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The Perceived Importance and Degree of Implementation of Ergonomics-Related Leading Safety Performance Indicators in the American Workplace

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THE PERCEIVED IMPORTANCE AND DEGREE OF IMPLEMENTATION OF ERGONOMICS-RELATED LEADING SAFETY PERFORMANCE INDICATORS IN THE AMERICAN WORKPLACE

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Title: The Perceived Importance and Degree of Implementation of Ergonomics-Related Leading Safety Performance Indicators in the American Workplace

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In the United States, ergonomic losses achieve recognition as the leading non-fatal occupational injury category (OSHA, 2000) and account for 33 percent of all worker injury and illness cases (OSHA, 2016).

The purpose of this study was to evaluate the degree to which leading ergonomic safety performance indicators (SPIs) are valued and utilized, identify the perceived difficulties in implementing leading ergonomic SPIs, and examine the role education and job classification have on the use and importance placed on leading ergonomic SPIs. This study examined ten leading ergonomic SPIs using survey responses from OSH professionals.

The researcher posited that measuring the degree of Ergonomic Management Control Program (EMCP) implementation, via tracking leading ergonomic SPIs, would enable OSH professionals to evaluate the effectiveness of their ergonomic efforts in an ongoing manner, forecast pending shortcomings, and afford OSH intervention to reduce risk and prevent future occupational loss events.

The following major findings were identified:

1. The use of leading ergonomic SPIs in the workplace is not a widely accepted practice. Approximately two-thirds of the companies participating in this study do not use leading ergonomic SPIs.
2. For those OSH coordinators who do use leading ergonomic SPIs, they generally perceived them as being valuable.
3. This study did not find significant differences in perceived levels of importance based on job classification or education. This was mostly due to the characteristics of the study sample.
4. Lack of management commitment and an absence of knowledge are commonly perceived barriers to implementing leading ergonomic SPIs. The cost of implementation was the least frequently perceived barrier.
5. Leading ergonomic SPIs most favored by the OSH Coordinators who use them included the measurement of workers' early reporting of ergonomic strains and sprains, tracking the number of job hazard analyses conducted to avoid ergonomic hazards, and tracking the use of pre-hazard controls to avoid ergonomic hazards.

Keywords: Ergonomics, Safety Performance Indicators, ISO 45001 OHSMS, Leading Indicators, Lagging Indicators, Safety and Health Management Systems, Occupational Safety and Health, and Risk.

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Lastly, the researcher wishes to acknowledge ASSE's generosity in their participation in this research by administering the survey instrument to their association of OSH professionals.

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CHAPTER ONE

THE PROBLEM

Introduction

Occupational loss events continue to cripple the productivity and livelihood of employers on a global scale. According to 2015 data from the U.S. Bureau of Labor Statistics (BLS, 2016), 4,836 American workers were killed while performing their work duties, equating to thirteen worker deaths every day, and another estimated 50,000 died during the same timeframe from occupational diseases. The annual financial cost of occupational injuries and illnesses is valued at a staggering $250 billion (OSHA, 2013a). Globally, over 6,300 people die each day from occupational-related loss incidents or diseases – nearly 2.3 million deaths each year, or one international occupational fatality every second (ILO, 2016 and ISO, 2015a). Moreover, this figure does not include the approximately 300 million non-fatal workplace loss incidents recorded worldwide each year (ILO, 2016). In the United States alone, over four million workers suffer a serious illness or injury every year, resulting in over 26 million lost working days (BSI, 2016). Ergonomic losses achieve recognition as the leading non-fatal occupational injury category, accumulating a projected loss total of $15-45 billion annually (OSHA, 2000). In 2013, the U.S. Bureau of Labor Statistics (BLS) reported MSD cases accounted for 33 percent of all worker injury and illness cases in the United States (OSHA, 2016).

This research pursues a reduction in ergonomic loss events due to the increased use of leading ergonomic safety performance indicators (SPIs) to measure Ergonomic Management Control Program (EMCP) effectiveness. A SPI is a lagging or leading indicator to measure performance and evaluate whether a certain OSH or safety and health management system (SHMS) goal has been achieved. The researcher will further explain how leading SPIs are

effective in achieving required evaluations of EMCPs and SHMS. In conjunction, current OSH research and literature demonstrate reduced risk and lower injury and illness rates to workers via the implementation of operative SHMSs (Bird, Germain, and Clark, 2003; Manuele, 2014a; Shultz, 2012; and UL, 2015). The World Health Organization (WHO) defines OSH as dealing with all aspects of safety and health in the workplace with a strong focus on the primary prevention of hazards (WHO, 2016). Unfortunately, the WHO further reports that only five to 10 percent of global workers in developing countries, and 20 to 50 percent of those in industrialized nations, have access to adequate OSH services (WHO, 2016).

The success of utilizing leading indicators in evaluating the effectiveness of OSH efforts has been established (Blair and O'Toole, 2010; Janicak, 2015; Manuele, 2009 and 2013; Schultz, 2012; Telogis, 2015; and UL, 2013). Today, five out of the five top-favored SHMS models promote the use of leading indicators to evaluate and predict OSH performance (ANSI, 2012; BSI, 2007; ILO, 2001; ISO, 2014; and OSHA, 2016). Lastly, judicious application of leading OSH indicators results in effective SHMSs, reduced risk, and less occupational loss events (Manuele, 2014a; Peterson, 2005; and UL, 2013).

The researcher posits that measuring the degree of EMCP (and ultimately SHMS) implementation via tracking leading indicators, traditionally known as key performance indicators (KPIs), would enable OSH professionals to evaluate the effectiveness of their OSH efforts in an ongoing manner and forecast pending shortcomings requiring OSH intervention, thereby further reducing risk and preventing future occupational injuries, illnesses, and fatalities. For the purposes of this original research on ergonomics, the study incorporated ten leading ergonomic indicators for consideration by survey respondents.

This study utilizes the OSH term *Safety Performance Indicator* or SPI. The researcher proposes the amplified acceptance of the terminology SPIs would better equip the OSH professional to adapt to the pending release of the International Organization for Standardization (ISO) 45001-2018 Occupational Health & Safety Management System (OHSMS) standard. The growing global importance of the OSH profession and the imminent impact of ISO 45001 merit the widespread reception of this terminology and an increased value of leading SPIs.

Since the tracking of leading SPIs is an expected component of certification-compliant SHMSs, the researcher suggests, via this research, the use of leading ergonomic SPIs would not only reduce risk and occupational ergonomic losses but may likely increase the utilization and certification of effective SHMSs throughout the globe and reduce occupational risk overall.

OSH professionals require fluid education on this topic if they will be empowered to take advantage of leading SPIs, SHMSs, and their associated benefits to the global worker. In the absence of increased implementation of SPIs and SHMSs, efforts for improved workplace safety in the global supply chain may continue to stall. OSH professionals are poised to take full advantage of SPIs and SHMSs through their clear understanding of the benefits and the opportunities for their implementation. The researcher posits the potential of SHMSs through the demonstration of its benefits via the systematic utilization and tracking of leading SPIs to validate their effectiveness. While the degree of ergonomic SPI implementation is the focus of this study, the researcher intends the results will support the global use of leading SPIs and the adoption of effective SHMSs. Guy Ryder, Director-General for the International Labour Organization, summed well the need for international cooperation in OSH (ILO, 2013, p. 1), "Occupational safety and health is an area where good practices in different contexts could be shared and one that could also be given higher priority in international cooperation."

The literature review performed for this study found ergonomic MSDs to be a significant loss event in the United States workplace, confirmed SHMSs requirements for the application of SPIs and presented widespread prior research predictive of SPI success in the general OSH arena. Hence, this study focuses on ergonomic losses, SHMSs, and SPIs.

The research was conducted using an online survey questionnaire emailed to OSH professionals, who are members of the American Society of Safety Engineers (ASSE), representing the industries of construction, manufacturing, healthcare, or services. The author intends the research findings to align with those conclusions drawn from the literature review, supporting the following observations.

1. Surveyed OSH Coordinators will have a favorable perception of leading ergonomic SPIs.
2. Surveyed OSH Coordinators will acknowledge a lack of education and/or on-the-job experience in leading ergonomic SPIs, or a lack of management support, as perceived difficulties in implementing these SPIs.
3. Full-time OSH Coordinators will more likely favor the use of leading ergonomic SPIs.
4. OSH Coordinators possessing an OSH (or similar) college degree will more likely favor the use of leading ergonomic SPIs.
5. Full-time OSH Coordinators will more likely utilize leading ergonomic SPIs.

The remaining chapter is divided into nine sections: Statement of the Problem, Questions to be Researched, Research Hypotheses, The Significance of the Problem, The Contribution This Study Will Make to the Profession, Assumptions, Delimitations, Limitations, and Definition of Terms.

Statement of the Problem

The significant loss of life, serious injuries and illnesses, and the dollars lost in the global workplace due to broken OSH management systems, unsafe practices, and unsafe conditions, along with the proven benefits ascribed to SHMSs in preventing said losses, make this a topic worthy of discussion, research, and consideration.

Literature supports the use of SPIs to result in the measure of SHMS effectiveness (Manuele, 2013 and UL, 2013). With the pending global implementation of ISO 45001, and the identification of occupational ergonomic losses as a national loss trend leader in the United States, this research is dedicated to promoting the tracking of leading SPIs to effectively evaluate and improve SHMS performance and result in reduced risk and reduced loss events across the workplace spectrum – focusing today on the SHMS subset of ergonomics.

Over the following pages of literature review, the degree of ergonomic loss potential is exposed, and clarification of the related strengths and weaknesses of SHMSs is presented. The researcher will also present the benefits of SPIs in demonstrating the degree of EMCP/SHMS implementation being accomplished and the lost potential to be sadly recognized if effective SHMSs are not integrated into the international community.

According to Anthony Wilkinson, Chief Executive of the Federation of Management Systems (FMS), "On a global scale, poor health and safety management cost four percent of the global gross domestic product, which is unacceptable" (FMS, 2014, p. 1). Clearly, there is significant room for improvement as it pertains to OSH performance in both the United States and the global OSH arena.

Questions to be Researched

The author has studied the following research questions.

RQ^1: Is there a significant difference in how respondents score leading ergonomic SPIs based upon whether they are utilizing them or not?

RQ^2: Will differences in OSH Coordinator job classifications influence respondent's individual importance scoring of leading ergonomic SPIs?

RQ^3: Will differences in OSH Coordinator education levels influence respondent's individual importance scoring of leading ergonomic SPIs?

RQ^4: What are the perceived difficulties in implementing leading ergonomic SPIs?

RQ^5: Is there a significant difference in the overall average SPI importance scoring across OSH Coordinator job classifications?

Research Hypotheses

The researcher presents the following research hypotheses.

RH^1: There will be a significant difference in how survey respondents score leading ergonomic SPIs based upon whether they are utilizing them – with those SPIs being scored high being utilized most often.

RH^2: Differences in OSH Coordinator job classifications will influence the perceived importance of leading ergonomic SPIs – with full-time OSH Coordinators scoring the value of these SPIs higher.

RH^3: Differences in OSH Coordinator education levels will influence the perceived importance of leading ergonomic SPIs – with OSH Coordinators having a college degree in safety and health or a related scientific field of study scoring the value of these SPIs higher.

RH^4: A majority of respondents will identify a lack of solid education on the topic of leading ergonomic SPIs (i.e., New Concept) and/or the lack of management support of SPIs as the perceived difficulties in implementing same.

RH^5: There will be a significant difference in the overall averaged leading ergonomic SPI scoring by OSH Coordinator job classification – with full-time OSH Coordinators presenting a consistently higher average scoring of SPIs than the other three job classifications.

The Significance of the Problem

The researcher posits the absence of integrating customized leading ergonomic SPIs into an employer's EMCP may result in increased risk and resulting worker injuries or illnesses. The following pages of chapter two will establish the link between the efficiency of SPIs in measuring EMCPs and OSH performance, the ability of EMCPs and SHMS to reduce risk, the obligation of SHMSs to monitor the effectiveness of same via SPIs, and the proposition that greater implementation of EMCPs and SHMSs worldwide would result in less occupational loss events.

Due to the significance of ergonomic loss potentials in the occupational setting, which may occur due to a failure to implement effective ergonomic risk treatments characteristically provided in an EMCP, the researcher purports it prudent to investigate how to improve the utilization of leading ergonomic SPIs to reduce said ergonomic loss events. Therefore, the purpose of this research study is to evaluate the following.

1. Whether the onsite OSH Coordinator was influenced to utilize leading ergonomic SPIs based upon:
    a. His/her job classification;

b. His/her educational level; and

c. His/her personal scoring of the ten proposed leading ergonomic SPIs.

2. Whether the lack of SPI education and/or experience by the OSH Coordinator, or the lack of management support, were perceived as principal barriers in implementing leading ergonomic SPIs.
3. Whether the overall averaged SPI scores by OSH Coordinator job classification significantly differs between the four job classifications.

The Contribution This Study Will Make to the Literature and the Profession

The researcher opines the results from this study on the use of leading ergonomic SPIs give rise to the following.

1. An increase in the use of leading ergonomic SPIs to measure EMCP effectiveness.
2. An increase in the use of SPIs to measure SHMS performance.
3. The identification of perceived difficulties in implementing leading ergonomic SPIs – allowing OSH professionals to prepare for and overcome same.

Assumptions

The author assumes the following.

1. The subjects completing the research survey instrument did so in an accurate and truthful manner.
2. The subjects targeted to fill out the research survey instrument were indeed the individuals completing the survey.
3. The subjects completing the research survey instrument are representative of ASSE membership.
4. The email addresses obtained from and used by ASSE are accurate and functional.

Delimitations

This study is delimited to the following.

1. OSH Coordinators targeted for the survey were active United States members of ASSE, a national association of OSH professionals.
2. The researcher did not pursue OSH Coordinators working outside the United States for a global view as a suitable method of global sampling was not deemed feasible due to language limitations.
3. The researcher selected the leading ergonomic SPIs used in the study based on the United States Occupational Safety and Health Administration's (OSHA) recommended seven-point ergonomic management process.
4. The researcher elected to utilize the respondent's three-year experience when reporting on their use of leading ergonomic SPIs at their worksite.

Limitations

This study is limited to the following.

1. The nature of the online study was considered a voluntary sample.
2. There could be other factors influencing the respondents' SPI importance scoring that were not examined in this study.

Definition of Terms

The following definitions address terms related to this research project.

1. Cumulative trauma disorder (CTD) - is the term used by OSHA for health disorders resulting from repeated biomechanical stress due to ergonomic hazards. Other terms that have been used for such disorders include musculoskeletal disorder (MSD), musculoskeletal injuries (MSI), repetitive motion injury (RMI), repetitive strain injury (RSI), repetitive stress injury, and occupational overuse syndrome (CDC, 2016). For the purpose of this research, the researcher has selected the term MSD. Refer to MSD.
2. Current indicator - means a direct snapshot measurement of OSH performance to provide management with current feedback on OSH trends necessitating correction to avoid losses. A current indicator may be lagging or leading.
3. DART rate - means Days Away, Restrictions and Transfers. This rate is factored on trending over 200,000 employee work hours, but it is not based on total injuries. Rather, it is calculated using only those injuries and illnesses severe enough to warrant the classification of Days Away, Restrictions and Transfers on the OSHA 300 recordkeeping log.
4. Ergonomics - "Ergonomics is the scientific study of people at work. The goal of ergonomics is to reduce stress and eliminate injuries and disorders associated with the overuse of muscles, bad posture, and repeated tasks. This is accomplished by designing tasks, work spaces, controls, displays, tools, lighting, and equipment to fit the employee´s physical capabilities and limitations." (CDC, 2016, p. 1).

5. Ergonomic hazards - "refer to workplace conditions that pose a biomechanical stress to the worker. Such hazardous workplace conditions include, but are not limited to, faulty work station layout, improper work methods, improper tools, excessive tool vibration, and job design problems that include aspects of work flow, line speed, posture and force required, work/rest regimens, and repetition rate. They are also referred to as *stressors*." (OSHA, 1993, p. 21)

6. Ergonomic Management Control Program (EMCP) - refers to an employer's written programming section within their SHMS containing risk treatments implemented to eliminate or control ergonomic risk factors. An EMCP typically includes OSHA's seven-point ergonomic management framework.

7. Ergonomic risk factors - "are conditions of a job, process, or operation that contribute to the risk of developing CTDs. Examples include repetitiveness of activity, force required, and awkwardness of posture." "Risk factors are regarded as synergistic elements of ergonomic hazards which must be considered in light of their combined effect in inducing CTDs. Jobs, operations, or work stations that have multiple risk factors will have a higher probability of causing CTDs, depending on the relative degree of severity of each factor." (OSHA, 1993, p. 21)

8. Ergonomics team - refers to those responsible for identifying and correcting ergonomic hazards in the workplace, including ergonomic professionals or other qualified persons, health care providers, engineers and other support personnel, plant safety and health personnel, managers, supervisors, and employees." (OSHA, 1993, p. 21)

9. Ergonomic symptom survey - is a questionnaire for completion by workers to identify work-related pain or injuries. Survey results are then analyzed to identify potential ergonomic hazards and risk factors for further attention and risk reduction.

10. Fatality or Serious Injury (FSI) - an event or potential to result in death or serious injury.

11. Key Performance Indicator (KPI) - a measurement of performance to evaluate whether a certain quality goal has been achieved (e.g., assessing the quality of a finished product's coating).

12. Job Hazard Analysis (JHA) - is a hazard/risk assessment tool used to detect and control workplace hazards with the aim of preventing injury to a worker. Risk treatments are then developed and applied to reduce the risk associated with the identified hazards to acceptable levels. A JHA is sometimes referred to as Job Safety Analysis (JSA).

13. Lagging indicator - means a periodic measurement/metric of loss incidents that give indications of past performance but are not predictive of future OSH performance.

14. Leading indicator - means a proactive measurement/metric periodically taken to identify areas of SHMS weakness prior to loss events, providing the possibility of taking action to avoid losses. Leading indicators are also used to drive OSH performance and are predictive of future OSH performance - both of which are linked to risk reduction.

15. Musculoskeletal disorder (MSD) - "include cases where the nature of the injury or illness is pinched nerve; herniated disc; meniscus tear; sprains, strains, tears; hernia (traumatic and nontraumatic); pain, swelling, and numbness; carpal or tarsal tunnel syndrome; Raynaud's syndrome or phenomenon; musculoskeletal system and connective tissue diseases and disorders, when the event or exposure leading to the injury or illness is overexertion and bodily reaction, unspecified; overexertion involving outside sources; repetitive motion involving microtasks; other and multiple exertions or bodily reactions; and rubbed, abraded, or jarred by vibration." (OSHA, 2016, p. 1).

16. MSD recorded cases - a MSD injury/illness recorded on the OSHA 300 Log caused by ergonomic hazards.

17. New-hire training - OSH training provided to new hires before job assignment (e.g., ergonomics, PPE, emergency preparedness, hazard communication, defensive driving, fire safety, workplace violence, etc.).

18. OSH contact - a one-on-one communication from a supervisor during which the supervisor addresses an OSH topic and/or comments on the worker's compliance with OSH rules or their need to comply with same.

19. OSH coordinator - an onsite person having responsibilities for OSH.

20. Permit to work program (PtW) - FSI-potential work tasks requiring a permit to be completed before conducting the work (e.g., lockout/tagout, permit-required confined spaces, hot work, line break, elevated work, high voltage, night work, temperature extremes, lone work, scaffolding, etc.).

21. Pre-hazard controls - means a comprehensive hazard/risk analysis of a worksite, conducted whenever operations are altered or changed, to avoid the potential to overlook needed OSH controls due to the development of new exposures. For example, the pre-hazard control may include the Prevention through Design (PtD) process that identifies and initiates appropriate risk treatments to prevent or otherwise control hazards at the new design and redesign stage. For situations requiring adjustments to existing systems or operations, the Management of Change (MoC) analysis process identifies and reduces potential risks to an acceptable level.

22. Process of change - a procedure for properly managing the OSH exposures and risks due to any change in the existing procedure, operations, and/or physical structures (a.k.a., Management of Change).

23. Safety by design - a process by which manufacturers or service providers evaluate the OSH potentials and risks of their product/service in the design phase, prior to release, with the goal of designing out the risk to protect the end user (a.k.a., Prevention through Design).

24. Safety and Health Management System (SHMS) - means a comprehensive OSH programming system to provide a framework for integrated, structured risk management (a.k.a., safety management system [SMS] in the United States and hazard prevention program [HPP] in the E.U. and Canada). SHMSs enable OSH to take on strategic importance, giving OSH greater authority and legitimacy while focusing on workers' safety and health (e.g., ANSI Z10:2012 OHSMS, BS 18001-2007 OHSAS, CAN/CSA Z1000-2006, ILO OSHMS-2001, ISO 45001 OHSMS, and OSHA-2015 SHPMG).

25. Safety perception survey - means a questionnaire for completion by workers to identify their attitudes, their behaviors, and their understanding of management's commitment to OSH at their worksite. Results normally provide organizations with leading SPIs to assist in addressing areas of concern and preventing loss events before they occur.

26. Safety Performance Indicator (SPI) - means a lagging or leading indicator to measure performance and evaluate whether a certain ergonomic, OSH, or SHMS goal has been achieved (e.g., are 100 percent of targeted ergonomic audits completed).

27. TCIR - means OSHA's Total Case Incident Rate, defined as the rate of work-related injuries incurred by 100 workers during a one-year period. Use of the TCIR to record workplace injuries is a lagging indicator allowing for an evaluation of accident and injury statistics across industries, among industry sectors, and from one year to the next.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

This research pursues a reduction in ergonomic loss events due to the increased use of leading ergonomic SPIs to measure EMCP effectiveness. This study has importance due to the overwhelming risk of loss, in both human potential and financial investment, due to adverse ergonomic events. A risk potential, the researcher claims, which can be significantly lessened by the application of leading ergonomic SPIs.

The remaining chapter is divided into three sections: Historical Overview of the Theory and Research Literature, Research in Cognate Areas Relevant to the Dissertation Topic, and Summary. Through these sections, the researcher will substantiate the suffering and financial loss due to ergonomic MSDs, lightly touch on available risk treatments, and review the theory of SHMSs and available options to the OSH professional. The researcher will define and discuss the extent to which SPIs are currently used in the workplace as indicators of OSH performance, promote the validity of using leading SPIs as a just measure of EMCP and SHMS effectiveness, and discourse on the related role of the OSH professional in the work setting.

For the researcher to verify the research was original and germane to the profession, multiple databases were utilized in the literature review process, including ProQuest, EBSCOhost/Academic Search Complete, Google Scholar, and Penn State WebAccess.

Historical Overview of the Theory and Research Literature

The researcher's review of current literature was initiated on July 17, 2015, spanned publication dates of 1999 to 2016 and concluded on November 28, 2016. Scholarly literature on the topic of this research included texts and journals to recognize and support the use of leading

and lagging SPIs to evaluate OSH performance. The theory and pre-existing research for KPIs is significant and presents a positive support for their use in quality control efforts (Baldauf, 2010 and Morrison, 2015). The literature on SPIs in OSH is prevalent only in the past nine years and supports the use of SPIs in effectively measuring and evaluating OSH performance (Blair and O'Toole, 2010; Manuele, 2009 and 2013; Schultz, 2012; Telogis, 2015; and UL, 2013). The researcher purports increased acceptance of the term SPI by the OSH profession is warranted due to the growing global importance of tracking leading indicators in OSH.

Research in Cognate Areas Relevant to the Dissertation Topic

The ergonomic theme of this study was selected to generate original research on the use of SPIs. The researcher suggests the use of leading ergonomic SPIs, to evaluate and continually reduce ergonomic exposures in the workplace, could be significant in the actual reduction of ergonomic risk and resulting occupational losses, improved productivity, enhanced quality, and elevated worker morale. No specific theory or research literature on the use of leading SPIs to evaluate EMCPs was located by the researcher.

The majority of current OSH literature on SPIs is found in the study of SHMS effectiveness. The consensus embraces the finding that tracking SPIs not only complies with the *performance evaluation* elements mandated within the American National Standards Institute (ANSI) Z10-2012, the British Standards (BS) 18001-2007, the OSHA Safety and Health Program Management Guidelines (SHMPG-2015), and the ISO 45001-2018, they also encourage a healthy OSH culture and climate to reduce risk and loss events. The researcher posits the same positive outcome will be acknowledged in the reduction of ergonomic risk and losses.

The researcher will now present and connect the four preparatory elements of literature review for this research to result in the study's outcome. The following pages of this chapter

include an overview of ergonomics and MSDs, a review of SHMSs, the ultimate connection of SPIs and their ability to measure the effectiveness of both ergonomic efforts and SHMSs, and the related role of the OSH Coordinator.

Impact of Ergonomic MSDs in the Workplace

Earlier, the researcher has briefly described the impact of MSDs and other ergonomic loss events upon the American work environment. Gaining a further working knowledge of these costly incidents better prepares us to seek their reduction and eventual prevention via effective EMCPs, SHMSs, and robust safety/risk performance measures.

> Work-related musculoskeletal disorders are the most widespread occupational health hazard facing our Nation today. Nearly two million workers suffer work-related musculoskeletal disorders every year, and about 600,000 lose time from work as a result. Although the median number of lost workdays associated with these incidents is seven days, the most severe injuries can put people out of work for months and even permanently disable them. In addition, $1 of every $3 spent on workers' compensation stems from insufficient ergonomic protection. The direct costs attributable to MSDs are $15 to $20 billion per year, with total annual costs reaching $45 to $54 billion. (OSHA, 2000)

Fred Manuele with Hazards Unlimited further elaborates:

> It is well established that successfully applied ergonomics initiatives result not only in risk reduction but also in improved productivity, lower costs and waste reduction. Furthermore, musculoskeletal injuries are a large segment of injuries and illness in all organizations. Since they are costly, reducing their frequency and severity will show notable results. (Manuele, 2014b, p. 289)

Ergonomics is the systematic study of people at work. Employers should consider an [ergonomic] MSD to be work-related if an event or exposure in the work environment either caused or contributed to the MSD or significantly aggravated a pre-existing MSD as required by OSHA's recordkeeping rule (OSHA, 2013b, p. 3).

> The goal of ergonomics is to reduce stress and eliminate injuries and disorders associated with the overuse of muscles, bad posture, and repeated tasks. This is accomplished by designing tasks, work spaces, controls, displays, tools, lighting, and equipment to fit the employee´s physical capabilities and limitations. (CDC, 2016, p. 1)

MSDs include disorders of the muscles, tendons, nerves, ligaments, joints, cartilage and spinal discs, except those hazardous occurrences caused by slips, trips, falls, motor vehicle collisions, or other similar trauma loss incidents (OSHA, 2003). Occupational ergonomic risk factors may include (Bird et al., 2003, p. 404):

- Force;
- Repetition;
- Posture;
- Vibration;
- Contact Stress; and
- Environmental Stress.

Exposure to these known risk factors for MSDs increases a worker's risk of injury (OSHA, 2016). While other OSH professionals may wish to add to the following listing, current literature provides us with the resulting descriptions of occupational MSDs, including but not limited to carpal tunnel syndrome, cumulative trauma disorder, De Quervain's syndrome, epicondylitis, herniated/ruptured disc, mechanical back syndrome, muscle and ligament strain,

musculoskeletal injuries, neck tension syndrome, occupational overuse syndrome, pinched nerves, radial tunnel syndrome, repetitive motion injury, repetitive strain injury, repetitive stress injury, rotator cuff tendonitis, sciatica, spinal disc degeneration, tendinitis, thoracic outlet compression, and trigger finger/thumb.

Work-related MSDs are among the most frequently reported causes of lost or restricted work time. As presented by the BLS in 2013 (BLS, 2013), MSD cases accounted for 33 percent of all worker injury and illness loss events in the United States Over the tracked eighteen-year period of this BLS study; the MSD rate continues to keep pace with the rise in lost time cases in the United States.

Ergonomic risk treatments. Work-related MSDs can be prevented. The science of ergonomics may be viewed more fundamentally as fitting a job to a worker versus forcing the employee into unhealthy work conditions. With the researcher adding bullets one, two, three, and five below, and deferring to Bird and OSHA (Bird et al., 2003 and OSHA, 1993) for the remainder, these ergonomic intervention strategies and related risk treatments should be accomplished or attempted in the order of the following 7-step ergonomic risk treatment hierarchy.

1. Avoidance - involves preventing the hazard from occurring, possibly by engaging Prevention through Design (PtD) risk analysis for new operations or utilizing Management of Change (MoC) risk analysis when contemplating modifications to an existing process, procedure, service, or product.
2. Eliminate - involves removing the hazard altogether, such as by eradicating dangerous machinery, modifying workstations, or moderating temperature extremes.

3. Substitution - involves replacing the material/process with something less hazardous, such as replacing 75-pound bags of flour in a bakery with 25-pound bags.
4. Engineering controls - involves job modification by the use of new or modified tools, workstations, equipment, or environmental controls.
5. Warnings - involves alerting workers to the hazards, such as signs, audible alarms, training, and verbal instructions.
6. Administrative controls - involves changing work processes such as job rotation, workload distribution, work time changes, etc.
7. Behavioral-based controls - involves modification of work behaviors such as having employees perform warm up exercises, taking stretch breaks, and striving for proper work postures and proper material handling techniques.

In the early 2000s, NIOSH funded 10 field-based studies to examine the exposure-response relationship between job physical risk factors and work-related musculoskeletal disorders. The studies focused on either the lower back or the upper extremity. Each of these studies addressed limitations of previous research on work-related musculoskeletal disorders by (1) Having a prospective design; (2) Making direct and quantitative measurements of job physical risk factors; (3) Assessing psychosocial and work organization factors; (4) Collecting self-reported symptoms; and (5) Assessing musculoskeletal symptoms and disorders through physical examinations. These studies … collectively show a strong link between job physical exposures and work-related musculoskeletal disorders. (CDC, 2016, p. 4)

The researcher suggests OSH professionals focus on a job's physical exposures and work-related MSDs via ergonomic risk treatments from the top layers of the prior proposed 7-step ergonomic risk treatment hierarchy.

OSHA ergonomic management process. "Implementing an ergonomic [management] process [within a SHMS] is effective in reducing the risk of developing MSDs in high-risk industries as diverse as construction, food processing, firefighting, office jobs, healthcare, transportation and warehousing." (OSHA, 2015, p. 1). In developing leading ergonomic SPIs to evaluate and improve an employer's existing ergonomic controls, it is valuable to digest the following OSHA-recommended elements of an ergonomic management process. Consider first that OSHA and industry best practice have formulated a programming strategy for protecting workers from ergonomic disorders, promoted by the researcher as an *Ergonomics Management Control Program* or EMCP. An EMCP operates most efficiently when viewed as an ongoing function, incorporated into the daily operations rather than as an individual OSH project. Second, functioning within an effective SHMS, an EMCP yields superior results if it correlates with the seven underlying ergonomic management constructs of an effective ergonomic management framework, as recommended by OSHA (OSHA, 2015), including:

1. Top management support;
2. Affected worker involvement;
3. Training and education;
4. Identifying ergonomic hazards;
5. Implementing solutions to control ergonomic hazards;
6. Early reporting of MSD symptoms; and
7. Evaluating progress of corrective actions to reduce ergonomic risk.

It is upon these seven constructs the researcher has developed the research's survey instrument to collect data for this study. Distilling down into further detail in Table 1, the researcher posits the following seven EMCP constructs from OSHA interact to reduce ergonomic risk and resulting loss events. Placement of an EMCP within the structure of the employer's existing SHMS will aid to ensure its acceptance, tracking, and effectiveness.

Table 1

OSHA's 7 EMCP Constructs

EMCP Constructs	Detail
Provide Management Support	A strong commitment by management is critical to the overall success of an ergonomic process. Management should define clear goals and objectives for the ergonomic process, discuss them with their workers, assign responsibilities to designated staff members, and communicate clearly with the workforce.
Involve Affected Workers	A participatory ergonomic approach, where workers are directly involved in worksite assessments, solution development, and implementation is the essence of a successful ergonomic process. Workers can: • Identify and provide relevant information about hazards in their workplaces. • Assist in the ergonomic process by voicing their concerns and suggestions for reducing exposure to risk factors and by evaluating the changes made as a result of an ergonomic assessment.
Provide Training and Education	Training is a vital element in the ergonomic process. It ensures workers are aware of ergonomics and its benefits, become informed about ergonomics-related concerns in the workplace, and understand the importance of reporting early symptoms of MSDs.
Identify Ergonomic Hazards	A central step in the ergonomic process is to identify and assess ergonomic problems in the workplace before they result in MSDs. Job hazard analyses (JHAs) are a standard tool of excellence to identify hazards in the work environment and from which to calculate risk to establish priority for correction.
Implement Solutions to Control Ergonomic Hazards	There are many possible risk treatments to consider implementing to reduce, control, or eliminate workplace MSD hazards and related risk.
Encourage Early Reporting of MSD Symptoms	Early reporting can accelerate the job assessment and improvement process, helping to prevent or reduce the progression of symptoms and the development of serious injuries and subsequent lost-time claims.
Evaluate Progress	Established evaluation and corrective action procedures are required to periodically assess the effectiveness of the ergonomic process and to ensure its continuous improvement and long-term success. As an ergonomic process is first developing, assessments should include determining whether goals set for the ergonomic process have been met (e.g., via SPIs) and determining the success of the implemented ergonomic solutions.

Note. Ergonomic Management Control Program (EMCP) (OSHA, 2015, p. 1)

Safety and Health Management Systems

Segueing from ergonomics into safety management systems, the researcher now provides the link between MSDs and SHMS. SHMSs enable OSH to take on strategic importance, giving OSH greater authority and legitimacy while focusing on workers' safety and health. The researcher posits the Plan-Do-Check-Act (PDCA) nature of modern SHMSs enhances traditional OSH efforts to result in significant reductions in occupational injuries and illnesses, including ergonomics and related MSDs. "The fact that many organizations in the U.S. and abroad are implementing management systems in occupational health and safety is evidence that these systems add value to their businesses" (ASSE, 2013, p. 3). For example, today the OSH profession views OSHA's 2010-vintage Injury and Illness Prevention Program (I2P2), and their 2015 Safety and Health Program Management Guidelines (SHPMG), as SHMSs. Resultantly, OSHA's Voluntary Protection Program (VPP) has a 20-plus year history of integrating the SHMS approach, via I2P2, into their premier OSH recognition program (OSHA, 2010 and OSHA, 2012).

> OSHA's VPP relies on [safety] management system principles and has reported success in improving occupational health and safety performance among participating companies. The average VPP worksite has a Days Away Restricted or Transferred (DART) case rate 52% below the average for its industry. VPP participation can also lead to lower employee turnover and increased productivity and cost savings. (OSHA, 2013c, p. 1)

These positive outcomes may be extrapolated to other assessed SHMSs by the similarity of their programming elements and their certification requirements. Equally, with OSHA's release of their revised SHPMG in late 2015, they finally pull alongside other national and international

SHMS standards. Result: The opportunities for SHMS formats that promote the tracking of lagging SPIs are numerous and growing.

> Recognizing that the *old specification standards* [e.g., OSHA regulations] are no longer a benchmark for SH&E professionals to use as guidance in their [safety] management efforts, management systems and performance type standards for safety, health, and environmental issues have begun to spring up around the globe. (Lopez, 2006, p. 1)

Lopez lends further professional clarity of SHMSs.

> The beauty of these [SHMS] systems standards is that they are highly adaptable to almost any organization. The downside to these standards is that they are not self explanatory. They do require the presence of SH&E professionals to implement a meaningful plan. As with all *program* non specification type standards the upside is their flexibility but the downside (if you view it as that) is their lack of direction to the novice. (Lopez, 2006, p. 6)

If current OSH professionals are tempted to shy away from SHMSs and SPIs because these are beyond their comfort level, vocabulary, and skill set, the researcher posits that:

1. The OSH profession is becoming largely risk-focused and that a risk-based approach to OSH is here to stay.
2. OSH professionals will need to adapt to this shift, as a risk-based approach will likely be the profession's focus for the next two to three decades.
3. SPIs are effective in promoting and measuring the efficacy of the risk treatments present in today's EMCPs, SHMSs, and consequently within the workplace.

In 1999, the British Standards Institute's BS 18001-1999 Occupational Health and Safety Assessment Series (OHSAS) was issued and then updated last in 2007. BS 18001-2007 OHSAS

now facilitates the management of OSH in firms operating in different geographic areas and integrates with already certified and implemented systems for quality (i.e., ISO 9001) and environmental protection (i.e., ISO 14001, Fernández-Muñiz, Montes-Peón, and Vázquez-Ordás, 2012). Then, in 2001, the International Labour Organization (ILO) introduced their Guidelines on Occupational Safety and Health Management Systems (OSHMS). To promote global implementation in both established and developing countries, OSHMS is free of charge for all users. ANSI Z10-2005 Occupational Health and Safety Management Systems (OHSMS) followed in 2005, with a significant and valuable upgrade in 2012. Canada contributed their SHMS version in 2006 with CAN/CSA Z1000-2006 Occupational Health and Safety Management (OHSM). OSHA's I2P2 ultimately entered the American OSH scene in 2010, and as noted prior, was upgraded in 2015 to their SHPMG-2015, reflecting some of the key elements of ANSI Z10-2012. In a capstone event, the ISO 45001 Occupational Health and Safety Management Systems (OHSMS) draft was released in 2014, with a planned release in 2018 – thereby replacing BS 18001 and likely its prior-listed SHMS competitors.

> As the field of Safety and Health continues to mature there is a growing movement toward using management systems approaches to safety, health and environmental (SH&E) programs that reflect the success companies have realized with similar approaches to their quality programs. One of the significant impacts of this shift to use of management systems in SH&E has been new approaches in changing what we look at when managing the safety, health and environmental issues to which an organization is exposed. The outcome has been a shift from managing regulations, hazards and pure *body count* to the implementation of managing the risk to which organizations are exposed. This shift in thinking is leading SH&E professionals to think less in terms of

zero accidents and *safety first* and more in terms of the concept of *Acceptable Risk*. Obsession with regulatory compliance is being replaced with assessing an organizations' risk exposures. (Lopez, 2006, p. 1)

This ultimately leads the modern OSH professional to focus their OSH programming and efforts not solely on regulatory compliance but in identifying and assessing risk and controlling the same to an acceptable level (a.k.a., the employer's risk appetite). With SHMSs being the primary mechanism by which OSH functions are being managed by many organizations, SHMSs and leading SPIs provide a businesslike approach to OSH. They result in a systematic, comprehensive process for managing OSH risks while providing for goal setting, planning, measuring performance, and developing strategies to attack identified OSH shortcomings.

The researcher will now demonstrate how EMCPs and SHMSs utilize leading SPIs to achieve the "Check" function of their PDCA cycle. SHMSs and SPIs can be viewed as ensuring OSH issues are woven deeply into the fabric of an organization where they become part of the culture or the way people do their jobs. Looking back,

> As the [American] SH&E field has matured so has the way it is managed. Thirty years ago the approach was the 3 E's of safety; Education, Engineering and Enforcement. This gave way to the *program approach* in which the various elements of what constituted a good SH&E program were broken out and implemented. The next wave was the *technocrat* approach in which it was thought that all ills could be cured with a specification standard for the topic. This was followed by the rebirth of the *human behavior* phase in which it was decided that since human factors were responsible for 80 to 90% of all incidents, if we could only control the people all would be well with the world. Through this entire transition the programmed standards driven approach was the

main thrust of the initiatives. Then ISO 9000 hit and the whole world went process improvement crazy. Naturally this has spread to the SH&E field making a management system standard based on the ISO 9001 process almost inevitable. (Lopez, 2006, p. 3)

Prudent employers should realize that the moral and cost-savings benefits from SHMS and SPIs are worthy of action now, not later. The researcher presents the additional groundwork for this research study by reviewing the SPI-promoting, global, SHMS options of:

- ANSI Z10-2012 OHSMS;
- BS 18001-2007 OHSAS;
- OSHA SHPMG-2015; and
- ISO 45001-2018 OHSMS.

ANSI Z10-2005 (2012) OHSMS. According to ANSI Z10-champion, Fred Manuele (2006), "Z10 is a management system standard, not a specification standard" (p. 26).

> The first effect of this *systems* thinking is that through the planning stage of the process an organization if forced to think beyond the simple concepts of zero accidents and *body count* type injuries and illnesses. The focus is on risk and what constitutes acceptable risk to an organization. Interestingly enough, nothing new was invented for the writing of this standard. In simple terms what was done was many of the modern management approaches in managing risk in an organization were for once incorporated in one document. The focus and businesslike approach that this document promotes regarding methods of seeking out the degree of risk associated with hazards and then turning that into the best systems to address these risks should result in dramatic lowering of catastrophic type losses and all loss in general. This new approach of [reviewing] the risks to which an organization is exposed, [prioritizing] these risks, [developing]

> measures to address the risks according to the prioritization and then auditing your success or failure with the intent of improving your management process is both beautifully simple yet highly effective. (Lopez, 2006, p. 4)

Lopez further opines, "In the future, safety and risk management students will study this as a seminal event in our field" (Lopez, 2006, p. 4).

The later revised ANSI Z10-2012 provides an overall blueprint for widespread benefits in OSH, as well as in productivity, financial performance, quality, and other organizational and business objectives (Smith, 2012a). The seven elements of Z10 include (ANSI, 2012):

1. Scope;
2. Definitions;
3. Management Leadership and Employee Participation;
4. Planning;
5. Implementation and Operation;
6. Evaluation and Corrective Action; and
7. Management Review.

Developing and tracking SPIs are encouraged to identify SHMS shortcoming or deficiencies and to promote ongoing SHMS improvement. Manuele further pronounces of ANSI Z10:

> Although establishing performance measures is not one of the subjects listed in the *shall* provisions of Section 6.0, the advisory comments read in E6.1C "organizations should develop measures of performance that enable them to see how they are doing in preventing injuries and illnesses" (Manuele, 2014b, p. 438).

Hence, the researcher posits SPIs can aid in Z10's *Evaluation and Corrective Action* element number six.

The subsequent 2012 edition of ANSI Z10, as with ISO 45001, has a clear focus on *risk*. Hence, these two standards include risk assessment components and terminology possibly new to some OSH practitioners, including acceptable risk, risk appetite, risk matrix, risk map, risk score, residual risk score, risk gap, risk assessment, and risk treatments.

BS 18001-1999 OHSAS (2007). British Standards (BS) 18001-2007 OHSAS is currently used as the basis for occupational SHMSs in thousands of companies around the world and will be phased out once ISO 45001 is adopted (ISO. 2015a). "As of 2005, around 16,000 organizations in more than 80 countries were using the BS 18001 OHSAS specification …and by 2009, more than 54,000 certificates had been issued in 116 countries to OHSAS or equivalent [employers]" (BSI, 2014, p. 1).

Updated in 2007, the overall aim of BS 18001-2007 OHSAS was to aid organizations in managing and controlling their health and safety risks and improving their performance of same. SPIs are promoted in BS 18001's *Checking* phase of this PDCA closed loop cycle. The complete structure of BS 18001 (BSI, 2007) contains the five-component framework of:

1. OH&S Policy;
2. Planning;
3. Implementation and Operation;
4. Checking; and
5. Management Review.

The researcher posits SPIs will aid in achieving component four of this SHMS scheme, *Checking*.

OSHA I2P2-2010 to OSHA SHPMG-2015. In 2010, the United States federal OSHA released their voluntary I2P2 guidelines for consideration as a future regulation. I2P2 has been a successful element of OSHA's VPP for years. "OSHA reports 34 states have some type of I2P2 program initiatives for worker safety and health protection…having a variety of names, including Accident Prevention Programs, I2P2, and Comprehensive Safety and Health Programs" (OSHA, 2014, p.1). Enumerated prior, ANSI Z-10, BS 18001, and ISO 45001 focus on risk. OSHA's I2P2 appears to focus on hazard analyses. In a December 2010 letter to Congress, ASSE President Dr. Darryl Hill was not pleased and advocated a stronger OSHA SHMS regulation when he wrote:

> OSHA's final I2P2 must encourage risk-based safety management that will help employers avoid proscriptive regulations, be highly flexible so that every industry can meet its requirements without unnecessary burdens, and be simple enough for the smallest employers to use without being burdened. We firmly believe OSHA can write a standard that meets those requirements. (Walter, 2011, p. 1)

Dr. Hill (Walter, 2011) then further wrote:

> An I2P2 standard should be harmonized with the most widely accepted voluntary consensus standards governing safety and health program management in the private sector, including ANSI Z10 and 18001 OHSAS, and efforts should be made to work with the standards development organizations responsible for those standards. (p. 1)

OSHA listened, and in late 2015, they released their OSHA-2015 SHPMG to replace their 2010 I2P2 guidelines. This 2015 release pursues alignment with the other pre-existing and prior-mentioned SHMS standards within which the tracking of leading indicators may be prescribed

and fulfilled via the use of SPIs. The structure of OSHA-2015 SHPMG (OSHA, 2015) includes the following seven constructs.

1. Management Leadership;
2. Worker Participation;
3. Hazard Identification and Assessment;
4. Hazard Prevention and Control;
5. Education and Training;
6. Program Evaluation and Improvement; and
7. Coordination and Communication on Multi-Employer Worksites.

The researcher posits SPIs can significantly contribute to achieving the *Program Evaluation and Improvement* component number six of OSHA SHPMG-2015.

Keeping in mind that business systems for quality, environmental, and occupational safety form the foundation of successful modern businesses,

> "The idea that excellence in safety and production go hand in hand is not new. As early as 1928, the American Engineering Council, based on an engineering and statistical study, demonstrated that an organization with decreasing injury rates is eleven times more likely to show increased production than an "unsafe' one." (Bird, Germain, and Clark, 2003)

We acknowledge much has changed since 1928. In the modern workplace, global businesses increasingly depend on the practice of outsourcing their parts, processes, and activities. These employers operate and compete increasingly on a supply chain level. With increasing supply chain pressures via voluntary global reporting initiatives, sustainability indexes, OSH expectations from customers, and new and existing international OSH regulations, it is becoming

necessary for host or focal employers to adopt a congruent process of the prior three SHMSs in a practical and logical flow, thereby enabling the prior SHMSs to be combined into a single SHMS. Appropriately, the researcher now introduces the proposed ISO 45001-2018 OHSMS for consideration in this study.

ISO 45001-2018 OHSMS. The researcher posits the future of SHMSs and the accepted and increased use of SPIs will receive prominence with ISO's as-yet-unpublished draft Occupational Health and Safety Management Standard, set to replace BS 18001-2007 OHSAS. The 2014 ISO 45001 OHSMS draft is significantly different from BS 18001; the structure, format, and terminology of this new standard will be substantially altered.

The new standard will follow the high-level structure format defined in ISO's Annex SL. Annex SL are the rules and format governing the development of all future ISO management standards – resulting in convenience for organizations who wish to have a single management system (Mors, 2013). The high-level structure will be a standard format for all new and revised ISO management system standards using common text in the standards. ISO 9001 (i.e., quality management, ISO, 2015b) and 14001 (i.e., environmental management, ISO, 2015c) are themselves undergoing the high-level structure format revision and are due shortly for publication. Building on the past fifteen years of global SHMSs, the high-level structure of the ISO 45001 standard (ISO, 2014) will appear as ten fundamentals.

1. Scope;
2. Normative References;
3. Terms and Definitions;
4. Context of the Organization;
5. Leadership;

6. Planning;
7. Support;
8. Operation;
9. Performance Evaluation; and
10. Improvement.

Items four, five, nine, and ten represent significant changes from pre-existing ISO management system standards. Likely, the dawning importance of SPIs, in relation to ISO 45001's fundamental number nine, *Performance Evaluation*, is growing ever clearer to the reader. Moreover, it is no small matter that 45001 will compel the transformation of thousands of currently BS 18001-certified management systems throughout the world. Shortly after ISO's draft release, the Federation of Management Systems' (FMS) Wilkinson, commented in 2014:

> ISO 45001 is not a minor editorial revision of BS OHSAS 18001; this is a significant restructuring, rewording and refocusing of a very important international standard. ISO 45001 will do away with many of the health and safety management system *traditions* that are familiar to many of us – organizations will need time to adjust. More than that, the new standard will require organizations to integrate the management of health and safety into the heart of their business and expect top management to get involved in the process. ISO 45001 introduces some significant changes to the familiar BS OHSAS 18001. It is important that organizations, especially senior management, begin to understand the new requirements at the earliest opportunity - they've got some big decisions to make. (RMS, 2014. p. 1)

OSH professionals facing ISO 45001 stand at the threshold of a significant event in the profession. The researcher posits the pending impact of ISO 45001 into the global community

has the potential to improve OSH performance, ultimately reduce risk, loss events, and associated loss costs while improving worker morale. With this pending international SHMS standard requiring ongoing SPI metrics towards the goal of continual risk reduction, the researcher now directs this project's discussion onward towards a better understanding of leading SPIs.

> A critical part of the safety professional's job is to show how safety performance is improving. The field for the most part has accepted the continuous improvement process as an integral component of program implementation. This continuous improvement process finds it roots in quality control in which a desired outcome is defined, activities are planned and implemented, measurements against this outcome are taken, gaps identified, changes made, and measurements taken again. In the safety arena, the development of safety performance improvement programs has been found to at times be more of a hit and miss approach rather than a systematic process. Unintended consequences of this approach can result in poor measures, a lack of performance improvement, wasted resources, and a disconnect between measurements, safety activities, and performance. (Janicak and Ferguson, 2009, p. 3-4)

Safety Performance Indicators

SPIs are leading indicators or lagging indicators, specific to OSH efforts within a SHMS, evaluating past OSH efforts and predicting future OSH performance. For decades, OSH professionals have struggled with measuring and evaluating their specialized performance. In 2005, Dan Peterson summarized his opinion on this subject as "The measurement of safety performance is, I believe, the [OSH] industry's most serious problem, and it has been a

stumbling block for many years. The measures we have used traditionally are often not reliable and thus invalid" (Peterson, 2005, p. v).

> Companies and safety professionals have developed a number of these [SPIs] with no real understanding as to how well they measure safety performance, the types of [SHMS] interventions that are most effective in creating change in improving the [SPIs], and what appropriate methods should be used to determine if the [SPIs] are adequate. (Janicak and Ferguson, 2009, p. 1)

Often to survive, our OSH profession must be able to justify if our SHMSs are making a positive impact on our organization, confirm whether they are meeting our OSH goals, and communicate the status of our OSH performance to the organization (Janicak, 2010). SPIs are typically detailed within an OSH Performance Measurement Program, intertwined into the substance of an organization's SHMS. OSH Performance Measurement Programs determine what to measure, identify data collection methods, collect and analyze the data, report on same, and follow up on the results (Janicak, 2010). Developed around the current context of the organization, their corporate strategies, and key business goals, leading SPIs allow organizations to steward their available resources effectively. Janicak clarifies:

> The key difference between performance measures and safety metrics is that performance measures evaluate the safety process and safety metrics are the standards of measurement (such as accident rates). A series of safety metrics make up a safety performance measure. One of the main advantages if using performance measures is that they enable companies to express the results of a safety process in quantitative, not qualitative, terms. (Janicak, 2010, p. 5)

SPIs are known in the OSH profession by many names. For the purpose of this research and its related literature review, these may include key performance indicators, key risk indicators, key safety indicators, leading performance indicators, risk performance measures, safety and health performance indicators, ESH performance indicators, safety program performance indicators, and safety performance measures. Safety, health, and risk performance measures may be so-named by the OSH professional using any of the above terms or one of their making.

Competing with the interchangeability of SPI terminology are the many definitions and theories of lagging and leading SPIs that have matured over the years and present themselves in current OSH literature. Manuele recently comments in 2013 "A uniform definition of leading indicators has not yet emerged, although the definitions being touted have the same base" (Manuele, 2013, p. 546). Many esteemed OSH colleagues have presented valuable definitions and theories of SPIs over the years, including just a few listed here in Table 2.

Table 2

Current OSH Industry SPI Definitions

SPI	Definitions
Lagging	1. "Lagging indicators are measurements linked to the outcome of loss events." (Manuele, 2013, p. 283) 2. "Lagging indicators are the traditional safety metrics used to indicate progress toward compliance with safety rules." (Middlesworth, 2014, p. 1) 3. "Lagging safety indicators …are historical metrics such as accident reports and statistics representing the traditional approach to measuring safety." (Telogis, 2015, p. 1) 4. "Outcome measures reflect the company's key safety objectives. [These measures, sometimes called] lagging indicators, typically demonstrate the final results of the safety process and measure safety performances that are the result of an activity." (Janicak, 2010, p. 7). 5. "Trailing or lagging safety indicators are after-the-fact indicators which measure events or consequences that have occurred. These events or consequences are often associated with unwanted events, such as injuries, illnesses, workers' compensation costs, hospital visits, notices of violation, regulatory fines and litigation costs." (Wachter, 2012, p. 1) 6. "Lagging metrics are a retrospective set of metrics that are based on incidents that meet the threshold of severity that should be reported as part of the industry-wide process safety metric." (CCPS, 2011, p. 4)
Leading	1. "Leading indicators are those safety activities that favorably impact on lagging indicators, are a precursor to safety degradation for early management reaction, and validate the financial business case for the OSH efforts being accomplished." (Manuele, 2013, p. 279) 2. Leading indicators "are a measure preceding or indicating a future event used to drive and measure activities carried out to prevent and control injury." (Middlesworth, 2014, p. 1) 3. "Leading indicators are predictive, measuring safety activities people are doing today that may prevent illness or injury tomorrow." (Peterson, 2005, p. 2) 4. "Activity measures monitor the performance of activities that are needed to reach key objectives. These measures, sometimes called leading indicators, typically demonstrate the state of work-in-progress in terms of cost, quality, and time…and are measures of the activity prior to the outcome." (Janicak, 2010, p. 24) 5. Leading indicators "are an alternative approach to performance management – [focusing] on efforts to anticipate issues before they occur or grow in size and complexity." (Daniels, 2015, p. 1)

Table 2 (*continued*)

Current OSH Industry SPI Definitions

SPI	Definition
Leading	6. "Leading indicators proactively draw attention to specific behaviors and activities – thereby enabling employees and managers to modify behaviors before incidents or accidents occur." (Hohn, 2016, p. 1) 7. Leading indicators "offer promise as an improved gauge of OSH activity by providing early warning signs of potential failure and, thus, enabling organizations to identify and correct deficiencies before they trigger injuries and damage." (Sinelnikov, Inouye, and Kerper, 2015, p. 241) 8. "Leading indicators are used to focus resources on preventive actions. They allow management to actively demonstrate commitment and leadership, enable workers to get involved with measurable processes, and focus resources on accident prevention processes." (Toellner, 2001, p. 47) 9. Leading metrics are a "forward-looking set of metrics which indicate the performance of the key work processes, operating discipline or layers of protection that prevent incidents…providing an early indication of deterioration in the effectiveness of key safety systems, and enable [remediation] to be undertaken to restore the effectiveness of these key [safety] barriers before any loss event takes place." (CCPS, 2011, p. 4 and 28)

A 2009 study by Janicak and Ferguson was conducted with 121 employers to determine how the OSH profession is assimilating SPIs into the corporate management system. The study's objective was to identify current practices in the industry to quantify and analyze safety performance data. Respondents were asked to identify the OSH metrics they use to measure their various OSH performance indicators. Results were broken down by leading, current, and lagging indicators. Findings from this valuable study include the following.

1. The most frequently identified leading indicators were measuring safety audits conducted and safety training programs.
2. Incident rates of some form were the most common lagging indicators identified.
3. Many organizations are collecting and analyzing data as a means for monitoring and improving OSH performance.
4. For almost all organizations, the safety manager at the facility level of the organization had input into the selection of the SPIs. For larger organizations, corporate level safety directors tended to have a greater role in the identification and selection of the OSH performance indicators.
5. In many cases, only one performance indicator was being used. For an OSH Performance Measurement Program to be effective, the organization should utilize a variety of leading and lagging SPI tied to the incidents that are adversely affecting OSH performance.
6. One potential limiting factor as to which companies do or do not use SPIs is the size of the organization. As can be expected, smaller organizations with limited resources are less likely to have a formalized OSH Performance Measurement Program in place.

7. The second highest rated reason for the difficulty in implementing the OSH Performance Measurement Program is being able to link OSH activities to the measures. It is difficult from a statistical standpoint to determine a true cause and effect relationship between the OSH activities and OSH performance. (Janicak and Ferguson, 2009)

Lagging indicators. The researcher elects to first discuss lagging SPIs due to their entrenchment and widespread acceptance in today's business community.

> In the past, measuring safety performance relied on measuring only a few [*lagging*] indicators such as the number of lost workdays or the amount of money spent on workers' compensation claims. This translates to after-the-fact hazard detection, which (like outdated quality programs based on inspecting defects at the end of a process) does not identify organizational errors - the true causes of accidents. (Janicak, 2010, p. 1)

Further, an OSH culture is unlikely to be positively affected when lagging indicators are the primary focus or are the sole OSH metrics an organization uses to assess performance (Blair and O'Toole, 2010). A thriving OSH culture is possibly the most valuable asset an employer can enjoy. Unfortunately, lagging SPIs do not effectively evaluate the OSH culture of a workplace. The value of an OSH culture can be appreciated because of its difficulty to acquire and maintain, a problem often encountered due to a dissimilar type of reactionary culture. A reactive management culture is presented by a business that responds to loss events when they happen and not to the warning signals prior. Likely, a reactionary employer will act on OSH needs after serious loss incident or after a less-than-ideal OSH review or audit (Telogis, 2015). SPIs and methods for measuring the OSH performance and OSH culture in the organization have gained importance since OSH professionals have come to understand the impact the OSH culture has

upon all other aspects of the SHMS and the degree to which the OSH culture can influence or hinder the other aspects of same (Janicak, 2010).

Peterson provides an excellent example to consider the shortcomings of our sole reliance on lagging indicators, in this example (Peterson, 2005, p. 5-6), pertaining to the OSHA incident rate.

> The OSHA incident rate measures the number of incidents (of a defined degree of resultant severity) per 200,000 man-hours worked in a facility, unit, company, state, or country. The rate was an offshoot of a pre-OSHA ANSI guideline (Z16.1) that attempted to measure the same thing with different definitions of an accident on a one million man-hour base. There are serious flaws with these results indicators.
>
> 1. They have little statistical validity in smaller units, measuring mostly luck and not performance.
> 2. They do not really tell most companies if they are improving - whether their OSH systems are better.
> 3. The measures are not diagnostic. They do not suggest why an organization is performing better or worse.
> 4. The measures do not tell an organization what it needs to do to fix what is wrong to make the organization more efficient.
> 5. Relying on any single metric is problematic.
> 6. OSHA rates do not drive superior OSH performance because they are overly inclusive and not very accurate; in fact, they are less and less accurate the more pressure you put on them.

7. The safety and health measurement mindset is one of tracking failure or showing loss avoidance, not one of positive contribution to the business.
8. Safety and health metrics undermine management credibility.

Considering that tracking traditional lagging SPIs has been commonplace since OSHA legislated a focus on their incident rate within the 1970 OSH Act, it is no wonder why reporting of frequency and severity rates of occupational loss incidents has been ingrained in the United States employer.

> As a result of these legal [OSHA] requirements, many organizations began to use these case rates as the sole indication as to the performance of their safety program. These case rates, which are trailing indicators of safety performance, became the standard by which organizations and safety professionals made decisions as to how the safety program should be administered. (Janicak and Ferguson, 2009, p. 1)

While lagging SPIs have their ancillary place in an OSH performance measurement process, alone, they are poor providers of valuable insight to prevent future loss events. Regrettably, the tracking of lagging SPIs alone summarizes only past loss experience and SHMS failures. Lagging SPIs do not predict future OSH success - they merely illuminate upheavals in our OSH systems. While these reactive metrics remain marginally useful to measure facility loss performance, lagging SPIs may also aid in benchmarking that particular performance against similar operations and in the development of risk treatments to prevent comparable loss events via effective root cause analysis (Wachter, 2012). Presented another way,

> Leading or upstream indicators are measures that allow you to anticipate and predict. They provide a precursor to any degradation in the safety process, enabling early

> management intervention. Lagging or downstream indicators are those metrics for events and conditions that already happened (or didn't happen). (Kaufman, 2009, p. 1)

Kaufman further illuminates the SPI road ahead as "Leading indicators can give us the insight and predictive power to drive our organizations while looking through the windshield rather than the rearview mirror" (Kaufman, 2009, p. 2).

> Often, the key obstacle to improvement is a singular focus on lagging indicators of workplace safety. The number of accidents incurred, injury rates, and lost work costs are important indications of the safety of a given workplace. However, this type of data reflects only the consequence of an unsafe workplace and provides little insight into the root causes actually responsible for safety incidents. Leading indicators, on the other hand, focus on those steps and processes that are designed to prevent an accident or loss from happening in the first place. When used in combination, leading and lagging indicators can foster sustained improvement in overall workplace safety efforts. (UL, 2013, p. 2)

Loss event investigations are often viewed in the OSH literature as lagging indicators. The researcher posits that aggressively investigating loss incidents after they occur is an effective exercise to prevent future loss events. The resulting loss cause analyses of these loss events typically identify gaps or failures in an organization's safety systems - allowing them to be corrected and as such should be considered as leading SPIs. Again, however, OSH professionals should not rely solely on lagging SPIs such as accident rates or loss event investigations. Schultz (2012) "…identifies three significant flaws in only focusing on reactive incident analysis: First, it's costly; second, it sends a negative message to your employees; and third, as your incident rate improves, you have fewer and fewer data points to analyze" (p. 1). Schultz's line of thought

is worthy of further consideration as he delves deeper into these three flaws with lagging indicators.

> The first flaw in relying on lagging indicators to prevent new incidents is [they are] expensive. The second major flaw is that waiting for incidents to occur before preventing new ones sends a very chilling message to employees about the company's safety culture. To put it bluntly, leaders are essentially saying, "Chris, I am going to wait until you are severely injured in our production process before I figure out how to ensure Joan doesn't suffer the same fate. In the meantime, stay safe, and keep that assembly line moving - we have profit goals to hit!" Finally [third], and most relevant to those who are experiencing measurable improvements in their injury-prevention programs, companies simply run out of incident data points to analyze and learn from. The devastating incident with the Deepwater Horizon oil rig, where 11 workers lost their lives in April 2010, unfortunately, helps make this point. According to reports, "The very day of the blast on the rig, executives were aboard celebrating its seven straight years free of serious accidents." I don't know what data that group was using to manage their risk levels, but if they were using incidents, then they had no data. Once a company reduces its incident rate to a low level, similar to the Deepwater Horizon, they run out of lagging data to analyze and have to turn to other data points, like leading indicators, to ensure continued low incident rates. (Schultz, 2012, p.3)

As the OSH profession ponders why lagging SPIs continue to play a prevalent role in current OSH measurement, Peterson presents an interesting summary of same (Peterson, 2005, p. 12).

Although it long ago became clear that these [lagging] measures offer little helpful data, they continue to be used today, perhaps for the following reasons:

1. OSHA requires firms to implement these measures;
2. At times, compliance directions are dictated by these measures;
3. The National Safety Council publishes these measures regularly, as does the United States government;
4. Some industry groups use them to compare member companies;
5. Most writers quote them; and
6. Most companies use them internally to judge safety system effectiveness.

As OSH professionals, we would do well to heed Peterson, as he further encourages the profession to consider the damage we can render from "questionable activities" that can result from our over-reliance on lagging SPIs at the expense of leading SPIs, including (Peterson, 2005):

1. Setting a goal to reduce injury rates from 3.0 to 2.0 (*who wants to be part of the 2.0?*);
2. Replacing a manager who does not reach this goal above;
3. Deciding who is "good" and "bad" in order to determine who should receive an OSH inspection or audit; or
4. Determining which company is *best* within an industry or which location is *best* within a company.

Many OSH professionals invest significant effort in gathering, analyzing, and reporting on OSH statistics. Toellner tells us "If these efforts do not directly lead to improved [OSH] performance, a site's safety resources are not being maximized" (Toellner, 2001, p. 47). However, as difficult as it may be at times, lagging SPIs offer some insight into an organization's

OSH performance. Used correctly, the results of lagging SPIs can aid management and employees to better understand overall OSH performance and the significance of relatively minor loss events (Toellner, 2001). As we progress now to a discussion of leading indicators, the researcher suggests we retain a modest degree of lagging SPIs in our workplaces and instead place an emphasis primarily upon leading SPIs.

Leading indicators. Leading SPIs have been employed and tracked since at least 1985, when the International Association of Oil & Gas Producers (OGP) began databasing safety incident statistics from its global member companies, providing trend analysis, benchmarking, and the identification of areas and activities on which OSH efforts should be focused to bring about the greatest improvements in performance to reduce loss events (OGP, 2013). Fast forward and today's

> Safety performance is now measured with the same tools and techniques common to quality control measures of other measures in the organization. Control charts, run charts, and Pareto diagrams can be used to track and monitor safety performance, establish trends, and evaluate program performance against accepted tolerances. (Janicak, 2010, p. 2)

In 2013, the Campbell Institute in Chicago launched a white paper developed by a panel of OSH experts that provided eight credible characteristics of leading SPIs (Campbell, 2013, p. 1), including:

1. Actionable;
2. Achievable;
3. Meaningful;
4. Transparent;

5. Easy to communicate;
6. Valid;
7. Useful; and
8. Timely.

The Campbell white paper also afforded the following agreed-upon enablers and barriers common to SPIs (Campbell, 2013, p. 2).

1. Key enablers of successful leading indicator implementation and usage:
    1.1. Executive buy-in on (not technical knowledge of) leading indicators;
    1.2. Roll-up and use of leading indicators at the corporate level;
    1.3. Communication and understanding of the predictive value of leading indicators by EHS and corporate leadership; and
    1.4. Targeted leading indicator data collection used to analyze specific, measurable actions rather than collected before the development of response actions.
2. Common barriers to successful leading indicator implementation and use:
    2.1. Absence of [*OSH Coordinator*] education on the value and use of leading indicators;
    2.2. Inability to develop consistently actionable leading indicators;
    2.3. Lack of reliable, consistent relationship between leading and lagging indicator performance;
    2.4. Sporadic, infrequent and non-standardized benchmarking; and
    2.5. Continuing top management reliance on traditional lagging indicators.

> Over the past decade, there has been an ever-growing demand placed upon [OSH] professionals to better quantify the [OSH] performance of the organization in which they work beyond how many people were injured, killed, or suffered from an occupational

> illness. With the adoption of ANSI Z-10…[OSH] metrics have begun to expand into leading indicators and current indicators. (Janicak and Ferguson, 2009, p. 1)

Lagging versus leading indicators. OSH professionals and the related literature frequently stumble on classifying near hits (a.k.a., near misses) as either lagging or leading SPIs. The researcher concurs with Manuele (2013) and jointly defers to the 2006 publication from the United Kingdom's Health and Safety Executive (HSE) titled: Developing Process Safety Indicators.

> Since a near miss is an actual event or discovery of a potentially unsafe situation, this metric could be defined as a lagging metric. A large number or increasing trend in such events could be viewed as an indicator of a higher potential for a more significant event; therefore, many companies use near miss metrics as a surrogate for a leading metric. (HSE, 2006, p. 32)

Near hits may be more closely aligned with leading indicators if we select related metrics such as the percentage of near hits investigated for loss cause analyses, or the percentage of near hits which are corrected or for which risk treatments are implemented. Progressing with an understanding that near hits will generally be considered as a leading SPI due to their potential for presenting hazards for possible risk treatments, a further clarification between lagging and leading SPIs is provided by the International Council on Mining and Metals. ICMM's findings are presented in Table 3, reflecting some key differences between the characteristics of leading and lagging SPIs.

Table 3

Key Differences Between SPIs

Lagging/Reactive SPIs	Leading/Proactive SPIs
1. Are retrospective	1. Are actionable, predictive and relevant to objectives
2. Identify hazards after the fact	2. Identify hazards before the fact
3. Require corrective actions to prevent another similar incident	3. Allow preventative actions before the hazard manifests as an incident
4. Indicate that circumstances have changed; control measures can be implemented after the incident	4. Allow response to changing circumstances through implementing control measures before the incident
5. Measure failures of control systems	5. Measure effectiveness of control systems
6. Measure outcomes	6. Measure inputs and conditions
7. Measure the current outcome without influencing it	7. Direct towards an outcome that we want or away from an outcome that we do not want
8. Measure system failures	8. Give indications of systems conditions
9. Measure what has gone wrong	9. Measure what might go wrong and why
10. Provide reactive monitoring of undesired effects	10. Provide proactive monitoring of the desired state
11. Are useful for external benchmarking	11. Are useful for internal tracking of performance
12. Identify weaknesses through loss incidents	12. Identify weaknesses through the risk control system
13. Are easy to identify and measure	13. Are challenging to identify and measure
14. Are static	14. Evolve as organizational needs change

(ICMM, 2012, p.5)

Digesting the ICMM data and moving onward, the researcher suggests there has already been a significant and adequate investment of paper, ink, and discussion as to whether certain SPIs are leading or lagging. Instead, the researcher posits we search for the proactive nature within SPIs to prevent loss from identified fatality or serious injury (FSI) potentials. As OSH professionals, we would be negligent were we to select SPIs that failed to take into account the context of our most important FSI potentials – our very real, high-hazard, problem areas (IUP, 2012). For example, we would think it foolish, and rightly so, to track and promote our low OSHA total case incident rate (TCIR) when we experienced two fatalities due to elevated falls over the past six months. Rather, in this case, we should utilize a leading SPI such as post-training competency examinations of employees completing fall protection training. Utilizing SPIs that are without worthwhile substance offer only the shadow of risk reduction. Once we have selected and developed leading SPIs that meet the context and needs of our organization, we may then rely on known lagging SPIs (e.g., loss frequency rates) to measure the effectiveness of same.

From a behavioral standpoint, lagging SPIs are often interpreted as negative (e.g., what went wrong) whereas leading SPIs are more likely seen as positive (e.g., high overall scores in an OSH audit of the EMCP). Moreover, while leading SPIs typically possess greater predictive value to top management, there is a limited number of typically classified lagging SPIs with positive, not negative, potential for consideration, including (Zwetsloot, 2016) (a) the percentage of productive planned work days realized and (b) employee satisfaction surveys.

OSH professionals tasked with developing leading SPIs should realize the importance of keying their SPIs to result in a relationship that produces an identifiable reduction in loss events via lagging indicators (Manuele, 2013). Regardless of the lead/lag direction to be undertaken by

the OSH professional, the development of leading and lagging SPIs should adhere to the following standard risk management hierarchy.

1. Analyze and identify workplace hazards;
2. Assess the risk of identified hazards - particularly FSI potentials;
3. Develop SPIs and related targets based on the risk assessment results and core corporate strategies, goals, and their context;
4. Track SPIs and readjust their course as necessary; and
5. Report results to shareholders via scorecards or dashboards.

OSH professionals should further tie these SPIs into the context of their organization and the elements of their SHMS. For example, the selection of the SPIs may be based upon the following (Janicak and Ferguson, 2009).

1. The organization's key business goals and risk management objectives.
2. The root causes of the loss incidents and/or near hits occurring in the organization.
3. OSH regulatory requirements.
4. Cost and convenience of data to measure the SPI.
5. The degree of the association between the SPIs and the SHMS's goals and objectives.
6. Data analysis techniques required to ascertain whether the SPI is acceptable or not.
7. The expertise of the OSH staff to utilize the SPI data.

Heim (2015, p. 3) cautions against mistakes to avoid in setting leading SPIs:

1. Failure to align your SPI with the company's business goals.
2. Failure to underpin your SPI with action plans.
3. Setting SPIs for things over which we have no control.
4. Setting too many SPIs.

5. Setting SPIs that are irrelevant.
6. Failure to conduct a risk assessment first.
7. Failure to get broad involvement in setting SPIs.
8. Failure to get management commitment to making the SPI(s) their "own."
9. Failure to communicate progress on SPIs and get help if things are slipping.
10. Failure to share the SPIs with the rest of the organization.

In 2012, two Caterpillar executives explained how they were able to successfully transition to a safety culture that utilizes proactive leading SPIs for safety in addition to traditional lagging SPIs. According to the executives, "Traditional metrics can help companies tell the score at the end of the game, but they don't help employers understand the strengths and weaknesses of their safety efforts and cannot help managers predict future success" (Smith, 2012b, p. 1). By utilizing SPIs that emphasized leading indicators of safety, Caterpillar experienced an 85% reduction of injuries and $450 million in direct/indirect cost savings (Smith, 2012b, p. 2).

This literature review consistently finds the recommendation to consider a combination of primarily leading and a few lagging indicators to measure and improve the OSH performance of a worksite. When using leading indicators, there is value in designing the SPI metrics grounded in performance. For example, as an alternative to simply measuring how many ergonomic-themed JHAs have been accomplished, consider measuring the impact of the JHAs' outcome by ergonomic risk treatments growing out of the process and improved worker satisfaction in the ergonomic design of their workstations.

A 2012 Underwriters Laboratories survey titled *Leading and Lagging Indicators in Action*, asked respondents to identify the leading and lagging indicators of greatest importance to

a successful workplace SHMS. Survey respondents identified the most important leading and lagging SPIs by category, in rank order, as shown in Table 4. In connecting the SPIs to SHMSs, Table 5 provides UL's potential SPI submissions for correlating leading and lagging SPIs with a breakout by standard SHMS sections.

Table 4

UL's Most Important Leading and Lagging SPIs

Most Important Leading and Lagging SPIs	Detail
Governance	• The number of investigations that are being examined by an organization's safety team and the number of urgent submissions that are being recorded by employees. • Overdue tasks – Tasks not completed by the required due date • Open investigations – Number of investigations currently under review • Open events – Events reported but not yet under investigation
Risk Assessment	• The relative risk of issues being reported and assessing whether submissions and events present a high, medium, low, or negligible risk to employees. • Submissions on observations of safe and at-risk conditions reported • Near hits – Report of incident that does not result in injury • Injury – Report of an incident that results in an employee injury
Activity Metrics	• Statistics about the specific kinds of submissions being reported, such as general observations, near hits or actual injuries or losses. • Percentage breakdown of submissions by type • Percentage of near hits receiving a formal investigation • Percentage of incidents with loss receiving a formal investigation

Table 4 (*continued*)

UL's Most Important Leading and Lagging SPIs

Most Important Leading and Lagging SPIs	Detail
Loss Statistics	• The types of losses experienced by an organization, including injured employees, lost workdays, or property damage. • Average number of days employees are absent due to work injuries • Number of employees absent from work due to work injuries • Injury events – Number of incidents that resulted in at least one injury
Cultural Indicators	• An assessment of an organization's overall OSH culture with regard to employees' commitment to OSH, the implementation of corrective actions, and ongoing training. • Employee submissions – Number of employees who are recording OSH submissions • Overdue corrective actions – Percentage of corrective actions not resolved on time • Average corrective actions/submissions – Average number of corrective actions implemented as a result of a single event

UL, 2013, p. 5

Table 5

Potential SPIs by SHMS Section

Program Element	Leading Indicator	Lagging Indicator
Management Support and Accountability	• Percentage of goals/ objectives incorporating OSH • Percentage of jobs preplanned • Average # of corrective actions per submission (incidents, near hits, observation, inspections)	• Percentage of projects that work without incidents • Documented meetings, metrics used compared to plan (+/-) • Preplan verified and onsite • Participation in OSH meetings, budgets for OSH, OSH metrics communicated
Employee Participation and Involvement	• Percentage of employees involved in OSH decision-making process • Percentage age of workforce submitting safe and/or at risk behaviors weekly • Tracking percentage age increase (or decrease) in the # of submissions being submitted by the workforce	• # of work method changes
New Hire Orientation, Training and Learning	• Percentage of employees trained prior to start of work • Percentage of employees /management trained	• # of incidents related to training • Percentage of training on time following observation or incident • # of training classes conducted
Inspections/Audits/ Observations	• # of inspections and observations • Percentage of compliant/safe conditions • Percentage of deficiencies • Percentage of severe/ imminent of risk severity index • Percentage completion of corrective actions within timeline	• Near hits • Incident rate (frequency and severity • Loss costs

Table 5 (*continued*)

Potential SPIs by SHMS Section

Program Element	Leading Indicator	Lagging Indicator
Incident, Near Miss and Observation Investigations	• Average time to complete investigations • Root cause(s) for loss identified • # of near hits investigated/ tracking • # of observations investigated/ tracking	• Repeat accident types and/or offenders
Performance Management Systems/Safety Related	• Percentage of performance reviews measuring success in achieving results • # inspections compared to individual objective • # of OSH meetings conducted compared to individual objective • # of one-on-one contacts • Percentage of losses tied to projects and individual objectives	• Near hits • Incidence rate (frequency and severity) • Loss costs • Percentage age of overall rating related to OSH performance/ metrics • Project profitability

UL, 2013, p. 5

Typically, the extent and degree to which leading or lagging SPIs are implemented rest upon the worksite's OSH Coordinator.

OSH Coordinator Role

The researcher posits that full-time OSH Coordinators (a.k.a., OSH professionals), those having greater than 50 percent of their job duties and time dedicated to OSH, and those possessing a college degree in an OSH or related field (e.g., engineering or chemistry), will possess a higher degree of formal and on-the-job education in the areas of ergonomics and leading SPIs. Resultantly, full-time OSH Coordinators with an OSH or related college degree will likely score leading ergonomic SPIs more highly and look on them more favorably for implementation in their workplace.

For job classifications in question 4.0 of the survey instrument, the researcher utilized the Bureau of Certified Safety Professionals (BCSP) definition of an OSH professional from their membership application. Hence the 50 percent rule, in which 50 percent or more of job duties and time dedicated to OSH, was integrated into the study (BCSP, 2016). The reader may refer to the utilized research survey instrument in Appendix B for further visualization.

The researcher has proposed in the preceding pages that tracking leading SPIs are mandated by certified SHMS to confirm the effectiveness of their operation. Certified SHMSs in turn, result in less occupational loss events through the process of hazard analysis, risk assessment, and corrective risk treatments (Manuele, 2006, 2013, and 2014a). Greater understanding and related use of leading ergonomic SPIs to evaluate EMCPs may, in turn, promote the increased use of certified SHMSs worldwide.

Summary

The researcher's efforts related to this literature review produced fruit in numerous areas. Ergonomic MSD losses present a significant toll in human suffering and business expense in the national workplace. OSHA's ergonomic management framework provides resources for leading SPI potentials to be developed and considered by the OSH profession. While SPIs are typically classified as lagging and leading, current SHMS constitutions utilize leading SPIs to achieve required ongoing OSH performance evaluations. Leading performance indicators are important and have been shown to reduce accident rates and improve safety management system performance.

While the literature review presented barriers to implementing SPIs in the overall OSH profession (Campbell, 2013), no existing literature was located in which difficulties in implementing leading ergonomic SPIs were addressed. SPIs are currently in use in some United States workplaces as an indirect means of improving occupational loss experience. The body of OSH literature does not provide for the opinion that OSH Coordinators influence leading ergonomic SPIs. The researcher posits they do. Lastly, the literature review spurred the researcher towards recognizing the benefits of actively using leading SPIs to fulfill the review and performance measurement requirements mandated by several global SHMS formats.

The purpose of this study was to evaluate the degree to which leading ergonomic SPIs are valued and utilized, the perceived difficulties in implementing leading ergonomic SPIs, as well as to examine the impact the person assigned OSH responsibilities has on the use and importance placed on leading ergonomic SPIs. The field of OSH literature supports the use of SHMSs and SPIs to evaluate same. The researcher thereby posits that the use of leading ergonomic SPIs will ensure the effectiveness of an EMCP within a SHMS and result in less ergonomic losses. In

addition, any increase in the acceptance and implementation of leading SPIs in the American workplace may promote the implementation of new EMCPs and additional certified SHMSs – which in turn may lead to less overall occupational losses in the national work environment.

CHAPTER THREE

RESEARCH PROCEDURES

Introduction

This research pursues a reduction in ergonomic loss events due to the increased use of leading ergonomic SPIs to measure EMCP effectiveness. The researcher sought to investigate whether there is a significant difference in how respondents score leading ergonomic SPIs based upon whether they are utilizing them or not and whether differences in the OSH Coordinator job classifications or education influence respondent's individual importance scoring of leading ergonomic SPIs. The researcher also sought to identify perceptions of difficulties in implementing leading ergonomic SPIs and establish if there is a significant difference in the overall average SPI importance scoring across OSH Coordinator job classifications. The remaining chapter is divided into four sections: Data Required, Setting of the Study, Method of Obtaining Data, and Data Analysis.

Data Required

An original research survey instrument (refer to Appendix B) was developed by the researcher in order to gather the necessary data. The survey questions were assessed for applicability and robustness via the process of face validity. Three faculty from the Indiana University of Pennsylvania's (IUP) Safety Sciences Department and one faculty emeritus from the Millersville University's Occupational Safety and Environmental Health Department reviewed the survey tool to accomplish the face validity technique.

Setting of the Study

The researcher's survey instrument was administered online to ASSE members in the United States within the trades of construction, healthcare, manufacturing, educational, and

services. "ASSE is a global association of [OSH] professionals representing more than 37,000 members worldwide…and is a visible advocate for OSH through proactive government affairs at the federal and state levels" (ASSE, 2016, p. 1). An electronic attachment was included with each survey tool to explain the purpose, scope, confidentiality, and importance of the research (Refer to Appendix A).

Study Sample

The sample size for this study was 4,721, the total number of surveys distributed. Cold email requests were submitted to United States-based ASSE members from January 30, 2017 to February 15, 2017. The research data collection period ran for seventeen days.

Data Collection

This data gathering was accomplished online via email, using the Qualtrics online survey software tool through IUP's Applied Research Lab. Respondent participation was voluntary. Qualified online surveys were completed and submitted through Qualtrics to the IUP Applied Research Lab. The researcher rejected incomplete survey responses.

Method of Obtaining Data

In concert with a review of current literature on effective research survey instruments to glean productive styles, the researcher developed the research survey instrument (See Appendix B). The instrument was developed with ten narrowly defined ergonomic risk treatments (ERTs), tracked as leading SPIs and tightly aligned with OSHA's seven pedigreed ergonomic management process constructs, supported by literature as elements of an effective ergonomic management framework.

Table 6 details how the research instrument was developed to include OSHA's seven recommended constructs for an effective EMCP. The researcher incorporated the elements into

the survey instrument, as ten SPIs, to structure the research around ergonomics and a proven related framework.

Table 6

OSHA's EMCP Constructs in the Survey Instrument

	OSHA's 7 Underlying Ergonomic Management Constructs of an Effective Ergonomic Management Framework (OSHA, 2015)	Corresponding Research Instrument Question
1.	Top management support	1.1 and 2.1
2.	Affected worker involvement	1.3, 1.7, 2.3, and 2.7
3.	Training/education	1.2 and 2.2
4.	Identify ergonomic hazards (e.g., JHA)	1.4, 1.5, 1.8, 2.4, 2.5, and 2.8
5.	Implement solutions to control ergonomic hazards	1.9 and 2.9
6.	Early reporting of MSD symptoms	1.6 and 2.6
7.	Evaluate progress of corrective actions to reduce risk	1.10 and 2.10

Data Analysis

Research Variables

The first ten survey questions, 1.1 through 1.10, were ordinal and utilized a Likert scale, asking the respondents to score the importance of the leading ergonomic SPIs on a scale of 1 through 5. The sum of the Likert scale items 1.1 to 1.10 was used to measure the overall importance scoring of leading indicators for further consideration of trends. Use of the Likert scale enabled the researcher to reduce complex responses into a sequence of ordinal numbers. Once inferential statistics were applied, a mean ranking score was utilized. The lower the mean ranking, the more importance the respondent was placing on the question item (e.g., scoring annual ergonomic audits as "Very Important"). The higher the mean ranking, the less importance the respondent placed on that question (e.g., scoring ergonomic improvements implemented as "Not At All Important").

The second set of survey questions, 2.1 through 2.10, were nominal with possible responses of "Yes," "No," and "Do not know." These items asked respondents if they use the

listed leading ergonomic SPIs, mirroring the SPI constructs within the previous ten questions, 1.1 through 1.10. Each of the survey questions 2.1 through 2.10 had a follow-up question if the respondent answered "No," asking them to provide their perceived reason for the difficulty in implementing that leading ergonomic SPI. Possible replies to a "No" response for questions 2.1.1 through 2.10.10 included "Too costly," "Too difficult to implement," "Lack of management support," "New concept – not known prior," and "Other."

Question 3.0 had the respondents inputting their employer's North American Industrial Classification System (NAICS) code for further consideration of trends.

Question 4.0 asked the respondents to classify their job description, selecting one option from "Full-time," "Part-time," "Human resources," or "Other."

Question 5.0 asked the respondents to classify their educational description, selecting one option from "College degree in Safety and Health or a related scientific field of study," "College degree other than Safety and Health or a related scientific field of study," or "No college degree."

Descriptive Statistics

The researcher summarized each of the variables in this study with appropriate descriptive statistics to analyze the data such that, for example, patterns might emerge from the survey results (Laerd, 2016a). Descriptive statistics simply describe our results. Inferential statistics allow us to infer, or make conclusions, beyond the data we have analyzed or reach conclusions regarding any hypotheses we have presented prior (Laerd, 2016a).

Inferential Statistics

While descriptive statistics provide information about our immediate group of data, we do not have access to the entire population of OSH professionals, but only a limited number of respondents (Laerd, 2016a). Inferential statistics are techniques to overcome sampling error in our data samples and allow us to generalize regarding the population of OSH coordinators. Hence, it is necessary that the sample accurately represents our population (Laerd, 2016a).

Mann-Whitney U test. According to Laerd (Laerd, 2016b), "the Mann-Whitney U test compares differences between two independent groups when the dependent variable is either ordinal or continuous, but not normally distributed." (p. 1)

***Variables*.** The researcher used median scores and compared those who use the SPI to those who do not use the SPI (Survey items Q1.1 - Q1.10 and items Q2.1 - Q2.10).

Assumptions of the test. The researcher is required to test the following four assumptions for a valid result

(Laerd, 2016b, p. 1).

1. Assumption #1: The dependent variable should be measured at the ordinal or continuous level.
2. Assumption #2: The independent variable should consist of two categorical, independent groups.
3. Assumption #3: The data should have the independence of observations, which means that there is no relationship between the observations in each group or between the groups themselves.
4. Assumption #4: The researcher should examine the distributions of the independent variables. If they have the same shape based on a visual analysis of the SPSS (statistical package for the social sciences) printout, the Mann-Whitney U Test should

compare the mean rankings of the dependent variable for the two groups of the independent variable of interest. If the two distributions have a different shape, the Mann-Whitney U test should compare mean ranks.

***Statistical hypothesis*.**

- Null hypothesis: There will be no significant difference in the mean scores for items 1.1 to 1.10 based upon whether they are being utilized.
- Alternative: There will be a significant difference in the mean scores for items 1.1 to 1.10 based upon whether they are being utilized.

Kruskal-Wallis test. According to Laerd (Laerd, 2016c), "the Kruskal-Wallis Test is a rank-based nonparametric test that can be used to determine if there are statistically significant differences between two or more groups of an independent variable on a continuous or ordinal dependent variable." (p. 1)

***Variables*.** The researcher sought to determine the mean scores of the perceived importance of SPIs based upon job classifications (Survey items Q1.1 - Q1.10 and item Q4).

Assumptions of the test. To analyze data using a Kruskal-Wallis Test, the researcher must test four assumptions (Laerd, 2016c, p. 1).

1. Assumption #1: The dependent variable should be measured at the ordinal or continuous level (interval or ratio).
2. Assumption #2: The independent variable should consist of two or more categorical, independent groups.
3. Assumption #3: The data should have the independence of observations, so there is no relationship between the observations in each group or between the groups themselves.

4. Assumption #4: In order to know how to interpret the results from a Kruskal-Wallis Test, we should determine whether the distributions in each group have the same shape or variability. If the same, we will seek the median. If varied, we will seek the mean.

Follow up Dunn-Bonferroni tests will be performed to examine pairwise comparisons.

***Statistical hypothesis*.**

- Null hypothesis: There will be no significant difference in the median scores for the perceived importance of SPIs based upon OSH Coordinator job classifications.
- Alternative: There will be a significant difference in the median scores for the perceived importance of SPIs based upon OSH Coordinator job classifications.

Kruskal-Wallis test.

***Variables*.** The researcher sought to determine the mean ranking of how survey respondents rank SPI items by their level of education (Survey items Q1.1 - Q1.10 and item Q5). The same procedures described prior for the Kruskal-Wallis Test and follow up Dunn-Bonferroni test must be followed.

***Statistical hypothesis*.**

- Null hypothesis: There will be no significant difference in the mean ranking, as differences in OSH Coordinator education will not influence the perceived importance of SPIs.
- Alternative: There will be a significant difference in the mean ranking, as differences in OSH Coordinator education will influence the perceived importance of SPIs.

Chi-Square for Goodness of Fit test. According to Laerd (Laerd, 2016d), "the Chi-Square for Goodness of Fit Test is a single-sample nonparametric test, used to determine whether the distribution of cases in a single categorical variable follows a known or hypothesized distribution." (p. 1)

***Variables*.** The researcher sought to determine the respondents' perceived difficulties in implementing leading ergonomic SPIs (Survey items Q2.1.1 - Q2.10.10).

Assumptions of the test. The researcher's data is required to pass these four assumptions for a Chi-Square for Goodness of Fit Test to produce a valid result (Laerd, 2016d, p. 1).

1. Assumption #1: One categorical variable.
2. Assumption #2: Independence of observations.
3. Assumption #3: The groups of the categorical variable should be mutually exclusive.
4. Assumption #4: There should be at least five expected frequencies in each group of our categorical variable.

***Statistical hypothesis*.**

- Null hypothesis: There will be no perceived difficulty in implementing leading ergonomic SPIs based on the education of the OSH Coordinator and/or due to a lack of management support.
- Alternative: There will be perceived difficulty in implementing leading ergonomic SPIs based on the education of the OSH Coordinator and/or due to a lack of management support.

ANOVA procedure. According to Laerd (Laerd, 2016e), "the one-way analysis of variance (ANOVA) is used to determine whether there are any statistically significant differences between the means of two or more independent groups." (p. 1)

***Variables*.** The researcher will seek to determine if there are significant differences in the average of the overall SPI importance scores based upon OSH Coordinator job classification, (Total of survey items Q1.1 - Q1.10 and item Q4).

Assumptions of the test. The researcher's data is required to pass the following six assumptions to be valid (Laerd, 2016e, p1.):

1. Assumption #1: The dependent variable is measured at the interval or ratio level.
2. Assumption #2: The independent variable consists of two or more categorical, independent groups.
3. Assumption #3: Independence of observations.
4. Assumption #4: No significant outliers.
5. Assumption #5: The dependent variable is approximately normally distributed for each category of the independent variable.
6. Assumption #6: There is homogeneity of variances.

If the data for the analysis of variance does not meet the assumptions of the ANOVA procedure, a Kruskal-Wallis Test and follow-up tests will be performed following the procedures detailed previously.

***Statistical hypothesis*.**

- Null hypothesis: There will be no significant differences in the average of the overall SPI importance scores based upon OSH Coordinator job classification.

- Alternative: There will be significant differences in the average of the overall SPI importance scores based upon OSH Coordinator job classification.

IBM's SPSS version 24.0 was utilized by the researcher to examine data from the study's results. Specifically, SPSS was applied in conducting Mann-Whitney U Tests, Kruskal-Wallis Tests, Chi-Square for Goodness of Fit Tests, and ANOVA Procedures.

CHAPTER FOUR

DATA AND ANALYSIS

Introduction

The purpose of this study was to evaluate the degree to which leading ergonomic SPIs are valued and utilized, the perceived difficulties in implementing leading ergonomic SPIs, as well as to examine the impact the person assigned OSH responsibilities has on the use and importance placed on leading ergonomic SPIs. In this chapter, the researcher presents the data obtained via the research and the analysis that was completed to produce the findings provided in chapter five. The remaining chapter is divided into the three sections of Participants, Descriptive Statistics, and Inferential Statistics.

Participants

For this study, email requests were sent to 4,721 ASSE members in the United States asking them to participate in this research. The email addresses were obtained from ASSE's National Director of Marketing. Thirty email requests were returned as undeliverable due to obsolete or incorrect email addresses. There were 224 respondents who replied to the survey from January 30, 2017 to February 15, 2017, for a resultant response rate of approximately five percent.

Seven responses were removed from the analysis as non-respondents as these individuals declined to participate once they started the survey. The researcher rejected forty-one survey submissions due to incomplete responses. This resulted in 176 valid cases for analysis. Additional follow-up email requests to stimulate more respondents were not an option available from ASSE.

Data Collection Measures

The research instrument was fashioned to include OSHA's seven recommended constructs for an effective EMCP. The face validity process was accomplished, with the involved parties agreeing on the strength of the research questions as being leading indicators. As a result, the instrument questions remained as originally proposed by the researcher.

Descriptive Statistics

The researcher summarized each of the variables with appropriate descriptive statistics to analyze the data such that, for example, patterns might emerge from the survey results. These identified patterns follow and include the Respondent's Profile, Respondent's SPI Scoring by Likert, and Respondent's Reported SPI Implementation.

Respondent's Profile

Of the 135 OSH Coordinators responding to these questions, 89.6 percent classified themselves as "Full-Time," and 60.7 percent reported they held a "College Degree in Safety and Health or a Related Scientific Field of Study." These results appear in Table 7 and Table 8.

Table 7

Respondent's Job Classification Profile

	Full-time *(50% or more of job duties and time dedicated to OSH)*		Part-time *(Less than 50% of job duties and time dedicated to OSH)*		Human Resources		Other		Total	
	N	%	N	%	N	%	N	%	N	%
OSH Coordinator Job Classification	121	89.6	6	4.4	2	1.5	6	4.4	135	100

Table 8

Respondent's Education Profile

	College degree in safety and health or a related scientific field of study (e.g., engineering or chemistry)		College degree other than safety and health or a related scientific field of study (e.g., engineering or chemistry)		No College Degree		Total	
	N	%	N	%	N	%	N	%
OSH Coordinator Education	82	60.7	39	28.9	14	10.4	135	100

Respondent's SPI Scoring by Likert

Respondents most frequently scored as "Very Important" the leading ergonomic SPIs of *Workers' Early Reporting of Ergonomic Strains and Sprains They Experience* (Q1.6 at 68.8 percent), the *Use of Pre-hazard Controls to Avoid Ergonomic Hazards* (Q1.4 at 59.8 percent), and *Ergonomic Improvements Implemented* (Q1.9 at 58.5 percent). The results appear in Table 9.

Table 9

Respondent's Leading Ergonomic SPI Scoring by Importance Rankings

Question	1 Very Important		2		3 Neutral		4		5 Not at all Important		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Q1.1 - Workers' perceptions of top/line management commitment to ergonomics safety (e.g., safety perception survey)	95	54.0	53	30.1	20	11.4	7	4.0	1	0.0	176	100
Q1.2 - The number of new hires being trained in ergonomics safety before the assignment of their work duties	75	42.6	64	36.4	25	14.2	8	4.5	4	2.3	176	100
Q1.3 - The number of new hires assigned an OSH mentor to coach them in avoiding the ergonomic hazards of their work duties	45	25.6	64	36.4	47	26.7	14	7.9	6	3.4	176	100
Q1.4 - The use of pre-hazard controls to avoid ergonomic hazards (e.g., Prevention through Design [PtD] and/or Management of Change [MoC])	107	59.8	50	27.9	10	5.6	6	3.4	6	3.4	179	100
Q1.5 - The number of job hazard analyses (JHAs) conducted to avoid ergonomic hazards	66	37.7	59	33.7	37	21.1	10	5.7	3	1.7	175	100

Table 9 (*continued*)

Respondent's Leading Ergonomic SPI Scoring by Importance Rankings

Question	1 Very Important		2		3 Neutral		4		5 Not at all Important		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Q1.6 - Workers' early reporting of strains/sprains they experience (e.g., ergonomic symptoms survey	121	68.8	35	19.9	12	6.8	7	4.0	1	0.0	176	100
Q1.7 - Worker participation in management-led stretch and flex exercises	49	27.8	69	39.2	33	18.8	14	8.0	11	6.2	176	100
Q1.8 - Ergonomic losses investigated for root causes within 24-hours	59	33.7	68	38.8	31	17.7	14	8.0	3	1.7	175	100
Q1.9 - Ergonomic improvements implemented	103	58.5	57	32.4	10	5.7	4	2.3	2	1.1	176	100
Q1.10 - Annual audit of the written Ergonomic Management Control Program	38	21.7	63	36.0	45	25.7	20	11.4	9	5.1	175	100

Note. Original question: *How important are the following leading safety performance indicators (SPIs) for reducing ergonomic musculoskeletal disorders (MSDs) in your workplace?*

Respondent's Reported SPI Implementation

The most often utilized leading ergonomic SPI, as reported by respondents, was the *Measurement of Workers' Early Reporting of Ergonomic Strains and Sprains They Experience* (Survey item Q2.6 at 59.5 percent). All remaining nine leading ergonomic SPIs presented in this study were more frequently reported by respondents as "No," and are not utilized at their worksites. The results appear in Table 10.

Table 10

Respondent's Reported Leading Ergonomic SPI Implementation

Question	Yes		No		Do Not Know		Total N	
	N	%	N	%	N	%	N	%
Q2.1 - Measuring workers' perceptions of top/line management commitment to ergonomics safety (e.g., safety perception survey)	55	33.5	103	62.8	6	3.6	164	100
Q2.2 - Tracking the number of new hires being trained in ergonomics safety before the assignment of their work duties	57	34.9	96	59.0	10	6.1	163	100
Q2.3 - Tracking the number of new hires assigned an OSH mentor to coach them in avoiding the ergonomic hazards of their work duties	28	17.1	123	75.0	13	7.9	164	100
Q2.4 - Tracking the use of pre-hazard controls to avoid ergonomic hazards (e.g., Prevention through Design [PtD] and/or Management of Change [MoC])	74	45.1	82	50.0	8	4.9	164	100
Q2.5 - Tracking the number of job hazard analyses (JHAs) conducted to avoid ergonomic hazards	76	46.3	78	47.6	10	6.1	164	100

Table 10 (*continued*)

Respondent's Reported Leading Ergonomic SPI Implementation

Question	Yes		No		Do Not Know		Total N	
	N	%	N	%	N	%	N	%
Q2.6 - Measurement of workers' early reporting of strains/sprains they experience (e.g., ergonomic symptoms survey)	97	59.5	58	35.6	8	4.9	163	100
Q2.7 - Measuring worker participation in management-led stretch and flex exercises	44	26.8	111	67.7	9	5.5	164	100
Q2.8 - Measuring ergonomic losses investigated for root causes within 24-hours	73	44.5	82	50.0	9	5.5	164	100
Q2.9 - Measuring ergonomic improvements implemented	70	42.9	81	49.7	12	7.4	163	100
Q2.10 - Conducting an annual audit of a written of the written Ergonomic Management Control Program	47	28.8	104	63.8	12	7.4	163	100

Note. Original question: *Over the past three years, has your company utilized the following leading safety performance indicators (SPIs) aimed at reducing ergonomic musculoskeletal disorders (MSDs) in the workplace?*

Inferential Statistics

The researcher performed the Mann-Whitney U Test, the Kruskal-Wallis Test, the Chi-Square for Goodness of Fit Test, and the ANOVA Procedure to test the research questions posed in this study.

Mann-Whitney U Test

The Mann-Whitney U Test was performed to compare differences in importance rankings between those respondents who use SPIs and those who do not use SPIs. The data met the assumptions required to perform the test. There was a significant difference in the mean rankings (Mann-Whitney $U = 3{,}351$, $p < .05$) when comparing those who score highly and use The Number of New Hires Assigned an OSH Mentor to Coach Them in Avoiding the Ergonomic Hazards of Their Work Duties (Survey item Q1.3). This means OSH Coordinators who used this indicator rated it significantly more important than those who did not. For all other items, the mean rankings were not significant. The results appear in Table 11.

Table 11

Mann-Whitney U Test – Perceived Importance of Leading Ergonomic SPIs Based Upon Use

Question	Yes, Use SPIs			No, Do Not Use SPIs			Mann-Whitney U	*p*
	M.R.	N	%	M.R.	N	%		
Q1.1 - Q1.1 - Workers' perceptions of top/line management commitment to ergonomics safety (e.g., safety perception survey)	80.1	55	34.8	79.2	103	65.2	2,800	.896
Q1.2 - The number of new hires being trained in ergonomics safety before the assignment of their work duties	70.8	55	34.8	84.1	103	65.2	3,310	.063
Q1.3 - The number of new hires assigned an OSH mentor to coach them in avoiding the ergonomic hazards of their work duties	70.1	55	34.8	84.5	103	65.2	3,351	.048*
Q1.4 - The use of pre-hazard controls to avoid ergonomic hazards (e.g., Prevention through Design [PtD] and/or Management of Change [MoC])	76.4	54	34.8	79.6	102	65.2	2,868	.652
Q1.5 - The number of job hazard analyses (JHAs) conducted to avoid ergonomic hazards	71.8	55	35.0	82.9	102	65.0	3,203	.124
Q1.6 - Workers' early reporting of strains/sprains they experience (e.g., ergonomic symptoms survey	72.4	55	34.8	83.3	103	65.2	3,221	.088

Table 11 (*continued*)

Mann-Whitney U Test – Perceived Importance of Leading Ergonomic SPIs Based Upon Use

Question	Yes, Use SPIs			No, Do Not Use SPIs			Mann-Whitney U	*p*
	M.R.	N	%	M.R.	N	%		
Q1.7 - Worker participation in management-led stretch and flex exercises	73.1	55	34.8	82.9	103	65.2	3,186	.178
Q1.8 - Ergonomic losses investigated for root causes within 24-hours	80.2	54	34.4	78.4	103	65.6	2,717	.803
Q1.9 - Ergonomic improvements implemented	77.2	55	35.0	79.9	102	65.0	2,902	.685
Q1.10 - Annual audit of the written Ergonomic Management Control Program	71.3	55	35.0	83.2	102	65.0	3,230	.105

Note. Mean Ranking (M.R.)
Note. Original question: *How important are the following leading safety performance indicators (SPIs) for reducing ergonomic musculoskeletal disorders (MSDs) in your workplace?*
* $p < .05$

Kruskal-Wallis Test

The researcher used the Kruskal-Wallis Test to examine two sets of hypotheses. First, was to determine if there were statistically significant differences in the mean rankings for respondents' scoring of SPI items based on job classifications. The job classifications provided in the survey were "Full-time," "Part-time," "Human Resources," and "Other." Examples of responses for the "Other" category included "Consultant," "Tech Writer," and "Risk Consultant."

The results from the SPI ranking against job classification appear in Table 12. The data met the assumptions required to complete a valid Kruskal-Wallis test. There was a significant difference in the mean rankings (Kruskal-Wallis = 10.88, $p < .05$) based on OSH Coordinator job classifications for *Worker Participation in Management-led Stretch and Flex Exercises* (Survey item Q1.7). The distributions in each group were determined to have variability; therefore, the mean was sought.

Table 12

Kruskal-Wallis Test – Perceived Importance of Leading Ergonomic SPIs by Job Classification

Question	Full-Time OSH Coordinator			Part-Time OSH Coordinator			Human Resources			Other			Kruskal-Wallis	*p*
	M.R.	N	%	M.R.	N	%	M.R.	N	%	M.R.	N	%		
Q1.1 - Workers' perceptions of top/line management commitment to ergonomics safety (e.g., safety perception survey)	66.9	121	89.6	82.7	6	4.4	84.2	2	1.5	67.2	6	4.4	1.572	.666
Q1.2 - The number of new hires being trained in ergonomics safety before the assignment of their work duties	67.5	121	89.6	86.7	6	4.4	98.2	2	1.5	51.1	6	4.4	4.070	.254
Q1.3 - The number of new hires assigned an OSH mentor to coach them in avoiding the ergonomic hazards of their work duties	68.1	121	89.6	61.6	6	4.4	91.2	2	1.5	65.0	6	4.4	.984	.805
Q1.4 - The use of pre-hazard controls to avoid ergonomic hazards (e.g., Prevention through Design [PtD] and/or Management of Change [MoC])	65.9	119	89.5	65.7	6	4.5	111.5	2	1.5	74.3	6	4.5	3.961	.266
Q1.5 - The number of job hazard analyses (JHAs) conducted to avoid ergonomic hazards	67.7	120	89.6	62.6	6	4.5	89.0	2	1.5	60.8	6	4.5	.983	.805

Table 12 (*continued*)

Kruskal-Wallis Test – Perceived Importance of Leading Ergonomic SPIs by Job Classification

Question	Full-Time OSH Coordinator			Part-Time OSH Coordinator			Human Resources			Other			Kruskal-Wallis	*p*
	M.R.	N	%	M.R.	N	%	M.R.	N	%	M.R.	N	%		
Q1.6 - Workers' early reporting of strains/sprains they experience (e.g., ergonomic symptoms survey	67.6	121	89.6	69.7	6	4.4	84.5	2	1.5	68.2	6	4.4	.543	.909
Q1.7 - Worker participation in management-led stretch and flex exercises	64.6	121	89.6	111.2	6	4.4	81.8	2	1.5	87.8	6	4.4	10.881	.012*
Q1.8 - Ergonomic losses investigated for root causes within 24-hours	66.1	120	89.6	73.5	6	4.5	98.8	2	1.5	78.8	6	4.5	2.333	.506
Q1.9 - Ergonomic improvements implemented	66.8	121	90.3	63.5	5	3.7	85.2	2	1.5	78.0	6	4.5	1.223	.748
Q1.10 - Annual audit of the written Ergonomic Management Control Program	66.5	120	89.6	96.8	6	4.5	66.2	2	1.5	58.3	6	4.5	4.075	.253

Note. Degrees of freedom is 3.0.
Note. Mean Ranking (M.R.)
Note. Original question: *How important are the following leading safety performance indicators (SPIs) for reducing ergonomic musculoskeletal disorders (MSDs) in your workplace?*
* $p < .05$

Pairwise comparisons using Dunn-Bonferroni tests were performed (See Table 13). "Part-time" OSH Coordinators had a significantly higher mean ranking than "Full-time" OSH Coordinators (Dunn-Bonferroni = -46.6, $p < .05$); meaning "Part-time" OSH Coordinators placed less importance on *Worker Participation in Management-led Stretch and Flex Exercises* (Survey item Q1.7) than "Full-time" OSH Coordinators. For all other comparisons, the mean ranks were not significantly different.

Table 13

Q1.7 Dunn-Bonferroni Results

	Full-Time OSH Coordinator	Part-Time OSH Coordinator	Human Resources	Other
Full-Time OSH Coordinator (M.R. = 64.6)	-	-	-	-
Part-Time OSH Coordinator (M.R. = 111.2)	- 46.6*	-	-	-
Human Resources (M.R. = 81.8)	-17.1	29.5	-	-
Other (M.R. = 87.8)	23.2	23.4	-6.1	-

Note. Mean Ranking (M.R.)
Note. Original question: *Worker Participation in Management-led Stretch and Flex Exercises*
* $p < .05$

Second, the Kruskal-Wallis test was performed to determine if the mean ranking of how survey respondents scored SPI items differed by their level of education. The data met the assumptions required to complete a valid Kruskal-Wallis test. There were two significant findings in the mean rankings for survey items Q1.1 and Q1.8; Q1.1, *Workers' Perceptions of Top/Line Management Commitment to Ergonomics Safety* (Kruskal-Wallis = 7.86, $p < .05$), and Q1.8, *Ergonomic Losses Investigated for Root Causes Within 24-hours* (Kruskal-Wallis = 8.05, p

<.05). The distributions in each group were determined to have variability; therefore, the mean was sought. The results from the SPI ranking against education level appear in Table 14.

Table 14

Kruskal-Wallis Test – Perceived Importance of Leading Ergonomic SPIs by Education

Question	College degree in safety and health or a related scientific field of study (e.g., engineering or chemistry)			College degree other than safety and health or a related scientific field of study (e.g., engineering or chemistry)			No College Degree			Kruskal-Wallis	*p*
	M.R.	N	%	M.R.	N	%	M.R.	N	%		
Q1.1 - Workers' perceptions of top/line management commitment to ergonomics safety (e.g., safety perception survey)	73.9	82	60.7	63.1	39	28.9	47.2	14	10.4	7.865	.020*
Q1.2 - The number of new hires being trained in ergonomics safety before the assignment of their work duties	65.1	82	60.7	76.8	39	28.9	60.4	14	10.4	3.385	.184
Q1.3 - The number of new hires assigned an OSH mentor to coach them in avoiding the ergonomic hazards of their work duties	67.7	82	60.7	68.6	39	28.9	68.1	14	10.4	.018	.991
Q1.4 - The use of pre-hazard controls to avoid ergonomic hazards (e.g., Prevention through Design [PtD] and/or Management of Change [MoC])	69.6	80	60.2	67.4	39	29.3	51.1	14	10.5	3.665	.160
Q1.5 - The number of job hazard analyses (JHAs) conducted to avoid ergonomic hazards	68.5	82	61.2	70.2	38	28.4	54.3	14	10.4	2.053	.385

Table 14 (*continued*)

Kruskal-Wallis Test – Perceived Importance of Leading Ergonomic SPIs by Education

Question	College degree in safety and health or a related scientific field of study (e.g., engineering or chemistry)			College degree other than safety and health or a related scientific field of study (e.g., engineering or chemistry)			No College Degree			Kruskal-Wallis	*p*
	M.R.	N	%	M.R.	N	%	M.R.	N	%		
Q1.6 - Workers' early reporting of strains/sprains they experience (e.g., ergonomic symptoms survey	67.4	82	60.7	73.9	39	28.9	55.2	14	10.4	3.465	.177
Q1.7 - Worker participation in management-led stretch and flex exercises	71.7	82	61.2	67.3	38	28.4	48.4	14	10.4	4.639	.098
Q1.8 - Ergonomic losses investigated for root causes within 24-hours	69.8	81	60.4	72.1	39	29.1	41.2	14	10.4	8.053	.018*
Q1.9 - Ergonomic improvements implemented	70.0	82	61.2	68.4	38	28.4	50.5	14	10.4	3.944	.139
Q1.10 - Annual audit of the written Ergonomic Management Control Program	70.5	81	60.4	66.5	39	29.1	47.0	14	10.4	5.093	.078

Note. Degrees of freedom is 2.0.
Note. Mean Ranking (M.R.)
Note. Original question: *How important are the following leading safety performance indicators (SPIs) for reducing ergonomic musculoskeletal disorders (MSDs) in your workplace?*
* $p < .05$

Pairwise Comparisons were performed on both of these significant observations. Responding OSH Coordinators with a "College Degree in Safety and Health Degree or a Related Scientific Field of Study" had a significantly higher mean ranking (Dunn-Bonferroni = 26.7, $p < .05$) in valuing *Workers' Perceptions of Top/line Management Commitment to Ergonomics Safety* (Survey item Q1.1) versus respondents with "No College Degree." This means those OSH Coordinators with a "College Degree in Safety and Health Degree or a Related Scientific Field of Study" place less importance on survey item Q1.1 than "No College Degree" respondents. The results are found in Table 15.

Table 15

Q1.1 Dunn-Bonferroni Results

	College Degree in Safety and Health or a Related Scientific Field of Study	Other College Degree	No College Degree
College Degree in Safety and Health or a Related Scientific Field of Study (M.R. = 73.9)	-	-	-
Other College Degree (M.R. = 63.1)	10.7	-	-
No College Degree (M.R. = 47.2)	26.7 *	15.9	-

Note. Mean Ranking (M.R.)
Note. Original question: *Workers' Perceptions of Top/line Management Commitment to Ergonomics Safety*
* $p < .05$

Responding OSH Coordinators classified as "No College Degree" had a significantly lower mean ranking (Dunn-Bonferroni = 28.59, $p < .05$) in scoring the *Ergonomic Losses Investigated for Root Causes Within 24-hours* (Survey item Q1.8) versus respondents with a "College Degree in Safety and Health Degree or a Related Scientific Field of Study" and

respondents with an "Other College Degree." This finding indicates OSH Coordinators classified as having an education level of "No College Degree" placed more importance on survey item Q1.8 than respondents classified as "Other College Degree" and "Safety and Health Degree or a Related Scientific Field of Study." The results are found in Table 16.

Table 16

Q1.8 Dunn-Bonferroni Results

	College Degree in Safety and Health or a Related Scientific Field of Study	Other College Degree	No College Degree
College Degree in Safety and Health or a Related Scientific Field of Study (M.R. = 69.8)	-	-	-
Other College Degree (M.R. = 72.1)	-2.2	-	-
No College Degree (M.R. = 41.2)	28.6 *	30.8 *	-

Note. Mean Ranking (M.R.)
Note. Original question: *Ergonomic Losses Investigated for Root Causes Within 24-hours*
* $p < .05$

Chi-Square for Goodness of Fit Test

The Chi-Square for Goodness of Fit test was used to determine the respondents' perceived difficulties in implementing leading ergonomic SPIs (Survey items Q2.1.1 - Q2.10.10). The data met the assumptions required to complete a Chi-Square for Goodness of Fit test. Eight of the ten leading ergonomic SPIs had significantly different frequencies of responses than expected (See Table 17). Of the options provided, "Lack of Management Support*"* was the most frequently identified barrier to implementing the leading ergonomic SPIs presented in the study. Of interest, "Too Costly" was the least frequently reported barrier to compliance. No

trends were observed with "Other*"* responses. Examples of barriers respondents provided in the Other category included:

1. "Our perception surveys do not include ergo questions."
2. "Measuring perception is very difficult. We focus on removing the hazard."
3. "No ergonomics program."
4. "No interest at higher levels."
5. "We use controls but have not identified this as a metric to track."

Table 17

Chi-Square for Goodness of Fit Test Results - Perceived Difficulties in Implementing Leading Ergonomic SPIs

Question	Too Costly		Too Difficult		Lack of Mgt. Support		New Concept		Other		X^2	*df*	*p*
	N	%	N	%	N	%	N	%	N	%			
Q2.1 - Measuring workers' perceptions of top/line management commitment to ergonomics safety (e.g., safety perception survey)	3	3.0	16	16.3	38	38.8	25	25.5	16	16.3	34.14	5	.000*
Q2.2 - Tracking the number of new hires being trained in ergonomics safety before the assignment of their work duties	5	5.4	11	11.9	26	28.3	26	28.3	24	26.1	20.717	4	.000*
Q2.3 - Tracking the number of new hires assigned an OSH mentor to coach them in avoiding the ergonomic hazards of their work duties	9	7.6	27	22.7	25	21.0	35	29.4	23	19.3	14.992	4	.005*
Q2.4 - Tracking the use of pre-hazard controls to avoid ergonomic hazards (e.g., Prevention through Design [PtD] and/or Management of Change [MoC])	7	9.1	12	15.6	20	25.9	19	24.7	19	24.7	8.390	4	.078
Q2.5 - Tracking the number of job hazard analyses (JHAs) conducted to avoid ergonomic hazards	1	1.4	14	19.2	25	34.2	12	16.4	21	28.8	23.370	4	.000*

Table 17 (*continued*)

Chi-Square for Goodness of Fit Test Results - Perceived Difficulties in Implementing Leading Ergonomic SPIs

Question	Too Costly		Too Difficult		Lack of Mgt. Support		New Concept		Other		X^2	*df*	*p*
	N	%	N	%	N	%	N	%	N	%			
Q2.6 - Measurement of workers' early reporting of strains/sprains they experience (e.g., ergonomic symptoms survey)	3	5.7	9	17.0	19	35.8	8	15.1	14	26.4	14.075	4	.007*
Q2.7 - Measuring worker participation in management-led stretch and flex exercises	4	3.8	16	15.4	33	31.7	16	15.4	35	33.6	32.625	4	.000*
Q2.8 - Measuring ergonomic losses investigated for root causes within 24-hours	5	6.3	15	19.0	24	30.4	16	20.2	19	24.0	12.329	4	.015*
Q2.9 - Measuring ergonomic improvements implemented	8	10.5	10	13.2	20	26.3	21	27.6	17	22.4	9.132	4	.058
Q2.10 - Conducting an annual audit of a written of the written Ergonomic Management Control Program	5	5.2	9	9.4	28	29.2	24	25.0	30	31.2	27.229	4	.000*

Note. Original question: *Over the past three years, has your company utilized the following leading safety performance indicators (SPIs) aimed at reducing ergonomic musculoskeletal disorders (MSDs) in the workplace?*
* $p < .05$

ANOVA Procedure

An overall importance score was calculated for respondents by summing their importance scores for each individual item survey item (Survey items Q1.1 to Q1.10). A one-way ANOVA procedure was attempted to determine if there were significant differences in the overall importance scores based upon the respondents' job classifications. Respondents who elected not to answer all of the articles in this question were excluded from this part of the study by the researcher.

The dependent variable residuals were not approximately normally distributed for each category of the independent variable as determined by the Shapiro–Wilk test and there were significant outliers identified visually using box plots. Therefore, a Kruskal-Wallis Test was performed following the procedures described previously. The resulting Kruskal-Wallis Test was not significant (Kruskal-Wallis = 4.075, $p > .05$). Hence, there were no significant differences in the mean rankings of the overall SPI importance scores based upon job classification (See Table 18).

Table 18

Kruskal-Wallis Test – Average Overall Leading Ergonomic SPI Importance Scores by Job Classification

	Full-Time OSH Coordinator			Part-Time OSH Coordinator			Human Resources			Other			Kruskal-Wallis	*p*
Question	M.R.	N	%	M.R.	N	%	M.R.	N	%	M.R.	N	%		
Q1.1 – Q1.10	66.5	121	89.6	96.8	6	4.4	66.2	2	1.5	58.3	6	4.4	4.075	.253

Note. *Degrees of freedom is 3.0.*
Note. Mean Ranking (M.R.)

CHAPTER FIVE

DISCUSSION AND CONCLUSIONS

Introduction

Leading indicators have been a well-documented component of global SHMSs to evaluate the OSH performance of these management systems. These indicators have been researched in this realm and the field of quality control. However, leading ergonomic SPIs have not been specifically studied for evaluating the effectiveness of EMCPs. The purpose of this study was to evaluate the degree to which leading ergonomic SPIs are valued and utilized, identify the perceived difficulties in implementing leading ergonomic SPIs, and examine the impact the person assigned OSH responsibilities has on the use and importance placed on leading ergonomic SPIs. This research is believed to be the first to study the perceived importance of leading ergonomic SPIs in the evaluation of EMCPs. This research functions as a baseline for the perception and use of leading ergonomic SPIs, and the possible obstacles to implementation faced by today's OSH professionals.

To achieve these goals, an original survey instrument was developed by the researcher to conduct this study. The research instrument was organized around OSHA's seven constructs of an effective ergonomic management framework and resulted in ten leading ergonomic SPIs for respondents to consider in regards to their ranking of importance, the degree of implementation in their workplace, and potential barriers to implementation. The study's variables examined in this research include (a) Perceived SPI importance based on the respondent's use, (b) Perceived SPI importance by the respondent's job classification, (c) Perceived SPI importance by the respondent's education level, (d) Perceived difficulties in implementing SPIs, and (e) Perceived difference in the overall average SPI importance scoring across respondent's job classifications.

Two open-ended questions were used to solicit the respondents' opinions on job classification and barriers to SPI implementation. The researcher surveyed a targeted population of OSH professionals in the United States.

The researcher has presented findings on the perception, utilization, and tracking of leading SPIs to validate the effectiveness of EMCPs. While the degree of ergonomic SPI implementation is the focus of this study, the researcher intends the results will support the global use of leading SPIs for all occupational exposures and the adoption of effective SHMSs.

The remaining chapter is divided into eight sections. The five initial sections address the study's research questions and the researcher's conclusions, including (1) Perceived Importance of Leading Ergonomic SPIs Based Upon Use, (2) Perceived Importance of Leading Ergonomic SPIs by Job Classification, (3) Perceived Importance of Leading Ergonomic SPIs by Education, (4) Perceived Difficulties in Implementing Leading Ergonomic SPIs, and (5) Average Overall Leading Ergonomic SPI Importance Scores by Job Classification. The remaining sections include the Implications for the OSH Profession, Conclusions, and Recommendations for Further Research.

Perceived Importance of Leading Ergonomic SPIs Based Upon Use

The researcher wanted to determine if there were significant differences in the perceived levels of importance of leading ergonomic SPIs based upon whether they were being used or not. To determine this, the researcher examined the perceived importance of each of the SPIs examined in this study and the extent to which they were being used.

Overall, respondents generally scored all of the leading ergonomic SPIs towards the "Very Important" end of the scale. SPIs scored most frequently as "Very Important" were *Workers' Early Reporting of Ergonomic Strains and Sprains They Experience* (Survey item Q1.6

at 68.6 percent), the *Use of Pre-hazard Ergonomic Controls to Avoid Ergonomic Hazards* (Survey item Q1.4 at 59.8 percent), and *Ergonomic Improvements Implemented* (Survey item Q1.9 at 58.5 percent). Almost 60 percent of respondents reported the most often utilized leading ergonomic SPI was the *Measurement of Workers' Early Reporting of Ergonomic Strains and Sprains They Experience* (Survey item Q2.6). However, an area of concern noted by the researcher is that for those who were familiar with the SPIs being tracked in the workplace, approximately 65 percent (Refer to Table 10) of the respondents indicated that for all SPIs examined in this study, they were not being used. This means that using SPIs examined in this study, as a way to improve ergonomics in the workplace, is not a widely accepted practice.

One SPI, the monitoring of the *Number of New Hires Assigned an OSH Mentor to Coach Them in Avoiding the Ergonomic Hazards of Their Work Duties* (Survey item Q1.3), was perceived differently by those who use it versus those who do not. Respondents who use this indicator rated it significantly more important than those who do not (Mann-Whitney $U = 3{,}351$, $p < .05$). It appears that OSH Coordinators value the importance of the mentorship concept due to their knowledge of a positive experience regarding this beneficial, leading ergonomic SPI. The researcher believes this finding could be used to encourage OSH professionals, who have not yet applied the use of mentors in the workplace for orienting new hires to the hazards of MSDs (and other OSH exposures) within their new occupational work setting, to do so.

Contrary to what the researcher expected, nine of the ten proposed leading ergonomic SPIs presented no significant difference in perceived importance ratings versus their use. It appears respondents who do not use the leading ergonomic SPIs examined in this study view them at the same level of importance as the respondents who do. This could mean that while employers who do not use the leading ergonomic SPIs still perceive them just as important as

those who do, they do not use them for reasons other than the perceived importance. The possible reasons why they are not being used will be explored further when discussing the perceived barriers.

Perceived Importance of Leading Ergonomic SPIs by Job Classification

The researcher wanted to determine if there were significant differences in whether the job classifications of the OSH Coordinators would influence their perceived importance of leading ergonomic SPIs. The researcher predicted full-time OSH Coordinators would score the importance of the study's leading ergonomic SPIs higher due to their education and favorable on-the-job experiences. To determine this, the researcher examined the perceived importance of each of the SPIs examined in this study by the job classification of the OSH Coordinator.

Approximately 90 percent (N = 121) of the study respondents classified themselves as "full-time," approximately 4 percent (N = 6) were classified as "part-time," another 4 percent (N = 6) as "other," and approximately 2 percent (N = 2) as "human resources." A significant difference in the mean rankings of the overall SPI importance scores based upon job classification for one of the ten proposed leading ergonomic SPIs was observed. Specifically, "part-time" OSH Coordinators placed less importance on *Worker Participation in Management-led Stretch and Flex Exercises* (Survey item Q1.7) than "full-time" OSH Coordinators (Kruskal-Wallis = 10.88, $p < .05$ and Dunn-Bonferroni = -46.6, $p < .05$). However, due to the overrepresentation of subjects in the "full-time" group and an under-representation of subjects in the remaining three groups, it would not be acceptable to draw any conclusions based on these results.

Perceived Importance of Leading Ergonomic SPIs by Education

The researcher wanted to determine if there were significant differences in how OSH Coordinators would rate their perceived importance of leading ergonomic SPIs, based upon their reported level of education.

Approximately 61 percent (N = 82) of the study's respondents classified themselves as having a "college degree in safety and health or a related scientific field of study," approximately 29 percent (N = 29) classified themselves as having a "college degree other than safety and health or a related scientific field of study," and approximately 10 percent (N = 14) as having "no college degree." This study found there were significant differences in two areas.

First, in valuing *Workers' Perceptions of Top/line Management Commitment to Ergonomics Safety* (Survey item Q1.1), those OSH Coordinators with a college degree (i.e., both "college degree in safety and health or a related scientific field of study" and "college degree other than safety and health or a related scientific field of study") placed less importance on this leading ergonomic SPI than respondents with no degree (Kruskal-Wallis = 7.86, $p < .05$ and Dunn-Bonferroni = 26.7, $p < .05$). The researcher did not expect this outcome. As we factor in their formal college education, perhaps these OSH Coordinators with a college degree may have more knowledge about how to manage an EMCP, and as a result, are more secure in what they are doing and less dependent on management commitment to accomplish their OSH responsibilities. Possibly, OSH Coordinators without a degree lack credibility in some workplaces and are therefore more reliant on their management to accomplish their OSH duties. Additional research would be beneficial to determine why this difference exists.

Regarding the second significant finding, OSH Coordinators, classified as having an education level of "no college degree," placed more importance on the *Ergonomic Losses*

Investigated for Root Causes Within 24-hours (Survey item Q1.8) than the other two educational classifications (Kruskal-Wallis = 8.05, $p < .05$ and Dunn-Bonferroni = 28.59, $p < .05$). Further questions to pursue beyond this study may include whether one education category performs more or less ergonomic loss investigations, thereby allowing that category to become more comfortable with the concept and have positive experiences in viewing the benefits. In addition, perhaps worksites served by non-degreed OSH Coordinators have a loss frequency rate elevated above worksites served by degreed OSH Coordinators, requiring them to conduct these ergonomic loss investigations more frequently. Lastly, perhaps non-degreed respondents are more likely to be part-time, and as such, work out on the floor with greater exposure to workplace hazards. This exposure may produce an appreciation for preventing future loss events via ergonomic loss investigations and root cause analysis. Additional research is required to determine why this difference exists.

Contrary to what the researcher expected, for the remaining leading ergonomic SPIs presented, there were no significant differences in perceived importance ratings by the respondents based upon their education level. The researcher has concluded there is no link between a respondent's education level and what they perceive to be important in relation to the leading ergonomic SPIs presented in this study.

Perceived Difficulties in Implementing Leading Ergonomic SPIs

The researcher wanted to determine if there were significant differences in the perceived difficulties or barriers OSH Coordinators experience in implementing leading ergonomic SPIs. The researcher predicted a majority of the OSH Coordinators would identify a lack of familiarity with the leading ergonomic SPIs (New Concept) and/or the lack of management support due to

the new nature of leading ergonomic SPIs. To determine this, the researcher examined the respondents' perceived barriers to implementation for each of the SPIs scrutinized in this study.

The study's statistical findings did support the researcher's prediction in regards to significant differences in the perceived difficulties or barriers OSH Coordinators experience in implementing leading ergonomic SPIs. The Chi-Square research results determined eight out of the ten leading ergonomic SPIs had significantly different frequencies of responses than expected ($p < .05$). Of the survey's ten SPIs, *Tracking the Use of Pre-hazard Controls to Avoid Ergonomic Hazards* (Survey item Q2.3) and *Measuring Ergonomic Improvements Implemented* (Survey item Q2.9) failed to produce significantly different frequencies of responses.

"Lack of Management Support" was identified as the most frequently selected barrier for four of the eight significantly different leading ergonomic SPIs presented in the study and tied with "New Concept" on a fifth SPI. The percentage of respondents citing lack of management support for these SPIs ranged from 28.3 to 38.8 percent. Theorizing on the impact "Lack of Management Support" may have on respondents' tracking the leading ergonomic SPIs in question, the researcher reviews each of these five designated SPIs. First, "Lack of Management Support" was identified as a leading barrier for the SPI involving the *Measurement of Workers' Perceptions of Top/Line Management Commitment to Ergonomics Safety*. Failure to track this leading ergonomic SPI blinds management from knowing to what extent compliance is achieved. If actually at full compliance, and management does not support the completion of worker OSH perception surveys, the employer may not learn of their workers' positive OSH climate. Unnecessary OSH budgets may then be expended to improve worker perception when such a need does not exist. Further, failure to track this SPI, due to a lack of management support, may hide the resulting fact that no worker OSH perception surveys are conducted. This, in turn, may

fail to warn management of low worker morale and a substandard OSH climate, resulting in poor worker performance and potentially increased the risk for ergonomic losses.

Second, a "Lack of Management Support" was identified as a leading barrier for the SPI involving *Tracking the Number of Job Hazard Analyses (JHAs) Conducted to Avoid Ergonomic Hazards*. Management's decision not to support and track this leading ergonomic SPI bars them from determining the SPI's actual level of compliance within their organization. If JHAs are indeed being produced and tracked, but the employer fails to support the tracking of the number completed, they lose their ability to gain an overall perspective on the connection between JHA completion and their organization's reduction in ergonomic loss cases. If the JHAs are being conducted, and a corresponding reduction in the lagging indicator of recordable ergonomic injuries does not occur, the employer can re-evaluate whether training for those performing the JHAs is adequate to identify ergonomic risk factors and produce effective ergonomic risk treatments. At the other end of the compliance scale, failure to support tracking JHAs has the possible consequence of management's failure to maintain the PDCA cycle of the EMCP and SHMS. For example, management's decision not to allow the completion and annual review of JHAs may thereby fail to accomplish the *Plan* and *Checking* phases of the PDCA loop.

Third, a "Lack of Management Support" was identified as a leading barrier for the SPI involving the *Measurement of Workers' Early Reporting of Strains/Sprains They Experience*. Incidentally, this leading ergonomic SPI was one of the top three SPI's respondents scored as "Very Important" (Refer to Table 9). Determining this SPI's actual level of compliance within a worksite provides management with data for formulating a response to reduce the risk of future ergonomic losses. A lack of management support for tracking the reporting of these early strains and sprains may fail to inform the employer that indeed, early reporting of strains and sprains is

accomplished. Again, if a corresponding reduction in the lagging indicator of recordable ergonomic injuries is not evident, the employer can re-evaluate whether the current employee ergonomic symptoms survey is adequate to identify adverse ergonomic risk factors. If management support for tracking this SPI is not present, and the OSH Coordinator is not tracking early reporting, then the employer would not know if they have ergonomic loss potentials and would be less likely to perform facility-wide ergonomic symptoms surveys in a timely manner. Perhaps instead, their reactionary management decision would dictate waiting for ergonomic loss events to occur and then developing risk treatments to prevent reoccurrence. This posture could result in a significant number of ergonomic loss events that may likely have been identified in the early stages by encouraging workers to report the strains and sprains they experience early in the process.

Fourth, a "Lack of Management Support" was identified as a leading barrier for the SPI involving the *Measurement of Worker Participation in Management-Led Stretch and Flex Exercises*. Failure to track this leading ergonomic SPI prevents the employer from ascertaining whether compliance is accomplished or not. If the employer elects not to support the tracking of this SPI, they lose the ability to make effective OSH decisions. For example, if they are currently in full compliance with tracking their worker participation in the stretch and flex process, yet they fail to track this SPI due to the limited corporate funding of this tracking, they may not observe that only 32 percent of their workers are participating. At the other end of the spectrum, the consequence of management's failure to support the tracking of this SPI could hide from their view that their middle management refuses to take on the *leader* role for these stretch and flex exercises. Such an attitude can send a negative signal into the workforce that the stretch and flex program, the EMCP, and the company's OSH efforts overall exist only for the

production personnel and are unimportant to the management levels. This management attitude can poison an organization's OSH climate and may result in additional occupational risk and unneeded ergonomic loss events.

Fifth, "Lack of Management Support" tied with "New Concept" as leading barriers for the SPI involving *Tracking the Number of New Hires Being Trained in Ergonomics Safety Before the Assignment of Their Work Duties*. Without tracking this SPI, employers could be unaware of their level of compliance. If the lack of management support prevents this tracking, management may not be informed that indeed, their new hires are being trained in ergonomics safety before the assignment of their work duties. If a reduction in the worksite's recordable ergonomic injuries does not then correspond with the successful training of new hires in ergonomic safety, and SPI tracking does not occur, management may then lose the potential to reach a conclusion that an audit and evaluation of the effectiveness of their ergonomic training curriculum is warranted. Subpar ergonomics training for new hires could thereby persist and result in unacceptable risk for additional ergonomic losses. From the standpoint of noncompliance, the consequence of management's failure to track this SPI could present a misconception that new hire training is being provided, when indeed it is not provided. This outcome may result in an elevated number of new hires complaining of ergonomic-related injuries.

The above results, addressing the lack of management support, mirror the findings from the researcher's literature review on the importance of top/middle management support and commitment for OSH efforts (UL, 2013) and support the researcher's posit that a lack of management support would be identified as a primary barrier.

"Other" was the most frequently selected barrier by respondents for two of the eight significantly different leading ergonomic SPIs presented in the study. The percentage of respondents citing "Other" for these SPIs ranged from 31.2.5 to 33.6 percent. "Other" was identified as a leading barrier for the SPI involving tracking the *Measurement of Worker Participation in Management-Led Stretch and Flex Exercises*. OSH Coordinators' individual responses to the open-ended question presented to them on answering "Other," included (a) "We have not identified this as a metric to track." (b) "Forced, Loss of voluntary participation." (c) "Participation is yes or no. If no, then make it yes. Soon participation is all yes." (d) "Considered ineffective." (e) "Not done currently." (f) "No Ergonomics Program." From these independent responses, the researcher in not able to identify any usable trends.

"Other" was also identified as a leading barrier for the SPI involving the *Conducting of an Annual Audit of the Written EMCP*. OSH Coordinators' individual responses to the open-ended question presented to them on answering "Other," included (a) "Ergo is addressed in our Site S&H Management Plan. It is not a separate program. Elements of the site plan are audited. Ergo would not be on an annual basis." (b) "No formal program exists." (c) "No Ergonomics Program." These three specific responses appear to identify the absence of an EMCP as a barrier to implementation. The researcher states here the obvious: An EMCP must exist if a leading ergonomic SPI is to be developed and tracked for the annual audit of same. The researcher recognizes a flaw in the study that should be addressed for further research. The respondents should be asked first if they have the SPI-targeted ergonomic programming in place (e.g., Do you have a written EMCP in place?). Then, they should be asked if they measure it using leading ergonomic SPIs.

"New Concept" was identified as a leading barrier for the SPI involving *Tracking the Number of New Hires Assigned an OSH Mentor to Coach Them in Avoiding the Ergonomic Hazards of Their Work Duties*. The lack of knowledge regarding this SPI may prevent the employer from determining whether their use of OSH mentors is being implemented effectively. Management may thereby lose their ability to determine that a lack of familiarity with mentoring programs, or the successes being realized, may prevent its full utilization by all departments. Failure to track this SPI may result in an employer's inability to identify possible zero compliance with ergonomics mentoring. Digging deeper, management may determine their OSH Coordinator lacks a perceived value in the importance of mentorship due to his/her lack of familiarity with the concept regarding this beneficial, leading ergonomic SPI.

The barrier "New Concept" tied with "Lack of Management Support" for the SPI involving *Tracking the Number of New Hires Being Trained in Ergonomics Safety Before the Assignment of Their Work Duties*. A lack of familiarity about this leading ergonomic SPI may have it off the OSH Coordinator's radar of SPIs to track. The result would be the absence of information as to whether new hires are being trained in ergonomics safety before the assignment of their work duties, or not. If the ergonomics training is indeed being conducted, and the employer fails to track and record this success, they may lose the opportunity to draw an association between this new hire training and their ergonomic losses. The absence of tracking this SPI could hide the fact that the employer is not conducting this training in a timely manner.

Overall, this "New Concept" finding supports the researcher's opinion that a lack of familiarity with the topic of leading ergonomic SPIs would be one identified as a primary barrier to implementation. Educating today's OSH professionals on the benefits, design, and

implementation of leading ergonomic SPIs, in both the academic and non-traditional educational spheres, could produce a positive change and increased SPI use.

"Too Costly*"* was the least frequently selected barrier for the eight significant leading ergonomic SPIs presented in the study. These SPIs included (1) *Measurement of Workers' Perceptions of Top/Line Management Commitment to Ergonomics Safety*, (2) *Tracking the Number of New Hires Being Trained in Ergonomics Safety Before the Assignment of Their Work Duties*, (3) *Tracking the Number of New Hires Assigned an OSH Mentor to Coach Them in Avoiding the Ergonomic Hazards of Their Work Duties*, (4) *Tracking the Number of Job Hazard Analyses (JHAs) Conducted to Avoid Ergonomic Hazards*, (5) *Measurement of Workers' Early Reporting of Strains/Sprains They Experience*, (6) *Measurement of Worker Participation in Management-Led Stretch and Flex Exercises*, (7) *Measuring Ergonomic Losses Investigated for Root Causes Within 24-hours*, and (8) *Conducting of an Annual Audit of the Written EMCP*. The researcher sees this on a positive note. The researcher finds when working in the profession that indeed, implementing and tracking leading SPIs involves a minor cost to the employer. Yet these SPIs have the potential to reap significant rewards in terms of reduced risk and reduced loss events.

The study found significant differences in the perceived difficulties or barriers OSH Coordinators experience in implementing leading ergonomic SPIs. Specifically, the barrier of "Lack of Management Support" should be granted attention by OSH Coordinators as they assemble their OSH Performance Measurement Programs and begin developing their leading ergonomic SPIs. Failure to avoid this common barrier to SPI implementation may risk the success of the SPI, and ultimately the success of the specific OSH effort it is tracking.

Average Overall Leading Ergonomic SPI Importance Scores by Job Classification

The researcher wanted to determine if there were significant differences in the overall average leading ergonomic SPI importance scores by the OSH Coordinators' job classification. The researcher predicted full-time OSH Coordinators would present consistently higher average overall scores of the leading ergonomic SPIs than the other three job classifications due to their education and favorable on-the-job experiences. To determine this, the researcher summed the perceived importance ratings of each of the SPIs examined in this study and then compared the means across the job classifications.

As was the case with the previous Kruskal-Wallis test involving job classifications, there was an overrepresentation of subjects in the "Full-Time OSH Coordinator" group and an under-representation of subjects in the remaining three groups. Therefore, it would not be acceptable to draw any conclusions based on these results. This may be prevented in the future by completing a stratified random sampling of a set number of respondents from each category.

Implications for the OSH Profession

Due to the significance of ergonomic loss potentials in the occupational setting, which may occur due to a failure to implement effective ergonomic risk treatments characteristically provided in an EMCP, the researcher thought it prudent to investigate how to improve the utilization of leading ergonomic SPIs to evaluate the effectiveness of EMCPs and thereby potentially reduce ergonomic loss events. The researcher now suggests the OSH profession increase their application of the leading ergonomic SPIs presented in this study, being mindful of the barriers to implementation that were addressed – primarily a lack of management support.

Approximately two-thirds of the companies participating in this study do not use leading ergonomic SPIs. Leading SPIs have a proven history of evaluating the effectiveness of SHMSs

to reduce risk (Manuele, 2014a; Peterson, 2005; and UL, 2013). Since EMCPs are a component of comprehensive SHMSs, the researcher believes the use of leading SPIs would be productive in evaluating the efficacy of EMCPs. This lack of leading SPI application may stem from the lack of familiarity of leading ergonomic SPIs, a lack of research or published articles on the topic, the absence of management support to implement leading SPIs at the worksites surveyed, an entrenched use of lagging indicators, or a combination of the prior listed. The researcher encourages additional research and education on the benefits of leading SPIs to increase their use in the OSH profession and within the nation's worksites.

OSH Coordinators responding to the research survey generally valued the leading ergonomic SPIs presented in this study with a level of importance in reducing MSDs despite their minimal degree of implementation in the workplace. This favorability is encouraging and reflects the OSH profession's positive view of ergonomic SPIs. This encouraging impression of leading SPIs, in concert with additional research and education on the benefits of leading SPIs, should increase the degree of leading SPI implementation.

Lack of management support was identified as a major barrier to implementing the use of leading ergonomic indicators. Management's failure to support ergonomic SPIs, and even other general OSH issues, can damage an employer's OSH climate. "People tend to use their leaders as models… wanting to please their leaders, and do so by following their behavioral example." (Bird et al., 2003, p. 46) Management commitment is a requirement of the major SHMS schemes, and its absence will result in a struggle to achieve risk reduction (ANSI, 2012; BSI, 2007; ILO, 2001; ISO, 2014; and OSHA, 2016). The OSH profession should increase the awareness of their management to the applicability and benefits for leading ergonomic SPIs at their worksite. "Ultimately, the responsibility is with OHS professionals to equip senior

management with the knowledge about leading SPIs in order to increase their awareness, support, and commitment to conducting rigorous evaluations of OHS performance" (Janicak, 2015, p. 47 and Sinelnikov, Inouye, and Kerper, 2015).

This research demonstrated that cost was the least frequently identified barrier to implementing the leading ergonomic SPIs presented in this study. Therefore, the researcher encourages the OSH profession that the perception of cost concerns should not deter OSH professionals from pursuing leading SPIs. We comprehend OSH professionals must understand and function within the charge given to their top management – whereas economic performance is the first responsibility of their business (Manuele, 2013). Fortunately, the cost of implementing leading ergonomic SPIs is minimal and is far outweighed by the potential benefits of reduced or eliminated risk of ergonomic or lesser loss events.

Lack of familiarity with the topic of leading ergonomic SPIs (New Concept) was also identified as a barrier to implementation. In the absence of education, we have ignorance. In the field of OSH, failure to educate our affected line personnel adequately on the hazards and risk treatments of their occupations can produce disastrous results. Likewise, failure to educate the OSH professional in ergonomics, EMCPs, SHMSs, and leading SPIs could create situations in which EMCPs and SHMSs operate at less than peak efficiency, resulting in "missed opportunities" and possible loss events. More research, published articles, and education on leading ergonomic SPIs is recommended.

Conclusions

The literature has shown using leading SPIs has a proven history of evaluating the effectiveness of SHMSs to reduce risk (Manuele, 2014a; Peterson, 2005; and UL, 2013). This study examined the perceived importance and implementation of SPIs related to ergonomics in

the workplace and identified three major findings. First, for those OSH coordinators who do use leading ergonomic SPIs, they generally perceive them as being valuable. Second, the use of leading ergonomic SPIs in the workplace is not a widely accepted practice. Third, a lack of management commitment and a lack of knowledge of leading ergonomic SPIs are commonly perceived barriers to their implementation.

While the subject matter may be relatively new to many OSH Coordinators, there is already a groundswell of understanding of the topic as demonstrated by the respondents participating in this study and the topic's growing presence in OSH literature. The researcher believes this groundswell is driven by current SHMS requirements for program evaluation within the primary SHMS certification schemes utilized by major employers. At the time of this research, five out of the five top-favored SHMS models promote the use of leading indicators to evaluate and predict OSH performance (ANSI, 2012; BSI, 2007; ILO, 2001; ISO, 2014; and OSHA, 2016). The researcher believes the growing pressure of OSH expectations on employers from the supply chain, and the imminent release of ISO 45001, will result in the increased use of leading ergonomic SPIs by the OSH profession. Because EMCPs are a component of comprehensive SHMSs, the researcher believes the use of leading SPIs would be effective in evaluating the effectiveness of EMCPs.

Further educating today's OSH professionals in the benefit, design, and implementation of leading SPIs, in both the academic and non-traditional educational spheres, will produce positive change for increased SPI usage. The researcher believes this research has value to the OSH professional as we prepare for the coming decade of a risk-based approach utilizing SHMS and leading SPIs, and observe a departure from a regulation-focused approach. OSH professionals in the future will need the analytical abilities required to manage an OSH

performance measurement program, and the academic community will need to develop OSH curricula that include material pertaining to leading SPIs. The curricula should also include strategies that can be used to overcome the lack of management commitment to using these measures. Ultimately, an effort such as this may encourage more use of leading ergonomic SPIs and further integration of SPIs into organizations' SHMSs.

"To best improve safety performance, an emphasis should be placed on leading indicators" (Janicak, 2015, p. 50). The researcher believes this study and its findings will supplement the growing body of OSH knowledge in regards to leading SPIs, the potential barriers to their implementation, and suggested methods for increasing their use. Through this end, we can achieve our mutual, professional goal of reducing risk and achieving zero losses.

Recommendations for Further Research

The author recommends further research on this topic for broadening the study's theme of applying leading SPIs within the OSH profession. Specifically, the researcher recommends the following:

1. The respondents should be asked first if they are using the ergonomic SPIs. Then they should be asked if they measure them using leading SPIs.
2. The study should be expanded beyond ergonomics to address FSI potential exposures. The researcher suggests this option in order to apply effectively, what are often limited OSH dollars, to risk treatments influencing the highest risk exposures. Leading SPIs will aid the OSH professional in achieving the greatest return on his/her employer's investment in FSI-potential exposures.
3. The study should be conducted using the added dependent variable of ergonomic loss case rate (ELCR). The researcher posits worksites that rank leading ergonomic SPIs as "Very

Important," and are implementing them - will produce a lower ELCR than worksites that do not. This has the potential to provide valuable economic benefits to employers from using leading ergonomic SPIs.

4. The study should be expanded beyond ergonomics to address certified SHMS, perhaps ISO 45001, and thereby add to the growing body of OSH knowledge on the broader field benefits of effective SHMSs. Further integration of leading SPIs into the OSH profession will naturally lead to the organic growth of SHMS usage. The researcher posits the increased utilization of certified SHMSs throughout the United States, and the world, will have a profound impact on reducing occupational risk and related loss events.
5. The researcher recommends utilizing respondents' NAICS codes to establish whether there is a significant difference between the perceived value and use of leading ergonomic SPIs and industry groups.
6. There was an overrepresentation of subjects in the "Full-Time OSH Coordinator" group and an under-representation of subjects in the remaining three groups. This would be prevented using a stratified random sampling technique and sampling of a set number of respondents from each category.
7. The study should be expanded to include a variable that measures the risk for MSDs. This would allow the researcher to compare high-risk sites to low-risk sites. This will permit the researcher to determine if there is a significant difference in the perceived value and use of leading ergonomic SPIs when comparing high-risk MSD worksites to low-risk MSD worksites.

References

ANSI (American National Standards Institute). (2012). *ANSI Z10-2012 Occupational Health and Safety and Health Management Systems standard (OHSMS).* Retrieved from http://www.asse.org/ansiaihaasse-z10-2012-occupational-health-safety-management-systems/ansi/aiha/asse-z10-2012-occupational-health-and-safety-management-systems/.

ASSE. (2013). *Tech Brief: ANSI/ASSE Z10-2013 - Updated Information*. Retrieved from http://www.safetybok.org/tech_brief__ansiasse_z10-2013_%E2%80%93_updated_information.

ASSE. (2016). *ASSE: About Us*. Retrieved from http://www.asse.org/about.

Baldauf, J. (2010). *Measuring Safety Performance: What are KPIs*. *EHS Journal, 13(10),* Retrieved from http://ehsjournal.org/http:/ehsjournal.org/jan-baldauf/measuring-safety-performance-kpis/2010.

Bird, F., Germain, G., & Clark, D. (2003). *Loss control management: Practical loss control leadership*. (Third ed.). Deluth, Georgia: Det Norske Veritas (USA), Inc.

Blair, E., & O'Toole, M. (2010). Leading measures: Enhancing safety climate and driving safety performance. *Professional Safety, 55*(8), 29-34.

BCSP (Bureau of Certified Safety Professionals). (2016). *BCSP Safety Certifications*. Retrieved from http://www.bcsp.org/Certifications/Safety-Certifications-At-A-Glance.

BLS (Bureau of Labor Statistics). (2016). *Work-Related Injuries and Illnesses with MSDs in 1992-2010*. Retrieved from http://www.boneandjointburden.org/docs/resize/G6B.1.1-481x401.png.

BSI (British Standards Institute). (2007). OHSAS 18001-2007 Occupational Health and Safety Assessment Series (OHSAS). Retrieved from https://www.bsigroup.com/en-US/OHSAS-18001-Occupational-Health-and-Safety/.

BSI. (2016). *ISO 45001 Whitepaper, ISO Revisions, A new international standard for Occupational Health and Safety Management Systems*. Retrieved from http://www.bsigroup.com/LocalFiles/en-GB/iso-45001/Resources/BSI-ISO45001-Revision-Whitepaper-EN-UK.pdf.

Campbell Institute/National Safety Council. (2013). *Transforming EHS Performance Measurement Through Leading Indicators*. White paper presented at the 2013 National Safety Council's Congress & Expo in Chicago, IL. Retrieved from http://www.cos-mag.com/safety/safety-stories/3595-8-characteristics-of-successful-leading-indicators-revealed-campbell-institute.html?print=1&tmpl=component.

CCPS (Center for Chemical Process Safety). (2011). *Process Safety Leading and Lagging Metrics: You Don't Improve What You Don't Measure*. Retrieved from https://www.aiche.org/sites/default/files/docs/pages/CCPS_ProcessSafety_Lagging_2011 2-24.pdf.

CDC (Centers for Disease Control). (2016). *Ergonomics and Musculoskeletal Disorders*. Retrieved from http://www.cdc.gov/niosh/topics/ergonomics.

Daniels, D. (2015). *Safety & Health: Performance Metrics - The Value of Leading AND Lagging Indicators*. Retrieved from www.iafc.org/on-scene/on-scene-article/safety-health-performance-metrics-the-value-of-leading-and-lagging-indicators#sthash.YtNiI3u9.dpuf.

Fernández-Muñiz, B., Montes-Peón, Jose., & Vázquez-Ordás, C. (2012). *Safety climate in OHSAS 18001- certified organizations: Antecedents and consequences of safety behavior. Elsevier: Accident Analysis and Prevention. 45(12),* 745-758. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/22269566.

FMS (Federation of Management Systems). (2014). *The Definitive Guide to ISO 45001:2016*. Retrieved from https://www.prlog.org/12297585-the-definitive-guide-to-iso-450012016-published-by-fms.html.

Heim, B. (2015). *Developing effective leading and lagging safety and health objectives*. PowerPoint presented at the 2015 Minnesota Safety & Health Conference in Saint Paul, Minnesota.

Hohn, J. (2016). *Applying Leading and Lagging Indicators to Workplace Safety Programs*. Retrieved from http://www.workplacemagazine.com/Ezine/FullStory.aspx?EzineDataID=2404.

HSE (Health and Safety Executive). (2006). *Developing process safety indicators: A step-by-step guide for chemical and major hazard industries*. Retrieved from http://www.hse.gov.uk/pubns/books/hsg254.htm.

ICMM (International Council on Mining and Metals). (2012). *Overview of leading indicators for occupational health and safety in mining*. Retrieved from http://hub.icmm.com/document/4800.

ILO (International Labour Organization). (2001). *Guidelines on occupational safety and health management systems*. ILO-OSH-2001. Retrieved from http://www.ilo.org/safework/info/standards-and-instruments/WCMS_107727/lang--en/index.htm.

ILO. (2016). *International Occupational Safety and Health Knowledge Network*. Retrieved from http://www.ilo.org/safework/cis/lang--en/index.htm.

ISO (International Organization for Standardization). (2014). *ISO 45001 Occupational health and safety management systems*. Retrieved from http://www.iso.org/iso/iso45001.

ISO. (2015a). *ISO 45001 OHSMS briefing notes*. Retrieved from http://www.iso.org/iso/iso_45001_briefing_note.pdf.

ISO. (2015b). *ISO 9001:2015 Quality management systems*. Retrieved from https://www.iso.org/news/2015/09/Ref2002.html.

ISO. (2015c). *ISO 14001:2015 Environment management systems*. Retrieved from https://www.iso.org/iso-14001-revision.html.

IUP (Indiana University of Pennsylvania). (2012). *Fatality Prevention Forum*. Retrieved from http://www.iup.edu/safetysciences/events/fatality-forum.

Janicak, C. (2010). *Safety metrics: Tools and techniques for measuring safety performance*. (Second ed.). Lanham, MD: Government Institutes.

Janicak, C. (2015). *Safety metrics: Tools and techniques for measuring safety performance*. (Third ed.). Lanham, MD: Bernan Press.

Janicak, C., & Ferguson, L. (2009). *Integrating Safety Performance Measures into the Safety Management System*. ASSE Session #712. Retrieved from http://www.safetybok.org/integrating_safety_performance_measures_into_the_safety_management_system.

Kaufman, J. (2009). *Leading indicators point the way*. Retrieved from http://www.ishn.com/articles/88257-leading-indicators-point-the-way.

Laerd Statistics. (2016a). *Descriptive and Inferential Statistics*. Retrieved from https://statistics.laerd.com/statistical-guides/descriptive-inferential-statistics.php.

Laerd Statistics. (2016b). *Mann-Whitney U Test using SPSS Statistics*. Retrieved from https://statistics.laerd.com/spss-tutorials/mann-whitney-u-test-using-spss-statistics.php.

Laerd Statistics. (2016c). *Kruskal-Wallis Test using SPSS Statistics*. Retrieved from https://statistics.laerd.com/spss-tutorials/kruskal-wallis-h-test-using-spss-statistics.php.

Laerd Statistics. (2016d). *Chi-Square Goodness-of-Fit Test in SPSS Statistics*. Retrieved from https://statistics.laerd.com/spss-tutorials/chi-square-goodness-of-fit-test-in-spss-statistics.php.

Laerd Statistics. (2016e). *ANOVA Test using SPSS Statistics*. Retrieved from https://statistics.laerd.com/spss-tutorials/one-way-anova-using-spss-statistics.php.

Lopez, G. (2006). *The paradigm shift in standards thinking: Management systems versus specification*. ASSE 2007 professional development conference white paper. Retrieved from http://www.safetybok.org/the_paradigm_shift_in_standards_thinking__management_systems_versus_specification.

Manuele, F. (2006). ANSI/AIHA Z10-2005: The new benchmark for safety management. *Professional Safety, 51(2),* 25-33.

Manuele, F. (2009). Leading & Lagging Indicators: Do they add to the practice of safety? *Professional Safety, 54(12),* 28-33.

Manuele, F. (2013). *On the Practice of Safety*. (Fourth ed.). Hoboken, NJ: John Wiley & Sons.

Manuele, F. (2014a). *Advanced Safety Management: Focusing on Z10 and Serious Injury Prevention*. (Second ed.). Hoboken, NJ: John Wiley & Sons.

Manuele, F. (2014b). ANSI/AIHA/ASSE Z10-20112: An overview of the occupational health & safety and health management systems standard. *Professional Safety, 59(4),* 44-51.

Middlesworth, M. (2014). *A short guide to leading and lagging indicators of safety performance*. Retrieved from http://ergo-plus.com/leading-lagging-indicators-safety-performance.

Morrison, M. (2015). *Health and Safety Key Performance Indicators – Sample KPI's*. Retrieved from https://rapidbi.com/SampleKeyPerformanceIndicatorsKPI/#HealthandSafetyKPIexamples.

Mors, T. (2013). *ISO 45001 – new occupational health and safety management standard. EHS Journal, 12(13),* Retrieved from http://ehsjournal.org/http:/ ehsjournal.org/terry-a-mors/iso-45001-new-occupational-health-and-safety-management-standard/2013.

OGP (International Association of Oil & Gas Producers). (2013). *OGP safety performance indicators 2012 data*. Retrieved from http://www.ogp.org.uk/pubs/2012s.pdf.

OSHA (Occupational Safety and Health Administration). (1993). *Ergonomics Program Management Guidelines for Meatpacking Plants*. Retrieved from https://www.osha.gov/Publications/OSHA3123/3123.html.

OSHA. (2000). *Presentation to the Subcommittee on Employment, Safety, and Training of the Senate Health, Education, Labor and Pensions Committee*. Retrieved from https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=TESTIMONIES&p_id=166.

OSHA. (2003). *Final Rule: 1904 Occupational Injury and Illness Recording and Reporting Requirements*. Retrieved from https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=17881.

OSHA. (2010). *Injury and Illness Prevention Program (I2P2)*. Retrieved from https://www.osha.gov/dsg/topics/safetyhealth.

OSHA. (2012). *Injury and illness prevention programs: White paper*. Retrieved from https://www.osha.gov/dsg/InjuryIllnessPreventionProgramsWhitePaper.html.

OSHA. (2013a). *Commonly used statistics*. Retrieved from https://www.osha.gov/oshstats/commonstats.html.

OSHA. (2013b). *Prevention of Musculoskeletal Injuries in Poultry Processing*. Retrieved from https://www.osha.gov/Publications/OSHA3213.pdf.

OSHA. (2013c). *Success with VPP*. Retrieved from https://www.osha.gov/dcsp/vpp/success_stories.html.

OSHA. (2014). *Injury and illness prevention programs*. Retrieved from https://www.osha.gov/dsg/topics/safetyhealth/states.html.

OSHA. (2015). *Safety and Health Topics: Ergonomics*. Retrieved from https://www.osha.gov/SLTC/ergonomics/index.html.

OSHA. (2016). *Safety and Health Program Management Guidelines*. Retrieved from https://www.osha.gov/shpmguidelines/SHPM_guidelines.pdf.

Peterson, D. (2005). *Measurement of Safety Performance*. (First ed.). Des Plaines, IL. American Society of Safety Engineers.

Schultz, G. (2012). *Don't Investigate Safety Incidents… Predict and Prevent Them*! *EHS Today*. *6(12).* Retrieved from http://ehstoday.com/safety/don-t-investigate-safety-incidents-predict-and-prevent-them.

Sinelnikov, S, Inouye, J, & Kerper, S. (2015). Using leading indicators to measure occupational health and safety performance. *Safety Science. 72(15),* 240-248.

Smith, S. (2012a). *ANSI Z10-2012 standard provides the blueprint to create an OSH management system*. *OSH Today*. *9(12),* 1-2. Retrieved from http://ehstoday.com/consensus/ansi-z10-2012-standard-provides-blueprint-create-ehs-management-system-0.

Smith, S. (2012b). *Caterpillar: Using Proactive Leading Indicators to Create World-Class Safety*. *ESH Today*. *9(12),* 1-2. Retrieved from http://ehstoday.com/safety/caterpillar-using- proactive-leading-indicators-create-world-class-safety.

Telogis. (2015). *Lagging or leading – What safety indicators does your fleet use?* Retrieved from www.telogis.com/blog/lagging-leading-safety-indicators-fleet.

Toellner, J. (2001). Improving Safety & Health Performance: Identifying & Measuring Leading Indicators. *Professional Safety, 46(9),* 42-47.

UL (Underwriters Laboratories). (2013). *UL White Paper: Using Leading and Lagging Safety Indicators to Manage Workplace Health and Safety Risk*. Retrieved from http://library.ul.com/wp-content/uploads/sites/40/2015/02/UL_WP_Final_Using-Leading-and-Lagging-Safety-Indicators-to-Manage-Workplace-Health-and-Safety-Risk_V7-LR1.pdf.

Wachter, J. (2012). Trailing Safety Indicators: Enhancing Their Value Through Statistics. *Professional Safety*. *57(4),* 48-53.

Walter, L. (2011). *ASSE share views, support on OSHA's I2P2 standard*. *NSMS Digest. (9),11*, Retrieved from www.nsms.us/pdf/2011/d1103.pdf.

WHO (World Health Organization). (2016). *Occupational health*. Retrieved from http://www.wpro.who.int/topics/occupational_health/en.

Zwetsloot, G. (2016). *Key performance indicators*. Retrieved from https://oshwiki.eu/wiki/Key_performance_indicators.

Appendix A

Opening Paragraph for ASSE Email Request to Participate

Greetings OSH Professionals:

The American Society of Safety Engineers (ASSE) has been most generous to forward you this request to participate in my brief research survey pertaining to the use of leading safety performance indicators in the occupational safety and health (OSH) field. My name is Fred Straub, and I am a graduate student in the Ph.D. program at the Indiana University of Pennsylvania (IUP). I am requesting your valued participation because of your involvement with ASSE and your important role in the OSH field.

Please open the research survey link below to access the Qualtrics survey from the Applied Research Lab at IUP. Kindly review the research purpose, follow the short survey directions and proceed to answer the five questions in this research study. Please remember to click on the *SUBMIT* button when you are finished so your appreciated response can be registered with the IUP Applied Research Lab and included in the research.

THIS PROJECT HAS BEEN APPROVED BY THE INDIANA UNIVERSITY OF PENNSYLVANIA INSTITUTIONAL REVIEW BOARD FOR THE PROTECTION OF HUMAN SUBJECTS (PHONE 724.357.7730).

On behalf of myself and the Safety Sciences Department at IUP, I thank you.

Blessings,
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Appendix B

Quantitative Research Survey Instrument

Purpose: The purpose of this research survey is to evaluate three aspects of leading safety performance indicators (SPIs) for reducing musculoskeletal disorders (MSDs): (1) their perceived importance, (2) their degree of implementation in the workplace, and (3) the perceived reason for difficulty in implementing leading ergonomic SPIs. Results will be tabulated and analyzed against the respondents' occupational safety and health (OSH) role. This survey should be completed by the person responsible for administering the OSH ergonomic activities at the worksite. Only one survey response will be accepted from each user.

Instructions: This research survey consists of five primary questions. The survey should take approximately nine minutes to complete. **All information will be kept anonymous, participation is voluntary, and results are not tracked back to the person or company providing the submission**. You may withdraw from the survey at any time during the completion process, and your data will be discarded. To withdraw from the survey, simply close the web browser before submitting your responses. If you happen to be interrupted or closed out of the browser, simply follow the link again to pick back up where you left off.

For the first question series, using a scale of 1 through 5, where 1 means *Very Important,* and 5 means *Not At All Important*; kindly complete the first question series and tell us how important each of the ten targeted leading ergonomic SPIs is to **you** in reducing MSDs.

For the second question series, please answer either *Yes* or *No* or *Do Not Know* as to whether the ten targeted SPIs have been utilized at your workplace over the past three years. Each of the second question series has a follow-up question if you answered NO, asking you to provide your perception of why it is difficult to implement that leading ergonomic SPI in your worksite. Possible answers to this follow-up question include *Too Costly, Too Difficult to Implement, Lack of Management Support, New Concept – Not Known Prior,* or *Other*. Please select only one best response.

The third question asks you to provide your employer's North American Industrial Classification System (NAICS) code. The fourth question allows you to select one of four classifications that best describes your occupational safety and health (OSH) role within your organization. Lastly, the fifth and final question allows you to select one of three classifications describing your education.

Please remember to click on the SUBMIT button when you are finished to register your responses with the IUP Applied Research Lab. Survey responses may not be withdrawn once they are submitted, as we have no way of identifying them in an anonymous data set.

We sincerely appreciate you participating in this research. Interested persons may obtain the study's results by emailing the researcher at F.D.Straub@iup.edu after May 15, 2017.

1. *How important are the following leading safety performance indicators (SPIs) for reducing ergonomic musculoskeletal disorders (MSDs) in your workplace?*

1.	Workers' perceptions of top/line management commitment to ergonomics safety (*e.g., safety perception survey*)	**1** Very Important	2	**3** Neutral	4	**5** Not At All Important
2.	The number of new hires being trained in ergonomics safety before the assignment of their work duties	**1** Very Important	2	**3** Neutral	4	**5** Not At All Important
3.	The number of new hires assigned an OSH mentor to coach them in avoiding the ergonomic hazards of their work duties	**1** Very Important	2	**3** Neutral	4	**5** Not At All Important
4.	The use of pre-hazard controls to avoid ergonomic hazards (*e.g., Prevention through Design [PtD] and/or Management of Change [MoC]*)	**1** Very Important	2	**3** Neutral	4	**5** Not At All Important
5.	The number of job hazard analyses (JHAs) conducted to avoid ergonomic hazards	**1** Very Important	2	**3** Neutral	4	**5** Not At All Important
6.	Workers' early reporting of strains/sprains they experience (*e.g., ergonomic symptoms survey*)	**1** Very Important	2	**3** Neutral	4	**5** Not At All Important
7.	Worker participation in management-led stretch and flex exercises	**1** Very Important	2	**3** Neutral	4	**5** Not At All Important
8.	Ergonomic losses investigated for root causes within 24-hours	**1** Very Important	2	**3** Neutral	4	**5** Not At All Important
9.	Ergonomic improvements implemented	**1** Very Important	2	**3** Neutral	4	**5** Not At All Important
10.	Annual audit of the written Ergonomic Management Control Program	**1** Very Important	2	**3** Neutral	4	**5** Not At All Important

2. *Over the past three years, has your company utilized the following leading safety performance indicators (SPIs) aimed at reducing ergonomic musculoskeletal disorders (MSDs) in the workplace?*

1.	Measuring workers' perceptions of top/line management commitment to ergonomics safety (*e.g.*, *safety perception survey*) If NO, then please select the single best reason □ Too Costly □ Too Difficult to Implement □ Lack of Management Support □ New Concept – Not Known Prior □ Other: _____	Yes	No	Do Not Know
2.	Tracking the number of new hires being trained in ergonomics safety before the assignment of their work duties If NO, then please select the single best reason □ Too Costly □ Too Difficult to Implement □ Lack of Management Support □ New Concept – Not Known Prior □ Other: _____	Yes	No	Do Not Know
3.	Tracking the number of new hires assigned an OSH mentor to coach them in avoiding the ergonomic hazards of their work duties If NO, then please select the single best reason □ Too Costly □ Too Difficult to Implement □ Lack of Management Support □ New Concept – Not Known Prior □ Other: _____	Yes	No	Do Not Know
4.	Tracking the use of pre-hazard controls to avoid ergonomic hazards (*e.g.*, *Prevention through Design [PtD] and/or Management of Change [MoC]*) If NO, then please select the single best reason □ Too Costly □ Too Difficult to Implement □ Lack of Management Support □ New Concept – Not Known Prior □ Other: _____	Yes	No	Do Not Know
5.	Tracking the number of job hazard analyses (JHAs) conducted to avoid ergonomic hazards If NO, then please select the single best reason □ Too Costly □ Too Difficult to Implement □ Lack of Management Support □ New Concept – Not Known Prior □ Other: _____	Yes	No	Do Not Know
6.	Measurement of workers' early reporting of strains/sprains they experience (*e.g.*, *ergonomic symptoms survey*) If NO, then please select the single best reason □ Too Costly □ Too Difficult to Implement □ Lack of Management Support □ New Concept – Not Known Prior □ Other: _____	Yes	No	Do Not Know

7.	Measuring worker participation in management-led stretch and flex exercises		Yes	No	Do Not Know
	If NO, then please select the single best reason	□ Too Costly □ Too Difficult to Implement □ Lack of Management Support □ New Concept – Not Known Prior □ Other: _____			
8.	Measuring ergonomic losses investigated for root causes within 24-hours		Yes	No	Do Not Know
	If NO, then please select the single best reason	□ Too Costly □ Too Difficult to Implement □ Lack of Management Support □ New Concept – Not Known Prior □ Other: _____			
9.	Measuring ergonomic improvements implemented		Yes	No	Do Not Know
	If NO, then please select the single best reason	□ Too Costly □ Too Difficult to Implement □ Lack of Management Support □ New Concept – Not Known Prior □ Other: _____			
10.	Conducting an annual audit of the written Ergonomic Management Control Program		Yes	No	Do Not Know
	If NO, then please select the single best reason	□ Too Costly □ Too Difficult to Implement □ Lack of Management Support □ New Concept – Not Known Prior □ Other: _____			

3. *Please provide the following information for your worksite:*

☐ North American Industrial Classification System (NAICS) Code

4. *Select the best occupational safety and health (OSH) role of the person completing this survey?*

○ Full-time in OSH
(e.g., 50% or more of job duties and time dedicated to OSH)

○ Part-time in OSH
(e.g., less than 50% of job duties and time dedicated to OSH)

○ Human Resources

○ Other

5. *Select the best educational description of the person completing this survey?*

○ College degree in safety and health or a related scientific field of study
(e.g., engineering, chemistry)

○ College degree <u>other</u> than safety and health or a related scientific field of study
(e.g., engineering, chemistry)

○ No college degree

Definitions of Terms

- **Ergonomics** - "Ergonomics is the scientific study of people at work. The goal of ergonomics is to reduce stress and eliminate injuries and disorders associated with the overuse of muscles, bad posture, and repeated tasks. This is accomplished by designing tasks, work spaces, controls, displays, tools, lighting, and equipment to fit the employee´s physical capabilities and limitations." (CDC, 2016, p. 1).
- **Ergonomic hazards** - "refer to workplace conditions that pose a biomechanical stress to the worker. Such hazardous workplace conditions include, but are not limited to, faulty work station layout, improper work methods, improper tools, excessive tool vibration, and job design problems that include aspects of work flow, line speed, posture and force required, work/rest regimens, and repetition rate. They are also referred to as stressors." (OSHA, 1993, p. 21)Ergonomic Management Control **Program** (EMCP) – refers to an employer's written section within their safety and health management system (SHMS) about risk treatments implemented to eliminate or control ergonomic risk factors. This may or may not include OSHA's seven-point ergonomic management framework.
- **Ergonomic risk factors** - "are conditions of a job, process, or operation that contribute to the risk of developing CTDs. Examples include repetitiveness of activity, force required, and awkwardness of posture. Risk factors are regarded as synergistic elements of ergonomic hazards which must be considered in light of their combined effect in inducing CTDs. Jobs, operations, or work stations that have multiple risk factors will have a higher probability of causing CTDs, depending on the relative degree of severity of each factor." (OSHA, 1993, p. 21)
- **Ergonomic symptom survey** - is a questionnaire for completion by workers to identify work-related pain or injuries. Survey results are then analyzed to identify potential ergonomic hazards and risk factors for further attention and risk reduction.
- **Job Hazard Analysis** (JHA) - is a risk assessment tool used to detect and control workplace hazards with the aim of preventing injury to a worker. Risk treatments are then selected and applied to reduce the risk associated with the identified hazards to acceptable levels. A JHA is sometimes referred to as Job Safety Analysis (JSA).
- **Lagging indicator** - means a periodic measurement of numbers of loss incidents that give indications of past performance but are traditionally not predictive of future OSH performance (e.g., accident severity and frequency rates).
- **Leading indicator** - means a measurement/metric periodically taken to identify areas of SHMS weakness in advance of loss events, providing the possibility of taking action to circumvent losses, used to drive performance, and predictive of future performance - linked to risk reduction.
- **Measuring** - the process of comparing the success of implementing a SPI against the written policy of same (e.g., measuring if an employer conducts new hire OSH training as described in their SHMS).

- **MSD** - "include cases where the nature of the injury or illness is pinched nerve; herniated disc; meniscus tear; sprains, strains, tears; hernia (traumatic and nontraumatic); pain, swelling, and numbness; carpal or tarsal tunnel syndrome; Raynaud's syndrome or phenomenon; musculoskeletal system and connective tissue diseases and disorders, when the event or exposure leading to the injury or illness is overexertion and bodily reaction, unspecified; overexertion involving outside sources; repetitive motion involving microtasks; other and multiple exertions or bodily reactions; and rubbed, abraded, or jarred by vibration." (OSHA, 2016, p. 1)
- **New hire training** - means OSH training provided to new hires before their job assignment (e.g., ergonomics, PPE, emergency preparedness, hazard communication, defensive driving, fire safety, fall prevention, workplace violence, etc.).
- **Pre-hazard controls** - means a comprehensive hazard/risk analysis of a worksite, conducted whenever operations are altered or changed, to avoid the potential to overlook needed OSH controls due to the development of new exposures. The Prevention through Design (PtD) process identifies and initiates appropriate steps to prevent or otherwise control hazards at the new design and redesign stage. For situations requiring adjustments to existing systems or operations, the Management of Change (MoC) process identifies and reduces potential risks to an acceptable level.
- **Tracking** - means the process of following an indicator (e.g., a supervisor determines the degree of OSH compliance by tracking the number of weekly OSH training sessions his group leaders accomplish with their staff).
- **Safety perception survey** - is a questionnaire for completion by workers to identify their attitudes, their behaviors, and their understanding of management's commitment to OSH at their worksite. Results typically provide organizations with leading SPIs to assist in determining areas of concern and prevent loss events before they occur.
- **Safety Performance Indicator** (SPI) - means a leading or lagging indicator to measure performance and evaluate whether a particular OSH or SHMS goal has been achieved (e.g., are 100 percent of targeted ergonomic training sessions completed).

Works Cited

1. CDC. (2016). Workplace Safety & Health Topics: Ergonomics and Musculoskeletal Disorders. Retrieved on 9/27/2016 from http://www.cdc.gov/niosh/topics/ergonomics.
2. OSHA. (2015). Safety and Health Topics: Ergonomics. Retrieved on 1/27/2016 from https://www.osha.gov/SLTC/ergonomics/index.html.