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# A Study in the Selection and Effectiveness of Leading Indicators in the Dairy Product Manufacturing Sector (NAICS 3115)

Peter Van Derlyke

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A STUDY IN THE SELECTION AND EFFECTIVENESS OF LEADING INDICATORS IN  
THE DAIRY PRODUCT MANUFACTURING SECTOR (NAICS 3115)

A Dissertation

Submitted to the School of Graduate Studies and Research

in Partial Fulfillment of the

Requirements for the Degree

Doctor of Philosophy

Peter Van Derlyke

Indiana University of Pennsylvania

August 2019

Indiana University of Pennsylvania  
School of Graduate Studies and Research  
Department of Safety Sciences

We hereby approve the dissertation of

Peter Van Derlyke

Candidate for the degree of Doctor of Philosophy

---

Majed Zreiqat, Ph.D., ASP  
Associate Professor of Safety Sciences, Advisor

---

Luz S. Marin, Sc.D.  
Assistant Professor of Safety Sciences

---

Christopher Janicak, Ph.D., CSP, CEA, ARM  
Professor of Safety Sciences

ACCEPTED

---

Randy L. Martin, Ph.D.  
Dean  
School of Graduate Studies and Research

Title: A Study in the Selection and Effectiveness of Leading Indicators in the Dairy Product Manufacturing Sector (NAICS 3115)

Author: Peter Van Derlyke

Dissertation Chair: Dr. Majed Zreiqat

Dissertation Committee Members: Dr. Luz S. Marin  
Dr. Christopher Janicak

This study aimed to examine the implementation of safety leading indicators their perceived effectiveness on the injury (frequency and severity) rates within the dairy product manufacturing sector in the United States. Scientific literature indicates there are potential benefits in implementing safety leading indicators to help reduce injury rates. The lack of research determining which, if any, leading indicators has a higher impact on reducing these rates leaves facilities on their own to pick ones they believe may be effective. This study examined safety indicators used in the dairy product industry that could have a higher impact on reducing injury rates. This study also discusses potential explanations as to why the implementation of safety leading indicators may not have the desired effect hoped for.

To gather data on the selection and effectiveness of safety leading indicators, an on-line self-administered questionnaire survey was distributed to all facilities with 11 or more employees. There was a significant agreement among those that completed the survey on which of the safety leading indicators were perceived to have the highest effectiveness on reducing both the overall OSHA injury rate and/or their severity rate. Additionally, there was an agreement of the respondents' perception regarding the implemented leading indicators on both the overall OSHA incident rate and severity rate reduction. This study showed that regardless of implementation, the respondents perceived observations, stop work authority, near miss reporting, preventative maintenance and audits as the most effective indicators associated with a reduction in injury rates.

This study identified no statistically significant difference, nor any correlation between the implementation of safety leading indicators and the reduction of injury rates. Furthermore, the study showed there was no significant difference in the injury rates for the facilities that hire safety professionals when compared to those that do not. These results could be explained by the descriptive results that showed the respondents believed that injury rates were elevated in the industry because of the lack of management support and the emphasis placed on production over safety.

While the study's statistical results did not show many significant differences in OIR and DART rates between those facilities that implemented and those that did not implement safety leading indicators, there was evidence that suggested the implementation of leading indicators did have a slightly positive effect on reducing these rates. The lackluster effect leading indicators seemed to have on injury rates could possibly be based on the answers given as to why respondents believe the dairy manufacturing industry has higher than average injury rates. Lack of upper management support for safety coupled with a culture that views production as more important than safety (the top two answers given) could be having a far more negative effect on the injury rates than the positive effect leading indicators could have. Respondents to the survey suggested that unsafe acts performed by employees are one of the reasons why the dairy industry has high injury rates. In the safety profession, it is understood that unsafe acts are performed by employees because of outside influences such as lack of management support for safety and production being the highest priority. The respondents answer that unsafe are a leading cause of higher injury rates could in fact be influenced by the first two reasons given as to why the industry has higher than average injury rates. A vicious cycle could be occurring where employees are taking risks and

performing unsafe acts which lead to injuries because they are working in a culture where upper management does not support safety and promotes the mentality of production at all costs.

## ACKNOWLEDGEMENTS

So, this is the part of the dissertation where researchers write who they want to thank for the perseverance and support they gave them to complete the process. Everyone says the same thing, “I’d like to thank my chair for helping guide me and my family for their support.....blah, blah, blah”, to most readers this is just idle chatter and no one truly ever reads this section (except for people that know the researcher and they want to see if their name was mentioned- Hi Mom and Dad!). My hope in beginning this acknowledgement section in a pessimistic way is that it will give pause to those reading it and see who really should be thanked for getting me through the process.

There are two specific people that deserve to be thanked first. One is my wife Alex and the other is Dr. Majed Zreiqat (affectionately known as Dr. Z). How are these people both on the same plain you may ask when most writers put them in two totally separate categories? First, I am only ranking them based on the completion of this project and secondly, all I can say is that both of them are vicious, tenacious and just downright a pain in the posterior region whenever I would begin to slacking off. Without either of them I doubt this project would have been finished. In the day of text messaging and email there is no longer anywhere to hide for too long. Obviously, my wife wins the award for the most harassment since I saw her more often. Nothing is better than walking through the door after a week of traveling for work to be met with a hug and kiss and the same question over and over and over again for more than a year “did you get it finished yet”? So, if Dr. Z was that persistent, just imagine what my wife was like ☺. Alex- I love you for all the support you have given me throughout life, not just this. Dr. Z- I don’t know if I love you, but I like you for pushing me to complete this and the additional work you had to put in to make sure it finally was finished.

Secondly, I would like to thank Dr. Luz Marin. While I never had Dr. Marin for a class, those that do should consider themselves lucky. The valuable input she was able to provide helped polish this paper into what it is. Her knowledge and research in safety culture opens your eyes to a whole different thought process. For those of you that are interested in safety culture and safety climate, I wholeheartedly suggest reading her articles. Dr. Marin definitely strengthens the safety department at IUP and makes me proud to be a graduate (or technically a hopeful graduate since I am typing this the day before I am actually defending, this could all be for naught!) of such an elite program.

I would also like to thank Dr. Chris Janicak. This guy is a statistics superstar, he actually may not be originally from this planet which would explain why I could only understand about half of what he was saying. If there is a Krypton for statisticians, that's where he is from. He helped all of us determine some of the best statistical analyses to run based on my project. As Benjamin Disraeli once said "There are three types of lies -- lies, damn lies, and statistics." Am I supposed to properly cite that in my reference section? Also, he had the foresight to let me enter the program the first year it was in place at IUP. If you have bothered to read this far, you can only imagine what my entrance essay to the program was like. Hopefully he hasn't regretted that decision. I still remember him saying that only 50% of the students make it through to the end. I thought he was insane for saying that, but it turns out I was almost one of those and I waited until the bitter end to complete it. For those of you reading this that are in a similar program, just keep with it because you'll regret it if you don't. Life will always get in the way but you have to stop making excuses.

Lastly, but certainly not least, is my work safety partner in crime David Crowley. Dave supported me throughout the entire process and offered his support in any way he could. No one



will ever find a better boss, mentor, colleague and friend than Dave. Dave is a safety Superman (another DC comics reference??? what a nerd) among men and he astounds me with his memory and knowledge in the safety arena. I have definitely tried to model my work after him. His selfless acts to grow others in safety field is unmatched. I don't know what else to say other than **THANK YOU** for everything.

Now, with that out of the way, let's get to the ~~good~~ great stuff (spoiler alert, if you read the conclusion section it will save you time).....

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## CHAPTER ONE

### INTRODUCTION

#### **Background**

Safety indicators are commonly used to measure the effectiveness of a facility safety management process and performance (Reiman & Pietikäinen, 2012). These indicators can be described as either lagging (reactive) or leading (proactive). Leading indicators are typically dependent on the culture of safety within an organization or location (Haight & Thomas, 2003) and share the following characteristics:

- They measure those behaviors and activities that can directly lead to improved workplace safety.
- They are understood and accepted by employees and managers as directly relevant to workplace safety.
- Their focus and intent are closely aligned with an organization's strategic goals and objectives.
- They are cost-effective, and easy to measure and use.

There are many articles and research papers written on the potential benefits of measuring safety leading indicators. Changing measured attention from lagging indicators to leading indicators helps to prevent loss and even has the added value of potentially predicting an event if proper action is not taken (Hohn, 2013; Sinelnikov, et al, 2015). This predictive factor provides an early warning signal allowing an organization to identify and correct deficiencies before the event occurs (Sinelnikov, et al, 2015).

While these articles on the benefits exist, there are very few, if any, research articles and papers that discuss which of the many leading indicators are implemented in the dairy product

industry. In addition, which implemented leading indicators in this industry have the biggest impact on lowering Occupational Safety and Health Administration (OSHA) Days Away, Restricted or Transferred, DART, (severity) injury rate and overall OSHA Incident Rate, OIR, (likelihood).

### Significance of Problem

Data from the Bureau of Labor Statistics indicates that there has been a relative plateau in the reduction of total OSHA incident rates as well as DART rates over the past five years in the American industries. This plateau trend is similar to that of the dairy industry. Table 1 displays the OIR and the DART rates for all industries in the United States as well as the dairy industry (NAICS 3115).

Table 1

*Comparison of OIR and DART Rates of All American Industries and the Dairy Industry From 2012-2016*

| Year    | All Industries |      | Dairy Industry |      |
|---------|----------------|------|----------------|------|
|         | OIR            | DART | OIR            | DART |
| 2016    | 3.2            | 1.7  | 5.1            | 3.4  |
| 2015    | 3.0            | 1.6  | 4.8            | 3.0  |
| 2014    | 3.2            | 1.7  | 5.2            | 3.5  |
| 2013    | 3.3            | 1.7  | 5.7            | 3.5  |
| 2012    | 3.4            | 1.8  | 5.8            | 3.6  |
| Average | 3.2            | 1.7  | 5.3            | 3.4  |

As evident in Table 1, the dairy industry rates (in red) are elevated when compared to the national average since 2012 (BLS, 2017). More troubling is that the DART rate is almost double the national average. It is important to recognize that injuries not only mean a failure in the



system that resulted in an injury event, it also costs organizations within the United States billions of dollars per year. According to the 2018 Liberty Mutual Workplace Safety Index, workplace injury events resulting in an employee missing six days or more from work cost American companies \$58.5 billion in direct workers' compensation costs per year (Liberty Mutual, 2018). This equates to more than \$1 billion per week (BLS, 2017). Using the information from Liberty Mutual and data from the Bureau of Labor Statistics (BLS), the calculated average cost for every lost workday injury is approximately \$48,328 (BLS, 2017; Liberty Mutual, 2018).

When examining injury events resulting in days away from work, the food manufacturing industry (NAICS 311) was found to have 1.4 cases per 100 full-time workers in 2011. This rate is about 27 percent higher than the rate for all private industry (1.1 cases per 100 full-time workers). Among the food manufacturing subindustries and private industry, dairy product manufacturing had one of the higher rates of cases with days away from work, at 2.2 cases per 100 full-time workers (Bhushan, 2011). These statistics have remained constant over the past seven years. Additionally, the food manufacturing industry was part of a six industry study that was conducted by the Bureau of Labor Statistics in 2012. Information was collected on case circumstances and worker characteristics for injuries that resulted in Days Away, Restricted or Transferred (DART) (BLS, 2016). This study showed that

the food manufacturing industry had 28,610 DART cases, with a rate of 198.4 cases per 10,000 full-time workers. The median duration of job transfer or restriction for this industry was 16 days (higher than the median of 15 days in both 2011 and 2012). The number of days of job transfer or restriction and the incidence rate in this industry were unchanged from 2011 through 2013. (BLS, 2015, pg. 4)

No specific injury cost statistical information for the dairy product manufacturing sector could be located anywhere. However, using the BLS injury data for NAICS 3115 and the average cost information, it could be estimated that the annual costs for the dairy industry for similar lost time injury events is as high as \$99.5 million (BLS, 2017; Liberty Mutual, 2018).

### **Statement of the Problem**

Literature supports the utilization of leading indicators in order to positively affect the lagging indicators as they relate to safety (Haight & Thomas, 2003; Pater, 2017; Reiman & Pietikäinen, 2012; Shultz, 2012). According to a 2012 article by Griffin Schultz, research conducted by a group from Carnegie Mellon University resulted in “leading indicator safety analytics programs” that can predict safety incidents with high accuracy rates. Performing and analyzing data from regular safety inspections was found to be the most effective leading indicator to predict incidents associated with ergonomic issues with accuracy rates as high as 80 to 97 percent (Shultz, 2012).

Honda of Canada also saw dramatic reductions in injury events when they incorporated leading indicators into their planned metrics. They created measures for how many employees were trained in ergonomics and how many ergonomic related conversations they had with other employees. In a 12-month time frame, they saw a 36% reduction in ergonomic related injuries (Pater, 2017). U.S. Steel also saw similar results when they measured the leading indicator of training events. After developing the proper measuring techniques, they were able to achieve a reduction of 40% to 55% in strains and sprains injuries at a facility that had older equipment and an aging workforce (Pater, 2017).

Due to the significance in elevated injury rates of the dairy product manufacturing sector compared to other industries, the stagnation in reduction of injury events and the exorbitant costs

associated with these events, the researcher found it is justified to investigate ways to improve the implementation of leading indicators to have a positive impact on the injury rates. The purpose of this study is to determine which leading indicators are currently being implemented in the dairy product manufacturing sector and determining those that have the biggest impact on reducing injury events. The study also questions respondents in the dairy product-manufacturing sector as to the reasoning behind the increase OIR and DART rates and the actions they believe could have a significant impact on reducing that trend.

### **Questions to be Researched**

This study was designed to identify the implemented safety leading indicators in the dairy product industry and evaluate their effectiveness on reducing injuries in the dairy product-manufacturing sector (NAICS 3115) within the United States. The study examined current trends, and indicators being implemented and measured. Additionally, the study examined differences in the implementation of safety leading indicators based on whether a facility employs a safety professional or not. Lastly, the study investigated which implemented leading indicators have the best positive impact on injury rates and severity.

A survey tool was developed by the researcher to gather data on organization information, respondents' characteristics, and the most effective safety leading indicators on the reduction of incident rates in the dairy product-manufacturing sector.

The design of the study sought to provide answers to the following research questions:

RQ1: Which safety leading indicators are implemented and measured in the dairy product-manufacturing sector (NAICS 3115)?

RQ2: Is there an overall agreement among respondents' perception on the rankings of the leading indicators on the effectiveness of reducing injury rates?

RQ3: Is there an agreement on the ranking of implemented leading indicators as effective in reducing injury rates?

RQ4: Is there any differences in the overall average change in OSHA incident rate (OIR) between the perceived three most effective safety leading indicators among the facilities that implemented them?

RQ5: Is there any differences in the overall average change in severity incident rate (DART) between the perceived three most effective safety leading indicators among the facilities that implemented them?

RQ6: Is there a correlation between the top ranked and implemented safety leading indicator (most effective) and the overall average change in incident rates since implementation?

RQ7: Is there a correlation between the top ranked and implemented safety leading indicator and change in severity (DART) incident rates since implementation?

RQ8: Is there any differences in the overall average change in incident rates (OIR) and/or DART rates among facilities that implemented the perceived most effective leading indicators when compared to facilities that did not implement them?

RQ9: Is there any differences in the incident rates (OIR) overall average among facilities with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector?

RQ10: Is there any differences in the severity rates (DART) overall average among facilities with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector?

RQ11: What do the respondents believe are the reasons for the high incident rates in the dairy product-manufacturing sector?

RQ12: What three actions do the respondents believe would help reduce the injury rates in the dairy product-manufacturing sector?

### **Hypotheses**

The researcher hypothesizes that the facilities with full time safety professionals would be more likely to differentiate leading indicators from lagging indicators and implement leading indicators compared to those facilities that did not. A second hypothesis stated that those facilities that implemented leading indicators would have a lower incident and severity rates when compared to those that did not.

The following hypotheses were developed regarding the specific research questions described above:

RQ2: Is there an overall agreement among respondents on the rankings of the leading indicators on the effectiveness of reducing injuries?

H<sub>0</sub>: There is no significant agreement among respondents on the rankings of indicators.

H<sub>1</sub>: There is a significant agreement among respondents on the rankings of indicators.

RQ3: Is there an agreement on the ranking of implemented leading indicators as effective in reducing injury rates?

H<sub>0</sub>: There is no significant agreement among respondents on the rankings of implemented indicators.

H<sub>1</sub>: There is a significant agreement among respondents on the rankings of implemented indicators.

RQ4: Is there any differences in the overall average change in 1 OSHA incident rate (OIR) between the perceived three most effective safety leading indicators among the facilities that implemented them?

H<sub>0</sub>: There is no significant differences in the overall average change in OSHA incident rate (OIR) between the three highest ranked safety leading indicators for the facilities that implemented them.

H<sub>1</sub>: There are significant differences in the overall average change in OSHA incident rate (OIR) for between the three highest ranked safety leading indicators among the facilities that implemented them.

RQ5: Is there any differences in the overall average change in severity rate (DART) between the perceived three most effective safety leading indicators among the facilities that implemented them?

H<sub>0</sub>: There is no significant difference in the overall average change in severity incident rate (DART) for the facilities that implemented the three highest ranked safety leading indicators.

H<sub>1</sub>: There is significant differences in the overall average change in severity rate (DART) between the three highest ranked safety leading indicators among the facilities that implemented them.

RQ6: Is there a correlation between the top ranked and implemented safety leading indicator (most effective) and the overall average change in incident rates since implementation?

H<sub>0</sub>: There is no correlation between the highest ranked and implemented safety leading indicator and overall average change in incident rates since implementation.

H<sub>1</sub>: There is a correlation between the highest ranked and implemented safety leading indicator and the overall average change in incident rates since implementation.

RQ7: Is there a correlation between the top ranked and implemented safety leading indicator and the overall average change in severity (DART) rates since implementation?

H<sub>0</sub>: There is no correlation between the highest ranked and implemented safety leading indicator and the overall average change in severity (DART) rates since implementation.

H<sub>1</sub>: There is a correlation between the highest ranked and implemented safety leading indicator and the overall average change in severity (DART) the overall average change in rates since implementation.

RQ8: Is there any differences in the overall average change in incident rates (OIR) and/or DART rates among facilities that implemented the perceived most effective leading indicators when compared to facilities that did not implement them?

H<sub>0</sub>: There is no significant difference in the overall average change in incident rates (OIR) or DART rate among facilities that implemented the perceived most effective leading indicators when compared to facilities that did not implement them.

H<sub>1</sub>: There is a significant difference in the overall average change in incident rates (OIR) or DART rate among facilities that implemented the perceived most effective leading indicators when compared to facilities that did not implement them.

RQ9: Is there any differences in incident rates (OIR) overall average among facilities with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector?

H<sub>0</sub>: There is no significant difference incident rates (OIR) overall average among facilities with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector.

H<sub>1</sub>: There is a significant difference in incident rates (OIR) overall average among facilities with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector.

RQ10: Is there any differences in severity rates (DART) overall average among facilities with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector?

H<sub>0</sub>: There is no significant difference in in severity rates (DART) overall average among facilities with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector.

H<sub>1</sub>: There is a significant difference in severity rates (DART) overall average among facilities with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector.

### **Definitions of Terms**

The following definitions address terminology found within this study:

1. DART rate- Abbreviation of Days Away, Restricted or Transferred rate. It is a mathematical calculation that describes the number of recordable incidents per 100 full time employees that resulted in lost or restricted days or job transfer due to work related injuries or illnesses (New Mexico Mutual, 2018). It is calculated by adding up the number of incidents that had one or more Lost Days, one or more Restricted Days or that resulted in an employee transferring to a different job within the company, and multiplying that number by 200,000, then dividing that number by the number of employee labor hours at the company (OSHA, 2019).
2. Indicator- A metric that indicates the state or level of something.
3. Lagging Safety Indicator- A reactive metric that measures events after the fact. Typical lagging indicators for safety are injury rates, lost work days, and workers' compensation costs (Hopkins, 2009).



4. Leading Safety Indicator- A proactive metric that precedes or indicates future events. Some examples include training participation, safety observations and audits finding (Hopkins, 2009).
5. (NAICS) – Abbreviation for the North American Industrial Classification System. It is the standard used by federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy.
6. OIR- Abbreviation for OSHA Incident Rate. It measures the frequency of injury events. It is a mathematical calculation that describes the number of employees per 100 full-time employees that have been involved in a recordable injury or illness (New Mexico Mutual 2018). The rate is calculated by multiplying the number of recordable cases by 200,000, and then dividing that number by the number of labor hours at the company (OSHA, 2019).
7. OSHA- Abbreviation for the Occupational Safety and Health Administration. An agency of the United States Department of Labor tasked with ensuring a healthy and safe work environment (OSHA, 2019).

### **Assumptions**

The research assumes the following:

1. It is assumed that all respondents will answer all survey questions honestly and to the best of their abilities.
2. It is assumed that the data collected on the questionnaire will accurately reflect the respondents' intended answers.

3. It is assumed that the person intended to complete the survey and answer the questionnaire is the individual that actually did so.

### **Limitations**

The following limitations have been identified by the researcher regarding this study:

1. The online questionnaire used to gather data is to be completed on a voluntary basis
2. It is possible that there are other factors (confounding factors) that could contribute to the injury rates differences that were not discussed in this study.
3. Other potential limitations will be dependent on the number of survey responses returned and could include small sample sizes for data analysis.
4. The potential of underreporting of incidents by facilities.

### **Delimitations**

The researcher has identified three delimitations associated with the study:

1. This study will only focus on examining the dairy industries inside of the United States.
2. The Northeast Dairy Manufacturing Directory and Dairy Farmers of America Directory will be used as the basis for selecting respondents in this survey population.
3. The study will only examine the past 5 years of incident and severity rates as they pertain to the implementation of leading indicators.

## CHAPTER TWO

### LITERATURE REVIEW

#### **Introduction**

A literature review was performed to determine whether prior studies have been conducted on the understanding of safety leading indicators in the dairy industry and what effectiveness the indicators have on reducing work-place injuries. The review also provided insight on the problems associated with measuring the success of an organization's safety program based on lagging indicators and why safety leading indicators are an important metric. The review of the literature directed the rationale, method and development of the research questions for this study.

This chapter will begin by investigating the concerns associated with gauging the success of an organization's safety program by solely relying on the measurement of safety lagging indicators; such as OSHA recordable injury events and experience modification rates. The second part of this section will describe what safety professionals commonly define as safety leading indicators and pronounce some of the more common indicators that are currently measured in the workplace that are perceived to have an effect on reducing the number of work-related injury events. The purpose is to review the existing supporting documentation to assess whether there is a connection in implementing and measuring specific safety leading indicators and the effect these indicators have on injury events. This chapter will conclude with a review on the importance of utilizing leading indicators as a metrics for safety performance.

#### **Issues Using Safety Lagging Indicators**

To start, it is important to understand the definition of an indicator. As a basic characterization, an indicator can be described as any quantitative or qualitative metric or

measure that is used to provide information on a particular issue of interest (Reiman & Pietikäinen, 2012). Lagging indicators, sometimes referred to as trailing indicators, measure information from past events and are typically reactive in nature, such as an injury event. Whereas leading indicators are proactive in nature and are intended to prevent adverse effects before they occur (Ale, 2009; Hale, 2009; Reiman & Pietikäinen, 2012; Sinelnikov et al., 2015; Toellner, 2001). Safety indicators are used to provide information to measure the overall success of a safety program at an organization. These measures can help provide motivation for organization to work on increasing their potential for safety (Reiman & Pietikäinen, 2012). Wreathall (2009) defined a safety indicator as “Indicators are proxy measures for items identified as important in the underlying model(s) of safety”.

The safety profession has continually used lagging indicators to measure success based on the number of injury events that occur in a month, quarter or even a year. While different injury metrics may be used to determine this success, the most common are injury events that result in medical only, days away or restricted time (DART), days away from work (DAFW), and experience modification rates (EMR) (Ale, 2009; Hale, 2009; Reiman & Pietikäinen, 2012). The initial concept behind the use of injury data as a measure was to provide consistency and comparability among industries of varying size (Antão et al., 2016). Additionally, lagging indicators, such as injury information, can provide data to be used in incident investigations to help determine root causes, however; it does little to provide predictive information or describe just how safe an organization truly is (Hinze et al., 2013; Grabowski et al., 2007). While these indicators offer significant feedback information, they are a reactive measurement approach to safety management because they measure outcomes that have already occurred (Shea et al., 2016). Using only lagging indicators as a method to help reduce injuries is utilizing only half of

the information available and will have limited effects as they highlight events that cannot change, since they represent things that have already occurred (Spigener, 2017; Hohn, 2013; Pater, 2018).

According to Shultz, there are three flaws associated with relying on lagging indicators. First, injuries are expensive for organizations and relying on lagging indicators to try and predict and prevent future injury events simply is not effective. According to statistics from the Occupational Safety and Health Administration (OSHA), recordable workplace injuries cost an estimated \$7,000 and fatalities as much as \$910,000. These dollar amounts are representative of direct costs, indirect costs can be up to three times higher. As seen by these figures, waiting for lagging indicator data to help reduce future risk can prove costly. Secondly, Shultz states that waiting for incidents to occur sends the message to employees that the organization takes a reactive approach to safety versus a proactive approach. This sends the wrong message about an organization's safety culture. Lastly, Shultz contends that as injury events and rates begin to decline, lagging indicator data points that are used for analysis do as well. Does an OSHA incident rate (OIR) of zero really indicate a proactive safety culture, or are they just lucky? Using the Deepwater Horizon incident could possibly be an example of this. Prior to the explosion, company executives were on the oil rig celebrating seven years of no serious accidents. Measuring the lagging indicator of serious accident events did not help predict the explosion that cost millions of dollars and the loss of eleven lives.

Research conducted by Juglaret et al. (2011) also identified the flaw that lagging indicators have "low cognitive capacity of these indicators". The majority of lagging indicators are expressed as an index, ratio or percentage and provide little information about the situation. An example is that an OIR rate of 1.2 is better than an OIR of 3.4, however, this piece of

information does nothing for employees to understand why or what decisions or corrective actions can be taken to improve safety performance. Additionally, when focusing attention on measuring the safety performance success by a number, a sudden increase in that measure could focus efforts on resources that are not necessary since the direct cause may not be known. This action could create a negative impact on the system if viewed by employees as a poor direction by management.

Finally, another flaw of focusing on lagging indicators is that when management is held accountable by measuring the traditional lagging indicators the potential for under-reporting increases in order to achieve the desired objective. This would in turn lead to a safety performance that is artificially improved (Juglaret et al., 2011).

Unfortunately, the focus on lagging (or trailing) indicators has been perpetuated by OSHA putting emphasis on reporting injury events on an annual basis. Prior to 2017, injury data from industries was compiled on a random basis by the use of a survey that was distributed by the Bureau of Labor Statistics (BLS). Now that data is compiled from the industries by using OSHA's electronic injury tracking application (ITA). These injury rates help the federal government determine which facilities in high-risk industries should be targeted for a programmed inspection. When using a lagging indicator like OSHA rates, one is only looking at the severity of the injury from the event, not the potential the event could have had or ways to prevent future occurrences. In a 2007 article, Martha Grabowski explains that many in the safety profession question the importance of measuring lagging indicators and argue that these indicators provide little pertinent information to assist in predicting and avoiding future incidents. This argument was further substantiated by a 2009 interview with Don Groover and Mike Mangan of DEKRA, a leading worldwide consulting firm dealing with managerial

practices and behavioral sciences. It discussed the lack of predictive qualities in safety lagging indicators and reiterate that, similar to every other metric, lagging indicators do not tell the entire story and when used as the only measure, there is a lot that is overlooked to help in reducing workplace injuries.

From decades of focusing on the lagging indicator of injury rates, companies have used those measurements as an all-inclusive metric on how to view their safety program's success (Ketokivi & Schroeder, 2004). According to Don Groover, using OSHA injury rates only helped simplify how to view the overall safety performance by "boiling it down to this one number". By only looking at the numbers, there may be no differentiation in potential between an employee who amputates his/her index finger reaching inside an operating machine and an employee who strains his/her back lifting a pencil from the floor. They are both classified the same, an OSHA recordable, which highlights the problem in using this metric (Spigener, 2017). In fact, by only looking at the numbers on the OSHA log, the muscle strain may appear to have more severe potential than an amputation, if the strain requires a person to be out of work for a day and the amputation allows the person to return to work with no restrictions the same day.

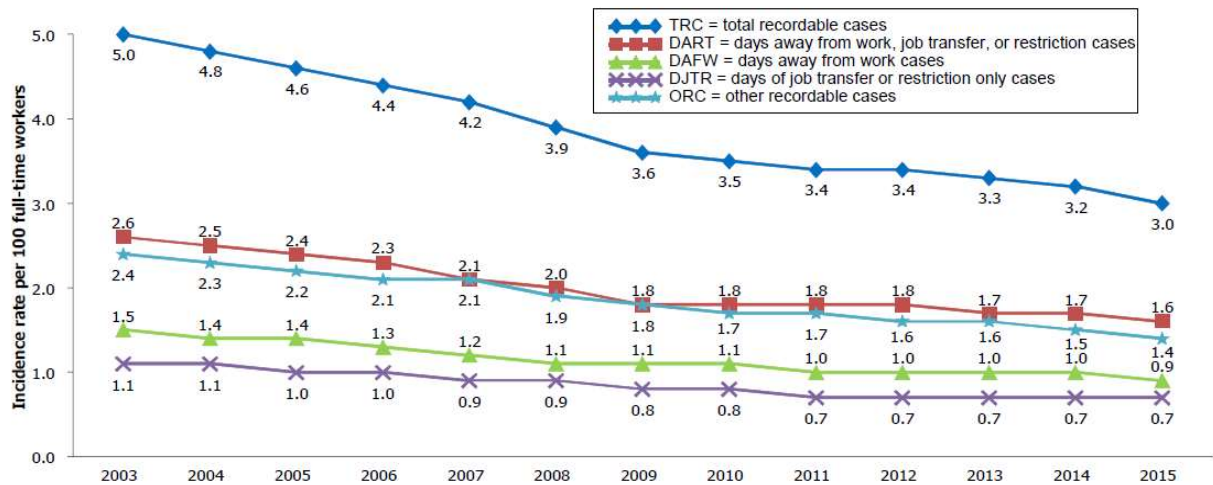
Finally, as reported by the BLS, there were 2.9 million non-fatal work-related injuries and illnesses in the United States during 2015. 1.6 million of these injuries resulted in days away from work or restricted time (DART) (BLS, 2015). Even with these statistics, there has been a recent scrutiny as to the accuracy of injury rates based on the potential of underreporting of injuries by organizations (Leigh, Marcin & Miller, 2004; Probst, et al., 2008). Recent research conducted has shown that there is no consistency in the reporting of injury rates and shows that there are reporting discrepancies not only between different types of industries but also within the same industrial groups (Juglaret et al., 2011). The reasoning behind the inaccuracy of

reporting is either due to organizations not properly recording the events on their OSHA forms or from employees not reporting injuries (Probst et al, 2008). Either way, this inaccuracy in reporting makes it difficult compare facilities against one another (Juglaret et al., 2011). During the construction of the Denver international airport, there were findings from a study that showed the number of Workers' Compensation claims involving payment and lost time injuries were more than double those found reported and published by the Bureau of Labor Statistics for that industry and location (Glazner et al., 1998; Probst et al., 2008). In a 2014 Department of Labor (DOL) mining research study, it was concluded that underreporting in the mining industry could be as high as 23 - 46% (DOL, 2014). Additional research has shown similar underreporting in other industries when comparing numbers of work related injuries from medical records and Workers' Compensation claims with BLS data (Leigh et al., 2004; Pransky et al., 1999; Probst et al., 2008). Another research study in 2014 concluded that the majority (90%) of the organizations surveyed in Washington State did not comply with OSHA recordkeeping regulations (Wuellner & Bonauto, 2014). It was determined that organizations "that incentivize low injury rates, had disorganized recordkeeping, and limited communication between BLS and survey respondents were barriers to accurate employer reports of work-related injuries and illnesses" (Wuellner & Bonauto, 2014).

While reviewing the data from the Bureau of Labor Statistics between 2003 and 2015, it was noted that there has been a relative plateau in the reduction of work-related injury events that resulted in days away from work as well as job transfer or resections (1.1 to 0.9 and 0.9 to 0.7, respectively), see Figure 1 below (BLS, 2016). According to Thompson et al. (1998), this plateauing has given a "perceived failure of safety technology to help organizations move off this plateau". For the last ten to fifteen years industries have been thinking outside of the box on



innovative ways to approach safety management (Thompson et al., 1998). It is arguable then that the focus on lagging indicators has little to no effect on the reduction of injury events in these categories.



*Figure 1.* Nonfatal occupational injury and illness incidence rates by case type, private industry, 2003-2015. Reprinted from “Incidence rates of nonfatal occupational injuries and illnesses by industry and case types”, Bureau of Labor Statistics 2017, Retrieved from <https://www.bls.gov/iif/oshwc/osh/os/ostb4732.pdf>

It should be noted that lagging indicators can serve a purpose when coupled with the measurement of leading indicators. Both indicators are typically measured on some type of time scale where leading indicators precede the event and lagging indicators trail the event (Reiman & Pietikäinen, 2012). Using this concept that lagging indicators trail an event, they could be utilized to how effective leading indicators are and would therefore show the present level of the overall safety system (Reiman & Pietikäinen, 2012).

Integrating leading indicators metrics into gauging the success of safety performance will most likely not prove easy. For more than forty years, safety professionals have relied on injury/illness reports, OSHA rates and educating senior leadership within organizations that OSHA compliance (not risk assessments) will help keep employees’ safety (Walaski, 2016). It

cannot be expected that changing the mindset within organizations will be something that will happen quickly.

### **Defining Leading Indicators**

The current literature surrounding the topic of leading indicators is a mixed compiling of thoughts, opinions, case studies, and even observational research from several different sources including industries, colleges and government agencies (Sinelnikov et al., 2015). In the professional safety community, there appears to be an agreement that leading indicators can be utilized to measure the overall success of occupational health and safety (OHS) performance, however, there still remains some uncertainty with the simple fundamentals associated with them, including a basic definition. While the research showed that there were many articles listing leading indicators, there was no guidance as to which of the indicators proved most effective (Rajendran, 2013). Reiman and Pietikäinen (2012) report that the concept is “all but clear.” Understanding that lagging indicators are measuring events after the fact should mean that leading indicators are proactive in nature and are intended to prevent adverse effects before they occur. While the basic definition is one that should be relatively easy to describe, its definition as well as the actual description of what is and what is not a leading indicator is a bit unclear (Reiman & Pietikäinen, 2012). One of the reasons as to why the confusion exists around the definition of leading indicators is simply because of the sheer number of terms that are used for the same thing. While the term “leading” is the most common phrase used to describe these types of indicators, many authors of the subject have used different descriptive terms throughout their literature. Sinelnikov, Kerper and Inouye pointed this out in their 2015 report stating, “in order to retain the most relevant qualities of indicators in respect to their own message”. Even many in the safety profession have used numerous phrases to try to represent what in fact leading

indicators are. These have included terminology, such as- proactive, predictive and upstream (Hinze et al., 2013).

One of the more simplistic approaches to define leading indicators is to concentrate on how they differ from lagging indicators (Reiman & Pietikäinen, 2012; Reason et al., 1997; Dyreborg, 2009). The method of separating leading from lagging indicators has become common when measuring safety performance (Shea T. et al., 2016; Dyreborg, 2009; Hopkins, 2009). Even this simplistic approach does not come without some complications since it is possible that lagging indicators can also act as leading indicators if they are to be used in a predictive fashion (Dyreborg, 2009).

According to Reiman and Pietikäinen (2012), categorizing whether a safety performance indicator should be labeled as leading or lagging is dependent on the fundamental model of safety within an organization. For example, if an organization is one that has a technical and machine-driven view on safety, one where the human is not viewed as a controllable variable, then near misses may be considered a type of leading indicator (Reiman & Pietikäinen, 2012; Reason et al., 1997; Dyreborg, 2009). In an organization that has a more active and complete management system approach on safety, near misses may be viewed more as past performances of safety; hence a lagging (not leading) type of indicator (Reason et al., 1997; Dyreborg, 2009). While there are varying definitions and terminologies on describing each indicator and the exact differences between leading and lagging, it is generally accepted that both indicators are measured on a time scale where lagging indicators occur after the unwanted event (harm) has taken place and leading indicators precede the unwanted event (harm) (Reiman & Pietikäinen, 2012). Because of this, Reiman and Pietikäinen (2012) determined that, “lagging indicators can be used in providing feedback on the functioning of the system to be used as further inputs into

the system.” This would mean that lagging indicators could be used to measure the current safety of the system and leading indicators could potentially measure the future level of the system.

Kjellén (2009) interprets leading indicators as measures of signs of changing exposures rather than precursors to an event. Reiman and Pietikäinen (2012) agree with this interpretation and believe that “leading indicators should measure things that might one day become precursors to harm or cause a precursor to harm.” With this thought process of defining leading indicators, Dyreborg (2009) stated that:

Lead safety indicators indicate either the current state and/or potential development of key organizational functions or processes as well as the technical infrastructure of the system. The current state includes a view on the changing vulnerabilities of the organization as well as its internal model of how it is creating safety. The lead monitor indicators indicate the potential of the organization to achieve safety. They do not directly predict the safety related outcomes of the sociotechnical system since these are also affected by numerous other factors such as external circumstances, situational variables and chance.

This widens the scope of what could potentially be defined as a leading indicator as it pertains to safety and allows categorization of different factors that may be measured as leading indicators with regard to safety performance (Shea, T., et al., 2016). A broadened focus of attention on leading indicators now includes metrics that encompass areas within an organization that one may not believe directly influences safety such as management and leadership style and the overall business culture of an organization or a facility. Since this could become burdensome when trying to focus on which specific leading indicators to measure to reduce the possibility of experiencing an unwanted event, research has narrowed the indicators into the categorizations of

safety climate, safety management systems and safety performance (Flin et al., 2000; Shea, et al., 2016; Reiman & Pietikäinen, 2012).

As Shea, T et al. (2016) discovered in their research, several of these categorizations are focused on “micro-level metrics” and/or have only been validated within one industry. In order to widen the applicability among other industries and organizational contexts and take a more inclusive approach, the authors proposed that the construct of leading indicators regarding safety performance encompasses 10 areas:

- Occupational health and safety OHS systems (policies, procedures, practices);
- management commitment and leadership;
- OHS training, interventions, information, tools and resources;
- workplace OHS inspections and audits;
- consultation and communication about OHS;
- prioritization of OHS;
- OHS empowerment and employee involvement in decision making;
- OHS accountability;
- positive feedback and recognition for OHS; and
- risk management.

When trying to define the characteristics of leading indicators, one needs to think of them as an antecedent to an unwanted event (Shea, T. et al., 2016; Grabowski et al., 2007; Baker et al., 2007). Accordingly, leading indicators should offer signs prior to a failure and afford organizations the ability to recognize, react and reduce or eliminate the risks before the unwanted event occurs (Shea, et al., 2016; Sinelnikov et al., 2015). Leading indicators are essentially different measures of proactive and positive actions that organizations can take in order to reduce

the potential from an unwanted incident occurring (Grabowski et al., 2007). Baker et al. (2007) define leading indicators as “A metric that attempts to measure some variable that is believed to be an indicator or precursor of future safety performance.” Toellner (2001) simplifies the core characteristic of leading indicators as those metrics associated with measurable system or individual behaviors linked to accident prevention. These indicators focus on maximizing safety performance by measuring, reporting and managing positive safe behaviors.

When managing safety, there are some basic characteristics regarding effective performance indicators:

- The indicator is valid; aka it measures what it intends to measure;
- The indicator is reliable;
- The indicator is sensitive to changes in what it is measuring;
- The indicator is not susceptible to bias or manipulation;
- The indicator is cost effective;
- The indicator is interpreted by different groups in the same way;
- The indicator is broadly applicable across company operations; and
- The indicator is easily and accurately communicated (Hale 2009, p. 480):

A safety programs' success is based on the ability to properly select the safety indicators that should be measured. The selection of the indicators needs to be based on the issues within the safety system that need to be managed and changed (Rajendran, 2013). Once these issues have been identified, management actions can then be taken that will address the issues and appropriate indicators that will help in the process can be chosen (Rajendran, 2013; Reiman & Pietikäinen, 2012; Grabowski, et al., 2007). It is important to note that whichever indicators are

chosen to be used should be part of the overall safety management process rather than an independent goal or function.

### **Safety Leading Indicators**

Safety leading indicators should not only provide a means for gathering information on safety, they should also help in changing employees' work behaviors and motivations to increase the safety performance within an organization (Hinze, 2003; Shea et al., 2016). While research is still needed to specifically identify the link between leading indicators and the effect they have on injury rates, studies have shown that there is an increasing interest in the safety profession to measure them because of the distinct possibility that a link does exist (Sinelnikov et al., 2015). Safety audits, behavioral observations, job hazard/safety analysis (JHA/JSA), trainings, safety climate measurements and safety culture measurements are all examples of the more common leading safety indicators (Yule, 2003).

### **Safety Audits**

Safety auditing is perhaps the most widely used form of leading indicator. In 1981, a study conducted by the National Institute of Occupational Safety and Health (NIOSH) showed that only 53% of American companies performed voluntary safety audits. By 1999, this number had risen to 85% (NIOSH, 2017). Safety audits can consist of auditing an organization's safety program(s), compliance with governmental regulations, unsafe conditions, as well as employee behaviors. Audits can prove to be beneficial for several reasons and the two most prominent are; they send a message to employees that management takes safety seriously and management cares about the well-being of its employees (Schiavi, 2014). They also help reveal unsafe conditions as well as unsafe behaviors that can be modified before an injury occurs. It is important to note that identifying issues through auditing is only part of the process. Developing and

implementing corrective actions plays an important part as well. This too shows employees that safety is taken seriously and that management is willing to correct issues to provide a safe and healthy work environment for its employees (Schiavi, 2014).

## **Observations**

Performing observations of work behaviors by employees are examples of leading indicators that can be used to help predict and potentially avoid an unwanted outcome (Mohamed, 2002). This is simply based on the thought that unsafe behaviors are characteristically associated with workplace injury events (Thompson et al., 1998; Mohamed, 2002). Safety professionals have understood that many injuries that occur in the workplace have some type of behavior component surrounding it (Krause et al., 1999). This has been known for several decades even when looking at the early safety work conducted by Herbert Heinrich in the 1930s and 1940s (Heinrich, 1941). Recent research focuses its attention on designing systems for observers to react to behaviors where employees are putting themselves in harm's way and provide feedback and alternative solutions while encouraging employee participation for designing corrective actions (Krause et al., 1999; Thompson et al., 1998; Schiavi, 2014).

Also, observed safe behaviors can act as a discussion points between managers and supervisors to employees in order to reinforce positive safety behavior and change at-risk behavior (Schiavi, 2014). Additionally, observations can be used to publicly praise positive behavior, so it will be repeated in the future. Praise has been shown to increase the chances of individuals repeating the wanted actions in the future (Mariotti, 1997) so this would increase the possibility of repeating the wanted action of safe behavior in hopes to reduce the chance of an injury event.



In 1978, a 25 week study was conducted in two departments within a food manufacturing plant. This study showed that when management performed behavioral observations and provided feedback of the observations to employees, they saw a 21% to 26% improvement in safety performance (Komaki et al., 1978). When the observations stopped, the safety performance dropped back to its original levels. A similar study was conducted in the 1999 with 73 facilities of differing manufacturing processes. It was reported that the facilities which implemented safety performance observations by management, with employee feedback, improved their performance by 26% in the first year and 69% by the fifth year (Krause et al., 1999).

## **Trainings**

As described earlier, leading indicators should be able to help improve the predictability of injury events in order to reduce the possibility of the event occurring. Providing adequate training does provide these means (Vredenburg, 2002; Jaselskis et al., 1996; Thompson et al., 1998). As Vredenburg (2002) stated “the basic difference between safe employees and those who frequently get hurt is that safe employees can recognize hazards and hazardous actions and understand the consequences”. In order for workers to be able to recognize hazards, they must be properly trained. Training has been recognized a vital component of an overall safety system and in turn to achieve positive safety performance. Of particular interest is training and orientation for new foreman. A study conducted by Jaselskis et al in 1996 showed that nearly three quarters of organizations that provided specific safety training and orientation for new foreman had an experience modification rate (EMR) lower than those organizations that did not.

In order to effectively influence safety performance, every employee should have the same type of quality and receive the same information during training sessions. For this reason,

it is important that safety trainings be both formalized and standardized to reduce the potential for deviation among workers. Additionally, assumption of risk can vary widely among employees lending itself to the possibility of injuries. This should be understood and incorporated into trainings to reduce the potential of injury. When assessing risk, the likelihood of an injury is not used in a person's judgement but instead the severity of the injury is (Vredenburg, 2002). To emphasize the importance of training, employees to have the ability to identify hazards within their work area. A 1995 study by Vredenburg and Cohen found that employees complied with warnings and instructions given to them as their level of perceived danger was better understood and recognized.

Research also states that to be effective, trainings must continue beyond orientation and a system developed to ensure that employees are continually retrained and re-educated in current safety issues (Jaselskis et al., 1996; Vredenburg, 2002). As Jaselskis (1996) stated, "safety training also appears to be most effective, as evidenced by lower injury rates, when there is some means of measuring the effectiveness of the training".

### **Near Miss Reporting**

Arguably near miss reporting could be considered either a lagging indicator or a leading indicator, since it possesses the properties of each (Sinelnikov et al. 2015). For the purpose of this report, it will be considered a leading indicator since it can be used to potentially predict and prevent the outcome of harm. While there are varying definitions of the term near-miss, the concept behind each definition is the same. Near miss events are those in which no injury, property damage or damage to equipment occurred but an underlying unsafe event or condition exists (Williamsen, 2013). Employees should be encouraged to report these events and proper investigations should be conducted to remove the possibility of reoccurrence and potential of

injury. As described in the conclusion of a study performed by Marks et al. in 2014 “identifying, reporting and analyzing safety leading indicators including near misses has shown to enhance abilities to identify hazards, safety training, and performance metrics”.

Mike Williamsen also discussed the importance of near miss reporting in his 2013 article. In this article, Williamsen detailed a construction company’s initiative to increase near miss reporting during the construction of a facility in hopes to lower injury rates. During the project, specific training on near miss reporting was given to employees and they were encouraged to report any and all events that they considered to meet the definition. Over the course of the project, the organization saw an increase of more than 100 times the number of near misses reported per week. Not only did the company injury rates significantly lower than the national average, they also realized the reporting program built the trust between management and employees because actions were taken on hazards that were identified in the process. It also provided a way for employees to become engaged and involved in the safety program.

Near miss events can be used as training material for employees in order to help reduce the chances of repeating events, and avoid potential injuries from occurring. Additionally, near miss investigation reports can be utilized to conduct trend analysis to target areas of concern and focus efforts and resources to those areas to improve performance (Hallowell et al., 2013).

### **Safety Climate, Safety Culture and Perception Surveys**

Because of the potential for predicting safety performance as it pertains to injury events, safety climate and safety culture have become of increasing interest to measure over the past 10 to 20 years (Schwatka et al., 2016). These two leading indicators are a little more difficult to measure because many of their metrics rely on perception of employees within the organizations. Safety climate and culture also have the difficulty of being truly defined, different individuals

have different understandings of what constitutes each. The varying explanations of safety climate and safety culture have led to a wide array of metrics and magnitudes when developing what to measure for climate and cultural successes (Yule, 2003). Safety culture and safety climate, while related, are two separate and distinct concepts (Schwatka et al., 2016). Culture reflects an organization's values and attitude toward safety while climate refers to thoughts and feelings that are shared among the employees on how they view the organization's commitment to safety (Mearns & Flin, 1999).

### **Safety Climate**

Studies have shown that employee perceptions of the safety climate within an organization or a facility have been linked, directly and indirectly, to safety outcomes (Donald & Canter, 1994; Hofmann & Stetzer, 1996; Lee, 1998; Mearns et al., 2001; Niskanen, 1994; Thompson et al., 1998; Zohar, 1980). The term "safety climate" is not new, in fact this concept was first discussed in an article by Zohar in the early 1980s (Zohar, 1980). Zohar (1980) referred to safety climate as "shared perceptions held by members of a team or organization about the way safety is managed within the organization". Since climate is generally measured by the beliefs and feelings of employees, the perception of the climate can change based on the time and circumstances at which the survey is completed. It is generally accepted that safety climate is an employee's perceptual measurement of managements' value of value within a particular moment of time (Mearns et al., 1997).

Interest in measuring safety climate has continued to grow since its first inception and, as evident by the increase in research articles, has seen a rapid growth since the mid-1990s (Casey et al, 2017). A search of articles conducted by Casey et al. in 2017 using the research platform Web of Science showed that only 11 articles included safety climate in their title between 1980

and 1996. Since 1996, 429 articles included “safety climate” in their title; of these, 70 were published between 1997 and 2006, and 359 were published between 2007 and 2016.

In Yule’s 2003 paper, he indicated that safety climate has been identified as a leading indicator that provides insight on safety performance and could potentially be used to predict injury and illness events. There are several metrics within the concept of safety climate that have been identified in the research literature that can be used to measure or gauge the climate of an organization.

To measure safety climate across organizations or large facilities, survey tools have been developed. These surveys, typically in the form of self-report questionnaires administered as large-scale surveys (Schwatka et al., 2016), focus on assessing respondents’ answers to questions regarding management and employee involvement in safety programs and management systems.

Measuring safety climate in a single facility or small organization can be completed by utilizing a more personal approach (Schwatka et al., 2016), such as staff focus groups, management interviews, and observation of normal operating procedures. Certainly, if time and resources permit, a best practice approach would use a combination of the methods mentioned.

It is important to note that while researchers have agreed that measuring safety climate is important to help positively impact the safety performance of an organization, they have not agreed on which factor within the safety climate influences safety performance the most (Yule, 2003).

## **Safety Culture**

The safety culture of an organization is reflected by the perception of that organization’s value they place on safety and how their beliefs guide their employees’ decision making and behaviors (Reason et al., 1998). Culture is built by the historic actions that have been taken with

regard to safety. A strong safety culture helps direct employees to make the correct behavioral decisions regardless if they are being watched by their direct supervisor or not. It also directs management to allocate appropriate resources, including both monetary and manpower, to safety initiatives and management systems. It is more than a symbolic gesture; it drives the overall attitude and outlook on safety within an organization (Thompson et al., 1998).

### **Safety Perception Surveys**

Safety perception surveys are typically used to measure the safety climate and safety culture within an organization or facility. As companies begin to realize that employees can be the source of solutions to issues within the organization, they also begin to understand the value and importance of seeking the opinions and perceptions of their employees (Ryan, 2009). We are starting to see that the issues affecting production, efficiencies, quality and other key performance indicators are also having an impact on safety. Many times, the issues affecting safety are not directly related, like program deficiencies or lack of training, but are instead associated with the perceptions of the organizations' value of safety (Ryan, 2009; and O'Toole, 2002). The best tool for determining and understanding the beliefs of both the employees and the organization is by using a safety perception survey.

Measuring perceptions of employees can help predict the likelihood of how employees will behave while in the workplace (O'Toole & Nalbone, 2011). This becomes increasingly important for facilities that have employees that work with little or no supervision in the hopes that these employees will make the proper decisions as they related to safety policies and procedures. As O'Toole and Nalbone stated in their 2011 article:

If perceptions about safety are low, that employee may be more likely to take a shortcut or engage in some other at-risk behavior which can lead to an injury. Where employee

perceptions of an organization's safety climate are low (negative), the incidence of injury tends to be higher than in those organizations where employee safety perceptions are high (positive).

D. Ryan (2009) echoes these statements by stating "To make a workplace safe, management must know what employees are thinking. If the culture fosters unsafe behaviors and procedural shortcuts, a perception survey will help uncover why. If the culture influences employees to work safely even when the boss is not around, a survey can help to maintain this high level of safety."

### **Importance of Measuring Safety Leading Indicators**

Organizational and management practices (leading indicators) have been identified that correlated with lower rates of workers' compensation claims or improved disability management (lagging indicators) (Hecker & Goldenhar, 2014).

Iyer et al.'s 2004 study conducted with several organizations showed that "a statistically significant, exponentially decreasing mathematical relationship has been shown between the incident rate and the intervention application rate (level of effort applied to the safety and health program activities)". This study shows that if an organization increases its level of effort they apply to their occupational safety and health program (intervention), then they would see a reduction in their incident rate (Iyer, et al., 2004). As described in the previous section of this chapter, effort placed on the safety and health programs is considered a leading indicator. The study further found that the "regression analysis also supported the notion that an intervention produces a carryover effect for the next six weeks with equal levels of carryover affect in each of the six weeks".

Vredenburg saw similar results in his 2002 study performed among 63 hospitals located throughout the United States. The purpose of his study was to examine specific elements within the leading indicators to determine predictability of injury rates. The conclusion was that when the hospitals focused their attention to measuring leading indicators, they not only saw a reduction in lost time rates but also a direct financial benefit as a result of reducing workers' compensation expenses. Additionally, he determined that "since safety behavior is often tied to quality of performance, it is probable that an added benefit of this approach may be an improvement in productivity."

In a longitudinal study of a railroad company where a perception survey was used to judge employees' feelings and beliefs on management's commitment to safety, it was shown to have a significant reduction in lost time injury rates (O'Toole, 2002). The study went on to state that:

the most significant factor linked to the reduction in the injury rates is the change in upper management's approach and the emphasis on safety leadership and commitment to safety that began in 1998. As part of that approach, upper management initiated a series of educational programs to assist lower level managers addresses key management practices. In addition, all managers were held accountable for not only the safety results as it related to injury rates, but also for what actions or processes they put into place to impact those results

In Sara Smith's 2017 interview with Greg Sizemore, vice president of HS&E and workforce development for ABC, he stated that "When leaders embrace safety, and companies do these six things and do them well, then [they] will show improvement in safety," and provided the following statistics:



1. Companies that provide more than 215 minutes of new hire orientation show a TRIR rate 1,827 percent lower and a days away restricted or transferred (DART) rate 1,662 percent lower than companies that provided 31 minutes or less of new hire orientation.
2. Companies that offered site-specific orientation had a TRIR rate 180 percent lower and a DART rate 158 percent lower than companies that did not complete site-specific orientation.
3. Companies that offer daily toolbox talks had a TRIR rate 276 percent lower and a DART rate 292 percent lower than companies that offered monthly toolbox talks and a TRIR rate 220 percent lower and a DART rate 233 percent lower than companies that offered weekly toolbox talks.
4. Companies that track near misses have a TRIR rate 169 percent lower and a DART rate 163 percent lower than companies that do not track near misses.
5. Companies that conduct weekly inspections with follow-up have a TRIR rate 239 percent lower and a DART rate 243 percent lower than companies that conduct monthly inspections with no follow-up.
6. Companies that have substance abuse programs have a TRIR rate 156 percent lower and a DART rate 156 percent lower than companies that do not have substance abuse programs.

While a strong safety management system will measure and monitor both leading and lagging indicators, it seems that recent research and literature reviews are placing more emphasis on the importance of the leading indicators. Using these indicators helps move away from the need of waiting for a factor within the system to fail and then developing corrective measures to

implement to allowing organizations to measure and monitor predictive metrics and correct issues before a system failure (Flin, 1998). This shift in thinking also allows organizations to become more aware of potential failures within the managerial system and reasoning as to human errors rather than associating root causes with technical failures (Weick et al., 1999).

In conclusion, with the information acquired during the literature review, it is evident that there is validity in continuing research on the effectiveness of leading indicators and their effect on lagging indicators, such as injury and severity rates. If continued focus is placed on measuring the appropriate leading indicators, not only will organizations see the benefits in lowered injury rates, but also the potential of carryover to improving other business key performance indicators not related to safety.

## CHAPTER THREE

### METHODOLOGY

This study examined the understanding of safety leading indicators and their perceived effectiveness on reducing injuries in the dairy product-manufacturing sector (NAICS 3115) within the United States. The perception of the content areas was determined based on the following research questions:

RQ1: Which safety leading indicators are implemented and measured in the dairy product-manufacturing sector (NAICS 3115)?

RQ2: Is there an overall agreement among respondents' perception on the rankings of the leading indicators on the effectiveness of reducing injury rates?

RQ3: Is there an agreement on the ranking of implemented leading indicators as effective in reducing injury rates?

RQ4: Is there any differences in the average overall OSHA incident rate (OIR) between the perceived three most effective safety leading indicators among the facilities that implemented them?

RQ5: Is there any differences in the average overall severity incident rate (DART) between the perceived three most effective safety leading indicators among the facilities that implemented them?

RQ6: Is there a correlation between the top ranked and implemented safety leading indicator (most effective) and the change in overall incident rates since implementation?

RQ7: Is there a correlation between the top ranked and implemented safety leading indicator and change in severity (DART) incident rates since implementation?

RQ8: Is there any differences in the change of overall incident rates (OIR) and/or DART

rates among facilities that implemented the perceived most effective leading indicators when compared to facilities that did not implement them?

RQ9: Is there any differences in overall incident rates (OIR) among facilities with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector?

RQ10: Is there any differences in overall severity rates (DART) among facilities with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector?

RQ11: What do the respondents believe are the reasons for the high incident rates in the dairy product-manufacturing sector?

RQ12: What three actions do the respondents believe would help reduce the injury rates in the dairy product-manufacturing sector?

### **Study Sample**

The survey population consisted of dairy product-manufacturing facilities with 11 or more employees throughout the United States. This population was chosen based on OSHA's partial exemption for recordkeeping and injury reporting for employers with 10 or fewer employees (OSHA, nd). Most recent data from the Bureau of Labor Statistics (2014) lists a total of 1139 dairy product-manufacturing establishments with 10 or more employees in the United States. Specifically, the employment size and number of establishments are as follows:

- 11-19 employees = 178 Establishments
- 20-99 employees = 259 Establishments
- >100 employees = 702 Establishments

To obtain sufficient data, all dairy product-manufacturing facilities with 11 or more

employees were asked and encouraged to participate in the survey. The survey was designed to be completed by an individual that oversees the safety program at the facility. To determine where to submit the survey, the facilities' contact information was obtained by working with the International Dairy Foods Association (IDFA), the Dairy Farmers of America (DFA), and the Northeast Dairy Association (NDA). Additionally, an internet research for dairy product-manufacturing facilities was conducted and a message was placed on the IDFA and DFA LinkedIn message boards to help increase participation.

### **Data Collection**

The following information describes the technique and reasoning in which the researcher performed the data collection for the descriptive research study.

#### **Methods of Obtaining Data**

Given the total number and geographical distribution of the facilities, an on-line survey was utilized to gather the information for this descriptive research study (see Appendix B). The researcher chose to use an online survey to overcome the disadvantages of the mail-in option, such as expense, length of time to perform data gathering and lower response rates to perceived sensitive questions.

#### **Survey Instrument**

To gather data on the knowledge of leading indicators as well as the association between safety leading indicators and the reduction of incident rates and/or their severity in the dairy product-manufacturing sector, an on-line self-administered questionnaire survey was distributed to all facilities with 11 or more employees. The survey was accompanied by an introductory cover letter, see Appendix A, which provided the purpose, description, and potential outcomes of the study in a manner intended to capture the respondent's attention with the importance of their

participation. It was also state that participation in the survey would be kept anonymous, voluntary and the participants could withdraw at any time. The cover letter also described the sample population as well as assurance that all results from the surveys would be kept confidential.

In an effort to increase the response rate, the researcher worked closely with the IDFA to encourage their members to open, read and respond to the survey in a timely manner. After two weeks of sending out the survey, follow-up emails were resent to potential respondents and new messages were placed on the IDFA and DFA LinkedIn message board to help increase participation.

The development of the on-line self-administered questionnaire was done by reviewing the literature from the Office of Behavior and Social Sciences Research (2016), Stanford University (2007) and University of Leeds (2001) to ensure the survey instrument would yield the highest response rate. The questionnaire was developed using simple terminology and user-friendly on-line technology such as simple click boxes.

The survey tool was constructed with a particular attention to question sequencing to ensure that individuals participating in the survey would utilize their personal knowledge on what constitutes a leading indicator. It was also developed to intentionally not use the labels of leading and lagging when discussing the indicators to ensure a true test of knowledge.

The questionnaire was developed using three separate sections:

1. A demographics section with questions used to gather characteristics about the respondents and their facility.
2. A knowledge-based section to determine the respondent's knowledge of leading and lagging indicators.

3. A perception-based section to determine the respondent's perception on which indicators have an impact on reducing the total number of injuries and/or their level of severity.

The demographics section was developed to characterize both the respondent and the facility. Individuals will be asked to provide information about their job title, education, work experience and any safety certifications they hold, such as the CSP, ASP, CIH, etc. In order to ensure anonymity, personal identifiers, such as names and gender will not be requested. Respondents will be also asked questions regarding their facility such as OIR, DART rate and size of the facility.

The knowledge section was developed to gain an understanding of the respondents' ability to determine the difference between leading and lagging safety indicators. This section requires the respondents to choose what they perceive as proactive indicators from a list of common leading and lagging indicators used in the industry. It also gives the respondent the ability to write in any other indicators that may not be on the list given to them.

The perception section of the survey asks the respondents to indicate which indicators have been implemented in the past five years, broken into segments of: within 0-1 year; within 2-3 and within 4-5. This section also asks the respondents to indicate which indicators, in their experience, have the biggest impact on lowering the OIR and/or DART.

To ensure that participants were not able to go back and change their selection/responses, the survey was designed to prevent participants from going backward and only move forward. Consequently, the survey had a statement to inform the participants of this constraints.

### **Pilot Study**

The survey tool was pilot tested using 5 facilities within HP Hood LLC dairy. The survey was distributed to both; the Safety Professional and HR Professional at each facility to critique the questions contained in the survey as well as the cover letter and instructions. The HR professionals were chosen as non-safety professionals due the fact that some of the facilities that the survey is sent to may not have dedicated safety professionals.

Feedback from the group resulted in minor modification of the questions' format on the survey. Respondents from the pilot study stated that the slide tool used to identify their facility's lost time incident rate was cumbersome because it was too sensitive to get to the number to second decimal place. This resulted in changing the slide tool on the survey for the lost time incident rate to read in first decimal place, which was how the OSHA incident rate was set up.

### **Data Analysis**

Upon receipt of the surveys, the responses were reviewed to ensure the surveys are accurate and complete according to the stated instructions. All data from the surveys were automatically extracted into an Excel spreadsheet and IBM's Statistical Package for Social Science (SPSS) version 25 for data analysis. The data was then checked for incorrect coding prior to data analysis, which included the methods of analysis listed below.

### **Descriptive Statistical Analysis**

A descriptive analysis of the survey was performed in order to summarize the demographic data and identify trends in the participants' responses. Descriptive statistics such as the mean, standard deviation, and percentages were used to summarize participants' demographic data (i.e., size of facility, certifications of respondents, safety education). Outliers were identified using boxplots. This data outcome is ordered and tabulated in the results chapter.



Descriptive statistics also was used to identify trends in the respondents' answers to differentiate proactive (leading) indicators from reactive (lagging) indicators. Descriptive statistics was also be used to answer:

RQ1: Which safety leading indicators are implemented and measured in the dairy product-manufacturing sector (NAICS 3115)?

RQ11: What do the respondents believe are the reasons for the high incident rates in the dairy product-manufacturing sector?

RQ12: What three actions do the respondents believe would help reduce the injury rates in the dairy product-manufacturing sector?

### **Inferential Statistics**

The following inferential statistics was used to answer the research questions posed by this study. To determine significance for all tests, an Alpha level of .05 were used.

#### **Kendall's Coefficient of Concordance (W)**

Kendall's Coefficient of Concordance (W) is a non-parametric statistic used to measure the amount of agreement among raters for a particular subject (Legendre, 2010). Kendall's Coefficient of Concordance (W) was used to measure agreement among the survey respondents with regard to the rankings of the implemented leading indicators. A value of "1" being the top ranked as the most effective safety leading indicator and "12" being the least ranked leading indicator. Kendall's Coefficient of Concordance (W) was calculated for respondents' rankings of the perceived effectiveness of leading indicators on incident reduction. The Chi-Square ( $\chi^2$ ) test was used to test the significance of the coefficient of concordance at Alpha level .05. This will address both RQ2: "Is there an overall agreement among respondents on the rankings of the leading indicators on the effectiveness of reducing injuries?" as well as RQ3: "Is there an

agreement on the ranking of implemented leading indicators as effective in reducing injury rates?” The significance of the coefficient of concordance will be tested using a chi-squared test of significance to evaluate agreement among respondents in their ranking for each indicator.

### **Friedman Test**

The Friedman Test is a non-parametric substitute for the parametric ANOVA to test for difference between means for ordinal dependent variables (Laerd, 2018e). The Friedman Test was used because the dependent variables (OIR and DART) did not meet the normality assumption across all independent variables. The Friedman test was conducted to answer RQ4: “Is there any differences in the overall average change in OSHA incident rate (OIR) between the perceived three most effective safety leading indicators among the facilities that implemented them?” and RQ5: “Is there any differences in the overall average change in severity incident rate (DART) between the perceived three most effective safety leading indicators among the facilities that implemented them?”. These tests will identify if there are any significant differences in the overall average change in OIR and DART rates between the top three ranked leading indicators among the facilities that have implemented them.

For this research question the variables are:

The independent variable- the leading indicator, which is nominal with three levels.

The dependent variables- the overall average change in OIR and DART. These have a scale format/continuous variable.

Assumptions for the Friedman Test are:

Assumption #1- One group that is measured on three or more different occasions.

Assumption #2- Group is random sample from the population.

Assumption #3- The dependent variable is measured at the ordinal or continuous level.

Assumption #4- Sample do not need to be normally distributed.

### **Spearman Correlation**

The Rank Biserial Spearman Correlation test is a non-parametric test that measures the strength of association between two ordinal variables (Laerd, 2018b). This test was used to answer RQ 6: “Is there a correlation between each of the three top ranked implemented as the most effective safety leading indicators and the overall average change in incident rates (OIR)?” and RQ 7: “Is there a correlation between each of the top ranked implemented as the most effective safety leading indicator and the overall average change in severity (DART) rates since implementation?”. These tests will identify if there is any correlation between each of the three top ranked as the most effective leading indicators among the implemented ones and the overall average change in incident rates (OIR and DART).

For these research questions the variables are:

The independent variable- the most effective implemented safety leading indicators.

Each one is defined as nominal variables with two levels (implemented vs not implemented).

The dependent variables- the overall average change OIR and DART rates. These are considered continuous variables.

Assumptions for the Spearman Correlation are:

Assumption #1- The two variables should be measured on an ordinal, interval or ratio scale.

Assumption #2- There is a monotonic relationship between the two variables.

### **Mann-Whitney Test (U-Test)**

The Mann-Whitney test, also known as the U-test, is used to compare differences between two independent groups when the dependent variable is either ordinal or continuous, but not normally distributed (Laerd, 2018c). According to Laerd statistics (2018c) “Unlike the independent-samples t-test, the Mann-Whitney U test allows the researcher to draw different conclusions about the data depending on the assumptions made about the data's distribution”. The Mann-Whitney test was used to replace the independent t-test, since the independent variables (OIR and DART) across the dependent variable which is the facility type (implemented the leading indicators vs did not implement). The overall average change in both OIR and DART was calculated since implementation for the facilities that implemented the leading indicator, however the overall average change for the whole six-year period (2013-2018) was calculated for the facilities that did not implement the leading indicator. The Mann-Whitney test was used to answer RQ8: Is there any differences in the overall average change in incident rates (OIR) and/or DART rates among facilities that implemented the perceived most effective leading indicators when compared to facilities that did not implement them?, RQ9: “Is there any differences in the incident rates (OIR) overall average among facilities with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector?” as well as RQ10: “Is there any differences in the severity rates (DART) overall average among facilities with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector?”

For these research questions the variables are:

The independent variable- Facility status (the implementation vs non-implementation of the perceived most effective indicators) for (RQ8) and the safety professional status

(Safety Professional vs non-safety professional) for (RQ9 and RQ10), both of which are nominal with two levels.

The dependent variable- OSHA incident rates (OIR) and the severity (DART) rates which are scale/continuous.

Mann-Whitney tests (U-tests) was conducted using the six year's overall average for incident and severity DART rates for RQ8 and the overall average change in OIR and DART for RQs 9&10.

According to Laerd statistics (2018c), there are four assumptions associated with the Mann-Whitney test:

Assumption #1- Dependent variable should be measured on the ordinal or continuous scale

Assumption #2- Independent variable should consist of two categorical, independent groups.

Assumption #3- There should be independence of observations, meaning there should be no relationship between the observations in each group or between the groups.

Assumption #4- A Mann-Whitney U test can be used when your two variables are not normally distributed.

### **Time Weighted Average (TWA)**

To calculate the overall average change in the OIR and DRAT rates over any specific period of time, the average was calculated as the Time Weighted Average (TWA) for every two consecutive years for the years (period) of implementation using the following equation:

$$TWA = \frac{\sum_{i=0}^n \Delta X_i}{Total\ Time}$$

Where,

n = number of years.

$\Delta X_i$  = Change in OIR or DART rate for every two consecutive years.

$$\Delta X_i = X_i - X_{i-1}$$

This equation was used to calculate the overall average change in OIR or DART over the years.

## CHAPTER FOUR

### RESULTS OF STUDY

This chapter presents and discusses the results of this research study. The objective of the study was to identify which, if any, safety leading indicators were being implemented in the dairy product manufacturing sector with employee populations greater than 11 within the United States and their effectiveness on reducing injuries' level of risk. As described in the methodology chapter, the information was collected using an on-line self-administered questionnaire (Appendix B). The data was analyzed and is presented in two separate sections; a descriptive analysis of the demographic data of the survey respondents and qualitative research questions followed by inferential statistics analysis, using SPSS statistical software, to answer the research questions posed by this study.

#### **Response Rate**

The anonymous website link for the on-line questionnaire was distributed directly via email to 312 dairy product manufacturing facilities throughout the United States over the course of a week starting on September 7<sup>th</sup>, 2018. Within 3 weeks, there were only 9 surveys completed and returned. On September 27<sup>th</sup>, 2018 a posting of the cover letter and the website link for the survey was posted on the researchers' LinkedIn page as well as the IDFA and Northeast Dairy Farmers of America's (NDFA) LinkedIn pages in hopes to increase participation. A call was also placed to the President of the NDFA to help promote the survey. After numerous postings, email reminders and discussions on professional teleconferences, by November 30<sup>th</sup>, 2018 a total of 84 surveys were completed. 84 of the 312 facilities that were directly emailed responded to the survey giving a response rate of 27%. This represents 7.4 percent of the total population within the United States.

## Demographic Data

The responses of the survey revealed the majority (79%) came from facilities with 100 or more employees (Table 2). Additionally, it was shown that a total of 18% of all responses from facilities completing the survey did not hire safety professionals (Table 3). Lastly, it was noted 77% of the individuals completed the survey had more than three years of safety responsibilities (Table 4) and the majority (67%) did not have any formal safety certification (Table 5).

Table 2

### *Respondents' Facility Size*

| Size of Facility | Number of Respondents | Percentage (%) |
|------------------|-----------------------|----------------|
| Small (11-19)    | 5                     | 6              |
| Medium (20-99)   | 13                    | 15             |
| Large (>100)     | 66                    | 79             |
| Total            | 84                    | 100            |

Table 3

### *Facilities With Safety Professionals*

| Size of Facility | Facilities with Safety Professional | Percentage (%) by facility size |
|------------------|-------------------------------------|---------------------------------|
| Small (11-19)    | 1                                   | 20                              |
| Medium (20-99)   | 10                                  | 77                              |
| Large (>100)     | 58                                  | 88                              |
| Total            | 69                                  | 82                              |

Table 4

### *Respondents' Length of Safety Responsibility*

| Length of Responsibility | Number of Respondents | Percentage (%) |
|--------------------------|-----------------------|----------------|
| >1 year                  | 5                     | 6              |
| 1-2 years                | 11                    | 13             |
| 3-5 years                | 24                    | 29             |
| 6-10 years               | 26                    | 31             |
| >11 years                | 14                    | 17             |
| Blank                    | 3                     | 4              |
| Total                    | 84                    | 100            |



Table 5

*Respondents' Certifications*

| <u>Certification</u>    | <u>Number of Respondents</u> | <u>Percentage (%)</u> |
|-------------------------|------------------------------|-----------------------|
| ASP                     | 3                            | 3.5                   |
| GSP                     | 4                            | 4.8                   |
| CSP                     | 13                           | 15.5                  |
| OHST                    | 1                            | 1.2                   |
| SMS                     | 1                            | 1.2                   |
| CDS                     | 1                            | 1.2                   |
| Multiple Certifications | 1                            | 1.2                   |
| NYS Building Codes      | 1                            | 1.2                   |
| PHR                     | 1                            | 1.2                   |
| SPHR                    | 1                            | 1.2                   |
| None                    | 57                           | 67.8                  |
| Total                   | 84                           | 100                   |

**Descriptive Statistics**

Descriptive statistics were used to answer the following proposed research questions in this study:

RQ1: Which safety leading indicators are implemented and measured in the dairy product-manufacturing sector (NAICS 3115)?

RQ11: What do the respondents believe are the reasons for the high incident rates in the dairy product-manufacturing sector?

RQ12: What three actions do the respondents believe would help reduce the injury rates in the dairy product-manufacturing sector?

**Research Question 1**

The sample for this research question consisted of 82 respondents. Two respondent questionnaires were excluded because no answers were provided. To answer Research Question1, “Which safety leading indicators are implemented and measured in the dairy product-manufacturing sector (NAICS 3115)?” a simple descriptive analysis was performed using each of the survey responses. Each respondent was given a list of 12 leading indicators and asked to

indicate which, if any, were being implemented at their respective facility. Eight leading indicators were implemented by more than half of the respondents, with safety audits, preventative maintenance and safety training attendance all implemented by 90% of respondents.

Table 6 summarizes the data of the leading indicators implemented.

Table 6

*Implementation of Safety Leading Indicators*

| Leading Indicator                 | Number of Facilities Implementing | Percentage (%) |
|-----------------------------------|-----------------------------------|----------------|
| Safety Audits                     | 74                                | 90             |
| Preventative Maintenance          | 74                                | 90             |
| Safety Training Attendance        | 74                                | 90             |
| Safety Observations               | 72                                | 88             |
| Safety Inspections                | 72                                | 88             |
| Near Miss Reporting               | 66                                | 80             |
| Stop Work Authority               | 58                                | 71             |
| JHA/JSA                           | 57                                | 70             |
| Safety Meeting Attendance         | 37                                | 45             |
| Corrective Action Completion Rate | 30                                | 37             |
| Worker Perception Survey          | 24                                | 29             |
| Attendance Tracking               | 20                                | 24             |

**Research Question 11**

The sample for this research question consisted of 76 respondents. Two respondent questionnaires were excluded because no answers were provided for this question and additional six were excluded because the response given by those completing the survey were “unknown” or “I don’t know”. To answer Research Question 11, “What do the respondents believe are the reasons for the high incident rates in the dairy product-manufacturing sector?” a simple descriptive analysis was performed using each of the survey responses. Each respondent was given the opportunity to list three reasons they believe contribute to the increased incident rates within the dairy manufacturing sector. While there were many responses, the data focuses on the four

major reasons that were given by 20% or more of the survey respondents. Table 7 summarizes the data.

Table 7

*Major Reasons Given for High Incident Rates in the Dairy Manufacturing Sector*

| Description                                | Number of Respondents | Percentage (%) |
|--------------------------------------------|-----------------------|----------------|
| Production 1 <sup>st</sup> Mentality       | 23                    | 30             |
| Lack of Safety Support by Upper Management | 23                    | 30             |
| Lack of Training/Knowledge                 | 18                    | 24             |
| Unsafe Acts by Employees                   | 16                    | 21             |

**Research Question 12**

The sample for this research question consisted of 75 respondents. Two respondent questionnaires were excluded because no answers were provided for this question and additional seven were excluded because the responses by the respondent were “unknown” or “I don’t know”. To answer Research Question 12, “What three actions do the respondents believe would help reduce the injury rates in the dairy product-manufacturing sector?” a simple descriptive analysis was performed using each of the survey responses. Each respondent was given the opportunity to list three effective ways they believe would help reduce the incident rates within the dairy manufacturing sector. While there were many responses, the data focuses on the four major measures that were given by 19% or more of the survey respondents. Table 8 summarizes the data.

Table 8

*Measures Given by Respondents to Effectively Reduce Incident Rates in the Dairy Product Manufacturing Sector*

| Measure                                       | Number of Respondents | Percentage (%) |
|-----------------------------------------------|-----------------------|----------------|
| More Effective Training/Education             | 33                    | 44             |
| Increase Management Support/Buy-in for Safety | 25                    | 33             |
| Increase Employee Involvement in Safety       | 20                    | 27             |
| Develop an Ergonomics Assessment Program      | 14                    | 19             |

## **Inferential Statistics**

Inferential statistics were used to answer the following proposed research questions in this study:

RQ2: Is there an overall agreement among respondents on the rankings of the leading indicators on the effectiveness of reducing injuries?

RQ3: Is there an agreement on the ranking of implemented leading indicators as effective in reducing injury rates?

RQ4: Is there any differences in the overall average change in OSHA incident rate (OIR) between the perceived three most effective safety leading indicators among the facilities that implemented them?

RQ5: Is there any differences in the overall average change in severity incident rate (DART) between the perceived three most effective safety leading indicators among the facilities that implemented them?

RQ6: Is there a correlation between the top ranked and implemented safety leading indicator (most effective) and the overall average change in incident rates since implementation?

RQ7: Is there a correlation between the top ranked and implemented safety leading indicator and the overall average change in severity (DART) incident rates since implementation?

RQ8: Is there any differences in the overall average change in incident rates (OIR) and/or DART rates among facilities that implemented the perceived most effective leading indicators when compared to facilities that did not implement them?

RQ9: Is there any differences in the incident rates (OIR) overall average among facilities

with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector?

RQ10: Is there any differences in the severity rates (DART) overall average among facilities with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector?

All statistical tests were analyzed using an alpha level of .05 to determine significance.

## **Research Question 2**

The sample for this research question consisted of 82 respondents. Two subjects were excluded because the respondents left the answers blank. To answer Research Question 2, “Is there an overall agreement among respondents on the rankings of the leading indicators on the effectiveness of reducing injuries?”. The following hypotheses were tested:

H<sub>0</sub>: There is no significant agreement among respondents on the rankings of leading indicators’ effectiveness in reducing the injury rates.

H<sub>1</sub>: There is a significant agreement among respondents on the rankings of leading indicators’ effectiveness in reducing of injury rates.

The results showed that the agreement was significant (Kendall’s  $W = .279$ ,  $\chi^2 = 251.317$ ,  $p = .000$ ) as depicted in Table 9. Therefore, there is a significant agreement between the survey respondents’ perception regarding the most effective leading indicators on incident rate reduction in the dairy product manufacturing sector. The Kendall’s Coefficient of Concordance (W) test showed the top three ranked (most effective) leading indicators are safety observations (mean rank = 3.88), stop work authority (mean rank = 4.72), and safety audit (mean rank = 4.8). As

reminder, the lower the rank, the more effective the leading indicator is. However, attendance tracking had the highest mean rank of 10.35.

Table 9

*Kendall's Coefficient of Concordance (W) for Leading Indicators' Rankings*

| Leading Indicator                             | Mean Rank    | Std. Deviation |
|-----------------------------------------------|--------------|----------------|
| Worker Safety Perception Survey               | 7.10         | 3.809          |
| Safety Audits                                 | <b>4.80*</b> | 2.826          |
| Safety Training Attendance                    | 7.34         | 3.389          |
| Safety Meeting Attendance                     | 8.33         | 2.699          |
| Safety Observations                           | <b>3.88*</b> | 2.795          |
| Stop Work Authority                           | <b>4.72*</b> | 2.631          |
| Machine/Equipment Preventative Maintenance    | 5.52         | 2.803          |
| Near Miss Reporting                           | 4.88         | 2.834          |
| Corrective Action Completion Rate             | 7.61         | 2.805          |
| Attendance Tracking                           | 10.35        | 2.015          |
| Job Hazard Analysis/Safety Analysis (JHA/JSA) | 7.90         | 3.114          |
| Safety Inspections                            | 5.56         | 3.304          |

*Kendall's  $W = .279$ ,  $\chi^2 = 251.317$ ,  $p = .000$ ,  $df = 11$*

*NOTE.* Rankings are 1 – 12 with 1 representing the most effective leading indicator on reducing injury rates and 12 representing the least effective leading indicator on reducing injury rates

\*Top 3 perceived most effective indicators by all respondents regardless of implementation

### Research Question 3

The sample for this research question consisted of 40 respondents as depicted by the results of the Kendall's Coefficient of Concordance. Table 10 shows the descriptive statistics associated with the number of facilities implementing the perceived leading indicators as the most effective and their rankings. Since only nine facilities implemented all 12 leading indicators, a statistical comparison was not possible to answer research question 3. To increase the sample size, the rankings were cross referenced with the number of facilities implementing the leading indicators (i.e. leading indicators with low rankings vs indicators with large number of implementation). As shown in Table 10, eight leading indicators were implemented by 40 or more facilities and these were the leading indicators chosen to be analyzed for agreement in

effectiveness by using Kendall's Coefficient of Concordance (W). The leading indicators were: Audits, Training Attendance, Observations, Stop Work Authority, Preventative Maintenance, Near Miss, JHAs and Safety Inspections.

Table 10

*Descriptive Statistics for Leading Indicator Rankings by Number of Facilities Implementing Them*

|                              | Implement | Did Not Implement | Mean Rank   |
|------------------------------|-----------|-------------------|-------------|
| Surveys                      | 25        | 59                | 5.2         |
| <b>Audits</b>                | <b>77</b> | <b>7</b>          | <b>4.9*</b> |
| <b>Training Attendance</b>   | <b>75</b> | <b>9</b>          | <b>7.4*</b> |
| Meeting Attendance           | 38        | 46                | 7.4         |
| <b>Observations</b>          | <b>73</b> | <b>11</b>         | <b>3.7*</b> |
| <b>Stop Work Authority</b>   | <b>58</b> | <b>26</b>         | <b>4.2*</b> |
| <b>Prevent Maintenance</b>   | <b>76</b> | <b>8</b>          | <b>5.5*</b> |
| <b>Near Miss</b>             | <b>68</b> | <b>16</b>         | <b>4.7*</b> |
| Corrective Action Completion | 30        | 54                | 6.4         |
| Attendance Tracking          | 20        | 64                | 9.3         |
| <b>JHA/JSA</b>               | <b>58</b> | <b>26</b>         | <b>7.7*</b> |
| <b>Inspections</b>           | <b>74</b> | <b>10</b>         | <b>5.5*</b> |

\*The eight leading indicators implemented by 40 facilities

To answer Research Question 3, "Is there an agreement on the ranking of implemented leading indicators as effective in reducing injury rates?" a Kendall's Coefficient of Concordance (W) was used to measure agreement among the survey respondents with regard to the effectiveness (rankings) of the eight implemented leading indicators described earlier. Kendall's Coefficient of Concordance (W) was calculated for respondents' rankings of the perceived leading indicators on incident reduction. The Chi-Square ( $\chi^2$ ) test was used to determine the significance of the coefficient of concordance at Alpha level .05. The following hypotheses were tested:

H<sub>0</sub>: There is no significant agreement among respondents on the rankings of

implemented leading indicators.

H<sub>1</sub>: There is a significant agreement among respondents on the rankings of implemented leading indicators.

The results showed 40 facilities implemented all eight leading indicators and the agreement on the ranking was significant (Kendall's  $W = .232$ ,  $\chi^2 = 64.950$ ,  $p = .000$ ) as depicted in Table 11. The researcher concluded there is a significant agreement among the survey respondents' perception regarding the implemented leading indicators on incident rate reduction in the dairy product manufacturing sector. The Kendall's Coefficient of Concordance (W) test showed the top three with the lowest mean ranking (most effective) categories of implemented leading indicators are safety observations (mean rank = 3.68), stop work authority (mean rank = 3.95) and near miss reporting (mean rank = 4.30). Job Hazard Analysis/Job Safety Analysis (JHA/JSA) had the highest mean rank of 8.30 which is perceived as the least effective indicator.

Table 11

*Kendall's Coefficient for Concordance (W) for Implemented Leading Indicators' Rankings*

| Leading Indicator                          | N  | Mean Rank    | Std. Deviation |
|--------------------------------------------|----|--------------|----------------|
| Safety Audits                              | 40 | 5.93         | 2.823          |
| Safety Training Attendance                 | 40 | 7.40         | 3.112          |
| Safety Observations                        | 40 | <b>3.68*</b> | 3.041          |
| Stop Work Authority                        | 40 | <b>3.95*</b> | 2.171          |
| Machine/Equipment Preventative Maintenance | 40 | 5.90         | 2.933          |
| Near Miss Reporting                        | 40 | <b>4.30*</b> | 2.691          |
| Job Hazard Analysis/Safety Analysis        | 40 | 8.30         | 2.839          |
| Safety Inspections                         | 40 | 6.13         | 3.131          |

*Kendall's  $W = .232$ ,  $\chi^2 = 64.950$ ,  $p = .000$ ,  $df = 7$*

NOTE. Ranking are 1-12 with 1 representing the most effective leading indicator on reducing injury rates and 12 representing the least effective leading indicator on reducing injury rates.

\*Top 3 perceived most effective leading indicators by the 40 facilities that implemented them



## Research Questions 4 and 5

The sample for this research question consisted of 55 respondents that implemented the top three highest ranked leading indicators (observations, stop work authority and near miss reporting). To answer Research Question 4, “Is there any differences in the average overall OSHA incident rate (OIR) between the perceived three most effective safety leading indicators among the facilities that implemented them?” as well as Research Question 5, “Is there any differences in the average overall severity incident rate (DART) between the perceived three most effective safety leading indicators among the facilities that implemented them?” a Friedman test was performed to determine which, if any, of the three most effective implemented safety leading indicators has the most impact on reducing the OIR or DART rates. The following hypotheses were tested:

H<sub>0</sub>: There are no significant differences in the overall average change in the OSHA incident rate (OIR) between the three perceived indicators as the most effective implemented safety leading indicators.

H<sub>1</sub>: There are significant differences in the overall average change in the OSHA incident rate (OIR) between the three perceived indicators as the most effective implemented safety leading indicators.

H<sub>0</sub>: There are no significant differences in the overall average change in the severity (DART) rate between the three perceived indicators as the most effective implemented safety leading indicators.

H<sub>1</sub>: There are significant differences in the overall average change in the severity (DART) rate between the three perceived indicators as the most effective implemented safety leading indicators.

As shown in the Tables 12 and 13 below, a non-parametric Friedman test of the differences among repeated measures was conducted and rendered a Chi-square value of 4.50 which was not significant ( $p > .05$ ) for OIR and a Chi-square value of .681 which was not significant for DART rate ( $p > .05$ ).

Table 12

*Friedman Test Results for the Top Three Implemented Leading Indicators and Their Impact on OIR*

| Safety Leading Indicator | Mean Rank | Mean (Change in OIR) | Std. Deviation |
|--------------------------|-----------|----------------------|----------------|
| Observation OIR          | 2.18      | -.5327               | 1.32791        |
| Stop Work Authority OIR  | 1.94      | -.9964               | 3.05408        |
| Near Miss OIR            | 1.88      | -.9836               | 2.34369        |

*Chi-Square = 4.039, df = 2, p = .133*

Table 13

*Friedman Test Results for the Top Three Implemented Leading Indicators with Their Impact on DART*

| Safety Leading Indicator | Mean Rank | Mean (Change in DART) | Std. Deviation |
|--------------------------|-----------|-----------------------|----------------|
| Observation DART         | 2.06      | -.2818                | .96955         |
| Stop Work Authority DART | 1.94      | -.1636                | 2.04399        |
| Near Miss DART           | 2.00      | -.3145                | 1.10494        |

*Chi-Square = .681, df = 2, p = .712*

### **Research Questions 6 and 7**

The sample for these research questions consisted of 55 respondents who indicated on the survey that they had implemented the top three safety leading indicators (observations, stop work authority and near miss reporting). To answer Research Question 6, “Is there a correlation between the top ranked and implemented safety leading indicator (most effective) and the change in overall incident rates since implementation?” as well as Research Question 7, “Is there a correlation between the top ranked and implemented safety leading indicator and change in severity (DART) incident rates since implementation?” a Biserial Spearman Correlation test was performed. To test the significance, an Alpha level of .05 was used and the following

hypotheses were tested:

H<sub>0</sub>: There is no significant correlation between the rankings for each one of the perceived most effective implemented safety leading indicator and the overall average change in OIR since implementation.

H<sub>1</sub>: There is a significant correlation between the rankings for each one of the perceived most effective implemented safety leading indicator and the overall average change in OIR since implementation.

H<sub>0</sub>: There is no significant correlation between the rankings for each one the perceived most effective safety leading indicator and the overall average change in DART rates since implementation.

H<sub>1</sub>: There is a significant correlation between the rankings for each one the perceived most effective safety leading indicator and the overall average change in DART rates since implementation.

**Observations.** A Biserial Spearman's correlation was run to assess the relationship between the rankings of the leading indicator "observations" and the overall average change in OSHA total incident rate (OIR) as well as the severity (DART) rate for the 55 respondents who implemented this indicator. Results of the test showed there is no statistically significant correlation between the rankings of observations and in the overall average change in OIR ( $r_s = .037$ ,  $p = .789$ ) or the DART rate ( $r_s = .012$ ,  $p = .933$ ).

**Stop work authority.** A Biserial Spearman's correlation was run to assess the relationship between the implementation of the safety leading indicator "stop work authority" and the overall average change in OSHA total incident rate (OIR) as well as the severity (DART) rate of the 55 respondents who implemented this indicator. Results of the test showed there is no

statistically significant correlation between the rankings of stop work authority and in the overall average change in OIR ( $r_s = .183$ ,  $p = .181$ ) or the DART rate ( $r_s = .067$ ,  $p = .628$ ).

**Near miss reporting.** A Biserial Spearman's correlation was run to assess the relationship between the implementation of the safety leading indicator "near miss reporting" and the overall average change in OSHA incident rate (OIR) as well as the severity (DART) rate of the 55 respondents who implemented this indicator. Results of the test showed there is no statistically significant correlation between the rankings of near miss reporting and the overall average change in OIR ( $r_s = .172$ ,  $p = .210$ ) or the DART rate ( $r_s = .178$ ,  $p = .194$ ).

### **Research Question 8**

The sample for this research question consisted of all 84 respondents for the comparison of change in OIR and 80 respondents for the comparison of change of DART rates. Four respondents were excluded of the DART data, because they left the answers to the DART rates blank. To answer Research Question 8, "Is there any differences in the overall average change in incident rates (OIR) and/or DART rates among facilities that implemented the perceived most effective leading indicators when compared to facilities that did not implement them?" a Mann-Whitney U test was performed on the six year average of each facility's overall incident (OIR) and severity incident rates (DART) to determine if there is a significant difference in the rates between facilities that implemented the leading indicators (observations, stop work authority and near miss reporting) versus those that did not. Mann-Whitney U was calculated for respondents' six-year OIR and DART averages. To test the significance an Alpha level of .05 was used and the following hypotheses were tested:

$H_0$ : There is no significant difference in the overall average change in incident rates (OIR) or DART rate among facilities that implemented the perceived most effective

leading indicators when compared to facilities that did not implement them.

H<sub>1</sub>: There is a significant difference in the overall average change in incident rates (OIR) or DART rate among facilities that implemented the perceived most effective leading indicators when compared to facilities that did not implement them.

The results showed that the difference in both overall incident rate (OIR) severity (DART) incident rate was not significant ( $U = 271.500$ ,  $p = .084$  two-tailed;  $U = 234.500$ ,  $p = .091$  respectively) for those facilities that implemented the leading indicator “observations” versus that that did not as depicted in Tables 14 and 15. The researcher concluded that there is no significant difference in OIR and DART rates in the dairy product manufacturing facilities that implemented the leading indicator “observations” versus those facilities that do not.

Table 14

*Mann-Whitney U Results for Differences in OIR Between Facilities Implementing and Not Implementing Observations*

| Observations | N  | Mean Rank | Sum of Ranks |
|--------------|----|-----------|--------------|
| Yes          | 73 | 40.72     | 2972.50      |
| No           | 11 | 54.32     | 597.50       |
| Total        | 84 |           |              |

*Mann-Whitney  $U = 271.500$ ,  $p = .084$ , two-tailed*

Table 15

*Mann-Whitney U Results for Differences in DART Rate Between Facilities Implementing and Not Implementing Observations*

| Observations | N  | Mean Rank | Sum of Ranks |
|--------------|----|-----------|--------------|
| Yes          | 70 | 38.85     | 2719.50      |
| No           | 10 | 52.05     | 520.50       |
| Total        | 80 |           |              |

*Mann-Whitney  $U = 234.500$ ,  $p = .091$ , two-tailed*

The results showed that the difference in the overall average change in incident rate (OIR) was significant ( $U = 527.000$ ,  $p = .028$  two-tailed) but was not significant for the overall average change in severity (DART) incident rate ( $U = 617.500$ ,  $p = .465$ ) for those facilities that

implemented the leading indicator “stop work authority” versus the ones that did not as depicted in Tables 16 and 17, respectively. Then, there is only a significant difference in OIR rates in the dairy product manufacturing facilities that implemented the leading indicator “stop work authority” versus those facilities that did not.

Table 16

*Mann-Whitney U Results for Differences in OIR Between Facilities Implementing and Not Implementing Stop Work Authority*

| Stop Work Authority | N  | Mean Rank | Sum of Ranks |
|---------------------|----|-----------|--------------|
| Yes implementing    | 58 | 38.59     | 2238.00      |
| Not implementing    | 26 | 51.23     | 1332.00      |
| Total               | 84 |           |              |

*Mann-Whitney U = 527.000, p = .028, two-tailed*

Table 17

*Mann-Whitney U Results for Differences in DART Rate Between Facilities Implementing and Not Implementing Stop Work Authority*

| Stop Work Authority | N  | Mean Rank | Sum of Ranks |
|---------------------|----|-----------|--------------|
| Yes implementing    | 55 | 39.23     | 2157.50      |
| Not implementing    | 25 | 43.30     | 1082.50      |
| Total               | 80 |           |              |

*Mann-Whitney U = 617.500, p = .465, two-tailed*

When testing the leading indicator “near miss reporting, the results showed the difference in both overall average change in incident rate (OIR) severity (DART) incident rate was not significant ( $U = 499.500$ ,  $p = .611$  two-tailed;  $U = 397.000$ ,  $p = .262$ , respectively) for those facilities that implemented the leading indicator “near miss reporting” versus those that did not as depicted in Tables 18 and 19. There is no significant difference in overall average change in both the OIR and the DART rates in the dairy product manufacturing facilities that implement the leading indicator “near miss reporting” versus those facilities that do not.

Table 18

*Mann-Whitney U Results for Differences in OIR Rate Between Facilities Implementing and Not Implementing Near Miss Reporting*

| Near Miss Reporting | N  | Mean Rank | Sum of Ranks |
|---------------------|----|-----------|--------------|
| Yes implementing    | 68 | 41.85     | 2845.50      |
| Not implementing    | 16 | 45.28     | 724.50       |
| Total               | 84 |           |              |

*Mann-Whitney U = 499.500, p = .611, two-tailed*

Table 19

*Mann-Whitney U Results for Differences in DART Rate Between Facilities Implementing and Not Implementing Near Miss Reporting*

| Near Miss Reporting | N  | Mean Rank | Sum of Ranks |
|---------------------|----|-----------|--------------|
| Yes                 | 65 | 39.11     | 2542.00      |
| No                  | 15 | 46.53     | 698.00       |
| Total               | 80 |           |              |

*Mann-Whitney U = 397.000, p = .262, two-tailed*

### Research Question 9

The sample for this research question consisted of all 84 respondents. To answer Research Question 9, “Is there any differences in incident rates (OIR) overall average among facilities with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector?” a Mann-Whitney U test was performed on the six year overall average of each facility’s OSHA incident rates (OIR) to determine if there was a significant difference in the incidents rates overall average between facilities with a safety professional versus those without. To test the significance an Alpha level of .05 was used and the following hypotheses were tested:

H<sub>0</sub>: There is no significant difference in the incident rates (OIR) overall average among facilities with safety professionals when compared to facilities without safety professionals in the dairy product-manufacturing sector.

H<sub>1</sub>: There is a significant difference in the incident rates (OIR) overall average among

facilities with safety professionals when compared to facilities without safety professionals in the dairy product-manufacturing sector.

The results showed the difference in the incident rate overall average was not significant ( $U = 432.500$ ,  $p = .321$ , two-tailed) as depicted in Table 20. There is no significant difference in the incident rates overall average in the dairy product manufacturing facilities that have safety professionals versus those facilities that do not.

Table 20

*Mann-Whitney U Results for Differences in OIR Between Facilities With and Without a Safety Professional*

| Safety Pro             | N  | Mean Rank | Sum of Ranks |
|------------------------|----|-----------|--------------|
| No Safety Professional | 15 | 36.83     | 552.50       |
| Safety Professional    | 69 | 43.73     | 3017.50      |
| Total                  | 84 |           |              |

*Mann-Whitney  $U = 432.500$ ,  $p = .321$ , two-tailed*

### Research Question 10

The sample for this research question consisted of 79 respondents. Four respondents were excluded because they left the answers to the severity rates blank. To answer Research Question 10, “Is there any differences in the severity rates (DART) overall average among facilities with safety professions when compared to facilities without safety professionals in the dairy product-manufacturing sector?” a Mann-Whitney U test was performed on the six year overall average of each facility’s severity rate (DART) to determine if there is a significant difference in the DART rates overall average between facilities with a safety professional versus those without. Mann-Whitney U was calculated for respondents’ six-year DART overall average. To test the significance an Alpha level of .05 was used and the following hypotheses were tested:

$H_0$ : There is no significant difference in the severity rates (DART) overall average among



facilities with safety professionals when compared to facilities without safety professionals in the dairy product-manufacturing sector.

H<sub>1</sub>: There is a significant difference in the severity rates (DART) overall average among facilities with safety professionals when compared to facilities without safety professionals in the dairy product-manufacturing sector.

The results showed that the difference in severity rate overall average was not significant ( $U = 434.500$ ,  $p = .569$  two-tailed) as depicted in Table 21. The researcher concluded that there is no significant difference in severity (DART) rates overall average in the dairy product manufacturing facilities that have safety professionals versus those facilities that do not.

Table 21

*Mann-Whitney U Results for Differences in DART Rate Between Facilities With and Without a Safety Professional*

| Safety Pro             | N  | Mean Rank | Sum of Ranks |
|------------------------|----|-----------|--------------|
| No Safety Professional | 15 | 36.97     | 554.50       |
| Safety Professional    | 65 | 40.71     | 2605.50      |
| Total                  | 80 |           |              |

*Mann-Whitney  $U = 434.500$ ,  $p = .569$ , two-tailed*

## CHAPTER 5

### DISCUSSION

#### **Collected Survey Review and Analysis**

This research study surveyed facilities in the dairy product manufacturing sector with 11 or more employees throughout the United States on their perception of the effectiveness of safety leading indicators and their impact on injury rates and/or severity. It was aimed to identify what safety leading indicators being implemented at these facilities and if the top three ranked leading indicators have any impact on the overall incident rates and/or their severity. The reasoning behind performing this study was due to the dairy product manufacturing sector continuing to see elevated injury rates when compared to the national average. If the possibility exists that implementing and measuring certain safety leading indicators leads to lower injury rates, then it could be possible to help the industry understand the importance of doing so. It would also allow the industry to focus their attention on specific leading indicators rather than implement ones that seem to have no effect on the injury rates.

The researcher utilized a self-administered questionnaire to gather the information for this research study. The gathering of information was limited to an on-line self-administered questionnaire survey instrument in hopes to increase participation. While the response was low, many of the responses did contain all the pertinent answers to the questions that were asked in the survey. The survey was directly emailed to 312 facilities and was also publicly posted on pertinent LinkedIn websites. The 84 returned surveys represented a return rate of 27% for the facilities that were directly emailed and 7% of the entire population within the United States. While the response rate was low, the surveys that were completed and returned show similar

trends in regard to the facility size distribution when compared to the entire population. Table 22 represents this information.

Table 22

*Respondents' Facility Size vs the U.S. Population for the Dairy Product Industry*

| Size of Facility | Percentage of all Facilities within U.S. (%) | Percentages of the 84 That Completed the Survey (%) |
|------------------|----------------------------------------------|-----------------------------------------------------|
| Small (11-19)    | 16                                           | 6                                                   |
| Medium (20-99)   | 22                                           | 15                                                  |
| Large (>100)     | 62                                           | 79                                                  |
| Total            | 100                                          | 100                                                 |

Due to the anonymity of the responses, it was not possible to identify if the surveys were returned from the facilities directly emailed or those that completed the survey from the hyperlink on the LinkedIn websites. Because of this, a follow up study can be performed, to separate anonymous links be used for each grouping of individuals to determine where the higher percentage of responses are gathered from. This would allow for additional requests to complete the survey be made via the media where the lowest percentage of responses came from in hopes to boost the number of responses gathered.

According to the results, 82% of the participating facilities stated they hired a safety professional yet 68% indicated they did not hold any formal certificates in the safety profession. The potential exists that while the facility has an individual with the title of safety professional (manager, specialist, supervisor, etc.) on site, it could be by title only. Anecdotally, it has been observed that there have been several times when production employees have been given the title of safety professional yet had no formal training and/or education in the safety sciences. This could have a profound effect on how the safety leading indicators are implemented and measured, which in turn impacts their effectiveness.

## **The Research Questions**

The main purpose of this study was to determine which leading indicators are currently being implemented in the dairy product manufacturing sector and determine which, if any, are the most effective in reducing the overall OSHA incident rate (OIR) and/or severity (DART) rate. It was hypothesized that facilities that implement and measure certain safety leading indicators would see a marked improvement in their OIR and/or DART rates in the years following implementation.

The data collected shows the majority of facilities did implement at least one safety leading indicator. In fact, 90% of the facilities indicated they implemented safety audits, preventative maintenance and safety training attendance. While audits and preventative maintenance were in the top five of rankings based on effectiveness, none of them were in the top three of rankings. It is important to note that audits as well as safety training attendance would be required by OSHA, so it is not surprising to see a high percentage of facilities implementing those indicators. Also, preventative maintenance typically is performed based on the advantages of cost savings. Proper maintenance to machinery and equipment allows for longer life and less downtime so the benefits are seen as a production savings versus for safety. Results also showed as the level of effort increases for the safety indicator the implementation percentage decreased (example- stop work authority had a 71% implementation rate). Based on the results of Kendall's Coefficient of Concordance (W) there was an agreement by all 84 respondents on the perceived ranking of leading indicators' effectiveness on reducing the injury rates (Kendall's  $W = .279$ ,  $\chi^2 = 251.317$ ,  $p = .000$ ). Additionally, the results show the 40 facilities that actually implemented all eight leading indicators have an agreement (Kendall's  $W = .232$ ,  $\chi^2 = 64.950$ ,  $p = .000$ ) on the perception of leading indicators' effectiveness on reducing

the injury rates. When compared together, regardless of implementation there was an overall agreement that the leading indicators: “observations”, “stop work authority”, “near miss reporting”, “preventative maintenance” and “audits” were the top five perceived most effective on reducing injury rates. Additionally, observations and stop work authority were ranked first and second on effectiveness regardless of implementation. It is important to mention that the ranking of the safety leading indicators’ effectiveness could be solely based on the respondents’ perceived effect the leading indicator has on reducing the injury rates and not necessarily any statistical analysis they had to justify this effect based on how the survey questions were constructed and formatted. As mentioned several times throughout this paper, studies have shown that if leading indicators are properly implemented and measured there is a direct reflection (reduction) in injury rates (Hinze, 2003; Shea et al., 2016). Articles and studies do not indicate that there are specific indicators that would be effective in all industries. Instead, the effectiveness of leading indicators is based on the implementation and measurement of those that will have a direct impact on lagging indicators associated with the individual facility (Manuele, 2009). This means that if the majority of a facility’s injuries are a result of slip, trips and falls, then the leading indicators that are in place should focus their attention on these types of hazards and behaviors. Knowing this, the perceived effectiveness of the indicators in this study compared to the true effectiveness would only be as close as the proper implementation and measuring.

The results of the Friedman tests, which are depicted in Tables 12 and 13, performed on this research survey’s data show there was no statistical significant difference in the overall average change in OSHA incident rate and severity rate among the facilities that implemented the three top most effective safety leading indicators ( $\chi^2 = 4.50$ ,  $df = 2$ ,  $p = .105$  and  $\chi^2 = .596$ ,  $df$

= 2,  $p = .742$ , respectively). While this indicates none of the three indicators are significantly any better than the others at reducing the rates, the overall average change in the OIR and DART rates for each leading indicator is negative demonstrating that there is potentially some slight effectiveness of one or more (combination of the eight if not the 12) of the leading indicators on reducing the rates. Even though the focus was on the perceived most effective three leading indicator, the separation between the individual impact of each leading indicator is impossible due to the fact that some of the leading indicators were either implemented at the same time or before the others.

Additionally, the Spearman correlation tests performed on the relationship between each of the three perceived most effective safety leading indicators on reducing injury rates (OIR and DART) show there was no significant correlation between the respondents' perceived effectiveness of the top ranked indicators and the overall average change in the OSHA incident and severity rates ("observation" OIR  $p = .798$ , DART  $p = .933$ ; "stop work authority" OIR  $p = .181$ , DART  $p = .628$ ; and "near miss reporting" OIR  $p = .210$ , DART  $p = .194$ ).

The results of the Mann-Whitney tests, found in Tables 14-21, show for both observations and near miss reporting implementation there were no statistical differences between the two groups' overall average change of both the OIR and DART ("observations" OIR  $p = .084$ , DART  $p = .091$ ; "near miss reporting" OIR  $p = .611$ , DART  $p = .262$ ). In the case of the leading indicator "stop work authority" however, it was found there was a significant difference in the overall average change of OIR for those that implemented versus those that did not ( $p = .028$ ), but no significant differences in DART rate were observed ( $p = .465$ ). The significant difference in the OIR for those facilities that implemented stop work authority versus those that did not could indicate the implementing facilities have more support for safety from

top management. Stop work authority requires the empowerment for employees to stop work if they have or perceive a concern regarding their safety. Stopping work goes against the grain of what industries have been built on and many employers, as well as employees, are production driven. So much so that employees that meet certain production goals are often celebrated and managerial bonuses are given when production numbers are met or exceeded. Because of this it can be deduced that some employees would be reluctant to stop the production line for something they believe could be a safety issue. Some companies have recognized the potential for this and have implemented a safety work card, signed by the senior site leader, that can be used at any time an employee feels as though there is a safety concern to stop production (Logsdon, 2014). For those facilities stating they implemented this indicator, it could reflect a culture in which safety is held with the same regard as production and upper management supports the program more so than those facilities that do not.

It is important to note that split of those who implemented observations and near miss reporting versus those that did not was much more weighted toward those who implemented (73/11 for observations and 68/16 for near miss reporting) versus those of stop work authority (58/26). The potential could exist that if these numbers were higher (bigger sample size), especially with those that did not implement, with a closer 50/50 split may show implementation does have an impact on OSHA and DART rates versus not implementing. Based on the probability value (p-value), this is more viable for “Observation”, compared to the two other leading indicators, since the p-value for OIR and DART were .084 and .091, respectively (Table 14 & 15) while the p-value was higher than .25 for the others (Tables 16-21). While the leading indicator of observations showed no significant differences between the OIR and DART rates for those that implemented versus those that did not, it was evident facilities implemented this

leading indicator have a slightly higher positive change in both OIR and DART rates than those that did not. This can be seen in Table 23.

Table 23

*Descriptive Statistics for the Overall Average Change in OIR and DART Rates Between Facilities Implementing and Not Implementing Observations*

| <u>Observations</u> | <u>Mean OIR Change</u> | <u>Mean DART Change</u> |
|---------------------|------------------------|-------------------------|
| Yes implemented     | -.4904                 | -.3629                  |
| Not implemented     | -.3182                 | -.3200                  |
| Total               |                        |                         |

It is interesting to see the results of this study are in direct conflict with the information gathered during the literature review. As discussed in Chapter two, many scholarly articles have been written on the importance of implementing safety leading indicators to help reduce the number of injury events that occur. Iyer et al.'s 2004 study which was conducted on several organizations showed when there is increased efforts place on safety and health programs, such as implementing and monitoring leading indicators, there were significant differences in the incident rates (there was a reduction in injuries). Vredenburg's 2002 study concluded when hospitals focused their attention to measuring leading indicators, they not only saw a reduction in lost time rates but also a direct financial benefit as a result of reducing workers' compensation expenses. Honda of Canada also saw dramatic reductions in injury events when they incorporated leading indicators into their planned metrics. In a 12-month time frame, U.S. Steel saw a 36% reduction in ergonomic related injuries (Pater, 2017). After developing the proper measuring techniques for leading indicators, U.S. Steel also saw a reduction of 40% to 55% in strains and sprains injuries at a facility that had older equipment and an aging workforce (Pater, 2017).

It is the common belief of safety professionals that if properly implemented and measured, safety leading indicators can be used as precursors to potential events which can be



avoided if appropriate corrective actions are taken. In fact, according to a 2012 article by Griffin Schultz, a research conducted by a group from Carnegie Mellon University resulted in “leading indicator safety analytics programs” that can predict safety incidents with high accuracy rates. So, if this is factual, why would the results of this survey show implemented leading indicators in the dairy product manufacturing sector have no significant effect on the OSHA incident rate and their severity rate? A possible explanation for this could be while respondents indicated leading indicators were/are implemented at their facilities, there was no indication as to how effectively implemented they were. Unfortunately, the questions on the survey only asked respondents to indicate if they are implementing certain leading indicators and for how long, they were not asked how they implement the specific indicator. To better explain the argument being made, we can examine the implementation of one of the highest ranked safety leading indicators, near miss reporting. Based on the data compiled through the survey, facilities could respond in the affirmative that they have implemented the leading indicator of near miss reporting regardless of what they do with the information on the report once it has been filed by an employee. If no action was taken to prevent the episodes from happening again, then the potential would theoretically still exist for an injury event to take place. Hence, implementing the safety leading indicator of near miss reporting in this instance could potentially have no effect on the injury rates. The same logic could be used on any of the 12 leading indicators that were implemented at these facilities. As Hallowell et al. (2013) found in their research study, the only way for safety leading indicators to be effective on reducing injury rates is if they are properly executed, periodically evaluated and proper action is taken when necessary.

Another component that could impact the effectiveness of implemented safety leading indicators is the amount of time needed and effort placed into a leading indicator program

throughout all levels of the facility. In fact, many times the time and effort placed on leading indicators are above and beyond the normal work duties of those performing the tasks (Pearce, et al. 2008). Not allowing sufficient time to complete items associated with leading indicators could have a negative to neutral effect on the desired outcomes. Facilities that have a culture where additional roles and responsibilities are absorbed into the routine workload usually do not understand the impact this has on the quality of the product (Pearce, et al., 2008; Ross, et al., 2018). Also, if facilities require a minimum number of items be completed by an individual, it could not only compound the problem of adding to the normal workload, but it can also lend itself for individuals to begin completing forms or documentation without performing the actual work (Choudhry & Fang, 2008). When workers are tasked with additional duties they fail to see value in, the level of effort significantly declines. Anecdotally, it is also important to mention that managers, supervisors and employees frantically completing observations, near miss cards and audits on the date they were due. This was always observed at facilities that required a minimum number of completed actions within a certain timeframe. How effective can the leading indicator responses actually be in reducing workplace injuries when they are being conducted in such a manner? When the focus of leading indicators is based solely on completing forms rather than the content, the effectiveness of those indicators on reducing injuries is more than likely non-existent. If safety and production were truly viewed as equal, then the importance would be shifted away from completion numbers and switched to the quality of information gathered. This could explain the lack of effectiveness leading indicators are having in the dairy manufacturing facilities. The respondents' answer that production is more important than safety in dairy manufacturing could indicate that leading indicators are focused more on quantity than quality and in fact not properly implemented and measured.

Another objective of this research study was to determine if there was any significant difference in OSHA incident and severity rates (OIR and DART) for dairy product manufacturing facilities that hire safety professionals versus facilities that do not. Based on the responses, 69 of the 84 (82%) facilities participating in the survey hire a safety professional. The Mann-Whitney statistical analysis performed (results summarized in Table 18 for OIR and Table 19 for DART) show there were no significant differences in the overall OSHA incident rates for facilities with safety professionals compared to those without safety professionals (Mann-Whitney  $U = 432.500$ ,  $p = .321$ , two-tailed). The same results were true when comparing the severity (DART) rates as well (Mann-Whitney  $U = 434.500$ ,  $p = .569$ , two-tailed). Based on the analysis, injury rates are no better for those facilities that have a safety professional compared to those that do not. It is believed this in fact is not the case and there are many other potential reasons as to why no significant differences are seen. Some of these reasons can be found in the responses gathered from the respondents' answers as to why they believed the dairy product manufacturing sector had injury rates higher than the national average. The mentality that production trumps all other aspects of the business and lack of upper management support for safety tied for the top reason (30%) as to why they believed injury rates were higher. Knowing these answers were given by individuals that are responsible for safety at the facilities, it is difficult to know the managers', supervisors' and employees' approach to safety. It has been seen that when employees feel safety is not given the same attention as production or they feel upper management does not fully support safety, then there is no buy in at any level for the program. This ultimately results in a poor safety culture and safety climate, which has been identified as one main reason for poor lagging indicator performance (Grote & Künzler, 2000; Reason, 1993; Schein, 1992). This idea is further supported by studies performed by Hallowell

et al. (2013) where they found safety performance (i.e.- reduced injury rates) was strongest in the construction companies where upper management was noticeably involved in safety by employees. Additionally, research performed by both Hinze (2001) and Hallowell & Gambatese (2009) found evidence that the amount of time upper management spends actively participating in safety correlates to a reduction in injury rates. This was identified during a recent perception survey at one of the facilities within the researcher's areas of responsibility. The facility had higher than average injury rates yet implemented several of the safety leading indicators mentioned in this survey. Following the perception survey performed at the researcher's facility, it was revealed employees believed management was not committed to the safety program and did not spend time on the floor reiterating the importance of safety. If this is the case for the facilities that completed the research survey, and based on the responses it seems to be, then it does not matter how many leading indicators are in place because the amount of effort put into the program will be lackluster at best.

The third major reason given for poor lagging indicator performance in the sector was training or lack of knowledge. Based on the responses, the lack of knowledge was for both line employees and supervisors. It was expected to see that all four measures given by respondents for research question 11 on how to help reduce injury rates corresponded directly with the top four reasons given on why the injuries are elevated in the sector, which they did. It was, however; interesting to see the top measure given by respondents on how to reduce injuries was to provide better training and education yet "lack of knowledge" was third for the reason as to the high rates. This again helps to potentially explain why the implementation of safety leading indicators would not have any effect on the injury rates. Specifically, this could support the reason as to why the implementation of the top three ranked (observations, stop work authority

and near miss reporting) indicators from the research survey would have no effect on injury rates. If employees are never properly trained as to what is safe and unsafe, then it would be safe to say the three top ranked leading indicators as the most effective could not be appropriately implemented or measured. Effective training is a continuous process to help foster and grow the safety culture within an organization (Williams, 2008). It supports feed the ownership of employees and shows them that upper management supports the overall system. Without effective training, the implementation of leading indicators would have little success in reducing the injury rates within a facility (Williams, 2008). Since 24% of the respondents stated lack of training and knowledge is a probable cause of higher injury rates and 44% of the respondents agreed effective training could help reduce the injury rates, it could be a reason as to why the implementation of at least the top three leading indicators did not show significant difference in the OSHA injury rates.

The fourth reason listed as to why dairy product manufacturing has higher than average injury rate was because of employees performing unsafe acts. The first three reasons mentioned above can ultimately have a huge impact on why employees would take short-cuts or perform unsafe acts. It is easy to blame an employee for doing something wrong like not following procedures or finding faster ways to complete tasks unsafely, especially following an injury event. Lack of support for safety or praising employees for increased production at all costs, coupled with poor training or knowledge of the job; lends itself for unsafe acts to be more commonplace. Several studies have shown job pressures influence an employee's behavior and those that feel they are rushed by their superior to complete the job or have been praised on completing jobs on time or early are more likely to take short cuts or supersede safety protocol (Choudhry & Fang, 2008; Flin et al., 2000; Mohamed 2002). As stated in Choudhry & Fang's

2008 research “The value of safety over performance pressure remains to be an important message that must be communicated by top management and the site management team including site engineers and supervisors”. Training, or lack thereof, also lends itself as a reason why employees tend to perform unsafe acts. Employees tend to perform unsafe acts because they have not been trained on how to perform the task in the real world but instead in a classroom setting, so they may not know how to act when a real-world situation arises (Wilson, 1998). Consequently, they learn on the floor by either following the actions of other workers (social conformity) or by trial and error when situations arise (Choudhry & Fang, 2008; Flin et al., 2000; Mohamed 2002; Wilson, 1998).

Implementing and measuring leading indicators in this environment would likely have little to no impact on the injury rates at the facility where this exists. Studies have shown lack of management support alone lends itself for employees to take unnecessary unsafe behaviors regardless of any proactive measures in place, because the mindset of safety not being important is trickled down from upper level managers, to mid-level managers, to supervisors and ultimately employees (Newaz, et al., 2019; Little & Little, 2006).

### **Study Limitations**

The major limitation in this study is the small size due to the limited response rate. The dairy industry may be very sensitive to share information that could be perceived as a competitive edge or as derogatory. Asking facilities to reveal their OIR and DART rates from the past six years could be viewed by them as one of these two. Another limitation is the nature of the survey questionnaire which is predetermined questions prior to dissemination. For example, this survey simply asked respondents to indicate whether or not they have implemented and measure leading indicators at their respective facilities. It did not ask them to define what

actions, if any, were taken following the implementation of the indicators. Future studies should refine the survey to gather any actions that are taken regarding following the implementation of leading indicators. This could better define the reasons as to why there is or is not any change in OSHA incident and severity rates following implementation. Unfortunately, this topic is out of the scope of this research and future analysis of such actions is recommended to determine if such factors play a role in reducing injury rates among the industry.

Another limitation was that the survey did not ask the respondents to define their roles as it pertains to safety responsibility. The survey simply asked if the facility hires a “safety professional” and did not differentiate if this was in title only or if the person responsible had formal training and or education in safety. Examining the results of the descriptive answers, 67% of the respondents did not have any formal safety certifications which could indicate the professional is in title only.

### **Recommendations for Future Research**

Future research should consider the following aspects:

1. Suggested methods to improve the significance of this research would be to increase the sample size of the population and ensure more representation of the dairy product manufacturing sector.
2. Determine the reasoning as to why respondents in the dairy industry believe there is lack of management support, production over safety mentality and lack of knowledge.
3. This research should be expanded to other industry sectors to determine if there are actually significant differences in injury rates based on the implementation of safety leading indicators.

4. Future research should conduct perceptions of the effectiveness of leading indicators for both management and line employees to determine if they are having the desired effect.
5. Recommended improvements to future research would be to:
  - a. Gather the respondents' reasons why they selected the leading indicators they implemented, and
  - b. gather the respondents' information on how they implement the leading the indicators and the actions they take with the information collected.

### **Conclusions**

This study examined if safety leading indicators are being implemented and their perceived effectiveness on the injury (frequency and severity) rates within the dairy product manufacturing sector in the United States. Examination of the literature indicated there are potential benefits in implementing safety leading indicators to help reduce injury rates. The lack of research determining which, if any, leading indicators have a higher impact on reducing these rates leaves facilities on their own to pick the ones they believe may be effective. This study tried to detail potential indicators that could have a higher impact on reducing injury rates in the dairy product manufacturing industry. This study also described potential reasons as to why the implementation of safety leading indicators may not have the desired effect hoped for.

There was a significant agreement among those that completed the survey on which of the safety leading indicators were perceived to have the highest effectiveness on reducing both the overall OSHA injury rate and/or their severity rate. Additionally, there was an agreement of the respondents' perception regarding the implemented leading indicators on both the overall OSHA incident rate and severity rate reduction. This study showed regardless of



implementation, the respondents perceived observations, stop work authority, near miss reporting, preventative maintenance and audits were the most effective in reducing the rates.

The most significant finding in the study was that there was no significant difference, nor was there any correlation, to the implementation of safety leading indicators and the reduction of injury rates. Furthermore, the study showed that there was no significant difference in the injury rates for the facilities that hire safety professionals when compared to those that do not.

While study's statistical results did not show many significant differences in OIR and DART rates between those facilities that implemented and those that did not implement safety leading indicators, there were some results that showed the implementation of leading indicators did have a slightly positive effect on reducing these rates. The lackluster effect leading indicators seem to have on injury rates could possibly be based on the answers given as to why respondents believe the dairy manufacturing industry has higher than average injury rates. Lack of upper management support for safety coupled with a culture that views production as more important than safety (the top two answers given) could be having a far more negative effect on the injury rates than the positive effect leading indicators could have. Unsafe acts performed by employees was also a reason given to explain why the dairy industry has high injury rates. If this is the case, where injuries are occurring because of unsafe acts, those acts could potentially be influenced by the first two reasons given. A vicious cycle could be occurring where employees are taking risks and performing unsafe acts which lead to injuries because they are working in a culture where upper management does not support safety and promotes the mentality of production at all costs.

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## Appendix A

### Informed Consent Form Letter

Dear Dairy Manufacturer Representative,

We are conducting a research project and need your help. Anyone 18 years or older and in charge of safety at the facility is asked to participate.

We want to help in reducing the number of injuries that are occurring in the Dairy Manufacturing sector (NAICS 3115). Your input will improve determining which leading indicators have an impact on lowering injury rates.

The purpose of this study is to rank the effectiveness of leading indicators as they pertain to lowering injury rates. Participants will be asked to complete an anonymous on-line questionnaire that provides information on demographics, OSHA rates, leading indicators that have been implemented as well as the participant's ranking of leading indicators on the effectiveness of lowering injury rates.

Completion of the questionnaire will be conducted utilizing a user-friendly web based administrator. Prior to beginning the questionnaire, it is recommended to have your facility's OSHA rate and DART rate calculations for the past 5 years (2012-present). Once those rates are calculated, the total time required to complete the questionnaire is less than 15 minutes. If you choose not to participate after beginning the questionnaire, you may exit the website at any time during the process.

If you are in charge of the safety of multiple facilities, please complete a separate questionnaire for each facility; or please forward this email to those individuals at each facility. Upon conclusion of the questionnaire, you will submit your anonymous survey results on the same website. If you have questions, or need additional information you may contact me at any time.

Your participation in this study is voluntary. You are free to decide not to participate in this study or stop at any time. If you choose to participate, all information will be maintained as confidential. The information obtained in this study may be published in scientific journals or presented at scientific conferences but your identity and information will be kept anonymous.

Again, thank you for your support and interest in Safety Research.

If you agree to voluntarily participate in this survey, please click here to begin:

[https://iup.co1.qualtrics.com/jfe/form/SV\\_aXaVJAUD4BFXhQN](https://iup.co1.qualtrics.com/jfe/form/SV_aXaVJAUD4BFXhQN).

Peter VanDerlyke, Safety Sciences PhD. Candidate,  
607-727-7635

[wfft@iup.edu](mailto:wfft@iup.edu)  
[panda2003@twc.com](mailto:panda2003@twc.com)

Majed Zreiqat, PhD. Faculty Advisor  
[zreiqat@iup.edu](mailto:zreiqat@iup.edu)

*This study has been approved by the Indiana University of Pennsylvania Institutional Review Board for the Protection of Human Subjects (724.357.7730).*

## Appendix B

### Dissertation Research Questionnaire

1. Job title of person completing this questionnaire
  - a. Safety Manager/Engineer/Specialist
  - b. HR Manager/Engineer/Specialist
  - c. Production Manager/Supervisor
  - d. Other: Please Specify
2. Which of the following safety certifications do you have (select all that apply)?
  - a. None
  - b. GSP
  - c. ASP
  - d. CSP
  - e. CIH
  - f. SMS
  - g. OHST
  - h. CHST
  - i. STS
  - j. Others: Please Specify
3. Are you the person responsible for safety at your facility?
  - a. Yes
  - b. No
4. How long have you been responsible for safety at your facility?
  - a. Less than 1 year
  - b. 1-2 years
  - c. 3-5 years
  - d. 6-10 years
  - e. 11 or more years
5. Does your company hire a safety professional?
  - a. Yes
  - b. No
6. What is the status of the safety professional at your facility?
  - a. Full-time
  - b. Part-time
  - c. Intern
  - d. Contractor
  - e. Other: Please specify



7. How many employees are there at your facility?
  - a. 11-19
  - b. 20-99
  - c. 100-499
  - d. 500+
8. What was your facility's OSHA Incident Rate (OIR) for the following years? To calculate OIR:  $(\text{total number of recordable cases} \times 200,000) / \text{total hours worked at the facility}$ . NOTE: total number of recordable cases and total hours worked are located on your OSHA 300 and 300A forms for each specific year:
  - a. 2013
  - b. 2014
  - c. 2015
  - d. 2016
  - e. 2017
  - f. Projected 2018
9. What was your facility's OSHA Days Away and Restricted Time rate (DART) for the following years? To calculate DART:  $(\text{total number of cases resulting in days away, restricted or transferred} \times 200,000) / \text{total hours worked at the facility}$ . NOTE: total number of cases and total hours worked are located on your OSHA 300 and 300A forms for each specific year:
  - a. 2013
  - b. 2014
  - c. 2015
  - d. 2016
  - e. 2017
  - f. Projected 2018
10. Rank by dragging the following safety metrics based on their effectiveness in reducing the injury/incident rate at your facility
  - a. Worker Safety Perception Survey
  - b. Safety Audits
  - c. Safety Training Attendance
  - d. Safety Meeting Attendance
  - e. Safety Observations
  - f. Stop Work Authority
  - g. Machine/Equipment Preventative Maintenance
  - h. Near Miss Reporting
  - i. Corrective Action Completion Rate
  - j. Attendance Tracking
  - k. Job Hazard/Safety Analysis (JHA/JSA)
  - l. Safety Inspections

11. If your facility implements the following metrics, drag and drop the metric into the box indicating the length of time the metric has been implemented. (NOTE- choices of boxes were: 0-1 year; 2-3 years; 4-5 years; 6 or more; Do Not Implement)
- a. Worker Safety Perception Survey
  - b. Safety Audits
  - c. Safety Training Attendance
  - d. Safety Meeting Attendance
  - e. Safety Observations
  - f. Stop Work Authority
  - g. Machine/Equipment Preventative Maintenance
  - h. Near Miss Reporting
  - i. Corrective Action Completion Rate
  - j. Attendance Tracking
  - k. Job Hazard/Safety Analysis (JHA/JSA)
  - l. Safety Inspections
12. Do you know that the dairy industry incident rates are greater than the national average?
- a. Yes
  - b. No
13. Why do you think the dairy industry has a high incident rate? Provide the three most important reasons in your opinion.
14. What three actions do you suggest to reduce the injury rate?