existing in the workplace.
- *Population:* Only three of the OBAs provide information and recommendation on the affected population as an outcome. Other OBAs might provide or use similar information, but not as an outcome. For instance, Manual Liberty Mutual Manual Materials Handling Tables provide an output where the output value estimates the percentage of population (workers) that can perform the task (considering certain input data) without risk of injury.
- *Frequency and duration:* Nine of OBAs provide information on posture, frequency and duration as well as the distribution and timing of task components. These tools are mostly quantitative and used for task analysis purposes.
- *Hierarchisation:* More than half of the OBAs generate information on severity and enable users to prioritize risk factors based on the estimated risk level. This feature would help these OBAs to be integrated into those RAMs that use risk matrixes.

### 3.2. OBA's inter-grouping classification

The following sections will discuss the characteristics and trends of the six OBAs inter-grouping categorization presented in Table 2.

### 3.2.1. Qualitative & Hazard identifying

These OBAs are all in checklist (yes/no) format. This simple format allows for a quick evaluation of many MSD hazards. Table 2 shows the broad scope of inputs covered by these OBAs. Specifically, the management, environment, and worker input types are clearly more considered by this group of OBAs compared to other groups. The fundamental structure of checklists means each OBA in this group will have outputs that generate a list of hazards. In addition, each checklist recommends the necessary managerial action according to assessment results. Also, half of the checklist provides a way to interpret the list of hazards in a hierarchical manner. Each OBA subject type (general workload, upper-limb activities, and manual material handling) is covered by at least one of the six checklists. With 74% coverage of all sub-input types, the most comprehensive OBA, addressing manual material handling, is the New Zealand code of practice for manual handling. Meanwhile, the Health and Safety Executive (HSE) upper-limb risk assessment method covers 62% of all sub-input types; and the PLIBEL considers general workload and 51% of all sub-input types.

### 3.2.2. Semi-quantitative & Hazard identifying

This group of OBAs is exclusive to two manual material handling assessments with a matrix format to identify hazards. Within these matrixes, both OBAs provide recommended handling weights according to specific task and worker characteristics.  Yet, the Liberty Mutual Manual Materials Handling Tables consider worker characteristics, and more so process and reactions. The Liberty Mutual Manual Materials Handling Tables also provide the percentage of the population protected from injury when completing a task.

## Table 2(a). Connections between input data and method categories

| Input Types | Input sub-types | Categories[a] | | | | | |
|---|---|---|---|---|---|---|---|
| | | Qualitative | | Semi-quantitative | | Quantitative | |
| | | TA | HID | CP | HID | CP | TA |
| Plans & Diagram | | | | | | | |
| | Task/workplace dimensions | | 2 | 17* | 19*, 20* | 23*, 3* | |
| | Relative body/work positioning | | 2, 3, 4, 5 | 12, 18* | 20* | 3* | |
| | Tool/object dimensions | | 2, 6, 7* | | 20* | | |
| Process & Reactions | | | | | | | |
| | External force, force type, workload | 1 | 3, 4, 7* | 9, 10, 15, 16, 17* | 20* | 21, 22, 24* | 25, 28, 30 |
| | Posture, support | 1 | 2, 3, 4, 5, 6, 7* | 8, 9, 10, 11, 12, 14, 15, 17*, 18* | 19*, 20* | 21, 22, 24*, 3* | 25, 26, 27, 28, 29, 30, 31* |
| | Perceived exertion | | | 10, 16 | | 21, 22 | 31* |
| | Movements | 1 | 2, 4, 5, 7* | 9, 10, 17*, 18* | 20* | 22, 23*, 24* | 25, 26, 28, 31* |
| | Contact forces | | 4, 5, 6, 7* | | | 22 | |
| | Precision requirement | | 4 | | | 22 | |
| | Vibration, jerks, shakes, impacts, torque | | 3, 4, 5, 6, 7* | 10, 11, 15, 17* | 20* | 22, 24* | 30 |
| Products | | | | | | | |
| | Weight | | 2, 3, 5, 6, 7* | 8, 11, 12, 15, 17*, 18* | 19*, 20* | 23*, 3* | 26, 28, 30, 31* |
| | Asymmetry, coupling | | 2, 5, 7* | 11, 17*, 18* | 19*, 20* | 22, 23* | 31* |
| | Tool usage, glove usage | | 2, 3, 4, 5, 6, 7* | 13 | | 22 | 28, 30, 31* |
| | Grip force/type | | 2, 3, 4, 5, 7* | 17* | | 22 | 30 |
| | Team handling | | 7* | 18* | | | |
| Frequency & Duration | | | | | | | |
| | Task frequency/duration/exposure time | | 2, 3, 4, 5, 6, 7* | 8, 9, 10, 12, 13, 14, 15, 16, 17* | 19*, 20* | 21, 22, 23*, 24*, 3* | 25, 26, 27, 28, 29, 30 |
| | Recovery time | | 2, 7* | 16, 17* | | 22 | |
| Management | | | | | | | |
| | Psychosocial/psychological factors | | 2, 4, 7* | 12 | | | |
| | Work pace, work organization | | 2, 4, 7* | 12 | | 21, 22, 23* | |
| | Co-worker support | | 4 | | | | |
| | Participation, task control | | 4, 7* | 10, 13 | | | |
| | Training | | 4, 7* | | | | |

[a] The number refers to the categories present in Table 1. TA = Task Analysing HID = Hazard Identifying CP = Consequence Predictive

## Table 2(b). Connections between input data and method categories

| Input Types | Input sub-types | Categories[a] | | | | | |
|---|---|---|---|---|---|---|---|
| | | Qualitative | | Semi-quantitative | | Quantitative | |
| | | TA | HID | CP | HID | CP | TA |
| Environment | | | | | | | |
| | Vibration | | 2, 4, 7* | | | 24* | 31* |
| | Noise | | 7* | | | | |
| | Site temperature | | 2, 4, 5, 6, 7* | 18* | 19* | 22 | |
| | Air movements | | 2, 4, 5, 6, 7* | 18* | | | |
| | Surface coupling | | 7* | 18* | | | |
| | Walking surface | | 2, 7* | 18* | | | |
| | Visual conditions, lighting | | 2, 4, 7* | 12, 18* | | | |
| | Predictability of task | | 2, 7* | | | | |
| | Working space | | 2, 7* | 18* | 19* | | |
| Standards & historical knowledge | | | | | | | |
| | Recommendations, thresholds | | | | 19*, 20* | 22, 23*, 3* | |
| | Improvised changes | | 4 | | | | |
| Worker (demographic-historical) | | | | | | | |
| | Sex | | 7* | | 20* | | |
| | Age | | 4 | | | | |
| | Task experience | | 4 | | | | |
| | Previous injury | | 4, 7* | | 20* | | |
| | Reports of aches and/or pains, Health | | 4, 7* | 10, 13 | | | |

[a] The number refers to the categories present in Table 1. TA = Task Analysing HID = Hazard Identifying CP = Consequence Predictive

## Table 3. Links between output data and categories

| Output Types | Output sub-types | Categories[a] | | | | | |
|---|---|---|---|---|---|---|---|
| | | Qualitative | | Semi-quantitative | | Quantitative | |
| | | TA | HID | CP | HID | CP | TA |
| Management/solution development | | | | | | | |
| | Actions/Recommendations | | 2, 3, 4, 5, 6, 7* | 8, 11, 14, 15, 16, 17*, 18* | 19*, 20* | 3*, 22, 23*, 24* | |
| List | | | | | | | |
| | List of risks | | 2, 3, 4, 5, 6, 7* | 9, 12, 18* | | 24* | |
| | Predicted workload level | 1 | | 10, 13 | | | 29 |
| Population | | | | | | | |
| | Population percentage protection | | | 18* | 20* | 23* | |
| Frequency & Duration | | | | | | | |
| | Posture frequency/duration | | | 8 | | | 25, 26, 27, 28, 29, 30, 31* |
| | Task/exertion frequency/duration | | | 8, 13 | | | 25, 26, 28, 30, 31* |
| | Distribution of other task characteristics | | | 13 | | | 25, 26, 28, 30, 31* |
| Hierarchisation | | | | | | | |
| | Risk index/level | | 4, 5, 7* | 8, 9, 11, 12, 13, 14, 15, 16, 17*, 18* | | 3*, 21, 22, 23*, 24* | |

[a] The number refers to the categories present in Table 1. TA = Task Analysing HID = Hazard Identifying CP = Consequence Predictive
n = General workload n = Upper-limb activities n* = Manual material handling

### 3.2.3. Semi-quantitative & Consequence predictive

These OBAs identify a hazardous task by primarily considering process and reactions, products, and frequency and duration (74% of all sub-inputs). Then, in almost all of these OBAs, the severity and consequence of this task is placed in a well-defined hierarchical class. Moreover, most of these assessments include an action recommendation along with hierarchical classification.

### 3.2.4. Quantitative & Task analysing

These OBAs quantify tasks according to process and reactions, products, and frequency and duration. For the most part, their principal application is to quantify task characteristics for research, as noted by Takala et al., 2010. This application may explain why a higher proportion of these OBAs address the subject of general workload. Almost all of the sub-inputs are within the process & reactions, products, and frequency and duration input types. Also, 94% of sub-outputs lie within the frequency & duration output type, and all assessments in this group contain a sub-output type of posture frequency/duration. Although these OBAs are good to quantify certain task characteristics, many input types are virtually absent, including plans & diagrams, management, environment, standards and historical knowledge, and worker, and outputs are limited to quantification and statistical descriptions of a task.

### 3.2.5. Quantitative & Consequence predictive

Five tools are categorized in this group. Similar to other OBAs that are consequence predictive, these assessments identify a hazardous task and grade the severity of consequences. However, the OBAs in this group provide an open-ended index to describe severity and hierarchy. For

instance, Strain Index (SI) provides a criteria for decision making purposes. As discussed by Moore (1995), if the SI is less than 3, then the job could be considered safe. Consequently, the SI of 3-7 indicates a moderate risk and the SI of more than 7 shows a high risk. Input type is mostly composed of process and reactions, products, and frequency and duration (72%). Three of five OBAs categorized in this group, consider work pace and threshold recommendations as input. All of the OBAs in this class have a hierarchical output and four of them provide action recommendations. There are no OBAs that assess general workload within this group.

### 3.2.6. Qualitative & Task analysing

The only OBA in this group is concerned with general workload within a snapshot of a task. Posture targeting considers external force, posture, and movements to provide a workload description. This tool does not provide guidelines for interpretation.

## 3.3. OBA and RAM integration

This section will discuss the potential candidates for OBA and RAM integration. A summary of the 62 risk assessment methodologies classified by Tixier et al. (2002) is displayed in Table 4. The type of OBA to be integrated and the specific goal or purpose of that integration must be considered when selecting compatible RAMs. Table 4 will help to determine the compatibility of RAMs with OBAs. The main goal of OBA and RAM integration is to address MSD hazards in the workplace using the same approach that organization use for other H&S hazards. To address H&S and MSD hazards, two approaches will be used including: a hazard identification; and b) risk assessment. The following sections discuss possible ways of integrating OBAs and RAMs for these two approaches.

### 3.3.1. Potential hazard identification integration

An integrated hazard identification approach that simply identifies MSD hazards along with other H&S hazards is an excellent way to bring attention to MSD workplace issues and their potential need for change. The OBAs that can accomplish this are displayed in the hazard identifying row of Table 1. Of the eight OBAs to use, selection depends on the users and their purposes for assessment. For example, if a user requires an OBA that covers a broad range of input types while addressing general workload and identifying MSD hazards, PLIBEL can be used.

On the other hand, potential RAMs that could integrate one of these hazard identifying OBAs must be considered. To choose an appropriate tool, a qualitative RAM should be used so that the non-quantitative (yes/no) output of hazard identifying OBAs match up. In addition, a RAM should have a deterministic component so that consequence of various targets, such as people, is considered. Probabilistic RAMs focus on the probability or frequency of hazardous situations (Tixier et al., 2002); hazard identifying OBAs cannot be used to predict such measures, therefore the integration of probabilistic RAMs and hazard identifying OBAs is not recommended. It may be best to use a RAM that has an application field of human factors, as the main focus of OBAs are on addressing MSD hazards among human subjects. Although RAMs refer to human factors as the potential for human error, this pre-existing consideration of the worker may allow for a more seamless integration of MSD hazard identification. If considering the use of a qualitative and deterministic RAM that focuses on human factors, there are five possible tools for integration. An example of a well-known, often used RAM with the characteristics for OBA integration is the HumanHAZOP.

### 3.3.2. Potential risk assessment integration

The integration of OBAs and RAMs becomes more important and challenging where the purpose is not simply identifying hazards in the workplace but to assess and evaluate the risks. The OBAs with potential to provide such information are displayed in Table 1 and categorized in the consequence predictive group. Depending on the purpose and the comprehensiveness of the assessment, an OBA that contains certain inputs, displays certain outputs, and addresses a certain subject can be selected. However, in order to truly evaluate risk and consequences, an OBA must provide a probability of injury, which none of these OBAs do. Therefore, epidemiological studies must be used to obtain hazard, risk, or odds ratios associated with OBA scores. These ratios can then be used in conjunction with economic data such as the Workplace Safety and Insurance Board's MSD cost information to predict MSD consequence. A couple of examples known to have this epidemiological information available are the NIOSH lifting equation, Strain Index, and ACGIH HAL (Garg et al., 2012 & Garg et al., 2014). Since the output of this risk calculation is continuous, interpretation must be guided by prioritization, which is required for integration of OBAs into RAMs. To achieve this integration, the selected RAM must be quantitative to accommodate the quantitative nature of risk.

In addition, deterministic and probabilistic RAMs will provide a platform for displaying risk probability and consequence and therefore need to be used. Lastly, a hierarchical output is preferred to prioritize risk which provides a risk rating or prioritization table that can guide the users to prioritize control actions.

**Table 4 (a). Review chart of risk analysis methodologies from Tixier et al. (2002)**

| No.[a] | Risk analysis methodologies | Qual vs Quant | Det vs Prob | Hier | App fields | Int |
|---|---|---|---|---|---|---|
| 1 | Action Errors Analysis AEA (Rogers, 2000) | Qualitative | Deterministic | | Human | O |
| 2 | Checklist Khan & Abbasi, 1998b | Qualitative | Deterministic | | Transport & Industrial Site | |
| 3 | Concept Hazard Analysis CHA (Rasmussen & Whetton, 1997; Rogers, 2000) | Qualitative | Deterministic | | Industrial Site | |
| 4 | Concept Safety Review CSR (Rogers, 2000) | Qualitative | Deterministic | | Industrial Site | |
| 5 | Failure Mode Effect Analysis FMEA (Khan & Abbasi, 1998b; Nicolet-Monnier, 1996; Rogers, 2000) | Qualitative | Deterministic | | Transport & Industrial Site | |
| 6 | Goal Orinted Failure Analysis GOFA (Rogers, 2000) | Qualitative | Deterministic | | Industrial Site | |
| 7 | Hazard and Operability HAZOP (Kennedy & Kirwan, 1998; Khan & Abbasi, 1998b; Nicolet-Monnier, 1996; Rogers, 2000; Tweeddale, Cameron, & Sylvester, 1992) | Qualitative | Deterministic | | Transport & Industrial Site | |
| 8 | Human Hazard and Operability HumanHAZOP (Kennedy & Kirwan, 1998) | Qualitative | Deterministic | | Human | O |
| 9 | Insurers involvement in risk reduction process (Sankey, 1998) | Qualitative | Deterministic | | Industrial Site | |
| 10 | Manager (Pitblado, Williams, & Slater, 1990) | Qualitative | Deterministic | | Human | O |
| 11 | Optimal Hazard and Operability OptHAZOP (Khan & Abbasi, 1997a; Khan & Abbasi, 1998b) | Qualitative | Deterministic | | Industrial Site | |
| 12 | Plant Level Safety Analysis PLSA (Toola, 1992) | Qualitative | Deterministic | | Industrial Site | |
| 13 | Potential domino effects identification (Delvosalle, Fievez, & Benjelloun, 1998) | Qualitative | Deterministic | ✓ | Industrial Site | |
| 14 | Preliminary Risks Analysis PRA (Nicolet-Monnier, 1996; Rogers, 2000;) | Qualitative | Deterministic | | Industrial Site | |
| 15 | Process Risk Management Audit PRIMA Hurst, Young, Donald, Gibson, & Muyselaar, 1996 | Qualitative | Deterministic | | Human | O |
| 16 | Profile Deviation Analysis PDA (Korjusiommi, Salo, &Taylor, 1998) | Qualitative | Deterministic | | Industrial Site | |
| 17 | Safety related questions for computer controlled plants (Chung, Broomfield, & Yang, 1998; Yang & Chung, 1998) | Qualitative | Deterministic | | Industrial Site | |
| 18 | Seqhaz Hazard Mapping SHM (Korjusiommi et al., 1998) | Qualitative | Deterministic | ✓ | Industrial Site | |
| 19 | Sneak Analysis (Rogers, 2000) | Qualitative | Deterministic | | Industrial Site | |
| 20 | Task Analysis TA (Rogers, 2000) | Qualitative | Deterministic | | Human | O |
| 21 | What if? Analysis (Khan & Abbasi, 1998b; Nicolet-Monnier, 1996; Rogers, 2000) | Qualitative | Deterministic | | Transport & Industrial Site | |
| 22 | World Health Organisation WHO (Khan & Abbasi, 1998b) | Qualitative | Deterministic | | Industrial Site | |
| 23 | Accident Sequences Precursor ASP (Holmberg, 1996) | Qualitative | Probabilistic | | Industrial Site | |
| 24 | Delphi Technique (Rogers, 2000) | Qualitative | Probabilistic | | Industrial Site | |
| 25 | Earthquake safety of structures and installations in chemical industries (Jezler, 1998) | Qualitative | Probabilistic | ✓ | Industrial Site | |
| 26 | Maximum Credible Accident Analysis MCAA (Khan & Abbasi, 1998b) | Qualitative | Det & Prob | | Industrial Site | |
| 27 | Reliability Block Diagram RBD (Rogers, 2000) | Qualitative | Det & Prob | | Industrial Site | |
| 28 | Safety Analysis SA (Khan & Abbasi, 1998b) | Qualitative | Det & Prob | | Industrial Site | |
| 29 | Safety Culture Hazard and Operability SCHAZOP (Kennedy & Kirwan, 1998) | Qualitative | Det & Prob | | Human & Industrial Site | |
| 30 | Structural Reliability Analysis SRA (Rogers, 2000) | Qualitative | Det & Prob | | Industrial Site | |
| 31 | Accident Hazard Analysis AHI (Khan & Abbasi, 1997b; Khan & Abbasi, 1998a) | Quantitative | Deterministic | ✓ | Industrial Site | |
| 32 | Annex 6 of SEVESO II Directive (La directive Seveso II: Annexe 6, 1997)] | Quantitative | Deterministic | ✓ | Industrial Site | |
| 33 | Chemical Runaway Reaction Hazard Index RRHI (Kao & Duh, 1998) | Quantitative | Deterministic | ✓ | Industrial Site | |
| 34 | Dow's Chemical Exposure Index CEI (American Institute of Chemical Engineers, 1994) | Quantitative | Deterministic | ✓ | Industrial Site | |
| 35 | Dow' Fire and Explosion Index FEI (American Institute of Chemical Engineers, 1987; Khan & Abbasi, 1998a) | Quantitative | Deterministic | ✓ | Industrial Site | |
| 36 | Fire and Explosion Damage Index FEDI (Khan & Abbasi, 1998a) | Quantitative | Deterministic | ✓ | Industrial Site | |
| 37 | Hazard Identification and Ranking HIRA (Khan & Abbasi, 1997b; Khan & Abbasi, 1998b) | Quantitative | Deterministic | ✓ | Industrial Site | |
| 38 | Instantaneous fractionnal loss index IFAL (Khan & Abbasi, 1998a; Khan & Abbasi, 1998b) | Quantitative | Deterministic | ✓ | Industrial Site | |

*(continued on next page)*

**Table 4 (b). Review chart of risk analysis methodologies from Tixier et al. (2002)**

| No.[a] | Risk analysis methodologies | Qual vs Quant | Det vs Prob | Hier | App fields | Int |
|---|---|---|---|---|---|---|
| 39 | Methodology of domino effects analysis (Dolladille, 1999)] | Quantitative | Deterministic | ✓ | Industrial Site | |
| 40 | Methods of potential risk determination and evaluation (Ja¨ger & Ku¨hnreich, 1998) | Quantitative | Deterministic | ✓ | Industrial Site | |
| 41 | Mond Fire Explosion and Toxicity Index FETI (Khan & Abbasi, 1998a; Khan & Abbasi, 1998b) | Quantitative | Deterministic | ✓ | Industrial Site | |
| 42 | SAATY methodology (Troutt & Elsaid, 1996) | Quantitative | Deterministic | ✓ | Industrial Site | |
| 43 | Toxic Damage Index TDI (Khan & Abbasi, 1998a) | Quantitative | Deterministic | ✓ | Industrial Site | |
| 44 | Defi method (Rogers, 2000) | Quantitative | Probabilistic | | Industrial Site | |
| 45 | Event Tree Analysis ETA (Gadd, Leeming, & Riley, 1998; Nicolet-Monnier, 1996; Rogers, 2000; Tiemessen & van Zweeden, 1998;) | Quantitative | Probabilistic | | Transport & Industrial Site | |
| 46 | Fault Tree Analysis FTA (Khan & Abbasi, 1998b; Nicolet-Monnier, 1996; Rogers, 2000) | Quantitative | Probabilistic | | Transport & Industrial Site | |
| 47 | Maintenance Analysis MA (Rogers, 2000) | Quantitative | Probabilistic | | Industrial Site | |
| 48 | Short Cut Risk Assessment SCRA (Rogers, 2000) | Quantitative | Probabilistic | | Industrial Site | |
| 49 | Work Process Analysis Model WPAM (Davoudian, Wu, & Apostolakis, 1994) | Quantitative | Probabilistic | | Human | |
| 50 | AVRIM2 (Ham, van Kessel ,& Wiersma, 1998) | Quantitative | Det & Prob | | Industrial Site | |
| 51 | Facility Risk Review (Schlechter, 1996) | Quantitative | Det & Prob | ✓ | Industrial Site | X |
| 52 | Failure Mode Effect Criticality Analysis FMECA (Rogers, 2000) | Quantitative | Det & Prob | ✓ | Industrial Site | X |
| 53 | IDEF3 (Kusiak & Zakarian, 1996; Larson & Kusiak, 1996) | Quantitative | Det & Prob | | Industrial Site | |
| 54 | International Study Group on Risk Analysis ISGRA (Khan & Abbasi, 1998b) | Quantitative | Det & Prob | | Industrial Site | |
| 55 | IPO Risico Berekening Methodiek IPORBM (Tiemessen & van Zweeden, 1998) | Quantitative | Det & Prob | | Transport | |
| 56 | Method Organised Systematic Analysis of Risk MOSAR (Perhillon, 2000; Rogers, 2000) | Quantitative | Det & Prob | | Industrial Site | |
| 57 | Optimal Risk Assessment ORA (Khan & Abbasi, 1998b) | Quantitative | Det & Prob | | Industrial Site | |
| 58 | Probabilistic Safety Analysis PSA (Khan & Abbasi, 1998b; Papazoglou, Noivolianitou, Aneziris, & Christou, 1992) | Quantitative | Det & Prob | ✓ | Industrial Site | |
| 59 | Quantitative Risk Assessment QRA (Khan & Abbasi, 1998b; Leeming & Saccomanno, 1994; Oien, Sklet, & Nielsen, 1998; Puertas, Sanz, Vaquero, Marono, & Sola, 1998; Rogers, 2000) | Quantitative | Det & Prob | | Transport & Industrial Site | |
| 60 | Rapid Ranking RR (Larson & Kusiak, 1996Tweeddale et al., 1992) | Quantitative | Det & Prob | | Industrial Site | |
| 61 | Rapid Risk Analysis Based Design RRABD (Khan & Abbasi, 1998) | Quantitative | Det & Prob | | Industrial Site | |
| 62 | Risk Level Indicators RLI (Oien et al., 1998) | Quantitative | Det & Prob | ✓ | Industrial Site | |

[a] Each methodology is referred to by a number Int = Potential for Integration
Qual = Qualitiative Quant = Quantitative Det = Deterministic Prob = Probabilistic Hier = Hierarchical App = Application
O = Potential for integration of hazard identifying OBAs X = Potential for integration of risk assessment OBAs

The results of this review considering the above discussion, four RAMs were found to be suitable for integration and these include: a) Failure Mode Effect Criticality Analysis (FMECA); b) Facility Risk Review; Probabilistic Safety Analysis (PSA); and c) Risk Level Indicators (RLI). However, the PSA is used for assessment of nuclear reactors and chemical installation while the RLI is used for petroleum production; therefore neither RAM is useful for the purpose of H&S and MSD risk assessment. Consequently, two assessments are identified to have the optimal characteristics for OBA integration: Failure Mode Effect Criticality Analysis FMECA,

or FMEA, and Facility Risk Review (FRR). FMEA is a systematic, proactive analysis technique that is widely used by several stakeholders within organizations to address different types of risk factors and failures. FRR is an approach used to prioritize loss prevention efforts and identifies the accidents or the failures, relative consequences of those failures, and their expected frequencies of occurrence (Casada, Kirkman, & Paula, 1990).

### 3.3.3. Additional factors

In addition to assessment properties and characteristics described in this review, other consideration must be taken into account including scientific data and the popularity and prevalence of use. When selecting assessment tools to integrate and use, success would likely depend on how familiar or comfortable the stakeholders within organizations are with using certain assessment techniques. In addition, a citation search could help to understand general awareness and popularity of an assessment technique, at least among researchers. In addition, assessment techniques could be proven to be or not to be associated with their purpose by epidemiological studies. A review by Takala et al. (2010) reported OBAs with epidemiological evidences. Other factors that need to be considered are ease of use, time commitment, technology required, cost, and expertise required.

## 4. Summary

MSD hazard identification and risk assessment seem to be partially outside of the main management process due to the complexity of most tools and the unfamiliarity of many stakeholders within organizations with these tools. This Chapter, based on a review of OBAs frequently used by practitioners in the arena of MSD prevention and ergonomics, and an assessment of their possible integration into RAMs, suggests that this integration could be

possible for tools that have common features and use the same types of methodology, input data and output data.

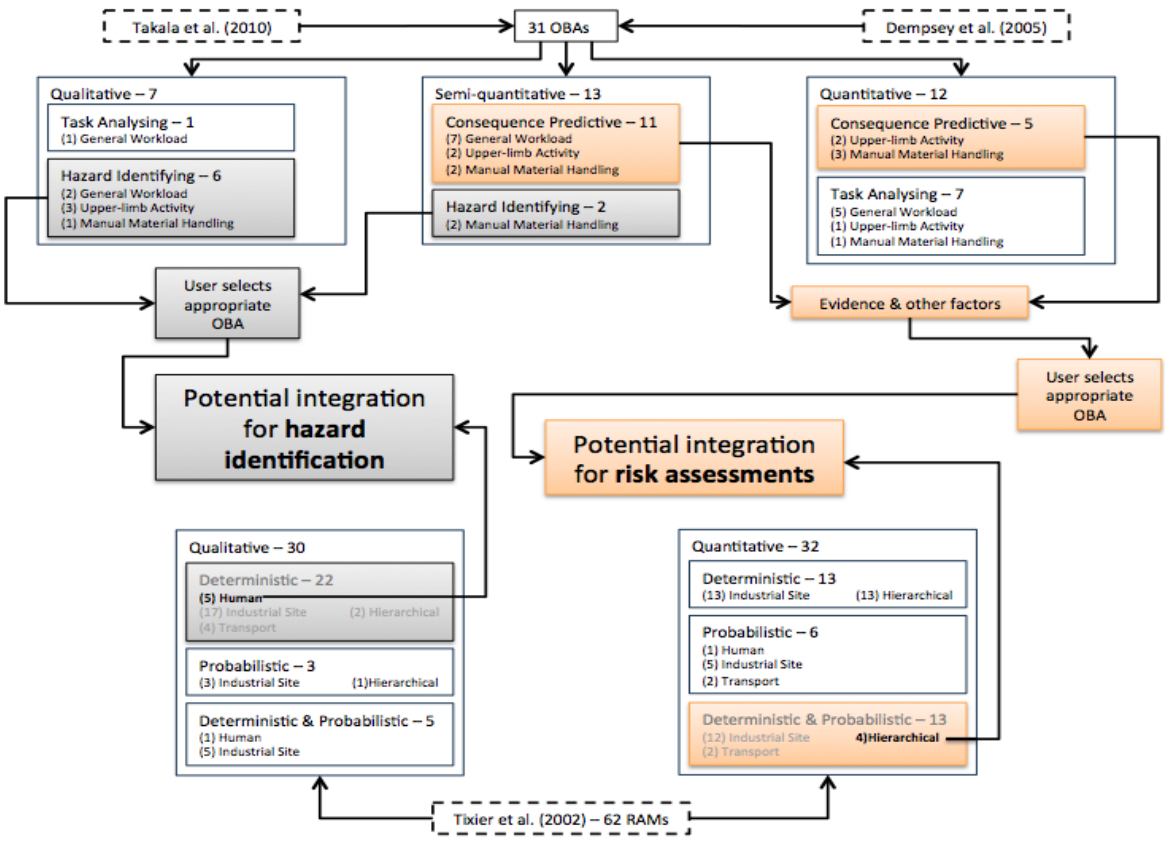


**Figure 2. Review process and number of tools in each category**

From the 31 OBAs reviewed, six groups were found: qualitative and hazard identifying, semi-quantitative and hazard identifying, semi-quantitative and consequence predictive, quantitative and task analysis, quantitative and consequence predictive, and qualitative and task analysing. The findings presented in Tables 1-3 provide an overview of the characteristics of each OBA and could be used to select an appropriate OBA for different purposes and for possible integration with tools presented in Table 4 that are widely used for other business drivers.

The result of this review suggests two levels of integration. The first is to integrate hazard identification tools into RAMs. The review of RAMs found that five of the RAMs including

Action Errors Analysis, Human Hazard and Operability, Manager, Process Risk Management Audit, and Task Analysis, could be appropriate candidates for integration of OBAs. Coming from the other direction, eight of the hazard identifying OBAs were potential candidates for integration into RAMs. These OBAs include: ACGIH lifting threshold limit value for low-back risk, Liberty Mutual Manual Materials Handling Tables, PLIBEL, Washington State ergonomic checklists, HSE upper-limb risk assessment method, Keyserling's cumulative trauma checklist, Ketola's upper-limb expert tool, and New Zealand code of practice for manual handling.

The second level of integration could be for tools aiming for more detailed assessment of risk. The study recommends two RAMs (FMECA and FRR) and 16 OBAs (consequence predictive tools presented in Table 1) with the potential of integration. However, most of these OBAs do not have epidemiological support, therefore they may not be appropriate for more accurate assessments of MSD hazards. This study cautions that other factors need to be taken into account to select an appropriate tool for integration, including: ease of use, time commitment, technology required, cost, expertise required, prevalence and preference of use. HumanHazop and PLIBEL for hazard identification of MSD and other types of hazards could be integrated and used within a hazard identification process in organizations. In addition, FMECA and NIOSH for MSD risk assessment in manual material handling could beneficially be used for integrative risk assessment purposes.

## 5. Conclusion

This paper provides a solid foundation for the integration of OBAs and RAMs for better prevention of MSD. Future research should implement and evaluate the integration and assess the applicability of this approach. In addition, future epidemiological research is needed to evaluate OBAs for predictive validity.

# CHAPTER VIII: Thesis Overview, Contributions and Further Research

## 1. Thesis overview

A management system is defined as a framework of individual processes, procedures, and resources to ensure achievement of certain objectives effectively and efficiently. An Occupational Health and Safety Management System (OHSMS) is a framework that helps organizations to reduce or prevent injuries, occupational diseases and fatalities in the workplace. While there are many (ergonomic) techniques that organizations can use to identify, assess and control musculoskeletal disorder (MSD) hazards, they do not seem to fit well into the methods that are widely used within OHSMS. Because MSD prevention activities lie partially outside the main management process, MSD hazards may not be addressed effectively as might be possible. The main purpose of this thesis was to explore possible practices and avenues to integrate MSD prevention activities into broader management frameworks such as OHSMS.

Several techniques and methodological approaches were used to conduct this thesis. These include a scoping review of literature, semi-structured interviews, document and record analysis, workplace site visits, content analysis, and thematic analysis.

The thesis presents the results of five studies that aimed at: a) identifying and summarizing the research evidence on embedding the prevention of MSD to management systems; b) assessing the compatibility of the program elements described in well-cited Participatory Ergonomics (PE) literature with the requirements in OHSMS standards; c) exploring the perspectives, experiences, and perceptions in prevention of MSD within an organization's management system and its main elements using health and safety key informants; d) documenting the techniques and approaches used by case- study companies to address MSD hazards and how they integrate these within their management systems and explore worker participation; e) exploring integration possibilities for tools to identify, assess, and evaluate MSD hazards within management systems.

### 1.1. Scientific literature review of incorporation of MSD prevention into management systems

The results of this scoping review study showed that there was very limited literature on integrating MSD prevention into management systems. The small literature available suggested that incorporating MSD prevention into organizational level approaches could improve production and preserve workers' health in workplaces. The results of the scoping review also raised the question of whether the high prevalence of MSD could be due to information concerning MSD hazards not being "on-the-table", and thus, not receiving adequate attention. The results of this review indicate that there was support for integration of MSD prevention activities to a broader management framework that may ultimately result in better prevention of MSD. Therefore, bringing ergonomics as a means of preventing MSD into organizations' management systems appears to be highly desirable.

### 1.2. Compatibility of PE with OHSMS standard elements

It is frequently recommended that MSD prevention be accomplished using a PE approach. Assessment of the compatibility of PE approaches, represented by internationally recognized and widely cited ergonomic programs, with the requirements in OHSMS standards indicated that irrespective of the strengths of PE, it does not match business processes and practices well. The PE literature did not speak to many elements described in OHSMS and even when it did, the language used was often different. This may negatively affect the effectiveness and sustainability of PE initiatives within organizations. On the other hand, analysis of the content of the well-cited PE articles found that the implementation of PE programs has not been reported or written about in a fashion that facilitates easy integration into an organization's management system

because of the structural and language differences. The study, however, did not find any conflict between these two approaches. This suggests that MSD prevention activities and approaches such as PE could be beneficially integrated into existing management structures. This approach should supply PE's absent elements and add to the range of techniques in OHSMS. Therefore, it is expected that paying adequate attention to and adopting management approaches and using the common language used in management system frameworks could make MSD prevention activities more effective and sustainable.

### 1.3. Key informants' perspectives

The key informants' interviews indicated that the core features of management systems, such as management commitment, worker participation, and training, are essential and that the Health and Safety (H&S) prevention activities should incorporate these elements to achieve better outcomes. The key informants said that strong management commitment would ultimately results in sustainability of prevention programs as well as the increased performance of the organization. Participants also said that linking MSD prevention to productivity and developing business cases could positively influence management's attention and support of MSD prevention. The integration of H&S into an organization's management structure was said to be an effective way to get sustainable management commitment to address H&S concerns at workplace. It was noted that MSD prevention needs to be sold as an "innovation and competitive advantage" and evidence needs to be gathered to show that improving H&S would add value to the core business of the organization.

With respect to workers' participation, key informants argued that the participation should not be seen as "negotiation". It was recommended that prevention activities using participatory

approaches should be integrated into a broader management system within the organization and this could be achieved by linking prevention goals to current practices in organizations such as "management of change" and "user participation".

As training is argued to be an important element of any management system and prevention activity, there was a strong agreement amongst key informants that training material should contain information about hazard identification and risk assessment. Similar to management commitment and workers participation, key informants argued that training programs for MSD prevention should be incorporated into organizational-wide training strategies. For MSD training programs to be effective, it was discussed that training should be continuous with frequent follow-up. It was said that "strategic positioning" and the use of common tools and language may result in effective training program that would consequently improve H&S in the workplace.

The key informants also indicated that a consistent organization-wide prevention strategy and approach needs to be implemented at the organization level to deal with both MSD and industrial hygiene problems despite differences between their risk factors. The participants argued that integration of MSD prevention into a wider organizational approach avoids creating "silos" within organizations. Such integration would ultimately give the same level of recognition to MSD prevention as other business drivers, resulting in more effective prevention. Such integration was said to positively impact the sustainability of prevention activities and the participants argued that this integration would raise the profile for several organizational concerns including performance and corporate social responsibility image. It was also suggested that MSD prevention could benefit from incorporation into approaches such as quality management systems, and continuous improvement approaches. The integration was said to be

more useful and cost-effective for small businesses. The key informants argued that MSD prevention should ideally be introduced into an organization's overall objectives and to do so, appropriate common language should be used. Incorporating MSD hazard assessment tools into current tools used by organizations was recommended to be an effective approach to develop harmonized assessment tools. The key informants recommended that using common assessment tools that are quantifiable, repeatable, reliable, and measurable would result in better integration of MSD prevention into an organization's overall approach to risk management. Failure Mode and Effect Analysis (FMEA), Job Safety Analysis (JSA), decision making tools, and process flow charts were recommended as being helpful in achieving this integration. Incorporating MSD prevention activities into Lean manufacturing and tools within Lean including Kamishibai and Ishikawa was also recommended.

### 1.4. Case-study approaches

The case studies showed that two participating plants within the same corporation implemented an OHSMS and an ergonomic program in different ways. The implementation and the success of these programs were primary dependent on the level of management commitment and support. The results of the interviews and document analysis showed that despite some successes, implementing parallel programs for MSD prevention and management of H&S did not result in a sustainable proactive approach to prevent MSD. Instead this separation could cause several barriers and challenges from resource allocation, to hazard identification and risk assessment, to increasing bureaucracy and even more isolation of MSD prevention from an organization's overall business structure. The results of this thesis suggest that initiatives to incorporate MSD prevention into other business drivers, led by a quality manager and an engineering manager,

resulted in better addressing MSD risk factors during the design process, installation, and operation. These approaches were said to get better management buy-in to invest in MSD prevention, to increase workers' participation, to improve communication, to increase awareness which lead to better prevention of MSD and a safer workplace.

### 1.5. Review of tools and possible integration

The review of frequently used observational methods designed for MSD hazard identification and risk assessment concluded that these tools could not easily be integrated into other risk assessment techniques used within organizations. By reviewing both observational tools for MSD hazard identification assessment and the wide range of hazard identification and risk assessment tools used in organizations for risks in general, integration was feasible in a few cases. Such integration could create the opportunity to use harmonized tools to identify, assess and evaluate MSD hazards within management systems.

### 1.6. Methodological Strengths and Limitations

Despite their limitations, qualitative methods were judged to be the best and most suitable approach to address the research questions posed in this thesis. The key informants' interview data may not represent the general perspective of a certain population but conducting it among multiple stakeholders provided the opportunity to look into the topics of interest from the perspectives of key role players in the arena of H&S. Conducting the case study in only two organization may limit the transferability of the findings to other organizations. However, the purpose of this research was not to comment on transferability of the findings rather to describe and document current approaches used by the two plants.

## 2. Thesis Contribution

The scientific literature on MSD prevention at work is dominated by the participative ergonomics paradigm. This thesis challenges this single approach and explores a complementary paradigm that aligns MSD prevention with the well-known Occupational Health and Safety Managements System framework. This reframing provides the opportunity for developing different approaches and tools to address these painful and costly disorders.

## 3. Conclusions and further research needed

The results of this thesis suggest that the current disconnection of MSD prevention activities from management structures creates silos within organizations that result in poor sustainability, isolation, and less management buy-in. Instead, integration of MSD prevention into management systems could benefit prevention through it receiving adequate attention, using existing resources, increased management support and buy-in, and sustainability. This can be achieved by using harmonized approaches and tools to bring MSD prevention "onto-the-table". This will ultimately result in better prevention of MSD.

Future research is needed to develop, implement and evaluate practices, tools and approaches aiming at incorporating MSD prevention into broader organization system frameworks. More case studies are needed to document success stories and approaches to incorporating MSD prevention activities into broader organizational-wide frameworks. Further work is also needed to measure the cost-benefit and cost-effectiveness of these integrative approaches and to publish the results in management and business as well as ergonomics journals.

## REFERENCES

Alonso, C., & Gavalda, J. (1998). A method to determine environmental risk in chemical process industries. In Proceedings from ninth international symposium loss prevention and safety promotion in the process Industries (pp. 1219-1227).

Alsop, P., & LeCouteur, M. (1999). Measurable success from implementing an integrated OHS management system at Manningham City Council. *Journal of Occupational Health and Safety Australia and New Zealand,* 15(6), 565-572.

Anema, J. R., Steenstra, I. A., Urlings, I. J. M., Bongers, P. M., De Vroome, E. M. M., & Van Mechelen, W. (2003). Participatory ergonomics as a return-to-work intervention: A future challenge? *American Journal Of Industrial Medicine,* 44(3), 273-281.

Arbouw Foundation., Guidelines on physical workload for the construction industry. Arbouw Foundation, (1997). Available from: http://www.lhsfna.org/files/ARBOUW_Guidelines.pdf

Arksey, H., & O'Malley, L. (2005). Scoping studies: towards a methodological framework. *International Journal Of Social Research Methodology,* 8(1), 19-32.

Arocena, P., & Núñez, I. (2010). An empirical analysis of the effectiveness of occupational health and safety management systems in SMEs. *International Small Business Journal,* 28(4), 398-419.

Badri, A., Gbodossou, A., & Nadeau, S. (2012). Occupational health and safety risks: Towards the integration into project management. *Safety Science,* 50(2), 190-198.

Bernard, B. P. (Ed.). (1997). Musculoskeletal disorders and workplace factors: a critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back (No. 97-141). US Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

Bohr, P. C., Evanoff, B. A., & Wolf, L. D. (1997). Implementing participatory ergonomics teams among health care workers. *American Journal of Industrial Medicine,* 32(3), 190-196.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research In Psychology,* 3(2), 77-101.

British Standard Institution. (2007). OHSAS 18001: Occupational health and safety management systems-specification. British Standards Institution, London.

British Standards Institution. (1996). BS 8800: guide to occupational health and safety management systems. London: British Standards Institution.

Buchholz, B., Paquet, V., Punnett, L., Lee, D., & Moir, S. (1996). PATH: A work sampling-based approach to ergonomic job analysis for construction and other non-repetitive work. *Applied Ergonomics,* 27(3), 177-187.

Bunn III, W. B., Pikelny, D. B., Slavin, T. J., & Paralkar, S. (2001). Health, safety, and productivity in a manufacturing environment. *Journal of Occupational and Environmental Medicine,* 43(1), 47-55.

Burgess-Limerick, R., Egeskov, R., Straker, L., & Pollock, C. (2000). Manual tasks blitz audit tool. Unpublished document. Division of workplace health and Safety, Department of Industrial relations, Queensland.

Burgess-Limerick, R., Straker, L., Pollock, C., Dennis, G., Leveritt, S., & Johnson, S. (2007). Implementation of the Participative Ergonomics for Manual tasks (PErforM) programme at four Australian underground coal mines. *International Journal of Industrial Ergonomics,* 37(2), 145-155.

Canadian Standards Association (CSA). Occupational Health and Safety Management. CSA Standard Z1000-06 (R2011). Mississauga, ON: CSA; (2006).

Caroly, S., Coutarel, F., Landry, A., & Mary-Cheray, I. (2010). Sustainable MSD prevention: Management for continuous improvement between prevention and production. Ergonomic intervention in two assembly line companies. *Applied Ergonomics,* 41(4), 591-599.

Chaffin, D. B. (2005). Improving digital human modelling for proactive ergonomics in design. *Ergonomics,* 48(5), 478-491.

Chung, M. K., Lee, I., & Kee, D. (2005). Quantitative postural load assessment for whole body manual tasks based on perceived discomfort. *Ergonomics,* 48(5), 492-505.

Chung, P. W. H., Broomfield, E., & Yang, S. H. (1998). Safety related questions for computer-controlled plants: derivation, organisation and application. *Journal Of Loss Prevention In The Process Industries,* 11(6), 397-406.

Cocianni, V., & Williamson, M. (2008, January). Safety Health And Ergonomics In Mobile Equipment: Combining Them Can Be Simple And Practical. In SPE International Conference on Health Safety and Environment in Oil and Gas Exploration and Production. Society of Petroleum Engineers. SPE 111516.

Cohen, R. (1997). Ergonomics program development: Prevention in the workplace. *American Industrial Hygiene Association Journal,* 58(2), 145-149.

Cole, B. L., & Parker Brown, M. (1996). Action on worksite health and safety problems: A follow-up survey of workers participating in a hazardous waste worker training program. *American Journal Of Industrial Medicine,* 30(6), 730-743.

Cole, D. C., Theberge, N., Dixon, S. M., Rivilis, I., Neumann, W. P., & Wells, R. (2009). Reflecting on a program of participatory ergonomics interventions: a multiple case study. *Work:* A *Journal of Prevention, Assessment and Rehabilitation,* 34(2), 161-178.

Corlett, E. N., Madeley†, S., & Manenica‡, I. (1979). Posture targeting: a technique for recording working postures. *Ergonomics*, 22(3), 357-366.

David, G., Woods, V., Li, G., & Buckle, P. (2008). The development of the Quick Exposure Check (QEC) for assessing exposure to risk factors for work-related musculoskeletal disorders. *Applied Ergonomics*, 39(1), 57-69.

Davoudian, K., Wu, J. S., & Apostolakis, G. (1994). The work process analysis model (WPAM). *Reliability Engineering & System Safety*, 45(1), 107-125.

De Looze, M. P., Urlings, I. J. M., Vink, P., Van Rhijn, J. W., Miedema, M. C., Bronkhorst, R. E., & Van der Grinten, M. P. (2001). Towards successful physical stress reducing products: an evaluation of seven cases. *Applied Ergonomics*, 32(5), 525-534.

Delvosalle, C., Fievez, C., & Benjelloun, F. (1998). Development of a methodology for the identification of potential domino effects in" SEVESO" industries. In Proceedings 9th International Symposium on Loss Prevention and Safety Promotion in the Process Industries (Vol. 3, pp. 1252-1261).

Deming, W. E. (1986). Out of the crisis, Massachusetts Institute of Technology. Center for advanced engineering study, Cambridge, MA, 510.

Dempsey, P. G., McGorry, R. W., & Maynard, W. S. (2005). A survey of tools and methods used by certified professional ergonomists. *Applied Ergonomics*, 36(4), 489-503.

Department of Labour, Te Tar Mahi. Code of practice for manual handling [Internet]. Wellington (New Zealand): Occupational Safety and Health Service of the Department of Labour, the Accident Compensation Corporation; (2001). Available from: http://www.osh.dol.govt.nz/order/catalogue/pdf/manualcode.pdf.

Dixon, S. M., Theberge, N., & Cole, D. C. (2009). Sustaining management commitment to workplace health programs: The Case of Participatory Ergonomics. *Relations Industrielles/Industrial Relations*, 61 (1): 50-74.

Dolladille, O. (1999). PROPOSITION D'UNE METHODE D'ANALYSE DES EFFETS DOMINO afin de prevenir les risques technologiques majeurs. *Preventique Securite*, (44), 62-70.

DOW's Fire & Explosion Index Hazard Classification Guide. (1987). American Institute of Chemical Engineers.

DOW's Chemical Exposure Index Guide. (1994). American Institute of Chemical Engineers (1st ed.).

Driessen, M. T., Proper, K. I., Anema, J. R., Bongers, P. M., & van der Beek, A. J. (2010). Process evaluation of a participatory ergonomics programme to prevent low back pain and neck pain among workers. *Implementation Science*, 5(1), 65.

Driessen, M. T., Proper, K. I., Anema, J. R., Knol, D. L., Bongers, P. M., & van der Beek, A. J. (2010). Participatory ergonomics to reduce exposure to psychosocial and physical risk factors for low back pain and neck pain: results of a cluster randomised controlled trial. *Occupational and Environmental Medicine*, 68, 674-681.

Eaton, A. E., & Nocerino, T. (2000). The Effectiveness of Health and Safety Committees: Results of a Survey of Public-Sector Workplaces the Effectiveness of Health and Safety Committees. Industrial Relations: *A Journal of Economy and Society*, 39(2), 265-290.

van Eerd, D., Cole, D., Irvin, E., Mahood, Q., Keown, K., Theberge, N., ... & Cullen, K. (2010). Process and implementation of participatory ergonomic interventions: a systematic review. *Ergonomics*, 53(10), 1153-1166.

European Council. Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work. OJ. 1989; L183: 1–8. European Agency for Safety and Health at Work. Retrieved November 1 2014. Available from: https://osha.europa.eu/en/legislation/directives/the-osh-framework-directive/1

Fallentin, N., Juul-Kristensen, B., Mikkelsen, S., Andersen, J. H., Bonde, J. P., Frost, P., & Endahl, L. (2001). Physical exposure assessment in monotonous repetitive work—the PRIM study. *Scandinavian Journal Of Work, Environment & Health*, 21-29.

Faville, B. A. (1996). One approach for an ergonomics program in a large manufacturing environment. *International Journal of Industrial Ergonomics*, 18(5), 373-380.

Fera, M., & Macchiaroli, R. (2010). Appraisal of a new risk assessment model for SME. *Safety Science*, 48(10), 1361-1368.

Flin, R. (2003). "Danger—men at work": Management influence on safety. Human Factors and *Ergonomics in Manufacturing & Service Industries*, 13(4), 261-268.

Fransson-Hall, C., Gloria, R., Kilbom, Å., Winkel, J., Karlqvist, L., & Wiktorin, C. (1995). A portable ergonomic observation method (PEO) for computerized on-line recording of postures and manual handling. *Applied Ergonomics*, 26(2), 93-100.

Frings-Dresen, M. H., & Kuijer, P. P. F. M. (1995). The TRAC-system: an observation method for analysing work demands at the workplace. *Safety Science*, 21(2), 163-165.

Gadd, S. A., Leeming, D. G., & Riley, T. N. K. (1998). Transport Riskat: The HSE quantified risk assessment tool for toxic and flammable dangerous goods transport by road and rail in Great Britain. In Proceedings from ninth International symposium loss prevention and safety promotion in the process industries (pp. 308–317).

Garg, A., Boda, S., Hegmann, K. T., Moore, J. S., Kapellusch, J. M., Bhoyar, P., ... & Malloy, E. J. (2014). The NIOSH Lifting Equation and Low-Back Pain, Part 1 Association With Low-Back Pain in the BackWorks Prospective Cohort Study. Human Factors: *The Journal of the Human Factors and Ergonomics Society*, 56(1), 6-28.

Garg, A., Kapellusch, J. M., Hegmann, K. T., Moore, J. S., Boda, S., Bhoyar, P., ... & Malloy, E. J. (2014). The NIOSH Lifting Equation and Low-Back Pain, Part 2 Association With Seeking Care in the BackWorks Prospective Cohort Study. Human Factors: *The Journal of the Human Factors and Ergonomics Society,* 56(1), 44-57.

Garg, A., Kapellusch, J., Hegmann, K., Wertsch, J., Merryweather, A., Deckow-Schaefer, G., ... & WISTAH Hand Study Research Team. (2012). The Strain Index (SI) and Threshold Limit Value (TLV) for Hand Activity Level (HAL): risk of carpal tunnel syndrome (CTS) in a prospective cohort. *Ergonomics,* 55(4), 396-414.

Geldart, S., Smith, C. A., Shannon, H. S., & Lohfeld, L. (2010). Organizational practices and workplace health and safety: A cross-sectional study in manufacturing companies. *Safety Science,* 48(5), 562-569.

Gillen, M., Kools, S., Sum, J., McCall, C., & Moulden, K. (2004). Construction workers' perceptions of management safety practices: A qualitative investigation. *Work: A Journal of Prevention, Assessment and Rehabilitation,* 23(3), 245-256.

Graves, R. J., Way, K., Riley, D., Lawton, C., & Morris, L. (2004). Development of risk filter and risk assessment worksheets for HSE guidance—'Upper Limb Disorders in the Workplace' 2002. *Applied Ergonomics,* 35(5), 475-484.

Haims, M. C., & Carayon, P. (1998). Theory and practice for the implementation of 'in-house', continuous improvement participatory ergonomic programs. *Applied Ergonomics,* 29(6), 461-472.

Haines, H., Wilson, J., (1998). Development of a framework for participatory ergonomics. Health and safety executive. Contract Research Report 174/1998. London: HSE Books.

Hallowell, M. R., & Calhoun, M. E. (2011). Interrelationships among highly effective construction injury prevention strategies. *Journal of Construction Engineering and Management,* 137(11), 985-993.

Halpern, C. A., & Dawson, K. D. (1997). Design and implementation of a participatory ergonomics program for machine sewing tasks. *International Journal Of Industrial Ergonomics,* 20(6), 429-440.

Ham, K. J. M., van Kessel, H. J. C. M., & Wiersma, T. (1998). Experiences with a safety report according to Seveso II: A pilot project in the Netherlands. In Proceeding from ninth international symposium loss prevention and safety promotion in the process Industries (pp. 1326–1340).

Hare, B., Cameron, I., & Roy Duff, A. (2006). Exploring the integration of health and safety with pre-construction planning. *Engineering, Construction And Architectural Management,* 13(5), 438-450.

Haslam, R. A. (2002). Targeting ergonomics interventions—learning from health promotion. *Applied Ergonomics,* 33(3), 241-249.

Health and Safety Executive. Guide to successful health and safety management, 2nd ed. HSG65. Sudbury: HSE Books; 1997.

Hendrick, H.W., Kleiner, B.M., 2002. Macroergonomics: Theory, methods, and applications. Mahwah, New Jersey.

Hess, J. A., Hecker, S., Weinstein, M., & Lunger, M. (2004). A participatory ergonomics intervention to reduce risk factors for low-back disorders in concrete laborers. *Applied Ergonomics,* 35(5), 427-441.

Hignett, S., & McAtamney, L. (2000). Rapid entire body assessment (REBA). *Applied Ergonomics,* 31(2), 201-205.

Holmberg, J. (1996). Risk follow up by probabilistic safety assessment-experience from a finish pilot study. *Reliability Engineering and System Safety,* 53, 3–15.

Holzmann, P. (1982). ARBAN—A new method for analysis of ergonomic effort. *Applied Ergonomics,* 13(2), 82-86.

Huang, Y. H., Verma, S. K., Chang, W. R., Courtney, T. K., Lombardi, D. A., Brennan, M. J., & Perry, M. J. (2012a). Management commitment to safety vs. employee perceived safety training and association with future injury. *Accident Analysis & Prevention,* 47, 94-101.

Huang, Y. H., Verma, S. K., Chang, W. R., Courtney, T. K., Lombardi, D. A., Brennan, M. J., & Perry, M. J. (2012b). Supervisor vs. employee safety perceptions and association with future injury in US limited-service restaurant workers. *Accident Analysis & Prevention,* 47, 45-51.

Hurst, N. W., Young, S., Donald, I., Gibson, H., & Muyselaar, A. (1996). Measures of safety management performance and attitudes to safety at major hazard sites. *Journal of Loss Prevention in the Process Industries,* 9(2), 161–172.

International Ergonomics Association., (2000). Triennial report. Santa Monica, CA: IEA Press.

International Labour Office. Guidelines on Occupational Safety and Health Management Systems. MEOSH/2001/2(Rev.). Geneva: International Labour Office; (2001).

Imbeau, D., Bellemare, M., Courville, J., Bergeron, S., & Desjardins, L. (2001). Ergonomics in a design environment, in: Karwowski, W. (Ed), International Encyclopedia of Ergonomics and Human Factors. Taylor & Francis, London, pp. 2118-2122.

Jager, P., & Kuhnreich, K. (1998). Approach to a systematic determination and evaluation of risk potential. In Proceeding from ninth international symposium loss prevention and safety promotion in the process industries (pp. 393–403).

Jezler, W. (1998). Earthquake safety of structures and installations in chemical industry in the context of risk analysis. In Proceeding from ninth international symposium loss prevention and safety promotion in the process industries, 414–421.

de Jong, A. M., & Vink, P. (2002). Participatory ergonomics applied in installation work. *Applied Ergonomics,* 33(5), 439-448.

Kadefors, R., & Forsman, M. (2000). Ergonomic evaluation of complex work: a participative approach employing video–computer interaction, exemplified in a study of order picking. *International Journal of Industrial Ergonomics,* 25(4), 435-445.

Kao, C. S., & Duh, Y. S. (1998). Chemical runaway reaction hazard index and risk assessment. Proceeding from ninth International symposium loss prevention and safety promotion in the process industries, 965-975.

Karapetrovic, S., & Willborn, W. (1998). Integrated audit of management systems. *International Journal of Quality & Reliability Management,* 15(7), 694-711.

Karasek, R., Brisson, C., Kawakami, N., Houtman, I., Bongers, P., & Amick, B. (1998). The Job Content Questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. *Journal of Occupational Health Psychology,* 3(4), 322.

Karhu, O., Kansi, P., & Kuorinka, I. (1977). Correcting working postures in industry: a practical method for analysis. *Applied Ergonomics,* 8(4), 199-201.

Kee, D., & Karwowski, W. (2001). LUBA: an assessment technique for postural loading on the upper body based on joint motion discomfort and maximum holding time. *Applied Ergonomics,* 32(4), 357-366.

Kemmlert, K. (1995). A method assigned for the identification of ergonomic hazards—PLIBEL. *Applied Ergonomics,* 26(3), 199-211.

Kennedy, R., & Kirwan, B. (1998). Development of a hazard and operability-based method for identifying safety management vulnerabilities in high risk systems. *Safety Science,* 30(3), 249-274.

Ketola, R., Toivonen IV, R., & Viikari-Juntura, E. (2001). Interobserver repeatability and validity of an observation method to assess physical loads imposed on the upper extremities. *Ergonomics,* 44(2), 119-131.

Keyserling, W. M., Stetson, D. S., Silverstein, B. A., & Brouwer, M. L. (1993). A checklist for evaluating ergonomic risk factors associated with upper extremity cumulative trauma disorders. *Ergonomics,* 36(7), 807-831.

Khan, F. I., & Abbasi, S. A. (1997a). OptHAZOP—an effective and optimum approach for HAZOP study. *Journal of Loss Prevention in the Process Industries,* 10(3), 191-204.

Khan, F. I., & Abbasi, S. A. (1997b). Accident hazard index: a multi-attribute method for process industry hazard rating. *Process Safety And Environmental Protection,* 75(4), 217-224.

Khan, F. I., & Abbasi, S. A. (1998a). Inherently safer design based on rapid risk analysis. *Journal of Loss Prevention in the Process Industries,* 11(6), 361-372.

Khan, F. I., & Abbasi, S. A. (1998b). Multivariate hazard identification and ranking system. *Process Safety Progress,* 17(3), 157-170.

Khan, F. I., & Abbasi, S. A. (1998c). Techniques and methodologies for risk analysis in chemical process industries. *Journal of Loss Prevention in the Process Industries,* 11(4), 261-277.

Koch, T., Horbal, R., Kagan, R., Sobczyk, T., & Plebanek, S. (2012). 10 commandments for the boss of a company implementing Lean philosophy. *Management and Production Engineering Review,* 3(2), 62-78.

Koppelaar, E., Knibbe, J. J., Miedema, H. S., & Burdorf, A. (2013). The influence of individual and organisational factors on nurses' behaviour to use lifting devices in healthcare. *Applied Ergonomics,* 44(4), 532-537.

Korjusiommi, E., Salo, R., & Taylor, R. (1998). Hazard analysis for batch processes and for special operations. Proceeding from ninth International symposium loss prevention and safety promotion in the process industries, 422–431.

Korunka, C., Dudak, E., Molnar, M., & Hoonakker, P. (2010). Predictors of a successful implementation of an ergonomic training program. *Applied Ergonomics,* 42(1), 98-105.

Kumar, K. (1989). Conducting key informant interviews in developing countries. Washington DC: Agency for International Development.

Kuorinka, I. (1997). Tools and means of implementing participatory ergonomics. *International Journal of Industrial Ergonomics,* 19(4), 267-270.

Kusiak, A., & Zakarian, A. (1996). Risk assessment of process models. *Computers & Industrial Engineering,* 30(4), 599-610.

La directive Seveso II: Annexe 6. (1997). edition legislative, bul 230, 6933–6947.

Labodová, A. (2004). Implementing integrated management systems using a risk analysis based approach. *Journal of Cleaner Production,* 12(6), 571-580.

Laing, A., Frazer, M., Cole, D., Kerr, M., Wells, R., & Norman, R. (2005). Study of the effectiveness of a participatory ergonomics intervention in reducing worker pain severity through physical exposure pathways. *Ergonomics,* 48(2), 150-170.

Laitinen, H., Saari, J., & Kuusela, J. (1997). Initiating an innovative change process for improved working conditions and ergonomics with participation and performance feedback: A case study in an engineering workshop. *International Journal of Industrial Ergonomics,* 19(4), 299-305.

Larson, N., & Kusiak, A. (1996). Managing design processes: A risk assessment approach. IEEE Transactions on Systems, Man, and Cybernetics—Part A: *Systems and Humans,* 26(6), 749–759.

Latko, W. A., Armstrong, T. J., Foulke, J. A., Herrin, G. D., Rabourn, R. A., & Ulin, S. S. (1997). Development and evaluation of an observational method for assessing repetition in hand tasks. *American Industrial Hygiene Association Journal,* 58(4), 278-285.

Lavoie-Tremblay, M., Bourbonnais, R., Viens, C., Vézina, M., Durand, P. J., & Rochette, L. (2005). Improving the psychosocial work environment. *Journal of Advanced Nursing,* 49(6), 655-664.

Lee, K. S. (2005). Ergonomics in total quality management: How can we sell ergonomics to management? *Ergonomics,* 48(5), 547-558.

Leeming, D. G., & Saccomanno, F. F. (1994). Use of quantified risk assessment in evaluating the risks of transporting chlorine by road and rail. *Transportation Research Record,* (1430), 27-35.

Lewandowski, J., (2000). Ergonomics in total quality management. Proceedings of the Human Factor and Ergonomics Society 44th Annual Meeting, San Diego, California, USA, pp. 284-287.

Lin, E., Village, J. and Neumann, W.P., (2012). Development and application of a human factors failure mode and effects analysis. Applied Ergonomics Conference, March 26-29, Nashville, TN.

Lingard, H., Blismas, N., Cooke, T., & Cooper, H. (2009). The model client framework: resources to help Australian Government agencies to promote safe construction. *International Journal of Managing Projects In Business,* 2(1), 131-140.

Lo, C. K., Pagell, M., Fan, D., Wiengarten, F., & Yeung, A. C. (2014). OHSAS 18001 certification and operating performance: The role of complexity and coupling. *Journal of Operations Management,* 32(5), 268-280.

Loisel, P., Gosselin, L., Durand, P., Lemaire, J., Poitras, S., & Abenhaim, L. (2001). Implementation of a participatory ergonomics program in the rehabilitation of workers suffering from subacute back pain. *Applied Ergonomics,* 32(1), 53-60.

Malchaire, J. B. (2004). The SOBANE risk management strategy and the Déparis method for the participatory screening of the risks. *International Archives of Occupational and Environmental Health,* 77(6), 443-450.

Marras WS, Hamrick C. The ACGIH TLV for low back risk. In: Marras WS, Karwowski W, editors. Fundamentals and assessment tools for occupational ergonomics. Boca Raton (FL): CRC Press; (2006). p 50:1–15.

Marshall, M. N. (1996). The key informant technique. *Family Practice,* 13(1), 92-97.

Martin, S. A., Irvine, J. L., Fluharty, K., & Gatty, C. M. (2003). A comprehensive wrk injury prevention program with clerical and office workers: phase I. *Work*: A *Journal of Prevention, Assessment and Rehabilitation*, 21(2), 185-196.

De Oliveira Matias, J. C., & Coelho, D. A. (2002). The integration of the standards systems of quality management, environmental management and occupational health and safety management. *International Journal of Production Research,* 40(15), 3857-3866.

Mays, N., Roberts, E. and Popay, J., (2001). Synthesising research evidence. In N. Fulop, P. Allen, A. Clarke and N. Black (eds) Studying the Organisation and Delivery of Health Services: Research Methods (London: Routledge), pp. 188-220.

McAtamney, L., & Nigel Corlett, E. (1993). RULA: a survey method for the investigation of work-related upper limb disorders. *Applied Ergonomics,* 24(2), 91-99.

Milgate, N., Innes, E. V., & O'Loughlin, K. (2002). Examining the effectiveness of health and safety committees and representatives: a review. *Work:* A *Journal of Prevention, Assessment and Rehabilitation,* 19(3), 281-290.

Van der Molen, H. F., Sluiter, J. K., Hulshof, C. T., Vink, P., van Duivenbooden, C., Holman, R., & Frings-Dresen, M. H. (2005). Implementation of participatory ergonomics intervention in construction companies. *Scandinavian Journal of Work, Environment & Health*, 31(3), 191–204.

Monnington, S. C., Pinder, A. D., & Quarrie, C. (2002). Development of an inspection tool for manual handling risk assessment. Health and Safety Laboratory.

Moore, S. J., & Garg, A. (1995). The Strain Index: a proposed method to analyze jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association,* 56(5), 443-458.

Mooren, L., Grzebieta, R., Williamson, A., Olivier, J., & Friswell, R. (2014). Safety management for heavy vehicle transport: A review of the literature. *Safety Science*, 62, 79-89.

Morag, I. (2007). Intel's incident-free culture: A case study. *Applied Ergonomics,* 38(2), 201-211.

Morse, T. (1998). Surveillance and the problems of assessing office-related injury. *Occupational Medicine* (Philadelphia, Pa.), 14(1), 73-80.

Motamedzade, M., Shahnavaz, H., Kazemnejad, A., Azar, A., & Karimi, H. (2003). The impact of participatory ergonomics on working conditions, quality, and productivity. *International Journal of Occupational Safety and Ergonomics*, 9(2), 135-147.

Munck-Ulfsfält, U., Falck, A., Forsberg, A., Dahlin, C., & Eriksson, A. (2003). Corporate ergonomics programme at Volvo Car Corporation. *Applied Ergonomics,* 34(1), 17-22.

Murphy, C.E., Mitchell, J., (2002). Developing sustainable ergonomic programs - a case study in the health care sector, making a case for ergonomics. Proceedings of the 33rd Annual Conference of the Association of Canadian Ergonomists.

Nagamachi, M. (1995). Kansei engineering: a new ergonomic consumer-oriented technology for product development. *International Journal of Industrial Ergonomics,* 15(1), 3-11.

Nastasia, I., Toulouse, G., Imbeau, D., (2006a). Integration of ergonomics and health and safety concerns into PVA kaizen interventions. Proceedings of the 36th Annual Conference of the Association of Canadian Ergonomists. Banff, Canada. 22-25/10/2006. IRSST.

Nastasia, I., Toulouse, G., & Imbeau, D. (2006b, July). Integration of ergonomics into PVA-Kaizen interventions: a feasibility study. In R. N. Pikaar, E. A. P. Koningsveld, & P. J. M. Settels (Eds.), Proceedings of the 16th world congress of the International Ergonomics Association Maastricht, Netherlands. Amsterdam: Elsevier Science B.V; 2006 (CD-ROM).

National Institute for Occupational Safety and Health (NIOSH) DHHS, (1997). Elements of Ergonomics Programs. Publication No. 97-117. Cincinnati, OH.

National Research Council (NRC)., (2001). Musculoskeletal Disorders and the Workplace, National Academy Press, Washington, D.C.

Neumann, W. P. (2004). Production Ergonomics: Identifying and managing risk in the design of high performance work systems (Vol. 10). Lund University.

Neumann, W. P., & Dul, J., 2010. Human factors: spanning the gap between OM and HRM. *International Journal of Operations & Production Management,* 30(9), 923-950.

Neumann, W. P., Wells, R., (2008). Mechanical exposure assessment in the design of work, in: Kumar, S. (ed) Biomechanics in Ergonomics. CRC Press, Boca Raton, ch. 3

Neumann, W. P., Winkel, J., Medbo, L., Magneberg, R., & Mathiassen, S. E. (2006). Production system design elements influencing productivity and ergonomics: A case study of parallel and serial flow strategies. *International Journal of Operations & Production Management,* 26(8), 904-923.

Neumann, W. P., & Village, J. (2012). Ergonomics action research II: a framework for integrating HF into work system design. *Ergonomics,* 55(10), 1140-1156.

Nicolet-Monnier, M. (1996). Integrated regional risk assessment: The situation in Switzerland. *International Journal of Environment and Pollution,* 6(4-6), 441–461.

Noro, K., & Imada, A. S. (1991). Participatory ergonomics. Taylor & Francis, London.

Nunes, I., & Machado, V.C. (2007). Merging Ergonomic Principles into Lean Manufacturing. Industrial Engineering Research Conference, 19-23/05/2007, Nashville, Tennessee.

Occhipinti, E. (1998). OCRA: a concise index for the assessment of exposure to repetitive movements of the upper limbs. *Ergonomics,* 41(9), 1290-1311.

Øien, K., Sklet, S., & Nielsen, L. (1998, May). Development of risk level indicators for a petroleum production platform. In Proceedings of the 9th International Symposium of Loss Prevention and Safety Promotion in the Process Industries (pp. 4-7).

Papazoglou, I. A., Noivolianitou, Z., Aneziris, O., & Christou, M. (1992). Probabilistic safety analysis in chemical installation. *Journal of Loss Prevention in the Process Industries,* 5(3), 181–191.

Périlhon, P. (2000). Analyse des risques, éléments méthodiques. Phoebus, la revue de la sûreté de fonctionnement, *l'analyse de risques,* 12, 31-49.

Pitblado, R. M., Williams, J. C., & Slater, D. H. (1990). Quantitative assessment of process safety programs. *Plant/Operations Progress,* 9(3), 169–175.

Polanyi, M. F., Cole, D. C., Ferrier, S. E., Facey, M., & Worksite Upper Extremity Research Group. (2005). Paddling upstream: a contextual analysis of implementation of a workplace ergonomic policy at a large newspaper. *Applied Ergonomics,* 36(2), 231-239.

Poth, C., & Ross, S. (2009). Meta-analysis, systematic review, or scoping review? Comparing methodologies in educational research. In Annual Conference of the Canadian Society for the Study of Education, Ottawa, ON, Canada.

ProQuest, (2010). Data bases. Available from: http://search.proquest.com/databases/advanced?accountid=14906 (accessed 16.03.12).

Puertas, I., Vaquero, J. S. C., Marono, M., & Sola, R. (1998). Procedure for the review of quantitative risk assessment of the process industries. In Proceeding from ninth International Symposium Loss Prevention and Safety Promotion in the Process Industries (pp. 283-288).

Punnett, L., & Wegman, D. H. (2004). Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. *Journal of Electromyography and Kinesiology,* 14(1), 13-23.

Rasmussen, B., & Whetton, C. (1997). Hazard identification based on plant functional modelling. *Reliability Engineering & System Safety,* 55(2), 77-84.

Rivilis, I., Cole, D. C., Frazer, M. B., Kerr, M. S., Wells, R. P., & Ibrahim, S. (2006). Evaluation of a participatory ergonomic intervention aimed at improving musculoskeletal health. *American Journal of Industrial Medicine,* 49(10), 801-810.

Rivilis, I., Van Eerd, D., Cullen, K., Cole, D. C., Irvin, E., Tyson, J., & Mahood, Q. (2008). Effectiveness of participatory ergonomic interventions on health outcomes: a systematic review. *Applied Ergonomics,* 39(3), 342-358.

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

Rogers, R.L. (2000). The RASE Project risk assessment of unit operations and equipment, http://www.safetynet.de/EC-Projects/. pp. 1-50.

Rohmert, W. (1985). AET—a new job-analysis method. *Ergonomics,* 28(1), 245-254.

Rosecrance, J. C., & Cook, T. M. (2000). The use of participatory action research and ergonomics in the prevention of work-related musculoskeletal disorders in the newspaper industry. *Applied Occupational and Environmental Hygiene,* 15(3), 255-262.

Rundmo, T. (1994). Associations between safety and contingency measures and occupational accidents on offshore petroleum platforms, *Scandinavian Journal of Work, Environment & Health,* 20: 128-131

Saksvik, P. Ø., & Quinlan, M. (2003). Regulating systematic occupational health and safety management: comparing the Norwegian and Australian experience. *Relations Industrielles/Industrial Relations,* 33-59.

Sankey, P. D. (1998). An insurer's involvement in the risk reduction process. Proceeding from ninth International symposium loss prevention and safety promotion in the process industries, 441-450.

Saurin, T. A., Formoso, C. T., & Cambraia, F. B. (2008). An analysis of construction safety best practices from a cognitive systems engineering perspective. *Safety Science,* 46(8), 1169-1183.

Schlechter, W. P. G. (1996). Facility risk review as a means to addressing existing risks during the life cycle of a process unit, operation or facility. *International Journal of Pressure Vessels and Piping,* 66(1), 387-402.

Shen, Y. J., & Walker, D. H. T. (2001). Integrating OHS, EMS and QM with constructability principles when construction planning-a design and construct project case study. *The TQM Magazine*, 13(4), 247-259.

Shephard, D., Villalta, D., & Potvin, J. R. (2003). A system to incorporate ergonomics into product design and processes for manufacturing assembly. In Proceedings of the Association of the Canadian Ergonomist Conference, London, Ontario.

Snook, S. H., & Ciriello, V. M. (1991). The design of manual handling tasks: revised tables of maximum acceptable weights and forces. *Ergonomics,* 34(9), 1197-1213.

St-Vincent, M., Kuorinka, I., Chicoine, D., Beaugrand, S., & Fernandez, J. (1997). Assimilation and use of ergonomic knowledge by nonergonomists to improve jobs in two electrical product assembly plants. *Human Factors and Ergonomics in Manufacturing & Service Industries,* 7(4), 337-350.

Stetson, D. S., Keyserling, W. M., Silverstein, B. A., & Leonard, J. A. (1991). Observational analysis of the hand and wrist: a pilot study. *Applied Occupational and Environmental Hygiene,* 6(11), 927-935.

Takala, E. P., Pehkonen, I., Forsman, M., Hansson, G. Å., Mathiassen, S. E., Neumann, W. P., ... & Winkel, J. (2010). Systematic evaluation of observational methods assessing biomechanical exposures at work. *Scandinavian Journal of Work, Environment & Health*, 3-24.

Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology,* 8(1), 45.

Tiemessen, G., & Van Zweeden, J. P. (1998). Risk assessment of the transport of hazardous materials. In Proceeding from ninth international symposium loss prevention and safety promotion in the process industries (pp. 299-307).

Tixier, J., Dusserre, G., Salvi, O., & Gaston, D. (2002). Review of 62 risk analysis methodologies of industrial plants. *Journal of Loss Prevention in the Process Industries,* 15(4), 291-303.

Toola, A. (1992). Plant level safety analysis. *Journal of Loss Prevention in the Process Industries,* 5(2), 119-124.

Torp, S., & Grøgaard, J. B. (2009). The influence of individual and contextual work factors on workers' compliance with health and safety routines. *Applied Ergonomics,* 40(2), 185-193.

Troutt, M. D., & Elsaid, H. H. (1996). The potential value of Saaty's eigenvector scaling method for short-term forecasting of currency exchange rates. *Siam Review,* 38(4), 650-654.

Tweeddale, H. M., Cameron, R. F., & Sylvester, S. S. (1992). Some experiences in hazard identification and risk shortlisting. *Journal of Loss Prevention in the Process Industries,* 5(5), 279-288.

Village, J., Trask, C., Luong, N., Chow, Y., Johnson, P., Koehoorn, M., & Teschke, K. (2009). Development and evaluation of an observational Back-Exposure Sampling Tool (Back-EST) for work-related back injury risk factors. *Applied Ergonomics,* 40(3), 538-544.

Vink, P., Peeters, M., Gründemann, R. W. M., Smulders, P. G. W., Kompier, M. A. J., & Dul, J. (1995). A participatory ergonomics approach to reduce mental and physical workload. *International Journal of Industrial Ergonomics,* 15(5), 389-396.

Vink, P., Urlings, I. J., & van der Molen, H. F. (1997). A participatory ergonomics approach to redesign work of scaffolders. *Safety Science,* 26(1-2):75–87.

Washington-State-Dept._of_Labor_and_Industries. (2003). Concise Explanatory Statement (RCW 34.05.325.6a) of WAC 296-62-051, Ergonomics. Available from: http://www.lni.wa.gov/Safety/Topics/Ergonomics/History/Documents/ces.asp

Waters, T. R., Putz-Anderson, V., Garg, A., & Fine, L. J. (1993). Revised NIOSH equation for the design and evaluation of manual lifting tasks. *Ergonomics,* 36(7), 749-776.

Wells, R., Norman, R., Frazer, M., & Laing, A. (2001). University of Waterloo ergonomics program implementation blueprint. [Internet]. 2001. Available from: http://www.ergonomics.uwaterloo.ca/bprint.html (accessed March 2014).

Westgaard, R. H. (1999). Effects of physical and mental stressors on muscle pain. *Scandinavian Journal of Work, Environment & Health,* 19-24.

Westlander, G., Viitasara, E., Johansson, A., & Shahnavaz, H. (1995). Evaluation of an ergonomics intervention programme in VDT workplaces. *Applied Ergonomics,* 26(2), 83-92.

Wiktorin, C., Mortimer, M., Ekenvall, L., Kilbom, A., & Hjelm, E. W. (1995). HARBO, a simple computer-aided observation method for recording work postures. *Scandinavian Journal of Work, Environment & Health,* 21(6), 440-449.

Wilson, J. R. (1995). Solution ownership in participative work redesign: The case of a crane control room. *International Journal of Industrial Ergonomics,* 15(5), 329-344.

Wilson, J. R., Haines, H. M., & Morris, W. (1997). Participatory ergonomics. Handbook of human factors and ergonomics, 2, 490-513.

Yang, S., & Chung, P. W. (1998). Hazard analysis and support tool for computer controlled processes. *Journal of Loss Prevention in the Process Industries,* 11(5), 333-345.

Yassi, A. (1998). Utilizing data systems to develop and monitor occupational health programs in a large Canadian hospital. *Methods of Information in Medicine,* 37(2), 125-129.

Yazdani, A., Neumann, P., Imbeau, D., Bigelow, P., Pagell, M., Theberge, N., Hilbrecht, M., & Wells, R. (2015). How compatible are participatory ergonomics programs with occupational health and safety management systems? *Scandinavian Journal of Work, Environment & Health,* 41(2):111–123

Zink, K. J. (1996). Continuous improvement through employee participation. Some experiences from a long-term study in Germany. Human Factors in Organizational Design and Management, Brown Jr., VO and Hendrick, HW (eds), Elsevier Science, 155-160.

## APPENDIX A: Interview protocols (Key Informants Interviews)

**Interview Protocol (Researchers)**

**Theme 1: Management commitment and MSD prevention**

*Based on your experience,*

1. What does management commitment mean to you? How important is management commitment in the implementation of a health and safety management system?

2. What do you believe is/are the best/good practice(s) in achieving management support and commitment for MSD prevention?

3. What needs to be done on a management level to achieve better prevention of workplace injuries such as MSD?

**Theme 2: Prevention of MSDs within management systems**

*Based on your experience,*

1. Are there any differences between prevention of MSD and other OHS risks such as noise, or slips and falls? If yes, please explain.

2. What is your opinion of incorporating MSD prevention into an organization's management system: similar to approaches in place for other OHS risks (slips, trips and falls etc.)?

3. What do you think about integration of MSD prevention into a companywide approach, such as quality?

4. What tools and approaches could be used to integrate MSD prevention into health and safety management systems or other management systems such as quality?

5. Have you ever addressed any of the above mentioned ideas in your research/publications? Please explain.

6. How can we achieve a sustainable approach for MSD prevention in organizations?

**Theme 3: Barriers and challenges for prevention for successful prevention of MSDs and possible solutions**

*Based on your experience,*

1. What do you think are the barriers and challenges for successful prevention of MSD in organizations?

2. How can we overcome these challenges?

3. Have you attempted to put in place any of these solutions? Please explain.

**Theme 4: Worker Participation and Training**

*Based on your experience*

1. Training has been recommended as one of the key elements of any management system. How can the organization implement an effective training program for MSD prevention (ergonomics) related issues in the workplace? What information should it contain?

2. Please give an example of how worker participation improves H&S and MSD prevention effectiveness. Where and when do you think workers should be involved? What can organizations do to encourage effective and sustainable participation of its employees in prevention of MSD?

**Theme 5: Psychological Health and Safety**

*Based on your experience,*

1. Are you aware of the newly developed CSA standard or similar standards for Psychological Health and Safety in the Workplace?

2. Do you see a link between psychological hazards and psychosocial factors for MSD prevention in the workplace? Please explain

**Theme 6: Successful prevention of MSDs and other role players**

*Based on your experience,*

1. What can researchers in the area of work and health do for successful prevention of MSD?

2. What can health and safety managers in general do for prevention of MSD to be successful?

3. What can consultants do for successful prevention of MSD?

4. What can policy makers such as Ministry of Labour, and other organizations such as Health and Safety Associations do for successful prevention of MSD?

**Interview Protocol (Consultants)**

## Theme 1: Management commitment and MSD prevention

*Based on your experience,*

1. What does management commitment mean to you? How important is management commitment in the implementation of a health and safety management system? How about its importance in the implementation of workplace interventions or MSD prevention programs?

2. What do you believe is/are the best/good practice(s) in achieving management support and commitment for MSD prevention?

3. What needs to be done on a management level to achieve better prevention of workplace injuries such as MSD?

## Theme 2: Prevention of MSDs within management systems

*Based on your experience,*

1. Are there any differences between prevention of MSD and other OHS risks such as noise, or slips and falls? If yes, please explain.

2. What is your opinion of incorporating MSD prevention into an organization's management system: similar to approaches in place for other OHS risks (slips, trips and falls etc.)?

3. What do you think about integration of MSD prevention into a companywide approach, such as quality?

4. What tools and approaches could be used to integrate MSD prevention into health and safety management systems or other management systems such as quality?

5. Have you ever designed such an approach or addressed any of the above mentioned ideas in your work? Or have you ever been asked by any of your clients about such an approach? Please explain.

6. How can we achieve a sustainable approach for MSD prevention in organizations?

## Theme 3: Barriers and challenges for prevention for successful prevention of MSDs and possible solutions

*Based on your experience,*

1. What do you think are the barriers and challenges for successful prevention of MSD in organizations?

2. How can we overcome these challenges?

3. Have you attempted to put in place any of these solutions? Please explain.

**Theme 4: Worker Participation and Training**

*Based on your experience*

1. Training has been recommended as one of the key elements of any management system. How can the organization implement an effective training program for MSD prevention (ergonomics) related issues in the workplace? What information should it contain?

2. Please give an example of how worker participation improves H&S and MSD prevention effectiveness. Where and when do you think workers should be involved? What can organizations do to encourage effective and sustainable participation of its employees in prevention of MSD?

**Theme 5: Psychological Health and Safety**

*Based on your experience,*

1. Are you aware of the newly developed CSA standard or similar standards for Psychological Health and Safety in the Workplace?

2. Do you see a link between psychological hazards and psychosocial factors for MSD prevention in the workplace? Please explain

**Theme 6: Successful prevention of MSDs and other role players**

*Based on your experience,*

1. What can researchers in the area of work and health do for successful prevention of MSD?

2. What can health and safety managers in general do for prevention of MSD to be successful?

3. What can consultants do for successful prevention of MSD?

4. What can policy makers such as Ministry of Labour, and other organizations such as Health and Safety Associations do for successful prevention of MSD?

**Interview Protocol (Managers)**

**Theme 1: Management commitment and MSD prevention**

*Based on your experience,*

1. What does management commitment mean to you? How important is management commitment in the implementation of a health and safety management system?

2. What do you believe is/are the best/good practice(s) in achieving management support and commitment for MSD prevention?

3. What needs to be done on a management level to achieve better prevention of workplace injuries such as MSD?

**Theme 2: Prevention of MSDs within management systems**

*Based on your experience,*

1. Are there any differences between prevention of MSD and other OHS risk such as noise, slips and falls? If yes, please explain.

2. What is your opinion of incorporating MSD prevention into an organization's management system: similar to approaches in place for other OHS risks (slips, trips and falls etc.)?

3. What do you think about integration of MSD prevention into a companywide approach, such as quality?

4. What tools and approaches could be used to integrate MSD prevention into health and safety management systems or other management systems such as quality?

5. Have any of the organizations that you have worked for, implemented such an approach to prevent MSD within management systems? Please explain

6. How can we achieve a sustainable approach for MSD prevention in organizations?

**Theme 3: Barriers and challenges for prevention for successful prevention of MSDs and possible solutions**

*Based on your experience,*

1. What do you think are the barriers and challenges for successful prevention of MSD in organizations?

2. How can we overcome these challenges?

3. Have you attempted to put in place any of these solutions? Please explain.

## Theme 4: Worker Participation and Training

*Based on your experience*

1. Training has been recommended as one of the key elements of any management system. How can the organization implement an effective training program for MSD prevention (ergonomics) related issues in the workplace? What information should it contain?

2. Please give an example of how worker participation improves H&S and MSD prevention effectiveness. Where and when do you think workers should be involved? What can organization do to encourage effective and sustainable participation of its employees in prevention of MSD?

## Theme 5: Psychological Health and Safety

*Based on your experience,*

1. Are you aware of the newly developed CSA standard or similar standards for Psychological Health and Safety in the Workplace?

2. Do you see a link between psychological hazards and psychosocial factors for MSD prevention in the workplace? Please explain

## Theme 6: Successful prevention of MSDs and other role players

*Based on your experience,*

1. What can researchers in the area of work and health do for successful prevention of MSD?

2. What can health and safety managers in general do for prevention of MSD to be successful?

3. What can consultants do for successful prevention of MSD?

4. What can policy makers such as Ministry of Labour, and other organizations such as Health and Safety Associations do for successful prevention of MSD?

**Interview Protocol (Union representatives)**

**Theme 1: Management commitment and MSD prevention**

*Based on your experience,*

4. What does (organization's) management commitment mean to you? How important is management commitment in the implementation of a health and safety management system?

5. What do you believe is/are the best/good practice(s) in achieving management support and commitment for MSD prevention?

6. What needs to be done on a management level to achieve better prevention of workplace injuries such as MSDs?

**Theme 2: Prevention of MSDs within management systems**

*Based on your experience,*

7. Are there any differences between prevention of MSD and other OHS risks such as noise, or slips and falls? If yes, please explain.

8. What is your opinion of incorporating MSD prevention into an organization's management system: similar to approaches in place for other OHS risks (slips, trips and falls etc.)?

9. What do you think about integration of MSD prevention into a companywide approach, such as quality?

10. How can we achieve a sustainable approach for MSD prevention in organizations?

**Theme 3: Barriers and challenges for prevention for successful prevention of MSDs and possible solutions**

*Based on your experience,*

4. What do you think are the barriers and challenges for successful prevention of MSDs in organizations?

5. How can we overcome these challenges?

## Theme 4: Worker Participation and Training

*Based on your experience*

3. Training has been recommended as one of the key elements of any management system. How can the organization implement an effective training program for MSD prevention (ergonomics) related issues in the workplace? What information should it contain?

4. How workers participation improves H&S and MSD prevention effectiveness. Where and when do you think workers should be involved? What can organizations do to encourage effective and sustainable participation of its employees in prevention of MSDs?

## Theme 5: Psychological Health and Safety and CSA standards

*Based on your experience,*

3. Are you aware of the newly developed CSA or ISO standard or similar standards for Psychological Health and Safety in the Workplace?

4. Do you see a link between psychological hazards and psychosocial factors for MSD prevention in the workplace? Please explain

5. Do policy makers such as MOL use CSA standards (i.e., CSA Z1000 and Z1004)? For what purposes?

## Theme 6: Successful prevention of MSDs and other role players

*Based on your experience,*

5. What can researchers in the area of work and health do for successful prevention of MSDs?

6. What can health and safety managers in general do for prevention of MSDs to be successful?

7. What can consultants do for successful prevention of MSDs?

8. What can policy makers such as Ministry of Labour, and other organizations such as Health and Safety Associations do for successful prevention of MSDs?

**Interview Protocol (Policy makers)**

**Theme 1: Management commitment and MSD prevention**

*Based on your experience,*

7. What does (organization's) management commitment mean to you? How important is management commitment in the implementation of a health and safety management system?

8. What do you believe is/are the best/good practice(s) in achieving management support and commitment for MSD prevention?

9. What needs to be done on a management level to achieve better prevention of workplace injuries such as MSDs?

**Theme 2: Prevention of MSDs within management systems**

*Based on your experience,*

11. Are there any differences between prevention of MSD and other OHS risks such as noise, or slips and falls? If yes, please explain.

12. What is your opinion of incorporating MSD prevention into an organization's management system: similar to approaches in place for other OHS risks (slips, trips and falls etc.)?

13. What do you think about integration of MSD prevention into a companywide approach, such as quality?

14. How can we achieve a sustainable approach for MSD prevention in organizations?

**Theme 3: Barriers and challenges for prevention for successful prevention of MSDs and possible solutions**

*Based on your experience,*

6. What do you think are the barriers and challenges for successful prevention of MSDs in organizations?

7. How can we overcome these challenges?

## Theme 4: Worker Participation and Training

*Based on your experience*

5. Training has been recommended as one of the key elements of any management system. How can the organization implement an effective training program for MSD prevention (ergonomics) related issues in the workplace? What information should it contain?

6. How workers participation improves H&S and MSD prevention effectiveness. Where and when do you think workers should be involved? What can organizations do to encourage effective and sustainable participation of its employees in prevention of MSDs?

## Theme 5: Psychological Health and Safety and CSA standards

*Based on your experience,*

6. Are you aware of the newly developed CSA or ISO standard or similar standards for Psychological Health and Safety in the Workplace?

7. Do you see a link between psychological hazards and psychosocial factors for MSD prevention in the workplace? Please explain

8. Do policy makers such as MOL use CSA standards (i.e., CSA Z1000 and Z1004)? For what purposes?

## Theme 6: Successful prevention of MSDs and other role players

*Based on your experience,*

9. What can researchers in the area of work and health do for successful prevention of MSDs?

10. What can health and safety managers in general do for prevention of MSDs to be successful?

11. What can consultants do for successful prevention of MSDs?

12. What can policy makers such as Ministry of Labour, and other organizations such as Health and Safety Associations do for successful prevention of MSDs?

## APPENDIX B: Interview protocols (Case Studies)

**Interview Protocol (H&S manager/ JHSC co-chairs)**

| | | | |
|---|---|---|---|
| Company code | | Date | |
| Interviewee code | | Time | |
| Interviewer | Amin Yazdani | Estimated length | 45 minutes |

**Theme 1: Roles and responsibilities**

1. Please describe your main role in the organization

2. Please describe your role in the organization with respect to OHSMS and MSD prevention.

3. How your roles in OHSMS link to your role in an ergo program?

**Theme 2: Organization's health and safety management system, issues and incentives**

1. What are the top four health and safety problems in your organization?

2. Does the organization's current approach (OHSMS) to manage health and safety issues help to solve these problems effectively? Please describe how.

3. Does your organization have systematic OHSMS based on CSA Z1000 or OHSAS 18001?

    a. If not, any plan for future?
    b. If yes, what is the main objective or target or prevention policy/strategy of organization on OHSMS that has been recently determined?

4. Is your OHSMS stand-alone system or is integrated into other management system?

5. What do you think is/are the challenges for your organization to integrate OHSMS into other management systems?

6. What do you think are the benefits of these type of management systems for your organization in general and health and safety of employees in particular?

7. What are the top three incentives for health and safety performance in your organization?

**Theme 3A: Health and Safety risk assessment**

1. What is/are the risk assessment technique(s) your organization uses to identify, assess, and evaluate health and safety risk factors?

2. How does the HR department participate in assessment of health and safety risk factors? What is your role in this process?

3. Do you find the current approach useful and effective to assess, evaluate and control different types of health and safety hazards? Please explain.

4. What areas do you think are not captured? How do you think this approach can be improved?

**Theme 3B: MSD prevention strategies, approaches and techniques**

1. What is/are the risk assessment technique(s) your organization uses to identify, assess, and evaluate ergonomics (MSD) risk factors?

2. How does the HR department participate in assessment of health and safety risk factors?

3. What is your role in this process?

4. Do you find the current approach useful and effective to assess, evaluate and control different types of MSD hazards? Please explain.

5. What areas do you think are not captured? How do you think this approach can be improved?

**Theme 4: Workers participation**

1. What is your take on workers participation in management of H&S including risk assessment and determining control actions?

2. How do you ensure the involvement and participation of workers in your department in organization's OHSMS?

3. Where and when do you think workers should be involved?

4. What can organizations do to ensure effective and sustainable participation of its employees in prevention of workplace injuries such as MSD?

**Theme 5: MSD prevention challenges, barriers, and integration**

1. What do you think are the barriers and challenges for prevention of MSD in this organization? How can organization overcome these challenges?

2. What would you do better to control MSD hazards in your workplace?

3. Do you believe integrating MSD prevention in other aspects of company management system, such as quality, would lead to successful prevention of these injuries?

**Theme 6: Management commitment and support**

1. What does management commitment mean to you? How important is management commitment in the implementation of health and safety management system or changes to improve health and safety in your workplace?

2. How do you find management commitment with respect to providing support for health and safety in general and MSD prevention in particular?

**Interview Protocol (HR manager)**

| | | | |
|---|---|---|---|
| Company code | | Date | |
| Interviewee code | | Time | |
| Interviewer | Amin Yazdani | Estimated length | 45 minutes |

**Theme 1: Roles and responsibilities**

1. Please describe your main role in the organization

2. Please describe your role in the organization with respect to OHSMS and MSD prevention.

**Theme 2: Organization's health and safety management system, issues and incentives**

1. What are the top four health and safety problems in your organization?

2. Does the organization's current approach (OHSMS) to manage health and safety issues help to solve these problems effectively? Please describe how.

3. Does your organization have systematic OHSMS based on CSA Z1000 or OHSAS 18001?

    a. If not, any plan for future?
    b. If yes, what is the main objective or target or prevention policy/strategy of organization on OHSMS that has been recently determined?

4. Is your OHSMS stand-alone system or is integrated into other management system?

5. What do you think is/are the challenges for your organization to integrate OHSMS into other management systems?

6. What do you think are the benefits of these type of management systems for your organization in general and health and safety of employees in particular?

7. What are the top three incentives for health and safety performance in your organization?

**Theme 3A: Health and Safety risk assessment**

1. How does the JHSC participate in assessment of health and safety risk factors? What is your role in this process?

2. Do you find the current approach useful and effective to assess, evaluate and control different types of health and safety hazards? Please explain.

3. What areas do you think are not captured? How do you think this approach can be improved?

**Theme 3B: MSD prevention strategies, approaches and techniques**

1. How does HR department participate in assessment of health and safety risk factors? How different is this from its role with MSD risk factors?

2. What is your role in this process?

3. Do you find the current approach useful and effective to assess, evaluate and control different types of MSD hazards? Please explain.

4. What areas do you think are not captured? How do you think this approach can be improved?

**Theme 4: Workers participation**

1. What is your take on workers participation in management of H&S including risk assessment and determining control actions?

2. How do you ensure the involvement and participation of workers in your department in organization's OHSMS?

3. Where and when do you think workers should be involved?

4. What can organizations do to ensure effective and sustainable participation of its employees in prevention of workplace injuries such as MSDs?

**Theme 5: MSD prevention challenges, barriers, and integration**

1. What do you think are the barriers and challenges for prevention of MSD in this organization? How can organization overcome these challenges?

2. What would you do better to control MSD hazards in your workplace?

3. Do you believe integrating MSD prevention in other aspects of company management system, such as quality, would lead to successful prevention of these injuries?

**Theme 6: Management commitment and support**

1. What does management commitment mean to you? How important is management commitment in the implementation of health and safety management system or changes to improve health and safety in your workplace?

2. How do you find management commitment with respect to providing support for health and safety in general and MSD prevention in particular?

**Interview Protocol (Maintenance manager)**

| | | | |
|---|---|---|---|
| Company code | | Date | |
| Interviewee code | | Time | |
| Interviewer | Amin Yazdani | Estimated length | 45 minutes |

**Theme 1: Roles and responsibilities**

1. Please describe your main role in the organization

2. Please describe your role in the organization with respect to OHSMS and MSD prevention.

**Theme 2: Organization's health and safety issues**

1. What are the top four health and safety problems in your organization?

2. Does the organization's current approach (OHSMS) to manage health and safety issues help to solve these problems effectively? Please describe how.

**Theme 3: MSD prevention strategies, approaches and techniques**

1. Are you aware of any risk assessment technique(s) in your organization uses to identify, assess, and evaluate health, safety, and MSD risk factors?

2. Are you involved in in hazard identification, risk assessment and specially determining control actions of H&S hazards? What is your role in this process? (If any)

3. What is the role of maintenance department in eliminating of H&S and MSD hazards?

4. How is the involvement of maintenance department in implementation of control actions suggested by JHSC or other stakeholders?

5. Do you find the current approach useful and effective to assess, evaluate and control different types of health and safety hazards including MSDs? Please explain.

    a. If yes, what areas do you think are not captured? How do you think this approach can be improved?

**Theme 4: Workers participation**

1. What is your take on workers participation in management of H&S including risk assessment and determining control actions?

2. How do you ensure the involvement and participation of workers in your department in organization's OHSMS?

3. Where and when do you think workers should be involved?

4. What can organizations do to ensure effective and sustainable participation of its employees in prevention of workplace injuries such as MSDs?

**Theme 5: MSD prevention challenges, barriers, and integration**

1. What do you think are the barriers and challenges for prevention of MSD in this organization? How can organization overcome these challenges?

2. What would you do better to control MSD hazards in your workplace?

3. Do you believe integrating MSD prevention in other aspects of company management system, such as quality, would lead to successful prevention of these injuries?

**Theme 6: Management commitment and support**

1. What does management commitment mean to you? How important is management commitment in the implementation of health and safety management system or changes to improve health and safety in your workplace?

2. How do you find management commitment with respect to providing support for health and safety in general and MSD prevention in particular?

**Interview Protocol (Engineering manager)**

| | | | |
|---|---|---|---|
| Company code | | Date | |
| Interviewee code | | Time | |
| Interviewer | Amin Yazdani | Estimated length | 45 minutes |

**Theme 1: Roles and responsibilities**

1. Please describe your main role in the organization

2. Please describe your role in the organization with respect to health and safety and MSD prevention.

3. What is (are) the role of engineers (those work under your supervision) with respect to health and safety and MSD prevention?

4. How would an ergo program helps you to meet your goals?

**Theme 2: Organization's health and safety issues and related procedures**

1. What are the top four health and safety problems in your organization?

2. What is (are) the organization's procedure (s) and policy (ies) in eliminating the health and safety risk factors during the designing and redesigning process?

    2.1. How about Musculoskeletal disorder hazards? What is (are) the organization's procedure(s) in eliminating the MSD hazards during the designing and redesigning process?

**Theme 3: MSD prevention strategies, approaches and techniques**

1. Are you aware of any risk assessment technique(s) your organization uses to identify, assess, and evaluate health, safety, and MSD risk factors?

    1.1 Please describe your involvement in assessment of these risk factors? What is your role in this process? (If any)
2. What is the organization's procedure on eliminating MSD hazards during the design and redesigning process?

3. Do you find the current approach useful and effective to assess, evaluate and control different types of health and safety hazards including MSDs? Please explain.
    3.1 If yes, what areas do you think are not captured? How do you think this approach can be improved?

**Theme 4: Workers participation**

1. What is your take on workers participation in design and redesign of their workstation?

2. How do you ensure the involvement and participation of engineers (that work under your supervision) in the organization's health and safety management system?

3. Where and when do you think workers should be involved?

4. What can organizations do to ensure effective and sustainable participation of its employees in prevention of workplace injuries such as MSDs?

**Theme 5: MSD prevention challenges, barriers, and integration**

1. What do you think are the barriers and challenges for prevention of MSD in this organization? How can we overcome these challenges?

2. What would you do better to control MSD hazards in your workplace?

3. Do you believe integrating MSD prevention in other aspects of company management system, such as quality, would lead to successful prevention of these injuries?

4. Have you attempted to integrate MSD prevention into approaches such as Lean, 6Sigma, or Lean? Please explain.

**Theme 6: Management commitment and support**

1. What does management commitment mean to you? How important is management commitment in the implementation of health and safety management system or changes to improve health and safety in your workplace?

2. How do you find management commitment with respect to providing support for health and safety in general and MSD prevention in particular?

## Interview Protocol (Production manager)

| | | | |
|---|---|---|---|
| Company code | | Date | |
| Interviewee code | | Time | |
| Interviewer | Amin Yazdani | Estimated length | 45 minutes |

### Theme 1: Roles and responsibilities

1. Please describe your main role in the organization

2. Please describe your role in the organization with respect to health and safety and MSD prevention.

### Theme 2: Organization's health and safety issues and incentives

1. What are the top four health and safety problems in your organization?

2. Does your organization has a formal health and safety management system like what is in place for quality? Please describe.

3. Does the organization's current approach (OHSMS) to manage health and safety issues help to solve these problems effectively? Please describe how.

4. What are the top three incentives for H&S performance in your organization?

### Theme 3: MSD prevention strategies, approaches and techniques

1. Are you aware of any risk assessment technique(s) your organization uses to identify, assess, and evaluate health, safety, and MSD risk factors?

    a. Please describe your involvement in assessment of these risk factors? What is your role in this process? (If any)

2. Do you find the current approach useful and effective to assess, evaluate and control different types of health and safety hazards including MSDs? Please explain.

    b. If yes, what areas do you think are not captured? How do you think this approach can be improved?

### Theme 4: Workers participation

1. What is your take on workers participation in management of H&S including risk assessment and determining control actions?

2. How do you ensure the involvement and participation of workers in the organization's health and safety management system?

3. Where and when do you think workers should be involved?

4. What can organizations do to ensure effective and sustainable participation of its employees in prevention of workplace injuries such as MSDs?

**Theme 5: MSD prevention challenges, barriers, and integration**

1. What do you think are the barriers and challenges for prevention of MSD in this organization? How can organization overcome these challenges?

2. What would you do better to control MSD hazards in your workplace?

3. Do you believe integrating MSD prevention in other aspects of company management system, such as quality, would lead to successful prevention of these injuries?

**Theme 6: Management commitment and support**

1. What does management commitment mean to you? How important is management commitment in the implementation of health and safety management system or changes to improve health and safety in your workplace?

2. How do you find management commitment with respect to providing support for health and safety in general and MSD prevention in particular?

**Interview Protocol (Production worker/supervisor)**

| | | | |
|---|---|---|---|
| Company code | | Date | |
| Interviewee code | | Time | |
| Interviewer | Amin Yazdani | Estimated length | 45 minutes |

**Theme 1: Roles and responsibilities**

1. Please describe your main role in the organization

2. Please describe your role in the organization with respect to health and safety and MSD prevention.

**Theme 2: Organization's health and safety issues and related procedures**

1. What are the top four health and safety problems in your organization?

2. Does the organization address these problems effectively? Please explain

**Theme 3: MSD prevention strategies, approaches and techniques**

1. If there is H&S hazard or issue in your workstation, what would you do first? Who do you report to first?

    a. Do you provide recommendation to eliminate the hazard or issue? How do you do that? If the problem has not been addressed in a logic time frame what would you do then?
    b. Are you involved in implementing these solutions?

2. Do you find this approach useful and effective to address and eliminate different types of health and safety hazards including MSDs? Please explain.

    a. How do you think this approach can be improved?

**Theme 4: Workers participation**

1. How you and your co-workers workers are involved in H&S? Please describe.

2. Does your supervisor provide you with required time to be involved in addressing H&S issues?

3. Where and when do you think workers should be involved in OHSMS?

4. What can organizations do to ensure effective and sustainable participation of its workers in prevention of workplace injuries such as MSDs?

**Theme 6: Management commitment and support**

1. How do you see the overall supervisor and management support and commitment towards health and safety? What can they do better?

## Interview Protocol (Quality manager)

| | | | |
|---|---|---|---|
| Company code | | Date | |
| Interviewee code | | Time | |
| Interviewer | Amin Yazdani | Estimated length | 45 minutes |

### Theme 1: Roles and responsibilities

1. Please describe your main role in the organization

2. Please describe your role in the organization with respect to health and safety and MSD prevention.

3. What is (are) the role of engineers (those work under your supervision) with respect to health and safety and MSD prevention?

4. Is there any links between H&S and MSD prevention with quality? Please explain

5. How would an ergo program helps you to meet your goals? How this help organization to achieve its quality goals?

### Theme 2: Organization's health and safety issues and related procedures

1. What are the top four health and safety problems in your organization?

2. Does the organization have a formal quality management system? Does the organization have a similar approach for H&S? Please elaborate. If not, why?

3. Does current approach to manage quality issues help to solve quality problems effectively and proactively? How about MSD problems?

### Theme 3: MSD prevention strategies, approaches and techniques

1. Are you aware of any risk assessment technique(s) your organization uses to identify, assess, and evaluate health, safety, and MSD risk factors?

    1.1 Please describe your involvement in assessment of these risk factors? What is your role in this process? (If any)

2. Do you find the current approach useful and effective to assess, evaluate and control different types of health and safety hazards including MSDs? Please explain.

    2.1 If yes, what areas do you think are not captured? How do you think this approach can be improved?

## Theme 4: Workers participation

1. How workers are involved in QMS? Please describe

2. What is your take on workers participation in addressing H&S issues and determining control actions?

3. Do you recommend the same approach that you have in place for Quality to be implemented for H&S as well?

4. How do you ensure the involvement and participation of engineers (that work under your supervision) in the organization's OHSMS?

5. Where and when do you think workers should be involved?

6. What can organizations do to ensure effective and sustainable participation of its employees in prevention of workplace injuries such as MSDs?

## Theme 5: MSD prevention challenges, barriers, and integration

1. What do you think are the barriers and challenges for prevention of MSD in this organization? How can we overcome these challenges?

2. What would you do better to control MSD hazards in this organization?

3. Do you believe incorporating MSD prevention in other aspects of company management system, such as quality, would lead to successful prevention of these injuries?

## Theme 6: Management commitment and support

1. What does management commitment mean to you? How important is management commitment in the implementation of health and safety management system or changes to improve health and safety in your workplace?

2. How do you find management commitment with respect to providing support for health and safety in general and MSD prevention in particular?

**Interview Protocol (Design engineer)**

| | | | |
|---|---|---|---|
| Company code | | Date | |
| Interviewee code | | Time | |
| Interviewer | Amin Yazdani | Estimated length | 45 minutes |

**Theme 1: Roles and responsibilities**

1. Please describe your main role in the organization

2. Please describe your role in the organization with respect to health and safety and MSD prevention.

3. How would an ergo program helps you to meet your goals?

**Theme 2: Organization's health and safety issues and related procedures**

1. What are the top four health and safety problems in your organization?

2. What is (are) the organization's procedure (s) and policy (ies) in eliminating the health and safety risk factors during the designing and redesigning process?

    2.1. How about Musculoskeletal disorder hazards? What is (are) the organization's procedure(s) in eliminating the MSD hazards during the designing and redesigning process?

**Theme 3: MSD prevention strategies, approaches and techniques**

1. Are you aware of any risk assessment technique(s) your organization uses to identify, assess, and evaluate health, safety, and MSD risk factors?

    1.1 Please describe your involvement in assessment of these risk factors? What is your role in this process? (If any)

2. What is the organization's procedure on eliminating MSD hazards during the design and redesigning process?

3. Do you find the current approach useful and effective to assess, evaluate and control different types of health and safety hazards including MSDs? Please explain.

    3.1 If yes, what areas do you think are not captured? How do you think this approach can be improved?

**Theme 4: Workers participation**

1. What is your take on workers participation in design and redesign of their workstation?

2. How do you ensure the involvement and participation of workers (that work under your supervision) in during design and redesign process?

3. Where and when do you think workers should be involved?

4. What can organizations do to ensure effective and sustainable participation of its employees in prevention of workplace injuries such as MSDs?

**Theme 5: MSD prevention challenges, barriers, and integration**

1. What do you think are the barriers and challenges for prevention of MSD in this organization? How can we overcome these challenges?
2. What would you do better to control MSD hazards in your workplace?

3. Do you believe integrating MSD prevention in other aspects of company management system, such as quality, would lead to successful prevention of these injuries?

4. Have you attempted to integrate MSD prevention into approaches such as Lean, 6 Sigma, or Lean? Please explain

**Theme 6: Management commitment and support**

1. What does management commitment mean to you? How important is management commitment in the implementation of health and safety management system or changes to improve health and safety in your workplace?

2. How do you find management commitment with respect to providing support for health and safety in general and MSD prevention in particular?