Advancing Construction Safety Best Practices:

Benchmarking Company Safety of Residential Carpentry Firms

Final Report prepared for Jobsite Safety Institute

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Advancing Construction Safety Best Practice

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Executive Summary: Performing work in a safe manner is essential for worker safety and critical for the success of a construction firm. Research has been conducted to identify drivers of a good performing safety culture for larger firms mainly in the commercial construction sector. These drivers and practices are not always practical for smaller firms due to fewer available resources (personnel, time, and money). This research examines safety-related practices for smaller companies performing the majority of their work in carpentry. Firms investigated in this study had a minimum of $100,000 reported annual payroll, five years of experience, and fell under governing code 5645 in work class "Carpentry."

A Delphi-type study was performed that collected initial data through a survey. Insight provided from the survey was then further examined with follow-up interviews. The purpose of the data collection was twofold. First, to identify benchmarking of safety practices for smaller construction firms performing work in residential carpentry. The second was to examine which company-level factors related to safety influenced company safety performance. The Experience Modification Ratio (EMR) was utilized as a quantitative measure for company level safety performance.

Best practices identified through this research to assist in improving the company level safety of small firms include: Company Structure, Owner Involvement, and Structured Safety Practices. In many cases, better performing companies had limitations on the types of work their workers could perform in order to avoid riskier tasks. These firms would only allow workers to perform the tasks that were safe and that they knew their workers were skilled to perform. The findings also indicate that owner involvement is key to safety for these smaller firms. Firms where the owner(s) participated in the selection of workers, performed site visits with a goal of verifying safety, actively involved in the coordination of safety meetings, and were actively involved in the firm's safety program performed better in terms of safety. These firms also focused on hiring quality and skilled workers, ensured that proper task training was completed, and were willing to spend more on the right equipment to do the job. Lastly, better performing firms also tend to have more formalized practices in terms of safety policies and procedures.

Table of Contents

List of Figures

List of Tables

1 Introduction

A 2015 US Department of Labor Occupational Safety and Health Administration report identified the construction industry as the third most dangerous occupational sector in the U.S., accounting for 21.4% of all private industry worker fatalities (Anderson, 2018). Construction job sites variables such as management, environment, equipment, materials, scope of work, and changing crews create a dynamic and challenging work environment that exposes employees to a significant amount of risk and safety hazard (Bigelow et al., 2012).

Improving safety within construction can have a significant impact on a massive industry. The construction sector accounted for more than 11% of world GDP in 2016, and it is also predicted that the construction industry will constitute 13.2% of the world's GDP by 2020 (Amiri and Ardeshir, 2017). Despite recent improvements in construction safety, the accident rate is still higher than most other industries (Mohammadi et al., 2018, Amiri and Ardeshir, 2017). In 2015, 11% of fatalities in the construction sector were in residential construction and 58% of the fatalities were due to falls. Additionally, the non-fatal injuries rate in residential construction was 3.8 per 100 full-time workers (Marin and Roelofs, 2018). Many of those injuries are attributed to smaller nonunion construction companies working as sub-contractors for larger general contractors (Bigelow et al., 2012).

This research looks to examine key drivers that help companies establish practices at the company level to promote better company-level safety performance.

1.1 Background

A review of the literature has shown a relationship between indicators of a healthy safety climate and injury and illness (Bigelow et al. 2012; Mohammadi et al. 2018). Three main motivators for controlling safety and developing a safety culture within construction are considered. The first is moral; no one should want someone else to get hurt. The second is a legal requirement from the government through the Occupational Safety and Health Administration (OSHA). The final motivator is financially driven. The costs of accidents incurred by a company can put them out of business. Additionally, poor safety performance causes insurance premiums to rise or for the company to lose coverage. With a poor safety performance, the company risks not being able to secure insurance protection, which is required by law. Safe project outcomes also increase project value as they relate to the success of the project and savings in project management and human resources costs and expenditures (Mohammadi et al., 2018).

1.1.1 Safety Legislation

The federal government was involved in the foundation of occupational health and safety regulations long before the formation of the Occupational Safety and Health Administration (OSHA) (Meeds, 1973). According to the U.S Department of Labor (2009), Massachusetts passed the first safety and health legislation in 1877 that required guarding of belts, shafts, and gears, protection on elevators, and adequate fire exits in factories. By 1920, almost every state had adopted occupational safety and health laws. However, Congress had not accepted efforts at the national level that moved towards occupational safety. Congress was cautious to not broadly infer its power due to the Commerce Clause (Meeds, 1973). The U.S Department of Labor's functions relating to occupational safety and health shifted from the Bureau of Labor Standards to a newly created agency in December of 1970 when congress passed the Occupational Safety and Health Act to form OSHA (U.S. Department of Labor, 2009).

Within the first twenty or so years after the Occupational Safety and Health Act was passed, initial construction safety improvements may be a direct response to the regulation enforcement by OSHA. However, more recent safety performance improvements appear to be in response to safety initiatives that extend beyond base-line regulatory compliance (Hinze, 2013). Just having safety rules and regulations in place does not create a problem-free work environment. For example, a disadvantage of safety regulations is that compliance involves a large amount of paperwork and can be time-consuming (Mohammadi et al.,

2018). OSHA (2016) recommends implementing a reporting system where organizations can develop communication through simple procedures that allow workers with any injuries, illnesses, incidents including near misses/close calls, hazards, or safety and health concerns to report issues without fear of retaliation. Additionally, cramming safety regulations and rules into workers' minds may improve their competence to complete work, but it does not guarantee that the employees will work safely. The employees may lack adequate safety awareness. Safety training should place emphasis on safety awareness in addition to regulations (Mohammadi et al., 2018).

1.1.2 Financial Motivations

The economic reasoning supporting the need for creating a safer work environment is linked to premiums and associated costs that accompany a work-related injury. Total accident costs to the contractor include both the direct and indirect costs associated with the accident (Mohammadi et al., 2018). Gagne (2011) identifies the direct costs in most cases as an emergency room and doctor visits, medical bills, medicines and rehabilitation. Direct costs are only the tip of the iceberg. Risk management institutions have shifted focus from direct injury coverage policies to a full prevention approach. This approach places importance on the indirect (unbudgeted) costs associated with an injury and getting the employee back to their pre-injury state (Gagne, 2011).

Construction contractors have an understanding of the financial implication of direct injury or fatality costs to an organization, but it is the indirect costs that end up crippling smaller organizations. Indirect costs form the more significant proportion of the total accident costs. Gagne (2011) identified indirect costs as:

- lost/decreased productivity, production downtime, and slowed work pace due to other employees fear of injury
- time to go to medical appointments
- administrative costs and time to hire a replacement, interviewing and training new employees
- delays in shipments and filling orders, loss of products or services
- company image and reputation damage (e.g. unwarranted negative media attention, reputation loss, degraded client loyalty and support)
- third party financial burdens (e.g. potential OSHA penalties, attorney fees, higher Worker's Compensation Insurance premiums)
- damages to equipment, machinery, materials and facility
- lost management time and expenses for inspections, investigations, and meetings related to accident
- lost employee time and expenses associated with assisting with the incident, administering first aid, and witness interviews
- loss of employee morale

1.1.3 Workers' Compensation Insurance

In 1898 in response to a workman's compensation act passed in Great Britain, the Social Reform Club of New York Introduced a bill with automatic compensation for an injury in some types of industrial accidents (Weinstein, 1967). Except for domestic servants, seasonal agricultural workers, and individual executives, all employees working for an organization with three or more resources must have workers compensation insurance (NCRB, 2018). Workers' compensation shifts liability for workplace accidents from negligence liability to a form of strict shared liability, where workers forfeit their rights to common-law negligence suits due to financial protection that workers compensation provides injured workers and their families (Fishback and Kantor, 1998). Workers' compensation is paid for by the organization. It is calculated based on the risk of the company in terms of safety and type of work being performed and scaled based on overall payroll that is being insured. Workers' compensation is generally expressed as a dollar value to every one-hundred dollars of payroll for a specific class of workers (NCCI, 2019).

Because of the unique relationship between insurance carriers and the construction industry, insurance agencies loss prevention representatives have a significant amount of access to construction companies and their workforce. This allows insurance carriers the ability to influence injury prevention interventions (Schofield et al., 2017). An indicator used for assessing the level of safety risk by insurance companies when offering protection and coverage is the Experience Modification Rate (EMR). A company's EMR is a widely used indicator of a contractor's performance; however, a disadvantage to this is that the firm's size can greatly influence the EMR because the value is heavily counted on the frequency of injuries instead of the severity of injuries (Jazayeri and Dadi, 2017).

1.1.4 Key Safety Factors

Key factors are found within the literature that addresses a successful safety culture and discuss the safety performance of a company. Karakhan et al. (2018) defines safety factors as elements of a decision used to assess the quality and performance of an alternative or a list of proposed alternatives. Said factors consist of many interdependent characteristics measurable in many ways to quantify the quality and performance of an option, or list thereof. Factors contributing to an organization's good safety culture, regardless of organization size are important because its size does not limit a company's safety culture. There needs to be an understanding of the challenges faced by companies of all sizes. Because of the complexity of worksite characteristics, work-practices, workforce ethos, stages of construction, and the general contractor's commitment to safety and health, safety culture is vital for the construction industry (Bigelow et al., 2012, Karakhan et al., 2018). The selection of contractors or subcontractors in some part by the prior record is one of the most effective strategies that project owners or general contractors can implement to improve project safety performance (Karakhan, 2018).

The Center to Protect Work's Rights (CPWR), also known as the Center for Construction Research and Training, found that enhancing leadership skills among foremen and other front-line supervisors could be a significant way to accelerate the establishment of good safety culture. The authors also noted that the enhancement of leadership skills applied to small companies with only one or two crews with the owner operating as foreman (Ringen et al., 2018).

1.2 Research Study Objective

The critical question to the current research is which factors and drivers of safety performance allow top performers, in terms of safety, the ability to distinguish themselves within the construction industry over everyone else? This research looks at identifying how various types of companies account for the dynamic working environment at the company level. The study is examining factors of safety performance and safety culture to determine which measures, methods, and practices are indicative of good company performance in terms of safety. The focus of the research is to see what top performers are doing within their safety culture that others are not doing that distinguishes those safer companies from the rest. This research utilized insurance company data to isolate various tiers of clients. The study is looking specifically at companies who identify as doing the majority share of their business in carpentry to see which factors from the literature are influencing good safety culture. Safety performance metrics including EMR, number of claims in terms of worker's compensation insurance, company size, and experience were examined to identify various bands of performers in terms of company-level safety. Surveys and interviews are then used to document the processes and views of these companies in terms of safety culture and climate. The groups of respondents, sorted by actual safety performance, are then compared to identify differences that distinguish performance level.

The analysis aims to identify a set of industry best practices for safety at the company level. From this study, metrics are outlined that may be used insurance companies to track the success of clients who implement the practices and the impact of these practices on workers compensation claims to the related class of clients involved in the study.

1.3 Methodology – Research Steps

The study is completed in four phases as defined in Figure 1.

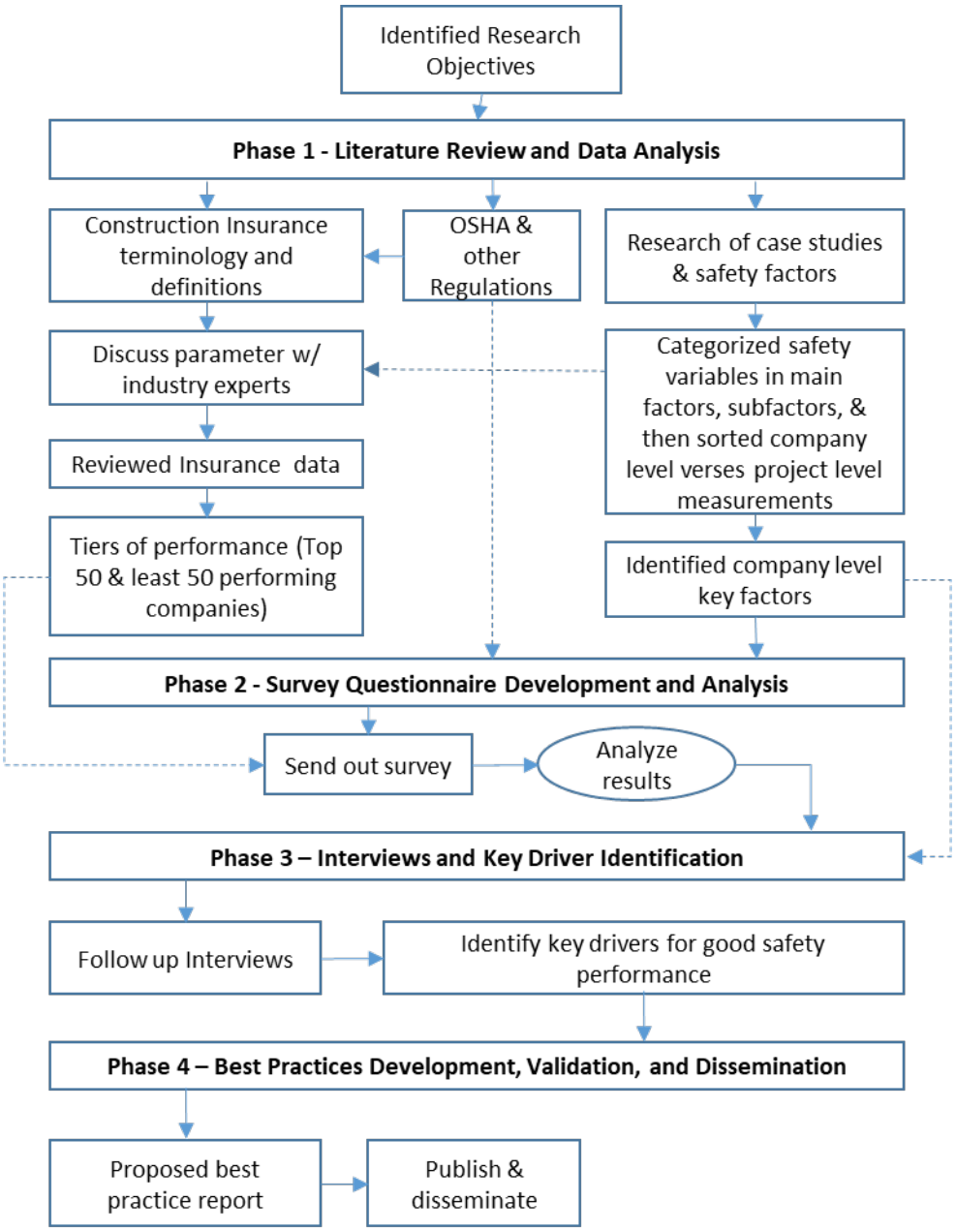


Figure 1: Research Methodology workflow

Phase I of the research consisted of a database review and identification of our sample population. The primary goals of phase one were to:

1. Identify participants: identify a mutually beneficial class or classes that can provide large enough sample of participants to identify trends and provide insight to the construction industry regarding behavior-based safety best practices
2. Identify key safety factors: identify company and project level factors from literature that affect safety that can be used in developing the survey for collecting data in phase 2.

Phase II focused on developing, distributing, and analyzing a survey. The survey includes key performance indicators as identified from the literature review. The survey is distributed to the top and bottom tier performers that were identified during the data analysis. A comparative analysis of the survey results identified the differences between the highest and lowest performing tiers of respondents. Areas yielding significant variation were used to develop a series of investigative questions used in the interviews conducted in Phase III. Interview responses were analyzed to identify consistency in actions/themes regarding safety program focus and operational approach.

Phase IV assess the finding from both the survey and interviews responses to develop a summary of our results and a Safety Best Practice(s) for the carpentry class of contractors. The final report and Best Practice Guide identify the critical drivers for firms to achieve top safety performance.

2 Literature Analysis: Identifying Key Safety Factors

The literature review focused on identifying key drivers of safety performance from a company/organization perspective. The keywords for determining the key safety drivers included construction safety performance, best practices, key factors, variables, and leading indicators. The primary objective of this literature review was to identify what prior studies and scholarly publications found to be the key drivers influencing company safety performance. The literature review was conducted in the following sequence.

Step 1: In the first step, a comprehensive literature review was completed to assemble a complete listing of construction safety key drivers, practices, factors, sub-factors, and leading indicators identified by published journal articles and scholarly studies on construction safety performance.

Step 2: In the second step, the key drivers of safety performance identified in Step 1 in a matrix framework were summarized. The matrix identifies key drivers that are supported in scholarly publications and/or established by prior research studies on key drivers of construction safety performance. The matrix provides the description and influence of the key safety drivers based on the respective publications.

Step 3: In the final step, the research team created a hierarchal framework that organized the key safety drivers into categories and themes relevant to company-level safety performance. The foundation for the hierarchical framework of key safety drivers is the main safety factors and sub-factors framework identified by Mohammadi, Tavakolan, & Khosravi (2018), which was modified to include other current and findings from the literature review.

A detailed review of each step of the literature review is provided in the following paragraphs.

2.1 Step 1: Identification of Key Safety Drivers

In this step of the literature review, the research team identified construction key safety drivers from published journal articles and scholarly studies on construction safety performance. The starting point was to search for published journal articles and studies on key safety drivers utilizing Science direct, Safety Science, American Society of Civil Engineers, and many scholarly resource databases. During this comprehensive review, the research team reviewed one hundred fifty-five (155) relevant scholarly publications and/or studies on safety performance. The distribution of the publication dates for these articles/studies is shown in Figure 2. Approximately 71% of the publications have been published since 2012. In these publications, the construction key safety drivers are primarily identified as key safety best practices, safety factors and sub-factors, or safety leading indicators. There were often differences in the labeling of 'similar' factors/practices influencing safety performance that were grouped within the matrix. For example, "*motivation*" is a safety factor that influences construction safety performance and its sub-factor is "*incentive program*" (Mohammadi et al. 2018). But according to Hinze et al. (2013), "*incentive program*" is mentioned as a safety factor that affects safety performance.

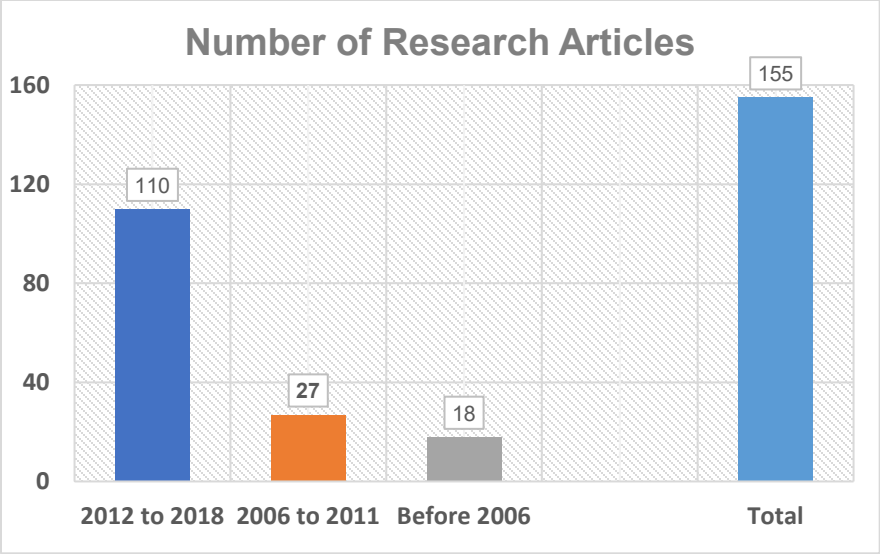


Figure 2: Timeline for Research Articles

The research team reviewed each study and publication to eliminate factors that were not relevant to company-level safety performance. Some of the primary reasons that scholarly studies and publications (hereafter called 'papers') were eliminated are as follows:

- The key drivers documented in the paper were duplicated in another paper(s). Also, many of these papers focused on a minimal number of drivers that influenced construction safety performance. The research team retained papers that had a complete listing and rigorous methodology.
- A number of papers focused on construction outside the United States. The research team eliminated these studies because the population for this current research effort is for construction company activities within the U.S.
- Another reason for the elimination of a paper was that its primary focus was safety practices regarding specific project activities rather than the examination of root causes that may be embedded in the company's approach and/or culture.

Upon completion of the review process, the research team reduced the relevant field of papers to the thirty-nine (39) listed in Appendix A. Included in the 39 papers is a recent study (Mohammadi, Tavakolan, & Khosravi, 2018) that summarizes and reviews 90 papers on construction safety performance indicators. The table in Appendix A includes the paper title, journal publication, year, author(s), and the research objective of each indicated study. The next stage of the review process was to assemble a comprehensive list of construction safety key drivers, best practices, factors, subfactors, or other designations assigned by the authors of the 39 studies for drivers of safety performance.

2.2 Step 2: Key Safety Factors Matrix Framework and Description

The key safety drivers were then organized into a hierarchical framework. A primary reason to create the framework was that many of the key drivers are titled or organized differently in terms of categories, factors, and sub-factors between the various research studies. For example, several studies have categorized "*management commitment*" as a main safety factor that influences safety performance, but other studies have categorized it as a sub-factor of "*safety culture*." To avoid confusion in the categorization of the safety key drivers, and provide support for the methodology, the research team built on the Mohammadi et al. (2018) framework that categorizes safety drivers into main factors and sub-factors.

The first task for this stage of the research was to validate the framework by creating a matrix from the 39 studies. The matrix aimed at cross-referencing the hierarchal framework with the studies in Appendix A and determine which safety factors are most often mentioned in the studies as primary, or key, drivers of company safety performance. The result of that cross-referencing effort resulted in the matrix as shown in Appendix B. Seventeen (17) of the 39 studies identified one or more of the twelve (12) key drivers noted in Table 1 as primary factors influencing safety performance. These 17 studies were particularly relevant and selected for further analysis because:

- All of these studies identified key safety drivers in the construction industry. They tested their influence on construction safety performance by creating models and hierarchical frameworks, analyzing survey questionnaires, and conducting interviews with construction industry experts.
- The findings and results of these studies established how safety factors, sub-factors, practices, leading indicators, and other relevant variables influence a construction company's safety performance.

Table 1: Key Safety Drivers Matrix

No #	Key Safety Best Practices/Drivers/Leading Indicators/Factors		Incentive Programs	Safety training and orientation	Financial Aspects (Investments and Accident/Incident costs)	Safety resources and equipment	Safety manager on-site	Provision of safety equipment	Work condition and pressure	Job-hazard analyses	Safety Culture	Safety Climate	Accident/Incident Investigation	Written Safety Policy/Plan
	Article Author, Year													
1	(Mohammadi, Tavakolan, & Khosravi, 2018)		X	X	X	X	X	X	X	X	X	X	X	X
2	(Hinze, Baud, & Hallowell, 2013)		X	X	X	X	X	X	X	X	X	X	X	X
3	(Guo & Yiu, 2016)		X	X		X		X	X	X			X	X
4	(Swacha, Naoum, & Fong, 1999)			X			X	X			X	X		X
5	(Gambatese & Hinze, 2003)		X	X						X			X	
6	(Hallowell & Calhoun, 2011)			X			X			X	X	X	X	X
7	(Wehle, Hinze, Baud, & Hallowell, 2013)		X	X						X	X	X	X	
8	(Findley, Smith, Kress, Petty, & Enoch, 2004)		X	X			X				X		X	X
9	(Cheng, Kelly, & Ryan, 2015)			X							X		X	X
10	(Hallowell & Gambatese, 2009)			X			X			X	X	X	X	X
11	(Russell, Anderson, & Jaselskis, 1996)			X			X				X		X	
12	(Choudhry, Fang, & Ahmed, 2008)		X	X		X		X		X	X			X
13	(Karakhan, Rajendran, Gambatese, & Nnaji, 2018)		X	X	X		X			X	X	X		
14	(Cheng, Ryan, & Kelly, 2012)			X			X				X		X	X
15	(Hallowell, 2011)			X	X		X			X	X	X	X	X
16	(Hallowell, 2010)			X	X		X			X	X	X	X	X
17	(Esmaeili & Hallowell, 2012)			X			X			X	X	X	X	X
	Total number of studies:		8	17	5	4	12	5	3	12	15	10	14	13

The matrix shows the number of studies that identified a variable as a key safety driver, best practice, and/or leading indicator. This indicates support and relative strength for each safety driver. For example, all the studies in the matrix identified "*Safety training and orientation*" as a key safety driver influencing construction safety performance. This would indicate that all of the studies found '*safety training and*

orientation' to be a key driver concerning safety performance. As a result, there is strong support that safety training and orientation is an important safety practice that influences safety performance in a construction company.

A point to be noted is that the 'title' for a key safety driver may differ from study to study, while the definition and meaning remain similar. For example, some studies described safety "*incentive programs*" as reward programs or motivational programs. Also, some of the studies identified concepts such as "*management commitment*," "*workers' behavior*," and "*supervisors*' *and workers' involvement*" as main factors while other studies noted them as sub-factors of safety culture and climate. The research team exercised the best judgment when organizing and summarizing the concepts.

2.3 Key Safety Drivers Description

The next task was to summarize the findings regarding each safety factor/concept to gain a broader understanding and insight to summarize the definition and variables influencing each key safety driver. The following is a review of each of the 12 main safety factors identified in Appendix B to develop the foundation for establishing a hierarchical framework for the key safety drivers along with their associated factors and sub-factors.

2.3.1 Safety Incentive Programs

Mohammadi, Tavakolan, & Khosravi (2018) identified "Safety incentive programs" as one of the key safety practices that influenced construction safety performance and categorized it under "Motivation." The sub-factors such as wage, job satisfaction, job motivators, reward and penalty, and peer pressure also influence the motivation of a worker or a superintendent, which reflects on project safety performance (Mohammadi, Tavakolan, & Khosravi, 2018). One of the main sub-factors of motivation is incentive programs (Mohammadi, Tavakolan, & Khosravi, 2018). Incentive programs are one of the most implemented and controversial safety programs in the construction industry (Gambatese & Hinze, 2003). Mohammadi, Tavakolan, & Khosravi (2018) submitted that an effective incentive program improved construction safety performance by rewarding appropriate safety behaviors. Safety incentive programs, whether monetary or behavior-based recognitions are reward techniques that construction organizations use to reduce injuries and incidents on job site and improve health and safety (Guo & Yiu, 2016; Hinze, 2002).

Safety incentive programs are cost-effective strategies that can be used to improve construction safety performance. These programs may include monetary rewards for workers and/or supervisory personnel for achieving a good safety standard (Feng, 2013). Guo, Yiu, & González (2015) argues that safety incentive programs are useful in the short term but not in the long-term because they fail to identify and manage hazards on the project site. The main objective of safety incentive programs is to encourage workers to perform safely on the construction site (Sparer, Herrick, & Dennerlein, 2015). Additionally, safety incentive programs strive to correct worker behavior and reduce incidents and injuries. However, some of these programs focus on project personnel. They may not have a substantive impact on company-wide results because injuries and incidents are often influenced by organizational policies and programs (Sparer, Herrick, & Dennerlein, 2015). Hinze (2002) found that safety incentive programs can influence project safety performance in both a positive and negative way. Construction companies that have excellent safety records do not always have safety incentive programs. Additionally, some companies with good safety records used low-value incentive programs to reward good safety performance frequently (Hinze, 2002).

2.3.2 Safety Training and Orientation

Another key safety factor identified in all 17 studies is safety training and orientation. The sub-factors that influence competency are safety experience, training and education, learning, safety knowledge, hazard awareness, quality of worker, prequalification of subs and contractors, and worker age (Mohammadi, Tavakolan, & Khosravi, 2018). All the safety studies discussed the importance of safety training and orientation and its influence on construction safety performance. Hinze, Baud, & Hallowell (2013) considers safety orientation and training as a key practice to improve construction safety performance. Safety training and orientation include training for workers, managers, supervisors, and other personnel involved in a construction project (Cheng, Kelly, & Ryan, 2015). Safety training involves the communication of project-specific goals on safety, safety hazards, safe work behavior, and safety policies to ensure all workers and employees know health and safety goals (Hallowell & Gambatese, 2009). Safety training also plays an essential role in workers' safety and keeps workers informed of project goals and procedures leading to better safety performance on the construction site (Gambatese & Hinze, 2003). Other studies found that safety orientation and training helped workers to identify hazards that reduced injuries and incidents (Wehle, et al., 2013). Additionally, safety training is identified as an essential element for an effective safety program to reduce construction injuries and incidents (Findley et al., 2004).

2.3.3 Financial Aspects of Safety Programs

Financial aspects of safety programs and their components were identified by five studies (Table 3) as influencing construction safety performance. The often-noted sub-factors that influence financial aspects of safety programs were the cost of accidents, safety program budget, safety investments, and return on investment. The investment in safety programs and the cost of accidents are interrelated and an essential factor influencing construction safety performance (Feng, 2015). Safety investment is the cost allocated to the best initiatives and practices by the construction organization to reduce injuries and accidents. In other words, safety investments are the expenses incurred to implement accident prevention strategies (Feng, 2013; Feng et al., 2014). Accident costs include both direct and indirect costs that occur on a construction site (Feng, 2015). According to Hallowell (2010), the investment in safety programs and initiatives can reduce incidents resulting in a reduction in the direct and indirect costs of accidents. However, Hallowell (2010) also notes that these investments should be cost-effective; initiatives such as subcontractor selection and management commitment were identified as the most cost-effective while employing full time on-site safety managers and record keeping were found to be the least cost-effective.

Safety programs and initiatives help an organization to reduce the total cost of injuries and accidents (Feng, Zhang, & Wu, 2015). Accident costs are the total of direct and indirect cost (Feng, 2015). In the US, the direct cost of accidents is covered by workers compensation insurance, but the indirect cost is covered by the construction organization (Feng, Zhang, & Wu, 2015). The direct cost of accidents includes insured costs, medical leave wages, medical expenses and compensation for the duration of incapacity which is covered by insurance. But the indirect cost of accidents which includes lost productivity due to an injured worker, losses due to replacement of the injured worker, lost productivity due to accident investigation, damaged equipment or property due to the accident, cost of transportation, additional work required due to the accident and lost time are covered by the construction organization (Feng, Zhang, & Wu, 2015). Thus, thoroughly evaluating the financial aspects of safety programs and accidents play an essential role in reducing the 'total' cost of injuries and accidents and overall company safety performance (Feng, Zhang, & Wu, 2015; Feng et al., 2014).

2.3.4 Safety Resources and Equipment

Another key safety factor identified by multiple studies that influence construction safety performance is safety resources and equipment. Sub-factors noted by the studies in Table 3 that influence safety resources and equipment are an on-site safety manager, safety instructors, safety personnel, provision of safety equipment, personal protection equipment, and equipment inspection. According to Mohammadi, Tavakolan, & Khosravi (2018), safety resources and provisions for safety equipment support site personnel's ability to manage safety issues, equipment assessment, and protection leading to a reduction in injuries and incidents. Besides, a number of studies have concluded the importance of safety company personnel present on the job site to help manage safety issues and reduce injuries and accidents. Hallowell & Calhoun (2011) in their study stated that a safety manager on site is one of the most central elements of an effective safety program, and Esmaeili & Hallowell (2012) claimed that the employment of a safety manager was one of the commonly adopted safety initiatives. Hallowell & Calhoun (2011) described a safety manager as a safety and health professional who was responsible for the development and implementation of safety rules/regulations and served as a resource to all workers and employees. Additionally, implementation of a safety manager improves project safety by enhancing hazard recognition, inspections, fire protection, regulatory compliance, accident investigation and emergency response (Guo & Yiu, 2016). Findley et al. (2004) in their study found that utilizing a safety manager was a key element to improve the safety performance of construction companies. Karakhan et al. (2018) suggests that an on-site safety manager influences workers' behavior and encourages a safer work environment.

Another related key factor in reducing injuries and improving safety performance is the provision for safety equipment (Mohammadi, Tavakolan, & Khosravi, 2018). Swacha, Naoum, & Fong (1999) concluded that the availability of safety equipment is one of the top five site safety issues that influence project safety performance. A key element is the Personnel Protection Program (PPE), which plays an important role. According to Choudhry, Fang, & Ahmed (2008), PPE should be included in a site safety plan, and the site manager should have the primary responsibility to enforce compliance to reduce injuries. Studies have found that the use of PPE by workers on site reduces incidents and injuries and should therefore be required for all workers to protect them from injuries (Chi, Kim, & Han, 2013). Additionally, the site manager and supervisory team should be responsible for training regarding and ensuring compliance of PPE (Chi, Kim, & Han, 2013). Safety resources such as safety manager and proper provisions for safety equipment helps to limit and eliminate unsafe acts on the job site, reduce accidents and injuries, and improves project safety performance (Choudhry, Fang, & Ahmed, 2008; Chi, Kim, & Han, 2013).

2.3.5 Work Condition and Pressure, Job-Hazard Analysis

Work conditions and work pressure are another key construction safety element that is important in influencing safety performance. Sub-factors that influence work conditions and pressure are production pressure, work overload, work environment, exposure to hazards, project hazard level, and safety conditions (Mohammadi, Tavakolan, & Khosravi, 2018). Work conditions and work pressure are two interrelated concepts that affect each other (Chi, Kim, & Han, 2013). According to Chi, Kim, & Han (2013), unsafe behaviors are the root cause of injuries on the jobsite. An optimum working condition is a work environment where safety hazards are identified, and workers can complete tasks without undue pressure (Guo & Yiu, 2016). The challenge in construction is that the work environment is continuously changing, and a changing work condition may lead to unknown hazards, which can create work misjudgment and inadequate preparation (Guo & Yiu, 2016). The inadequacies and misjudgments can lead to production pressure in which workers are encouraged to use shortcuts and unsafe practices to accomplish the job (Guo & Yiu, 2016). In their study, Han et al. (2014) found that work performed under pressure induced by the cost overrun and/or schedule delay can increase the risk of incidents and injuries. One of the initiatives used

during planning to make the work environment safer is job-hazard analysis (Hallowell & Gambatese, 2009; Hallowell, 2010). With hazard analysis, a construction safety team identifies potential hazards associated with activities in a proactive effort to promote safe practices and reduce injuries (Hallowell & Gambatese, 2009; Hallowell, 2010).

2.3.6 Safety Culture and Climate

Safety culture and climate is a key factor identified by most of the studies that influence safety performance at both the organizational and project level (see Table 3). Sub-factors that influence safety culture and climate safety culture, safety climate, supervisory environment, leadership, and a supportive environment (Mohammadi, Tavakolan, & Khosravi, 2018). Safety culture and climate are relatively new concepts recognized by the construction industry to enhance project safety performance (Choudhry, Fang, & Mohamed, 2007). Many studies on the safety domain define safety culture and climate differently. Choudhry, Fang, & Mohamed (2007) described safety culture as the personal dedication and accountability of all organizational personnel involved in any activity. In other words, "*safety culture is the product of individual and group values, attitudes, perceptions, competencies, and pattern of behaviors that determine the commitment to and the style of proficiency of an organization's health and safety management* (Choudhry, Fang, & Mohamed, 2007)". In their study, Frazier et al. (2013) defined safety culture as the values, behaviors, attitudes, beliefs, perceptions, and competencies related to safety. Safety climate can be described as an employee's perception of safety and is a component of safety culture (Choudhry, Fang, & Mohamed, 2007). Newaz et al. (2018) defined safety climate as employees' perception of values, attitudes, policies, and procedures that are related to safety within an organization.

According to Jin & Chen (2013), there is not a universal agreement on the definition of safety culture and climate, and there is a lack of consensus on whether safety culture and climate are distinct or interchangeable. Choudhry, Fang, & Mohamed (2007) stated that safety culture is a top-down organizational approach that is determined by the firm's management while workers' perception and the role determine the safety climate, they play in promoting a safe work environment. Some researchers have purported that safety climate is a leading indicator of safety culture (Fang & Wu, 2013) and a snapshot of organizational safety supported by project management (Choudhry, Fang, & Mohamed, 2007) which serve as the root causes of good or poor safety performance (Newaz, et.al 2018). Some studies have concluded that the safety culture represents the organizational culture regarding construction safety. Additionally, safety climate is a subfactor of safety culture that influences organization strategy, decision-making, and employees' perception of safety strategies (Rowlinson, Leicht, & Niu, 2016).

A number of studies have identified factors and subfactors that influence and measure safety climate and culture in construction organizations. Choudhry, Fang, & Mohamed (2007) identified four factors of safety climate that enhance construction safety performance. These factors were management commitment, employee involvement, inappropriate safety procedures, and work practices (Choudhry, Fang, & Mohamed, 2007). Frazier et al. (2013) identified four safety climate and culture constructs which were management concern, personal responsibility, peer support for safety, and safety management systems. Mohammadi, Tavakolan, & Khosravi (2018) identified safety management systems as one of the main factors that enhance construction safety performance. Newaz et al. (2018) identified 13 safety climate factors in their study which were management commitment, safety systems, supervisor's role, worker's involvement, communication and relationships, safety training, work pressure, safety attitudes, appraisal for safety risk and hazards, safety responsibility, safety resources, competence, and risk-taking behavior. Most of the mentioned safety culture and climate factors were also identified by other studies such as Jin & Chen (2013) and Rowlinson, Leicht, & Niu (2016).

To better understand the influence of safety culture and climate factors on construction organizations, some studies have developed models. Frazier et al. (2013) developed a model that presents a hierarchical factor analysis of safety culture for measurement of a firm's safety culture using surveys. Choudhry, Fang, & Mohamed (2007) developed a model of construction safety culture to explore the application of safety culture factors on a construction site. Choudhry, Fang, & Mohamed (2007) showed the application and interrelationships of safety culture factors that include: perceptional, psychological, behavioral, and managerial. Fang & Wu (2013) developed a safety culture interaction model that demonstrates the evolvement and interrelationship of construction safety culture and its factors. The safety culture interaction model by Jin & Chen (2013) shows the interrelationship of the worker, the construction environment, and their behavior and how it influences project safety performance and defines the organization's safety culture and climate. In another conceptual model for safety culture the interrelationship of hazard prevention practice, error management practice, and mindful practice alongside workers' involvement and behavior to show the influence of safety culture and climate on safety performance is demonstrated (Feng, Trinh, & Jin, 2018).

2.3.7 Accidents/Incidents Investigation

Another key factor identified by a majority of the studies in Table 3 with an influence on construction safety performance is jobsite accident investigation. Several published studies have concluded that accident investigation and inspection improve safety performance and allow construction organizations to identify the root cause of an accident (Mohammadi, Tavakolan, & Khosravi, 2018). One of the main sub-factors of the accident investigation is near-miss reporting which has been found to enhance safety performance on the job site. Marks, Teizer, & Hinze (2014) stated that near-miss data reporting, collection, and analysis were leading indicators for improved safety performance. Marks, Teizer, & Hinze (2014) also identified several practices of near-miss reporting and created a near-miss reporting guideline that utilize a framework to measure factors that cause accidents or near-misses and contribute to the development of jobsite hazards.

2.3.8 Written Safety Plan/Policy

Written safety plan/policy is another key safety factor that influences safety construction performance. Hinze, Baud, & Hallowell (2013) identified a written safety plan that is implemented in all projects as the foundation of a good safety program. Hallowell (2010) defines a written safety plan/policy as a documented plan that identifies project-specific safety objectives, unique hazards, and practices for achieving good performance. Cheng, Kelly, & Ryan (2015) defines a written safety plan and policy as the safety requirements of a construction project. Mohammadi, Tavakolan, & Khosravi (2018) argues that safety policies are one of the four main factors influencing site safety on any project. Hallowell & Calhoun (2011) found that a site-safety plan was the most central element of an effective safety program to reduce incidents and injuries. Cheng, Kelly, & Ryan (2015) noted that a written safety policy is one of the main elements that explain the variance of a company's safety performance. A site safety plan is one of the most effective program elements to communicate organizational expectations, establish acceptable practices, and minimize potential hazards (Choudhry, Fang, & Ahmed, 2008).

2.4 Step 3: Key Safety Drivers' Hierarchal Framework

In this step of the literature review, the research team created a hierarchal framework using Mohammadi, Tavakolan, & Khosravi (2018)'s framework as the foundation to identify and create a flow between key safety drivers, safety subsets and themes, and safety sub-factors. The key safety drivers' hierarchal framework is shown in Appendix B.

3 Preliminary Data Collection and Analysis - Survey

3.1 Selecting Participants

Concurrently while the initial literature review and analysis was taking place, safety performance data from a partnering insurance company was examined from a prior five-year period. Multiple class codes of work were examined. Carpentry (NCCI Governing Class Code 5645) was determined as the most feasible pool of potential respondents. This was based on the quantity of companies that fit the restrictions of a minimum of five years of data, disparity between good and poor performers in terms of safety, firms with a minimum of $100,000 annual payroll, and likelihood to get a large enough sample size to analyze the data for key drivers of company level safety performance.

To limit the variables that may affect safety performance, such as type of work and lack of experience, the research study looked specifically at carpentry firms within residential construction with a minimum size ($100,000 annual reported payroll) and experience (minimum five years of data available to review). The utilization of one major work class helped to eliminate the inherent danger of work experienced by crews that do different types of work from influencing the results of the study.

Two tiers of participants within those classified as doing Carpentry were isolated. 125 companies from good performing firms and 125 companies from poorer performing firms were grouped based on EMR. Due to the overall size of companies that meet the minimum requirements, grouping the potential respondents in these two tiers allowed for a gap of .2 in terms of EMR between the two groups.

3.2 Survey Design

Key safety factors from Appendix B were grouped based on company-level, project-level, or personnel-level factors. Company-level factors were examined further in the context of small construction firms. From these factors, higher-level survey questions were developed to isolate the factors that indicated an effect on safety performance. The relationship of the survey questions to the Safety Categories and key factors is shown in Table 2. Follow-up interviews explored these factors in more depth.

Table 2: Survey level Inquiry

Key safety categories (from literature)	**Safety subsets (coded)**	**Survey Questions**
Job-Hazard analysis	Hiring Process, Drug/substance abuse (Hazard prevention practices, drug testing)	Are any of the following included as part of your hiring process? Drug test, Experience requirements, Employment verification (I-9, Green Card, and others), Background check (criminal record), Reference checks, and or Task-specific certification/credentials.
Safety Training and Orientation	Safety Experience (Competence, Worker age, Safety knowledge, Skill/quality of worker, and subcontractor and contractor prequalification on safety	Does your company require OSHA 10 and or 30 certifications for Workers, Supervisors, or Project Managers?
	Safety Education (Safety orientation and training)	Who is primarily responsible for providing safety training in your company? Project

		Manager, Field Supervisor, Consultant, Company Owner, or a Safety Coordinator. • What percentage of their time is dedicated to safety?
	Superintendent, foremen, supervisor, employees, worker level Training (frequency) Management Level Training (Joint safety committee, safety orientation test) Safety training, participation, and certification (project-specific training and safety meetings, in-person training and certification)	When, if ever, does your company provide safety training for on-site supervisor(s)? When does your company provide PPE, Toolbox, General task, and or site-specific safety training for workers?
Safety resources and equipment, full-time safety manager on-site, provision of safety equipment	Safety resources (safety personnel, equipment)	Do you use third-party support material? (Consultant, Insurance company and others) Who purchases the following Personal Protection Equipment (PPE) for your employees? Hard hat, Reflective vest, Steel-toed boots, Safety glasses, Fall protection (harnesses), and Safety gloves.
Safety Incentives Program	Worker Safety Motivation	Do you offer any of the following safety incentives? Gift card, On-site celebrations (e.g., BBQ lunch), Monetary bonuses, Raises, and or Awards of recognition (certificate, plaque, and others) How often, if ever, are safety incentives given to Workers, Field Supervisors, and or Project Managers? Does your company have a formal safety incentive program? • If yes, how long have you had your formal safety incentive program?
Safety Culture and Climate	Safety culture (Shared values, management safety concerns and organization's safety policy)	Which of the following job site activities are formal policies for your company? 100% hard-hat, 100% reflective vest, 100% steel-toed boots, 100% safety-glasses, 100% gloves, 100% fall protection, Pre-hire drug test, Random drug

		test, Stop-work policy (worker authority to stop unsafe activity), and First-aid log.
	Supervisor's behavior (Supervisors attitude, perceived safety state, risk perception)	In your opinion, how important is safety for Profitability, Securing work, Worker productivity, Company reputation, Worker motivation?
	Safety Responsibility (accountability, safety compliance, job safety audit)	To what extent does a worker's safety performance influence their salary, bonus, promotion and or job assignment
	Subcontractor safety (Subcontractor safety standards compared to the General Contractor)	How important is EMR (Experience Modification Rate), Financial Stability, Bond capacity, References, and work experience in your selection of subcontractors? • Do you have an EMR threshold for hiring your subcontractors?
Accident and incident investigation	Accidents/incidents statistics (First aid rate, tracking of near misses, lost work time injury rate, zero injury techniques)	Which of the following does your company track? Reportable accidents, Near misses, Restricted work or job transfer, Days away from work, Direct costs of accidents, and Indirect cost of accidents.
	Accident/incident prevention policies (PPE inspection and maintenance policy, work-hour restriction)	How often do you request third-party (i.e., OSHA/Consultant) inspection?
Financial Aspects and Productivity	Safety cost control (Cost of accident, tracking injury costs)	
	Project-based financial aspects (bidding/contract price, Project size, quality and company expenditures)	

3.3 Survey Administration

Qualtrics was used to administer a web-based survey that consisted of thirty-two (32) questions. The questions were designed to identify the differences between the tiers of respondents based on what the literature analysis identified as critical factors for improved safety performance. Categories of questions included demographics (firm age, volume of work, number of employees, and type of work), hiring processes (for both supervisor and workers), safety training practices, safety procedures (internal process and third-party support), accident tracking practices, and views on the importance of safety. A target response pool for the survey was identified using factors that included carpentry being the primary form of work performed by the company, a reported payroll of $100,000 or more, and five years of minimum experience. The response pool was located within the southeastern United States, mainly in North Carolina, South Carolina, and Tennessee.

Since the intent of the survey and study was to isolate variables of safety based on safety performance, EMR was used as a key variable. The available response pool had an EMR range of .77 to over 1.8. One-hundred and twenty-five (125) respondents from each performance tier were invited to participate in the

survey. The survey invitations were first sent via email with a reminder after two weeks. After another two weeks, written invitations and paper copies of the survey were mailed to those who did not respond. This was followed by phone call invitations. Of the 250 initial respondents, a number of them were not reachable due to change in email address, paper surveys being returned, and phone numbers that were disconnected. In total, twenty-four (24) complete and unique responses were received for companies that fit the criteria, as noted above.

A complete survey is included as Appendix C.

3.4 Survey Findings

For purposes of analysis and comparison of various factors on safety performance, the respondents were grouped by EMR in two groups of approximately equal size with those who had a 0.92 EMR or less (11 respondents with a mean EMR of 0.83) and those with a 0.94 EMR or more (13 respondents - multiple respondents with .94 EMR – with a mean EMR of 1.11). The hypothesis going into the research was that drivers of safety performance that were found in literature from past research efforts would be different between those who had a better performance in terms of safety (0.92 EMR or less) and those who were poorer performers in terms of safety (0.94 EMR or more). Statistical analyses were run on the separate groups, and there were minimal statistical differences between the responses. The statistical insignificance can possibly be attributed to the size of the samples once the groups were formed. Contrary to the original hypothesis, there were many similarities in how the groups of respondents approached and viewed safety.

Though there were few statistical differences, there were observations of different trends that was used in conducting follow-up interviewers. The hope was that detailed questioning to collect qualitative information about company processes would help identify more apparent differences in these areas.

The first part of the survey asked demographic questions to establish volume of work, age of firm, and types of work (Figure 3).

Figure 3: Company Demographic and Type of Work Questions

Company Name: _____ Address: _____

Approximate Age of Firm: _____ Years _____

Volume of work last year: $_____ _____

Residential:	_____%	*2 stories or less:*	_____%	*Interior only:*	_____%
Commercial:	_____%	*3 stories or more:*	_____%	*Exterior (or both):*	_____%

As shown in Table 3, the respondents had an EMR range of .77 to 1.51 and an average EMR of 0.98. The average payroll was $394,356, with a $5.2 million average volume of work (range of volume $675,000-$20,000,000). The average age of the firm was 18 years, with an average size of eight (8) employees. The respondents reported conducting work as 88% in residential, 79% in two (2) stories of height or less, and about equal between interior (49%) and exterior work (51%) (Table 4). The groups had similar types of work and were of similar size and age.

Table 3: Respondent Demographics

Demographics	***All Firms***		***Low EMR (0.92 or less)***		***High EMR (0.94 or greater)***	
	Mean (μ)	***Range***	***Mean (μ)***	***Range***	***Mean (μ)***	***Range***
EMR	0.98	0.77 – 1.51	0.83	0.77 - 0.92	1.11	0.94 - 1.51
Estimated Payroll	$394,356.50	102,187 - 1,535,000	$468,984	229,900 - 1,256,000	$331,210	102,187 - 1,535,000
Age of Firm	18.46	2 - 34	17.73	2 - 30	19.08	7 - 34
Approximate volume of work ($)	$5,202,428	$675,000 – $20m	$6,000,000	$800,000 - $20m	$4,527,559	$675,000 - $15m

Table 4: Type of work performed (%)

	All Firms		***Low EMR (0.92 or less)***		***High EMR (0.94 or greater)***	
	Mean (μ)	***Range***	***Mean (μ)***	***Range***	***Mean (μ)***	***Range***
Residential	88	66 - 100	92	66 - 100	84	25 - 100
Commercial	9	0 - 33	8	0 - 33	10	5 - 25
<=2 Stories	69	0 - 100	79	0 - 100	60	0 - 100
3 or More	11	0 - 80	12	0 - 80	10	0 - 50
Interior	35	0 - 100	31	0 - 70	37	0 - 100
Exterior	43	0 - 100	35	0 - 50	50	0 - 100

3.5 Hiring Practices

One of the key safety factors highlighted in the literature was hiring practices. In the context of this study, based on the literature, "Hiring Practices" include *drug testing, Experience Requirements, Employment Verification, Background check (criminal record), Reference checks,* and whether any *Task-specific certification/credential* is required to be considered for employment. Figure 4shows the section of the survey that documented the respondents' use of specific hiring practices.

Figure 4: Hiring Processes survey question

Are any of the following included as part of your hiring process?

	Worker		On-Site Supervisor	
Drug test	*yes*	*no*	*yes*	*no*
Experience requirements	*yes*	*no*	*yes*	*no*
Employment verification (I-9, Green Card, etc.)	*yes*	*no*	*yes*	*no*

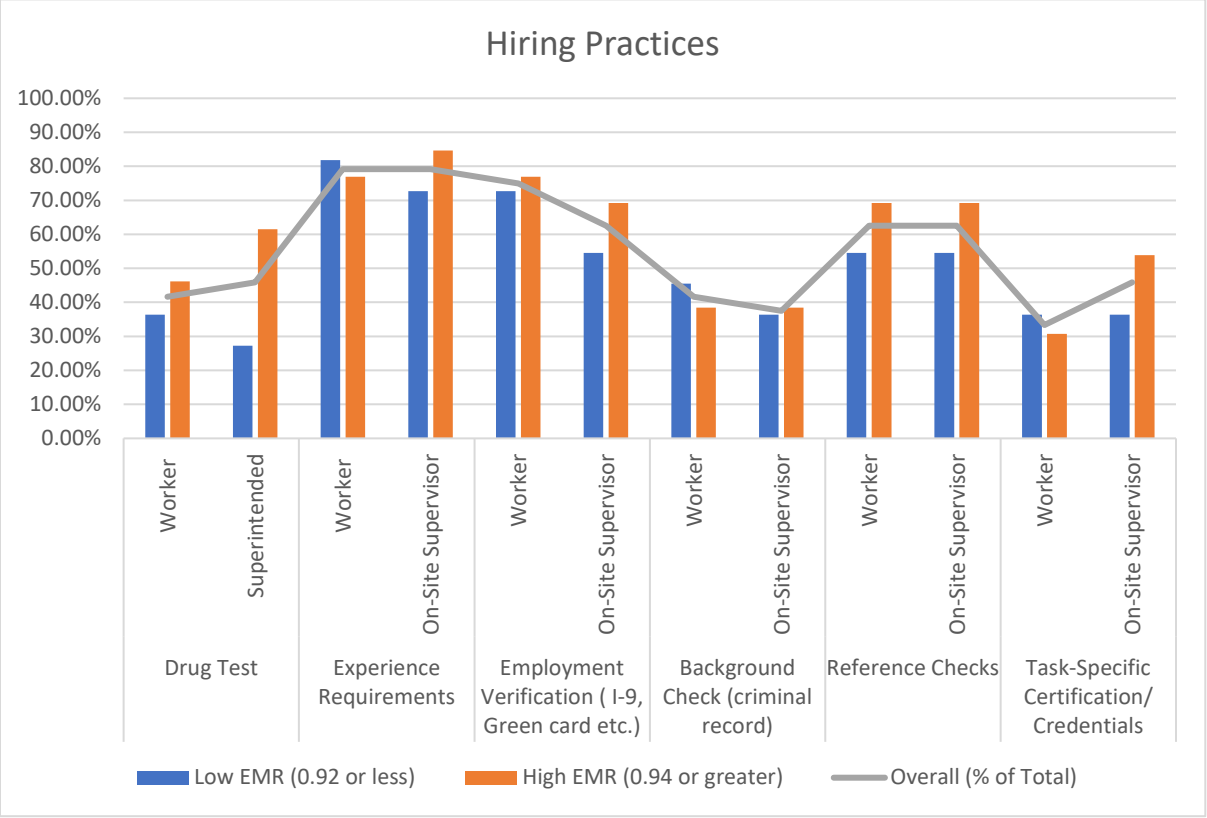
Table 5 and Figure 5 shows a summary of hiring practices results. The questions did not identify which practice was given more weight during hiring process, simply that it was considered. "Experience Requirements" and "Employment Verification" were the factors with the highest frequency of references for both groups when hiring workers, or labor. "Reference Checks" for workers was also frequently referenced for the High EMR group firms more so than the Low EMR group firms. For Supervisors, "Experience Requirements" was top ranked followed by "Employment Verification" at a lower frequency than the work. Thirdly, at the same rate as "Employment Verification" for supervisors was "Reference Checks".

Table 5: Summary of Hiring Practices

Hiring Practices (Category 2)

Activity	***Position***	***All Firms***	***Low EMR (0.92 or less)***	***High EMR (0.94 or greater)***	***% Change between Low and High***
Drug Test	Worker	41.67%	36.36%	46.15%	9.79%
	Supervisor	45.83%	27.27%	61.54 %	34.27%
Experience Requirements	Worker	79.17%	81.82%	76.92%	4.90%
	Supervisor	79.17%	72.73%	84.62%	11.89%
Employment Verification (I-9, Green card etc.)	Worker	75.00%	72.73%	76.92%	4.20%
	Supervisor	62.50%	54.55%	69.23%	14.69%
Background Check (criminal record)	Worker	41.67%	45.45%	38.46%	6.99%
	Supervisor	37.50%	36.36%	38.46%	2.10%
Reference Checks	Worker	62.50%	54.55%	69.23%	14.69%
	Supervisor	62.50%	54.55%	69.23%	14.69%
Task-Specific Certification/ Credentials	Worker	33.33%	36.36%	30.77%	5.59%
	Supervisor	45.83%	36.36%	53.85%	17.48%

Figure 5: Hiring Practice by Group



The biggest differences between the two groups was for the Supervisor in "Drug Test" followed by "Task-Specific Certification/Credentials" where these were indicated more often for the High EMR group. The Higher EMR group requires drug testing for their on-site supervisors more than the lower EMR group. The Lower EMR group requires less "Task-Specific Certification/Credentials" for their supervisors but in both groups these are required less than 35% of the time. For the Workers, there was minimal difference except for "Reference Checks" which was indicated more often by the High EMR group. More detailed questions pertaining to the hiring process and what factors are looked at as more significant was explored in the interview phase of the research. More than 70% of companies in both groups have *experience requirements* for their new hires, and both groups require *employment verification (I-9, Green card, and others)* for their workers.

3.6 Safety Training and Orientation

Another factor noted in past studies as having significant impact on company safety performance was the types of safety training and orientation provided to their employees. Questions were asked in the survey to gauge the types of training provided for both supervisors and workers. For the supervisors, the question was asked "When, if ever, does your company provide safety training for on-site supervisor(s)?" The options included: when hired, beginning of project, periodic (i.e. quarterly), pre-task, and never. Table 6 shows the compiled results of this question. Note that respondents were able to mark all that apply so respondents so the total does not add up to the number of respondents. A respondent may have indicated both "When Hired" and "Pre-Task" for example.

Table 6: On-Site Supervisor Safety Training

Group	*Respondents*	*When Hired*	*Beginning of Project*	*Periodic*	*Pre-Task*	*Never*
Lower EMR	11	3	3	7	3	0
Higher EMR	13	7	3	7	3	1
Overall	24	10	6	14	6	1

*Mark all that apply

Figure 6 shows a breakdown by percentage of respondents for both groups and overall respondents. The most noticeable difference was that training was offered to supervisors in the Higher EMR group at a rate of 54% compared to 27% of those in the Lower EMR group. A slightly higher number (10%) of Lower EMR firms offer training to on-site supervisors periodically. Note there were no questions pertaining to what was covered in the types of training, this was identified in the interview phase of the research. Additionally, because of the difference in offering safety training when hired between the two groups, this may be an indication that Lower EMR firms place more significance on experience for supervisors with the understanding that good safety practices are understood based on their experience. This was also explored in the interview phase.

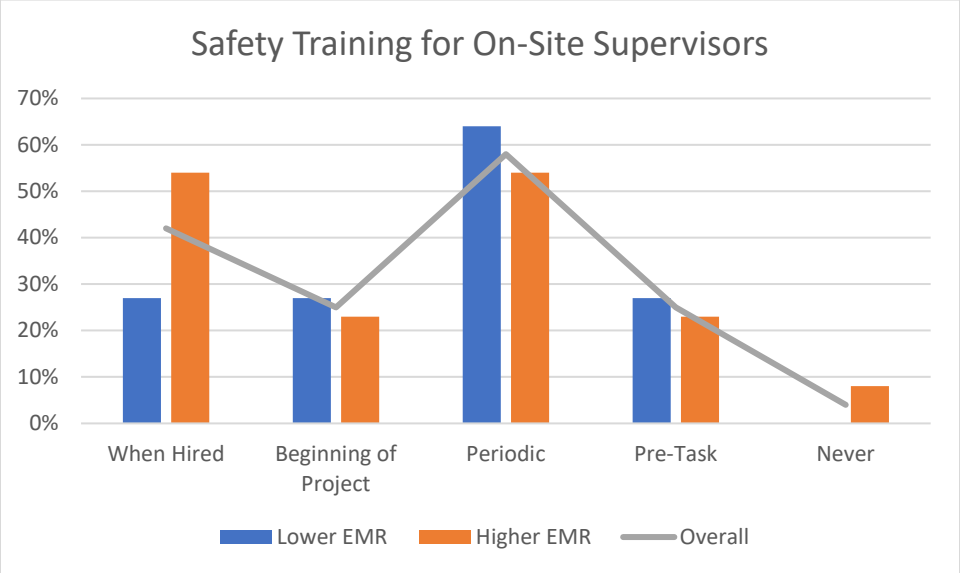


Figure 6: On-site supervisor safety training by group

The question for worker safety training was broken down into the types of training that could be offered as well as the frequency of each type of training (Figure 7).

Figure 7: Safety Training Frequency for Workers

When does your company provide the following safety training for workers? (check all that apply)

	When hired	*Beginning of project*	*Weekly*	*Monthly*	*Pre-task*	*Never*
PPE training						
Toolbox						
General task						
Site specific						

As shown in Table 7, most PPE training was offered more frequently when hired and then at the beginning of the job.

Table 7: PPE Training for Workers

Group	***Respondents***	***When Hired***	***Beginning of Project***	***Periodic***	***Pre-Task***	***Never***
Lower EMR	11	6	3	1	3	2
Higher EMR	13	6	4	3	1	0
Overall	24	12	7	4	4	2

As shown in Figure 8 PPE training in both groups is similar for "When Hired" and "Beginning of Job". There is a difference between the groups where the Higher EMR group offers more "Periodic" training while the Lower EMR group offers more "Pre-Task Training". This may suggest that the Lower EMR group has more specialized training relevant to the activities taking place. Additionally, there is a large group of Lower EMR firms that indicate they never offered PPE training. This may speak to the type of experience they expect their workers to have when hired. The specifics related to hiring of experienced persons will be explored further during the interview phase.

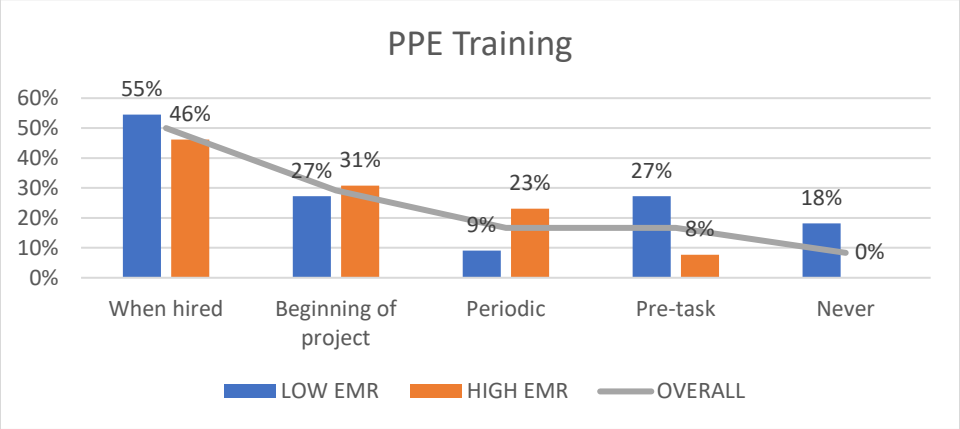


Figure 8: PPE Training Distribution by Group

The responses for general task training of workers is shown in Table 8 and Figure 9. Overall, there was a balanced response for when general task training is offered to workers with "When Hired" the most frequent and "Periodic" the least frequent. The differences are observed more when looking at the frequency between the groups. The Higher EMR group offers more general task training "When Hired". This may indicate a lower skill level being hired so more task training is needed. There is also a difference between "Periodic"

where the Higher EMR group offers more general task training and "Pre-task" where the Lower EMR group offers more general task training.

Table 8: General Task Training for Workers

Group	*Respondents*	*When Hired*	*Beginning of Project*	*Periodic*	*Pre-Task*	*Never*
Lower EMR	11	3	3	1	5	0
Higher EMR	13	6	4	4	2	0
Overall	24	9	7	5	7	0

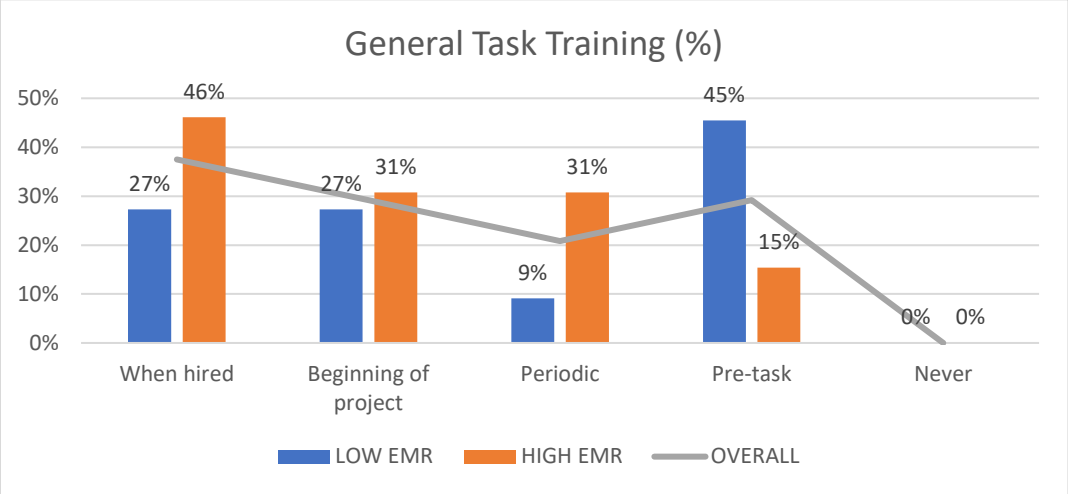


Figure 9: General Trask Training Distribution by Group

The frequency of using site-specific safety training for workers is shown in Table 9 and Figure 10. The "Beginning of Project" was the highest noted which is not surprising considering hazards related to the site should be covered when the job begins. Additionally, the Lower EMR group did "pre-task" site-specific training more frequently which may indicate training takes place relevant to current site conditions and the hazards associated with which ever task is occurring. Another observation is that the Higher EMR firms indicated a more frequent "Site Specific Safety Training" when workers were hired. This may indicate that new workers are being hired on a job-by-job basis or as the job progresses. Regular employees that are around from job-to-job would more likely be trained for site specific conditions at the beginning of the job.

Table 9: Site Specific Safety Training for Workers

Group	*Respondents*	*When Hired*	*Beginning of Project*	*Periodic*	*Pre-Task*	*Never*
Lower EMR	11	1	6	1	4	1
Higher EMR	13	4	5	2	2	1
Overall	24	5	11	4	7	2

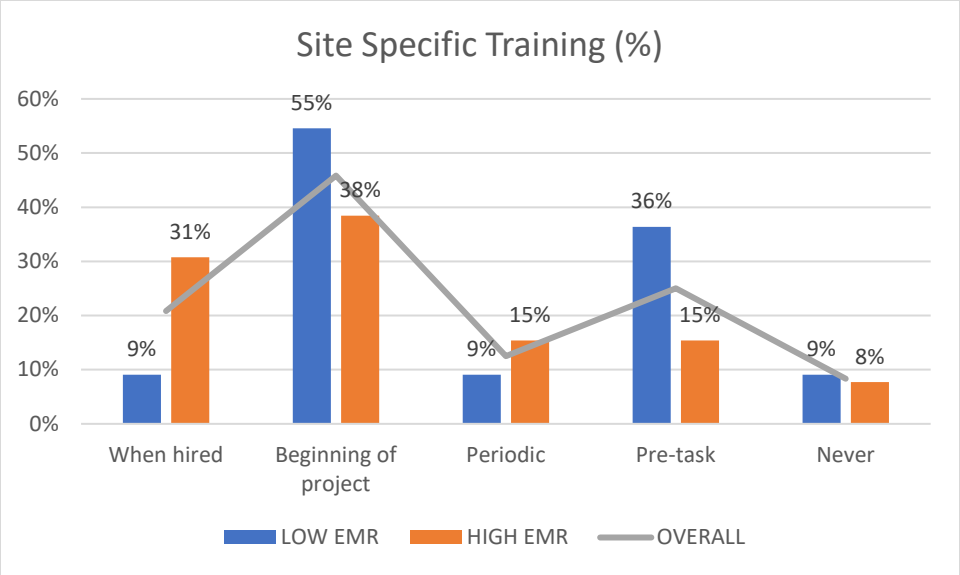


Figure 10: Site Specific Training Distribution by Group

3.7 Responsible Person

Within the literature, there was indication that the person responsible for safety had an effect on the safety culture and success of a firm in terms of safety performance. The question was asked: "Who is primarily responsible to provide safety training in your company?" with a follow up of what percentage of their time was dedicated to safety. Table 10 and Figure 11 shows the distribution of who is responsible for safety.

Table 10: Person Primarily Responsible for Safety Training

Group	*Respondents*	*Safety Coordinator*	*Company Owner*	*Project Manager*	*Field Supervisor*	*Consultant*
Lower EMR	11	2	3	2	3	1
Higher EMR	12	0	3	3	6	0
Overall	21	2	6	4	7	1

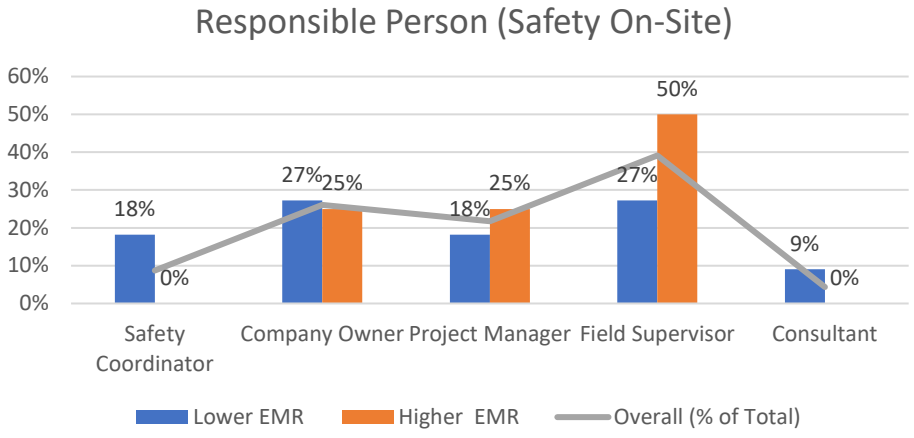


Figure 11: Person responsible for safety On-Site Survey Results

For the Lower EMR firms, 8 out of the 11 responses (73%) listed a higher level of management or the owner as of the responsible party for safety training (3-company owner, 2-safety coordinator, 1-consultant, and 2-project manager). This differs greatly from the higher EMR group where 54% responded that a field supervisor was responsible for safety training on-site. Both groups identified that the person in charge of safety spent, on average, about 9% of their time dedicated to safety (Table 11).

Table 11: Percentage of responsible person's work dedicated to safety

	Responsible Person:			
	Good		Poor	
	MEAN	STDEV	MEAN	STDEV
% Job to Safety	9.1	10.0	9.5	5.8

There are several potential reasons why who is responsible for providing safety training may be impactful on safety performance. First, the message of the importance of safety may be more consistent when upper management conducts the training. Should multiple field supervisors in charge of separate crews be responsible for training, that training can lack consistency. Alternatively, the workers may take the message of safety more serious when training is conducted by senior management. Lastly, if left to field management, the training and leadership of the field supervisor then become an important factor as to how they can effectively provide safety training while managing other activities on site. Advanced leadership skills among front-line supervisors (field supervisors/foreman) have been identified as having an impact on a company's ability to establish a good safety culture (Ringen et al., 2018). In some smaller companies, where the owner takes more of a front-line management role of the crews, they may also have better leadership skills. The level of involvement of the owner in field-level management and safety training of field personnel, as well as general company structure of the firms, will be explored more in-depth during the next phase of the research.

3.8 Certifications

Literature identified benefits of certifications and training for employees and how it affects the safety culture of a company which can be linked to overall company safety performance. Respondents were asked about required certifications for both supervisors and workers. The question was asked: "Does your company require any of the following certifications for the following personnel?" Categories of responses for both Workers and Supervisors to indicate requirement of "OSHA 10" or "OSHA 30" certifications were given. None of the responding firms indicated that they required OSHA 30 certifications for either level of employees. Less than one-third of each group required OSHA 10 certification. Only one company indicated an OSHA 10 training as a requirement for workers after being hired. Three companies indicated the requirement for OSHA 10 for supervisors and project managers. None of the respondents indicated the requirement of OSHA 30 certifications.

3.9 Third Party Support

With some firms, third party resources are available to provide safety advice and guidance to project supervision and the workers. These third-party resources have reference and training materials and consist of written content as well as other forms of multi-media. Some common parties that offer these support and training materials are consultants, insurance companies, trade organizations, as well as OSHA. Participants were asked "Do you use any of the following third-party support resources for safety training?" The responses are listed in Table 12.

Table 12: Use of Third Party Support Resources

Group	*Respondents*	*Consultant*	*Insurance Company*	*Trade Organization*	*OSHA*
Lower EMR	11	3	5	2	5
Higher EMR	13	3	8	3	1
Overall	24	6	13	5	6

As shown in Figure 12, both group utilized resources by consultants and trade associations a similar rate. The utilization of Insurance Company resources was the most used. The Higher EMR group utilized insurance company resources at a rate of 17% more often than the Lower EMR. There was a large difference (37%) between the groups in utilizing resources provided by OSHA and other federal agencies related to workplace safety.

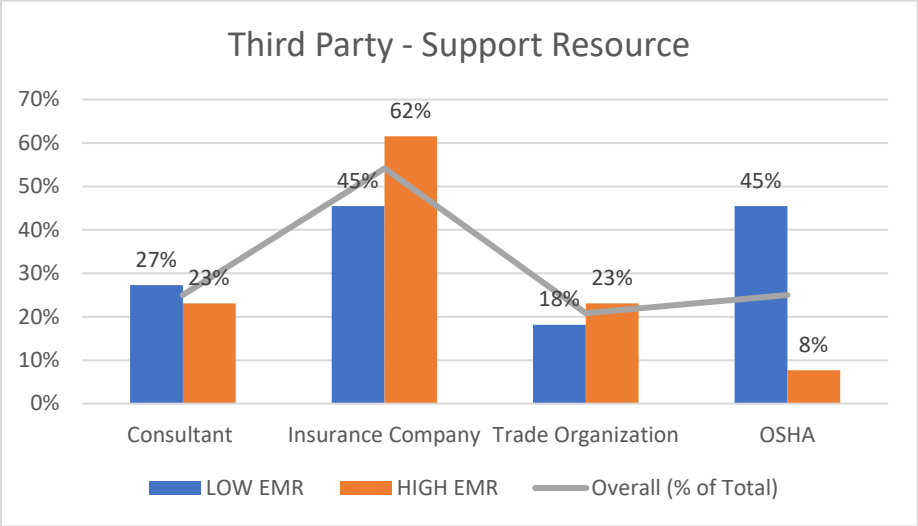


Figure 12: Third-Party - Support Resources

Another resource provided by third party groups is for site inspections and safety consultations. It is common place to have safety professionals assist the company when the firm is conducting work with a hazardous scope. Additionally, insurance companies have risk managers that who help support safe operations within a company. The respondents were asked how often they request site safety inspections or safety consultation from third parties. The responses are shown in Table 13.

Table 13: Third Party Site Inspection/Safety Consultation

Group	*Respondents*	*Beginning of Job*	*Pre-task*	*Periodic/ As-Needed*	*Never*
Lower EMR	11	0	0	4	7
Higher EMR	12	0	0	3	9
Overall	23	0	0	7	16

As shown in Figure 13, none of the responding firms indicated use of site inspections or consultations of a third part at the beginning of the job. There was only an indication of periodic inspections by 36% of the

Low EMR group and 23% of the High EMR firms. The majority of both groups and all respondents never utilized a third party for site safety inspections or safety consultation. The low number of consultation may be due to the types of work and familiarity with conditions by the respondents. As they all perform carpentry as their main volume of work, there may be familiarity with the hazards associated with the job and therefore do not feel the need to consult a third party for assistance in identifying and mitigating those hazards.

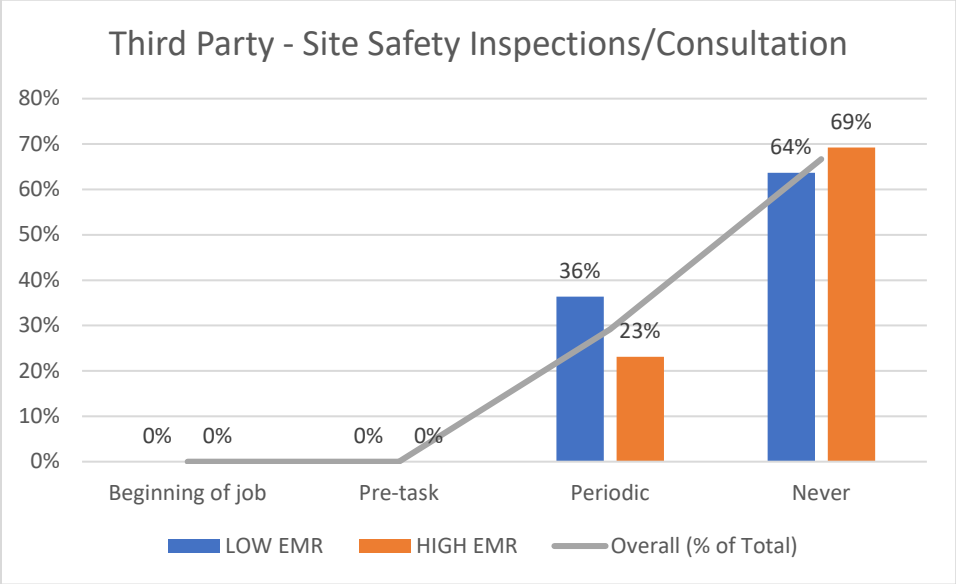


Figure 13: Distribution of Third Party Safety Inspections/Safety Consultation

3.10 Safety Incentives

The literature review also indicated that the use of safety incentives could be a factor for safety performance. The benefits of safety programs for correcting worker behavior and reducing incidents and injuries are especially impactful when connected to organizational policies and programs (Sparer et al., 2015). However, there is not always a correlation of those companies who have safety incentive programs and safe work performance (Hinze, 2002). This lack of correlation is evident in the survey results which shows those firms with a better safety performance (lower EMR firms) used fewer incentive programs at a lesser frequency than the Higher EMR group. Table 14 shows the distribution of types of incentive programs and by the two different groups. The Lower EMR group only utilized "On-site Celebrations" and incorporated safety into raises (Figure 14). Additionally, the Lower EMR group only randomly distributed the incentives (Figure 15). This differs from the Higher EMR group who utilize more methods of incentives and a higher frequency.

Table 14: Use of Safety Incentives

Group	***Respondents***	***Gift Card***	***On-Site Celebration***	***Monetary Bonuses***	***Raises***	***Awards of Recognition***
Lower EMR	11	0	1	0	2	0
Higher EMR	13	2	3	2	3	0
Overall	24	2	4	2	5	0

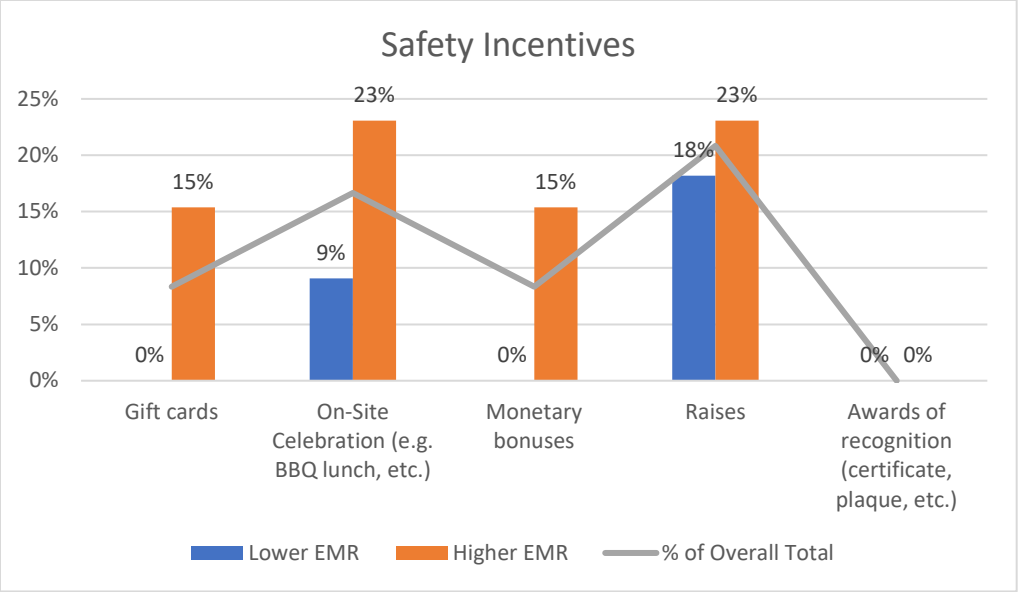


Figure 14: Safety Incentives

Table 15: Frequency of Safety Incentives

Group	*Respondents*	*Never*	*Randomly*	*Monthly*	*Quarterly*	*Annually*
Lower EMR	11	9	2	0	0	0
Higher EMR	13	6	3	0	2	1
Overall	24	15	5	0	2	1

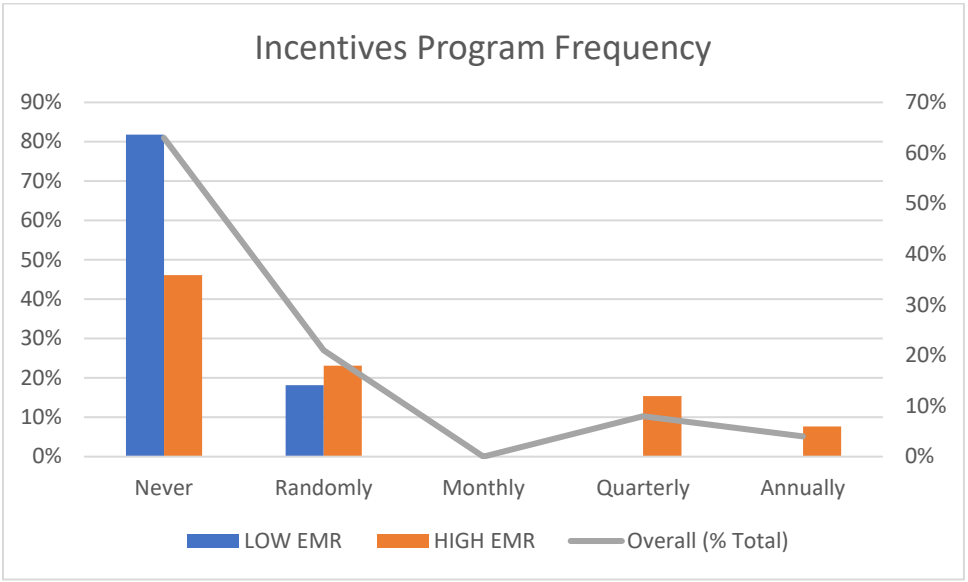


Figure 15: Safety Incentives Program Frequency

3.11 Safety Culture and Climate

The following questions were designed to identify the perceptions and influence of specific variables on the safety culture and climate of an organization. Variables from literature were used in formulating these questions.

The first question asked "To what extent does a worker's safety performance influence their:" with categories of: salary, bonus, promotions, and job assignment. A Likert scale response was used to indicate 1 = Does not Influence to 5 = Extremely Important. The overall impact was listed as "moderately important" for all variables (Table 16).

Table 16: Employees Safety Performance Impact

Worker Safety Performance influence on:			
Categories	**Mean (μ)**	**SD (σ)**	**T-Test (p)**
Salary	2.64	1.36	0.17
Bonus	2.41	1.37	0.05
Promotion	2.86	1.49	0.47
Job Assignment	3.05	1.46	0.90

Figure 16 and Figure 17 show the distribution of respondents. The Higher EMR Group indicated that the worker's safety performance was more important related to Bonuses and Salary than the Lower EMR Group (Figure 17).

Figure 16: Distribution of Worker Safety Performance Influence – Overall Respondents

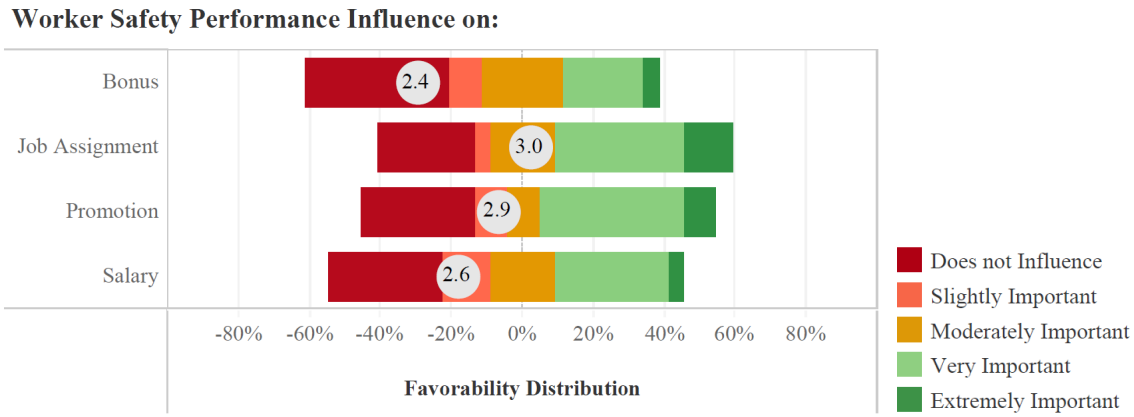
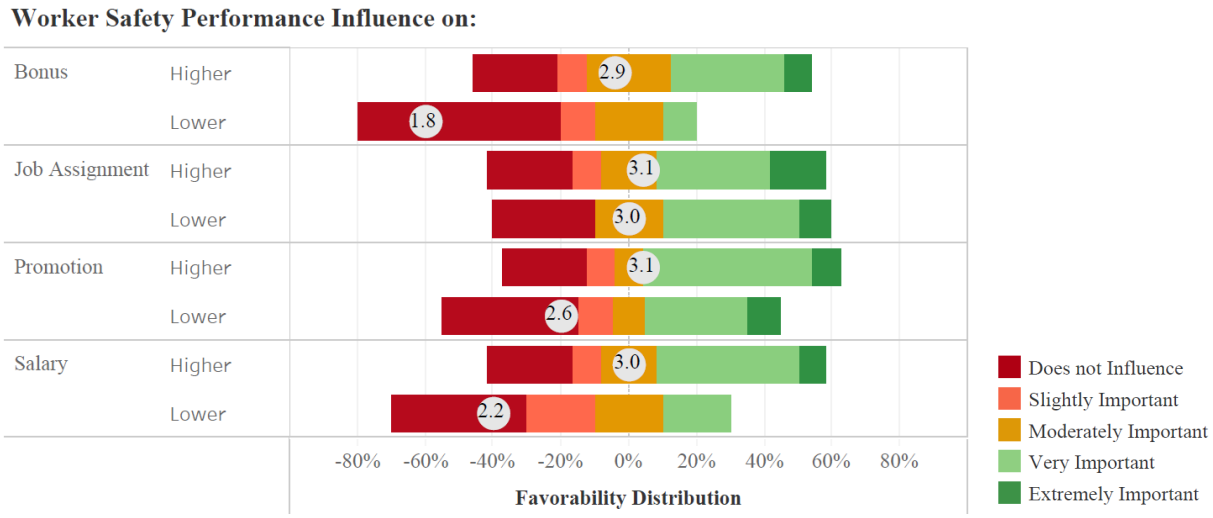


Figure 17: Distribution of Worker Safety Performance Influence – By Group



Another measure of the safety culture within a firm is the inclusion of a formalized safety manual that documents formal safety policies. Specific policies for safety are often more beneficial than a general or informal requirement for use of PPE and other safety related activities. Table 17 shows the responses and use of various formal safety policies. Considering the nature of the work by the respondents in performing primarily carpentry it is not surprising to see policies related to Fall Protection and Safety Glasses being used the most as it related to typical hazards of the trade. Similarly, the lower use of policies such as reflective vests can easily be tied to the types of work being performed as well.

Table 17: Use of Formal Safety Policies

Group	***Respondents***	***Hard Hat***	***Reflective Vest***	***Steel-Toed Boots***	***Safety Glasses***	***Gloves***	***Fall Protection***	***Pre-hire Drug Test***	***Random Drug Test***	***Stop-work Policy***	***First Aid Log***	***Average # of Policies per Respondent***
Lower EMR	11	2	1	2	6	3	8	4	2	7	2	3.4
Higher EMR	13	4	0	3	8	3	7	4	5	8	3	3.5
Overall	24	6	1	5	14	6	15	8	7	15	5	3.4

The distribution between the groups for using different policies is fairly close. Larger differences are observable in the use of "Fall Protection", where 19% more of the Lower EMR firms have established policies. Opposite results were found with "Random Drug Test," where 20% more of the Higher EMR firms indicated its use over the Lower EMR firms.

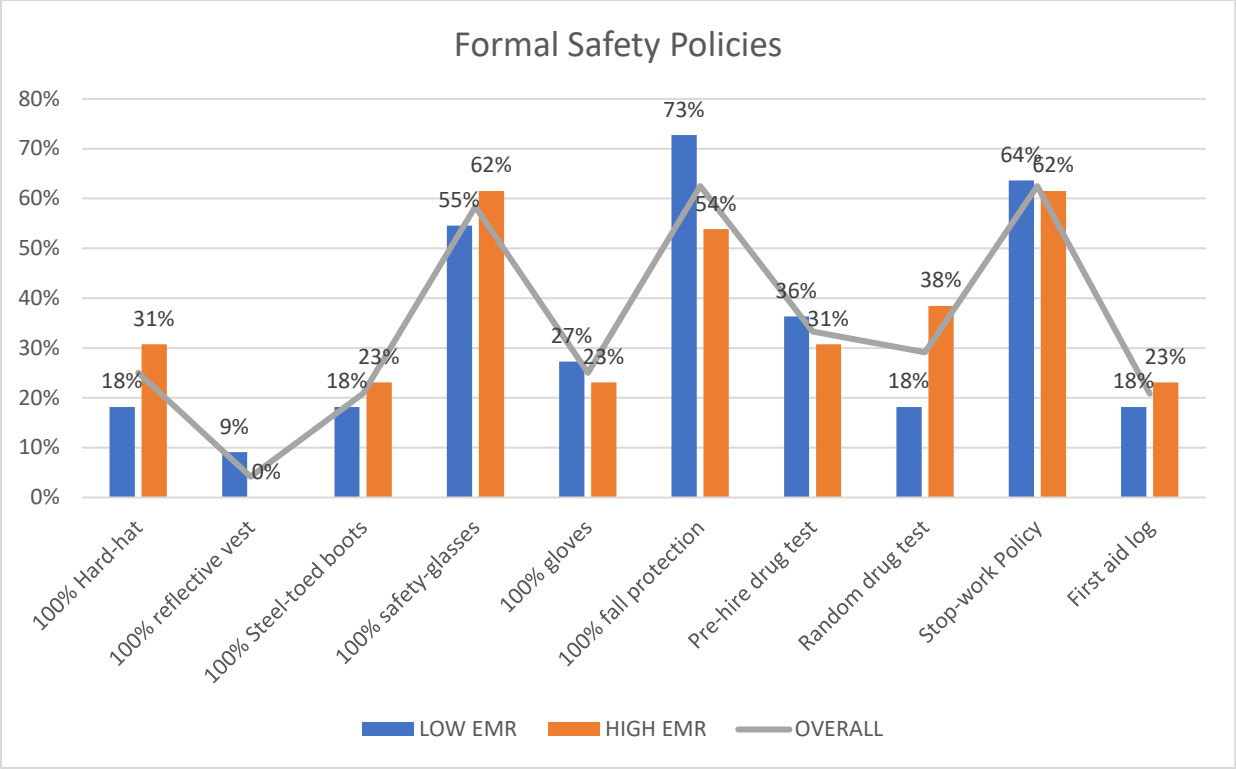


Figure 18: Company Formal Safety Policies

Pertaining to the formal policies and use of PPE there was some evidence in literature that correlated the provision of the PPE by the company to the importance of its use by the worker. The firms were asked which PPE the company purchased for the worker if it was needed for their job. The findings are broken down in Table 18. Overall, when needed, Hard Hats, Safety Glasses, and Fall Protection are provided at a high rate by the firms. Based on the type of work the firms primarily do, carpentry, these findings are not surprising and align with major risks they would typically face, primarily eye injuries and falls.

Table 18: Company purchased PPE

Group	*Respondents*	*Hard Hat*	*Reflective Vest*	*Steel Toed Boots*	*Safety Glasses*	*Fall Protection*	*Safety Gloves*
Lower EMR	11	9	5	2	8	8	4
Higher EMR	13	9	8	3	10	11	12
Overall	24	18	13	5	18	19	16

Similar rates of supplying PPE are between the two groups were indicated except for the purchase and supply of safety gloves that had a 56% higher rate of supply by Higher EMR companies (Figure 19).

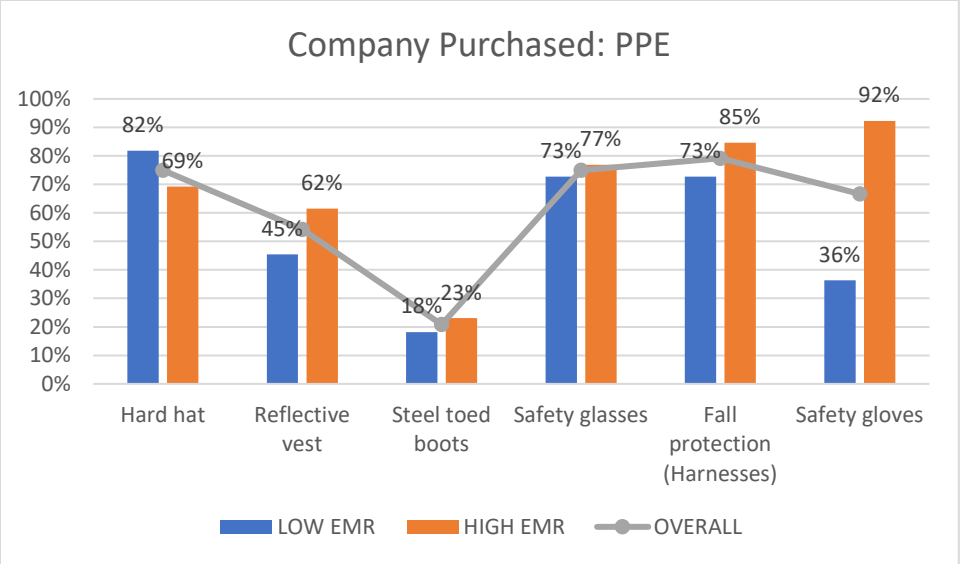


Figure 19: Personal Protection Equipment Provision

3.12 Accident and Incident Investigation

As discussed in the literature review, how accidents and incidents are tracked and data is used can be very useful in creating a safer working environment and developing a stronger safety culture. The respondents were asked which types of information their company track. The results are shown in Table 19.

Table 19: Tracking of Incidents/Accidents

Group	*Respondents*	*Reportable*	*Days away from work*	*Restricted Work*	*Near miss*	*Direct Costs*	*Indirect Costs*
Lower EMR	11	7	3	2	0	3	3
Higher EMR	13	10	6	3	1	2	1
Overall	24	17	9	5	1	5	4

"Reportables" was identified as the most tracked category which should not be a surprise. There may have been some interpretation for the response based on the safety performance of a company. Some companies may not have had any or many reportable incidents in recent time so they may have indicated that they do not track them if there is nothing to track. Also, due to the smaller nature of the companies it is understandable that incidents do not happen at a frequency high enough to track more than what is required by insurance for claims information. The interviews will go further into the safety performance and types of reporting.

Tracking the costs of accidents has benefit to the bottom line of a company's financial performance and can serve as a motivator to improve safety and implement additional safety practice to prevent those costs. The costs were tracked by firms with a Lower EMR at a higher rate than the Higher EMR group of firms. The only other larger difference was 19% higher indication of tracking days away from work by Higher EMR firms than Lower EMR firms.

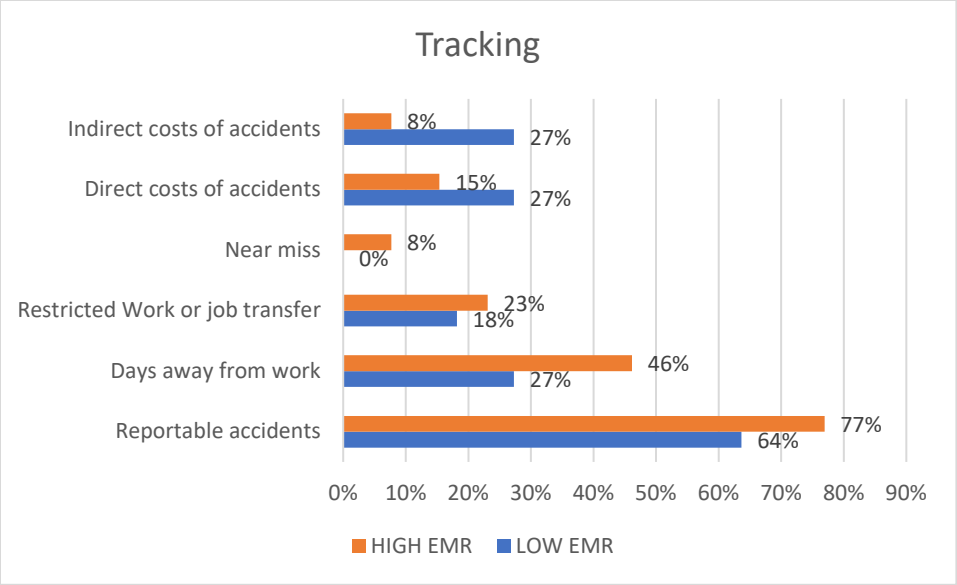


Figure 20: Incident Tracking Survey Results

One of the important issues that was not easily captured with the survey and was explored in the interviews was the level of investigation when looking at events as well as what is done with the information once it is gathered. Hinze et al. (2013) identified that formal lessons learned from investigations and detailed investigation of indirect costs have an impact on the overall safety culture of an organization. It is worth noting that those firms who reported tracking additional measures beyond reportable instances were not the larger firms in terms of annual volume and employees that may have more resources available to spend on these activities. This suggests that the firms have identified some internal value for collecting the information.

3.13 Safety Influence

Another section of the survey was used to gauge the overall perception of safety and its effect on other aspects of a company's performance. Likert scale style questions were used to document "In your opinion, how important is safety for each of the following?" with the aspects of company performance being listed as: profitability, securing work, worker productivity, company reputation, and worker motivation. The respondents were asked to rank them from 1 – 5 with 1 being Not Important, 3 being Moderately Important, and 5 being Extremely Important.

As shown in Figure 21, the highest importance by the overall respondents were listed as Company Reputation followed by Profitability and Worker Productivity, which were equally ranked. Additionally, Securing Work was ranked with an overall rating of "Very Important" with a mean of 4.0. Worker motivation was the lowest with a rating of 3.7, however this is still an overly positive ranking between moderately and very important.

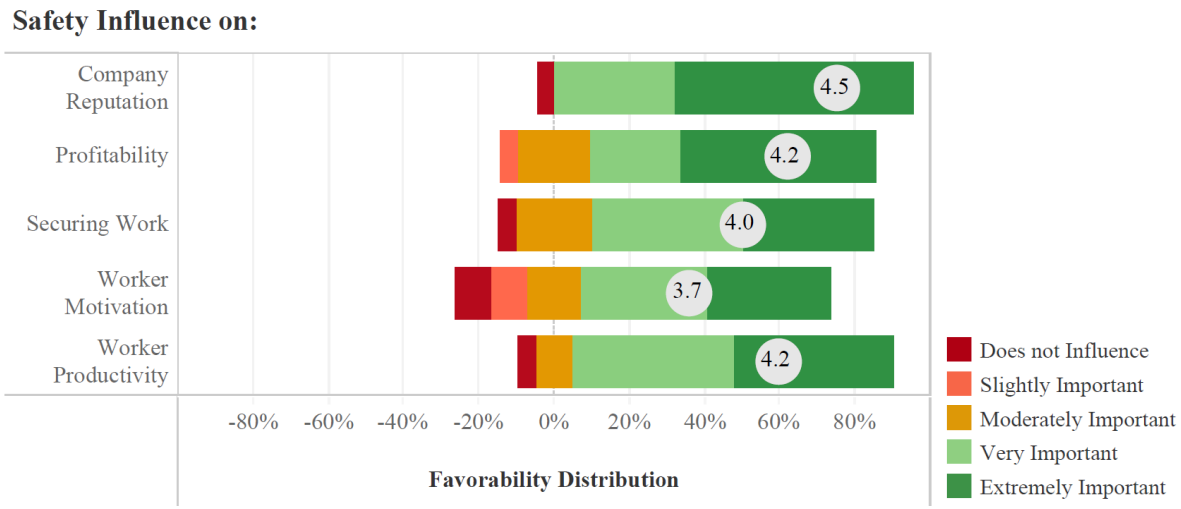


Figure 21: Perception of Safety Influence on Company Performance Indicators - Overall

When looking at the breakdown between groups, there are larger difference in perspective is in "Worker Mortivation" where the higher EMR group indicated a 3.3 in agreement at Moderately Important compared to the lower EMR group who indicated a 4.2 in agreement between Very Important and Extremely Important. There is a clear difference in perception for the effects of safety on Worker Motivation (Figure 22).

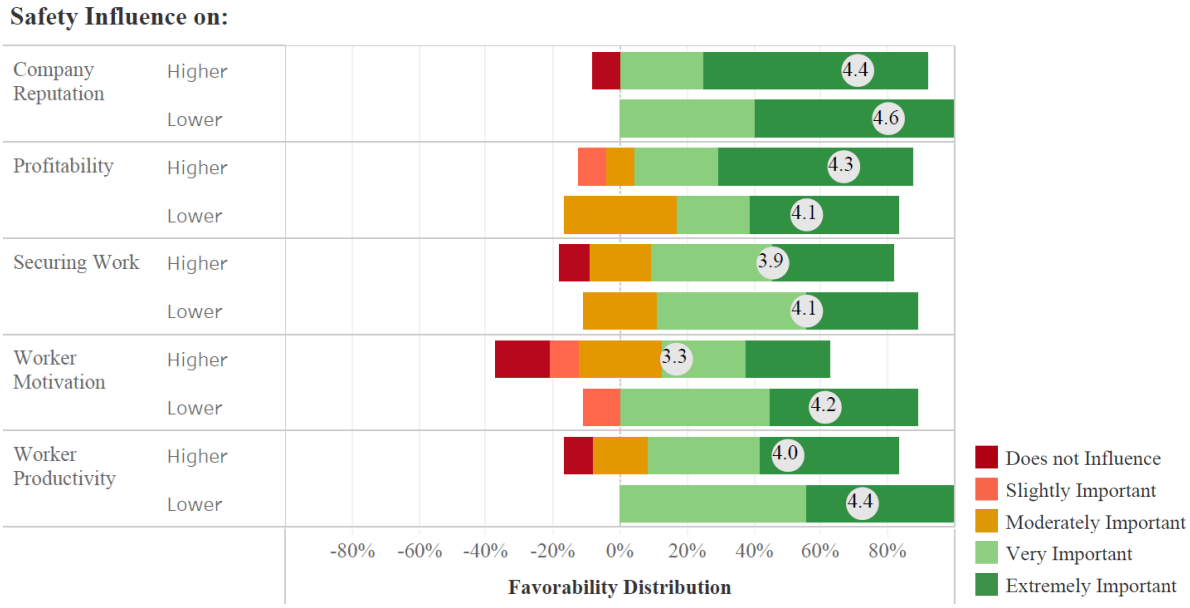


Figure 22: Perception of Safety Influence on Company Performance Indicators - by Group

The respondents were also asked how various factors influenced their selection of subcontractors. The factors they were asked to give a rating to include: Bond Capacity, EMR, Financial Stability, References, and Work Experience. The ratings were from 1-5 on a Likert based scale where 1 was Does not Influence, 3 was Moderately Important, and 5 was Extremely Important.

The overall ratings and distribution are shown in Figure 23. Work Experience was the most important factor while references and financial stability were both listed primarily within the Very Important and Extremely Important range. Bond Capacity and EMR were on the bottom end of importance with the majority of respondents rating them as Does not Influence or Slightly Important.

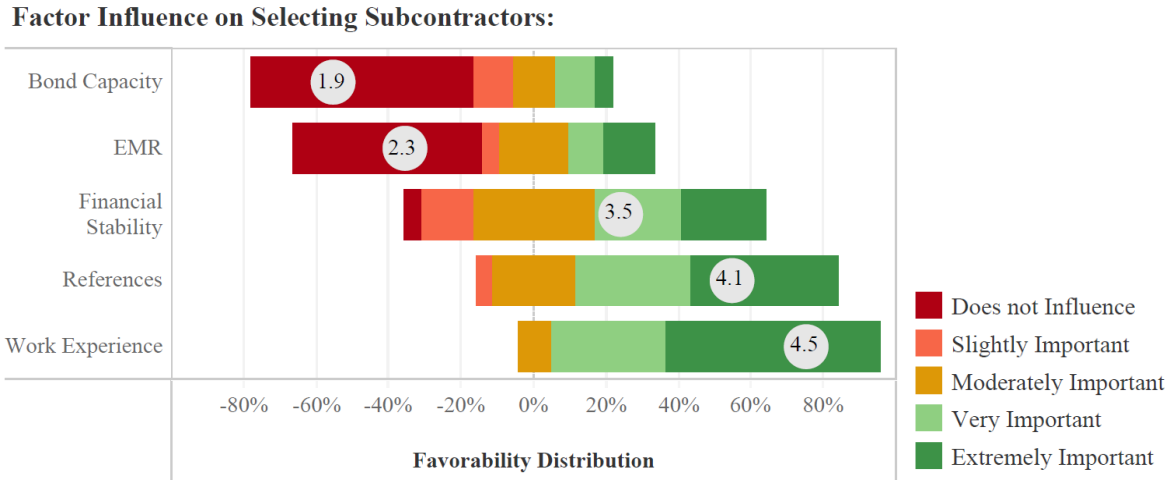


Figure 23: Factors that Influence Subcontractor Selection – Overall

Looking at the breakdown by group in Figure 24 shows that for Work Experience, References, and Financial Stability the factors are view about the same. There is a slightly higher rate of ranking both Bond Capacity and EMR as "Does not Influence" for the Higher EMR group.

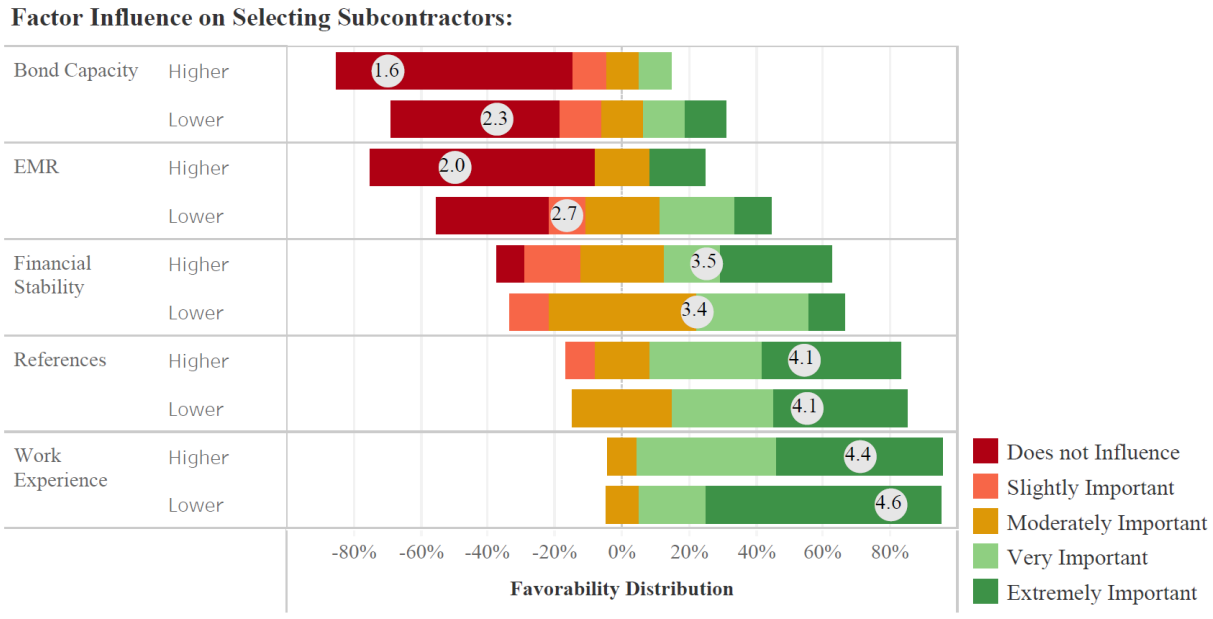


Figure 24: Factors that Influence Subcontractor Selection – by Group

4 Survey Discussion and Observations

It is important to note that several safety factors found and discussed in the initial literature review were not measurable in a mostly quantitative survey. For instance, due to the length of the survey, experience requirements and extents of background checks were not included in the survey. The survey also did not explore the importance of the findings of these activities on hiring personnel. Training frequency and types of training were identified in the survey, however, specifics on methods of delivery and exactly what was covered was not explored.

Other observations and areas that required further consideration are listed in this section.

4.1 Hiring Processes

Sorting the data by "Age of firm" as an indicator of experience, all the younger firms (6 to 17 years of existence) had experience requirements for workers, and only 58% of the older firms (18 years to 34 years existence) noted experience requirements for their workers (Figure 25). Moreover, 92% of the younger firms also noted experience requirements for their supervisors in their hiring process, and 67% of the older firms stated experience requirements for supervisors. Younger firms also rated on Employment verification, background checks, and reference checks more often. 58% of younger firms noted Task-specific credentials requirements for workers verses, only 8% of the older firms. 75% of younger firms stated Task-specific credentials requirements for their supervisors, and 17% of older firms noted this requirement (Figure 26). Though age of firms was not further explored as a factor during the interviews, the younger firms appear to be looking for experience requirements and validation of those skills. Note: age of firm does not correlate with safety performance.

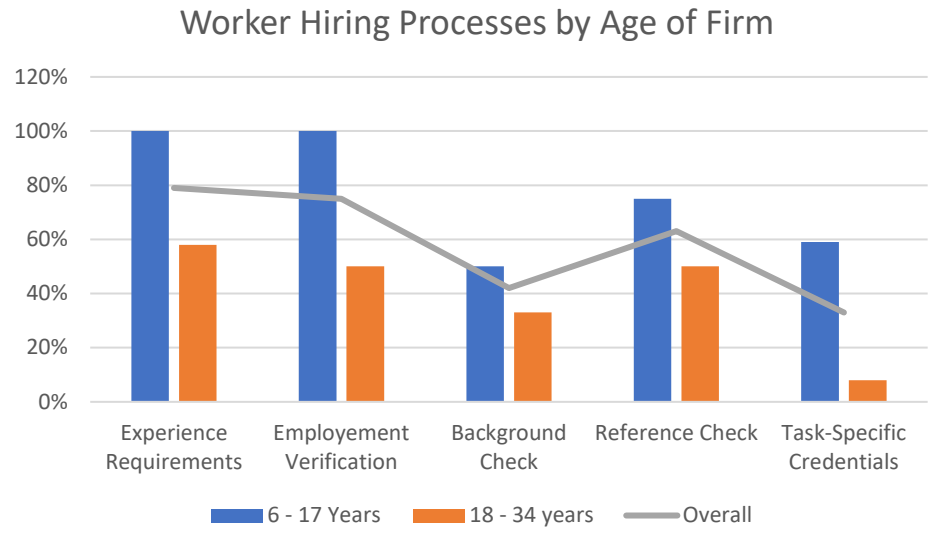


Figure 25: Worker Hiring Processes by Age of Firm

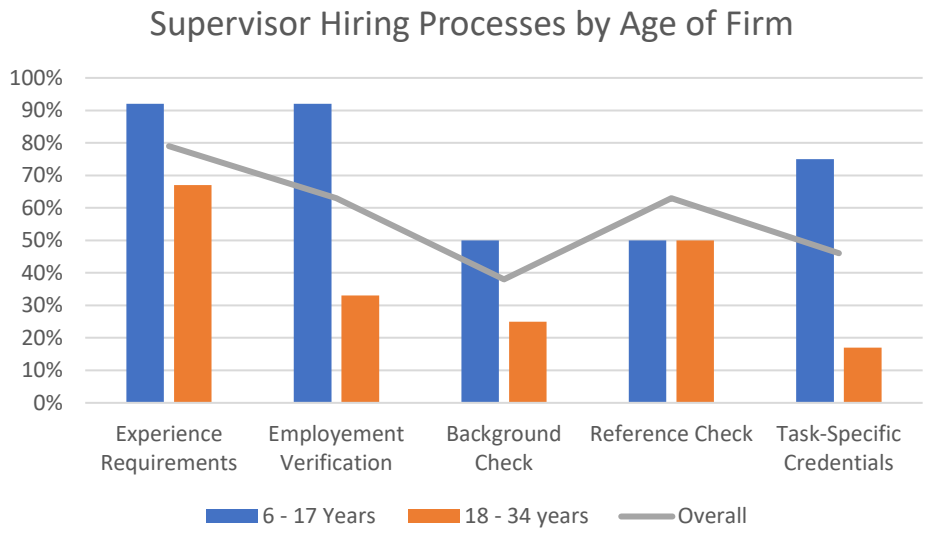


Figure 26: Supervisor Hiring Process by Age of Firm

When sorted by "Growth" and grouping firms by those who indicated less than 10% and those who indicated more than 10% growth, those that have more growth have more hiring processes. Overall mean of 8 processes indicated per firm versus 5 for companies with less growth. Similarly, when the groups are sorted by "Volume of Work" companies with a larger volume of work indicated more hiring processes than those with smaller volume. These number are not necessarily surprising as larger firms may more frequently be hiring new employees to replace those lost through retirement, etc. and firms that are growing at a faster rate would likely be hiring more people to complete the additional work as the firms grow.

4.2 Safety Training and Orientation

When sorting the data by "Age of firm," older firms do more training when hired and pre-task. Sorting by "Growth," those with lower growth performed more training. When the data is sorted by "Volume of Work," 83% of companies with larger volume of work indicated periodic training for on-site supervision and only 33% of the companies with less volume of work. Overall, companies with larger volume of work indicated utilizing more types of training and offering training more often.

4.3 Third-Party Support

As noted earlier in literature, safety resources and provisions for safety equipment enhanced the site personnel's ability to manage safety issues, equipment assessment, and protection leading to a reduction in injuries and incidents (Mohammadi, Tavakolan, & Khosravi, 2018). Several studies have concluded that the presence of safety personnel on-site helped manage safety issues and reduce injuries and accidents. (Hallowell & Calhoun, 2011) In their study found that a safety manager on site is one of the most central elements of an effective safety program, and (Esmaeili & Hallowell, 2012) claimed that the employment of a safety manager was one of the commonly adopted safety initiatives. Due to the size of the type of firms participating in this research, we assumed that our sample population would either have an employee functioning in multiple roles, including that of a safety coordinator because of limited resources. It was not surprising to find very few safety coordinators listed as responsible for safety due to the size of the firms.

According to the survey, companies with better EMR utilize OSHA support resources more. Whereas companies with poorer safety performance utilize insurance company resources more. When sorting companies by Volume of Work, companies who perform a larger volume of work took advantage of more support resources.

4.4 Safety Incentives

One of the main sub-factors found in the literature for motivating safer work practices was incentive programs (Mohammadi, Tavakolan, & Khosravi, 2018). It was stated that Incentive programs are one of the most implemented and controversial safety programs in the construction industry (Gambatese & Hinze, 2003). This may be attributed to the implementation of a safety incentive program after a trend of unsafe behavior to help improve company safety culture and to correct worker behavior. The reasons for implementing, or not implementing, safety incentive programs and the benefits gained from implementing safety incentive programs were explored in the next phase of the research.

When sorted by "Age of firm," the younger firms utilize more safety incentives and provide them at a higher frequency.

4.5 Safety Culture and Climate

The literature discussed safety climate as a subfactor of safety culture, influencing an organization's strategy, decision making, and the organization's employees' perception of safety strategies (Rowlinson, Leicht, & Niu, 2016).

When sorting the survey data by "Age of firm," Younger firms had a higher level of agreement on factors that are affected by worker safety (Figure 27). Specifically in terms of Job Assignment and Promotion, the safe performance of the worker had a positive influence. For all aspects identified, the older firms indicated minimal influence of work safety.

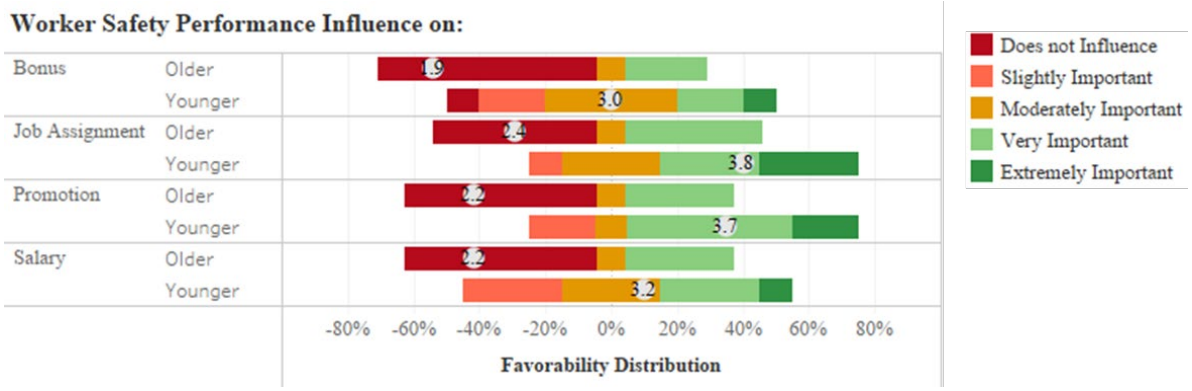


Figure 27: Worker Safety Influence by Age of Firm

When looking at the effects that safety has on various aspects of a company and work, the older firms indicated a higher level of agreement for all categories (Figure 28). The largest differences between the two groups by age were the effects of safety on company reputation, profitability, and to a lesser extent worker productivity.

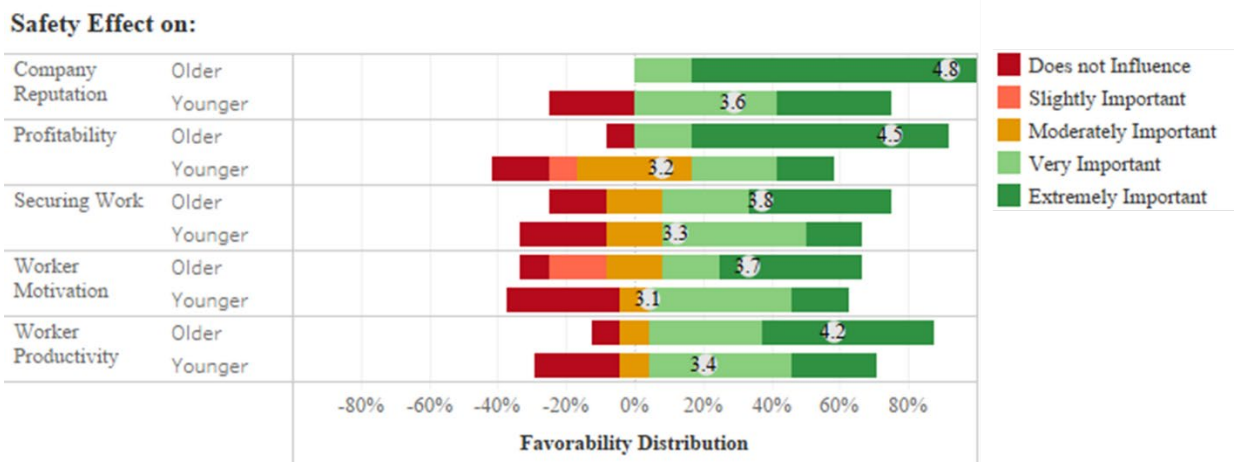


Figure 28: Effect of Safety by Age of Firm

4.6 Accident and Incident Investigation

As supported in the literature, one of the main sub-factors of accident investigation is near-miss reporting, which has been found to enhance safety performance on the job site. However, according to the survey results, both groups tracked reportable incidents more. It is important to note that this might be the case because the tracking of reportable incidents is required by OSHA. More companies with higher EMR appear to track "Days away from work" and "Restricted work or job transfer". To gain better understanding of the what was tracked and why was explored during the interview process.

Sorting the survey data by "Growth" companies with more growth tracked more data related to safety. When sorting the participants by "Volume of Work," the larger companies conducted more tracking of accidents/incidents. The company's size and financial growth factors into their ability to realize the value of accident investigation and inspection as drivers for improved safety performance as discussed by (Mohammadi, Tavakolan, & Khosravi, 2018).

5 Follow-up Interview

In order to further understand the trends indicated in the survey, interview question were developed to conduct semi-structured interviews. The questions were designed to explore hiring practices, management and owner involvement in hiring and safety, and specifics about safety programs that are in place for participating companies. These were areas within the results of the survey that showed signs of differences between the groups when they were sorted based on safety performance (EMR).

5.1 Interview Design and Administration

An interview script was created to guide the discussions through the key topics being explored. This script is included in Appendix D. Key safety factors that were found in literature but not fully measured through the survey were included as a basis for some of the topics explored. All respondents from the survey who indicated the willingness to answer follow up questions were contacted to schedule interviews. The interviews were designed to be conducted over WebEx and lasted between 30-60 minutes. The participants gave consent to having the conversations recorded for coding accuracy and to expedite the call by minimizing the need for stopping to take extensive notes. The interviews were summarized and coded.

5.2 Interview Results

The interviewees consisted of company owners, managing partners and company presidents. The sample also captured participants in both the Lower and High EMR groups, with an EMR range of 0.8 – 1.45. There were similarities in the overall average size and age of participating firms between the two groups (Table 20).

Table 20: Interview Participant Firms

	OVERALL		**LOW EMR (4 PARTICIPANTS)**		**HIGH EMR (3 PARTICIPANTS)**	
	MEAN (μ)	**RANGE**	**MEAN (μ)**	**RANGE**	**MEAN (μ)**	**RANGE**
EMR	1.02	0.8 – 1.45	0.82	0.8 – 0.83	1.29	1.07 – 1.45
Participant Position			Owners, Managing Partners		Company Presidents	
Volume of Work ($)	$6,261,895	$1,500,000 - $20,000,000	$6,375,000	$1,500,000 - $20,000,000	$6,111,088.3	$2,833,265 - $12,000,000
Age of Firm	19	2 - 34	17.75	2 - 30	20	7 - 34

5.3 Company Structure

To understand the roles and responsibilities of the company and how firms manage their safety risks on the jobsite, general company structure questions were asked. A trend among all of the firms was the use of 1099 workers as independent contractors as opposed to payroll W-2 employees (Table 21). This was not an expected assumption at the beginning of the project and influences the way data can be reviewed since the safety of a 1099 worker would typically not have direct effects on the EMR rating of a company. Of note was that more of the lower EMR companies were utilizing more 1099 workers. The workers on their direct payroll were primarily in supervisory rolls. One respondent indicated that the W-2 employees for the company were not allowed to be up on the roof framing. They were to supervise crews and only allowed to

do work on the ground. This distribution of labor would minimize the liability risk of the lower EMR companies. Some reasons that were captured for utilizing 1099 workers included: being able to be competitive and shifting liability with a benefit of reducing risk and owner stress.

Table 21: General Company Structure

Topic	LOW EMR	HIGH EMR	COMMON THEMES
Company structure (number of employees, subcontractors)	¾ noted utilizing on 1099 contracts, salary paid workers typically management or low risk work	1 company noted using solely 1099 workers, the others used labor on their payroll	Majority 1099 workers.
Work own labor (W-2 employees) performed	Lower risk work, on the ground, management and supervision	All aspects of work	

5.4 Hiring Practices

Hiring practices and the type of person doing the work and working for a company was identified in literature as a key factor to the safety performance of a company. Overall, leadership involvement, required skills sets, background checks, and worker turnover rate were considered as factors for exploration (Table 22).

Table 22: Summary of Hiring Practices

Subject	LOW EMR	HIGH EMR	COMMON THEMES
Leadership involvement in hiring process	Majority owner involved	Some delegated hiring responsibility	Most companies in both groups noted owner involvement in hiring, more so with Lower EMR Group.
New hire skill level	Skilled	Right attitude/ Cultural fit	
Background/reference check	Not extensive, Network of builders	Network of builders	Referencing network of builders
Worker turnover rate	Low	Low	Both groups noted retaining their works because of high demand of resources.

For the lower EMR group the input provided by the participants was that their hiring process was highly controlled by the owner, or managing partner. For the high EMR firms, the owners were involved but stated they shared the responsibility. Others were involved in the decisions.

There was more of a notice with the attitude based on skill level of new hires. The lower EMR group focused more on skill and quality over cost when hiring workers or selecting subcontractors. The indication

from the firms in the higher EMR group was that they were willing to train the right person based on cultural fit, attitude, and willingness to work. They expressed quality as something they wished to maintain, but their hiring practices did not focus on this. Interviewees from both firms indicated a difficulty finding labor in the current market. Most commonly, both of the groups only performed reference checks based on work history and contacting the builders that the workers or subs have worked for in the past.

Neither group conducts an extensive background/reference check. Half of the companies who participated in the interviews contacted other homebuilders regarding possible new hires for skilled labor. Most of all the participants mentioned very high work tenure for their employees with low turnover. Some companies from both groups noted the importance of retaining resources in the construction industry. However, the lower EMR group shared more stories of employees at their firms for longer periods of time (lifetime job).

Those who utilize a higher level of 1099 independent subcontractors indicated a high level of dedication to keep those individuals busy and supplied with work. Utilizing a core group of subs was indicative of maintaining a level of performance that meets the expectations of the builder as well as reduces the amount of orientation time needed. Most, but not all, of the builders who utilized 1099 independent subcontractors required them to participate in the onsite training and tracked attendance. Many of the builders also indicated assisting 1099 independent subcontractors in learning new skills and training them for new tasks similar in a way that they would train employees if they were on their own crew. Some comments received about working with the 1099 subcontractors were they "helped get them off the ground and organized as a crew," "help them make sure their equipment is safe", and sharing resources and discounts to make sure equipment was properly procured and available for their use during the job.

5.5 Owner/Management Involvement in Safety

Literature showed that the leaderships skills often associated with higher-level management in conveying the importance of a culture within a company can influence the safety performance of that company. This is also linked to the perspectives of the company leadership as to how they view the importance of safety and their involvement in sharing that message with the workers. The interviewees were asked about their perceptions of safety and their involvement in actively implementing the safety plan within their company (Table 23).

Table 23: Owner/Management Involvement in Safety

Subject	LOW EMR	HIGH EMR	COMMON THEMES
Key safety drivers	Experience, training, equipment	Common sense, awareness	
Communication of safety importance	Documented Process (safety manual, checklist, safety sheet)	Training Meetings	
Safety Participation	Directly involved	Monthly meetings	Both groups encourage reporting of unsafe practices
Safety oriented jobsite inspections and regulations	50% said they have fired a worker for unsafe practices, more frequently conduct inspection	Have not fired a worker for unsafe practices, less frequently conduct inspections	

The hypothesis, based on indications from literature, was that if an owner, especially in a smaller company, was more involved and placed a higher level of importance on a consistent message of safety that the firm should perform at a higher level in terms of safety. This appears to be evident within the results of the surveys and the interviews. Three out of four within the lower EMR group firms indicated a high involvement in safety and personally conducting the safety training or closely coordinating with a safety consultant who developed and conducted the training with them. They also indicated a high level of "safety comes first" in their responses. These responses were beyond "safety is important" to the point where connections were identified between skilled employees being trained do things in a specific, safe way, performing quality work on a clean site, and the importance of having access to and using the right equipment. All these factors were identified as the safety culture of the firm. The programs and processes for the lower EMR group were more formalized through check lists and trained processes.

In contrast, the higher EMR group responded to questions related to their thoughts of drivers of safety and how to have a safe work site as "common sense" and "awareness of surroundings". These are arguably important to ensure that workers are working safe, but if the person were also not as qualified, skilled, or trained, which is the perception based on the hiring practices of the higher EMR group, then simple "common sense" and "awareness of surroundings" would need to be supported by other practices. The lower EMR group indicated "common sense" and "awareness of surroundings" as pieces of a safe working culture, but they also had formalized processes in place to ensure that the workers were equipped to make safe choices and perform work safely.

During the interviews lower EMR firms noted that they communicated the importance of safety and ensured workers were experienced to perform duties before they were assigned those duties, implemented policies for checking and evaluating equipment more often, and conducted site inspections at a higher frequency with a larger participation of the owners.

5.6 Safety Program and Training

The use of a formalized safety program, including the processes for checking and maintaining a safe work environment supported by worker training, was identified in literature as an indicator of a strong safety culture. The interview responses pertaining to formalized safety programs and training are included in Table 24.

Table 24: Safety Programs

Subject	LOW EMR	HIGH EMR	COMMON THEMES
Formalized safety program (Training content & process)	More in print, detailed		Programs based of 3rd party support resources, Safety training depends on a worker's Experience.
Safety discipline process (awareness)			Various multi-step processes for correcting action and later firing.
Safety training	Slightly higher frequency		Bi-weekly, Monthly meetings, Pre-task training done for unskilled workers, overall safety training depends on skill level or project.
Stop-work authority			All employees are aware of their authority to stop work.
Safety incentives benefits			Most participants do not offer

When discussing their *Formalized safety programs*, both groups noted using various forms of 3rd party support resources. Material discussed included; OSHA produced resources, insurance company cut sheets and safety educational material, safety consultant jobsite safety manuals, electronic safety application, and key topics to be covered. The lower EMR firms described formal safety programs that were written in their company handbook where most of the higher EMR firms stated a process was followed but is was not clearly documented. For smaller companies with someone in charge of the process it did not seem out of the ordinary that every procedure was not formally written out in detail. More detailed processes typically become common place when the process becomes more decentralized to ensure common compliance. Most written material was identified as typical safety procedures and expectations within an employee handbook that was covered when the person was hired.

The *Safety training content and process* varied depending on the experience of the worker. Most companies in both groups identified the team lead as the person conducting project and task specific training. However, the Lower EMR group had more owner/higher level involvement for new hire training.

Most safety training talks for all firms occurred on a monthly or bi-weekly basis. Only one had a more formal quarterly meeting with a training emphasis. A low number of firms from both groups tracked attendance for safety training.

None of the survey participants saw value in providing workers with safety incentives for performance. Some firms in the lower EMR group stated that their workers were expected to work at a safe level and should not be rewarded to meet the firm's standards. Some firms from the higher EMR group noted the lack of resources or failed to consider a policy. In summary, the higher EMR firms were more willing to consider safety incentives while the lower EMR firms did not think it would be of value to them.

5.7 Tracking of Safety Data

The literature identified that tracking direct and indirect costs associated with accidents and events to clearly understand the impact of each incidence. Past studies have promoted investigation of safety incidents and accidents to review processes, procedures, and in an effort to develop safer practices and promote a better safety culture within the firm. The interviewees were questions about the types of information they tracked and how it was utilized (Table 25).

Table 25: Tracking Safety Data

Interview Question (s)	**LOW EMR**	**HIGH EMR**
Safety performance history	Less injuries over a long period of time.	Higher frequency of minor events
Accidents and injuries data tracking and benefits (use of findings)	Document for insurance. Investigate cause, though do not typically use to change processes	Typically document for insurance purposes only.

The lower EMR firms, as would be expected, had a less frequent rate of injury. Many of them had been working for over ten years without a reportable event. The high EMR firms divulged more frequent injuries, though mostly not major, and only a few reportable events that involved worker's compensation insurance. Many of the lower EMR companies stated they did not track events and utilize the data because there was not enough data for them to reasonably analyze. Some of them recorded near misses in daily logs but would only refer to them if and something happened to show a record of correction. The higher EMR firms did

not see value in tracking anything outside of what was needed for the insurance company or OSHA and the firm did not investigate beyond the minimal requirements. None of the interviewees had a frequency of events that would justify tracking and making modifications to their practices. Since they were smaller companies with fewer jobs and crews this was not unexpected. Larger companies with more employees would likely have more events based on volume of work and workers and therefore could get more meaningful data in an appropriate time period to modify their best practices.

6 Key Safety Drivers Comparison between interview and survey findings

A comparison of the findings from the survey that were further explored during the interviews was analyzed to provide a better understanding of the data that was collected during the survey phase of the research. The demographics of the response groups between the survey and interview were comparable in age, EMR, and volume of work. The High EMR Group that were interviewed had a slightly higher volume of work than those in the survey however their volume of work is comparable to that of the Low EMR group who participated in the interviews. (Table 26).

Table 26: Company Demographics Comparison

	LOW EMR Group	***HIGH EMR Group***	***Overall***
Survey			
Mean age of firm:	17.73	19.08	18.46
EMR Range:	0.77-0.92	0.94-1.51	0.77 to 1.51
EMR Mean:	0.83	1.11	0.98
Volume of Work Mean:	$6,000,000	$4,527,559	$5,202,428
Interview			
Mean age of firm:	17.75	20	19
EMR Range:	0.8-0.83	1.07-1.45	0.8 to 1.45
EMR Mean:	0.82	1.29	1.02
Volume of Work Mean:	$6,375,000	$6,111,088	$6,261,895

During the interview stage, the company structure was also explored. As previously noted, there was tendency to utilize 1099 independent contractors for a large portion of the labor force, especially for those in the lower EMR group.

6.1 Hiring Practices

The survey was conducted at a higher level so the interview was used to gain a better understanding of what the survey was showing. Areas such as skill or what characteristics of an employee were looked at in more detail were of importance and allow for a better understanding of the differences between the groups (Table 27).

Table 27: Hiring Practices

LOW EMR	HIGH EMR	COMMON THEMES
Survey • Less task-specific credentials for supervisors • Reference checks • 90% noted "Work Experience Requirements"	**Survey** • A larger percentage of companies required Drug testing for their Superintended. • 70% noted "Work Experience Requirements"	**Survey** • Require employment verification
Interview • Mostly use 1099 subcontractors for workers • Own employees at lower risk • Emphasize quality and skill over cost • Owner sole responsibility for hiring	**Interview** • Mix of 1099 subcontractors and owner labor • Emphasize employee fit and company culture – "willing to train" • Skill important, but not driver • Owner involvement for final hiring approval	**Interview** • Both groups only utilized their industry networks for background checks • Both groups emphasized the value of retaining workers.

The level of skill required by both groups for new hires was further explained in the interview and there was a higher emphasis in the Low EMR group on quality of work and worker skill. It was also identified from the survey that the owner played a larger role in the Lower EMR group recruiting of new workers. In the Higher EMR group the owner would be involved as the point of final approval, but a crew lead or superintendent was typically involved more in the recruiting and initial interviews.

6.2 Safety Programs and Culture

The interviews looked to expand more on the types of safety training and orientation that were offered by each of the participating companies. As summarized in Table 28, it was determined from the survey data that different types of training were being offered by the two groups. This was viewed as a potential indicator that employees with different levels of experience were being hired. This was confirmed in the interviews where the Lower EMR group expressed a desire to hire based on quality. This would also explain why less pre-task training was needed and offered if the worker was skilled for that task when hired. For both groups, periodic meetings (mostly monthly) were used as a means to remind workers of safety. The Lower EMR group identified these meetings more as a structured discussion that were supported by developed material. Several of the companies also indicated tracking which talks were given and attendance through an app-based program. The higher EMR group had meetings to discuss relevant information however tracking attendance and topic was not as formal.

Table 28: Safety Training and Orientation

LOW EMR	**HIGH EMR**
Survey • Training offered mostly "when hired" over "pre task". • 73% of the companies listed a higher level of management or the owner as the responsible party for safety training • identified that the person in charge of safety spent on average 9% of their time	**Survey** • Training offered mostly pre-task. • 54% responded that a field supervisor was responsible for safety training on site. • identified that the person in charge of safety spent on average 9% of the time
Interview • Training offered by owner. • Periodic (mostly monthly) meetings are used for recurring safety discussions • Views Pre-task training as very important for someone who lacks a skill	**Interview** • Training offered by on site lead. • More training of workers but they tend to hire more unskilled. • Periodic (mostly monthly) meetings are used for recurring safety discussions • Views Pre-task training as only necessary if needed

Related to safety operations was the use of third party resources. Though the question was not specifically asked, during the survey and the interviews many respondents indicated the use of third party resources (Table 29). The sources that were used the most as indicated during the interviews were OSHA cut sheets on specific topics.

Table 29: Third Party Safety Resources

LOW EMR	HIGH EMR	TRENDS
Survey Majority utilize OSHA and consultant safety resources	**Survey** Majority utilize trade organizations and insurance company safety resources	**Survey** • On average one third-party support resource was utilized by each respondent • 100% safety glasses, 100% fall protection, and stop-work safety policies
Interview Some utilization of consultants, one utilized a third party app	**Interview**	**Interview** OSHA cut sheets primarily used.

The use of safety incentives was also explored. There was not a high level of indication during the survey that safety incentives were offered so the interview looked more into why they were not being offered or considered. (Table 30). Most of the interviewees from both groups stated they did not consider offering them and had not thought about potential benefits. Two of the lower EMR group interviewees stated they were not offering safety incentives because it would be like rewarding workers for doing what they should be doing anyway, which is performing work safely. They provided bonuses more on quality and would occasionally consider safety performance for promotions and raises. Higher EMR interviewees expressed more willingness to consider offering safety incentives but did not typically have resources to dedicate. There were some interviewees from both groups that indicated the use of project-based rewards (ex: bbq at the end of a job, etc.), bonuses, pay raises, and promotions where safety was one aspect of the decision; schedule and quality were typically other areas that went into these types of decisions.

Table 30: Safety Incentives

LOW EMR	HIGH EMR	TRENDS
Survey Safety Incentives not offered	**Survey** 23% of the companies randomly gave safety incentives	**Survey**
Interview Did not offer and does not consider offering	**Interview** Might consider offering.	**Interview** No safety incentives are given

The use of accident and incident tracking data can be very advantageous to understanding the cost and cause of incidents. However, based on the size of the companies, the survey indicated very little collection of data besides reportable events reported for worker compensation claims or otherwise as required by OSHA (

Table 31). Outside the worker compensation claim the cost of safety events was not tracked. Many of the interviewees from both groups stated that they did not see a benefit in tracking anything outside of what was needed for insurance because the number of incidents for their small, low volume firm was so low that 'trends' were virtually nonexistent. However, the lower EMR interviewees had a more formalized process to follow if there was an incident in order to document an internally designed process for investigating the case further. The higher EMR group respondents seemed to rely more heavily on direct interaction with insurance companies and supplying them the needed information and did not indicate a self-initiated review of the incident.

Table 31: Accident and Incident Investigation

LOW EMR	HIGH EMR	TRENDS
Survey • 64% track reportable accidents • 27% reported tracking direct and indirect costs of accidents.	**Survey** • 23% tracked restricted work or job transfer resulting from an accident • 46% track days away from work • 77% track reportable accidents	**Survey**
Interview	**Interview**	**Interview** Both groups seemed not to be tracking accidents and incidents outside of OSHA requirements

Another indication of the development of a firm's safety culture was the use of formalized policies company and operational procedures related to safety (Table 32). The survey documented the types of formal policies implemented by companies and the interview process went into more depth of what was involved in those policies and operational procedures. The survey did not show any significant different between the two groups. However, the interviews that went more into depth revealed some differences. When asked about performing site visits primarily for a safety inspection only one respondent from the Low EMR group indicated they would conduct a safety-related site visit. The Low EMR group indicated safety was one of many things they look for when on a site visits. Some respondents from the Low EMR group indicated the use of a formal checklist for site visits of which safety issues were included while others had a more detailed process they followed in looking for specific safety items. The Higher EMR group was less formal in terms of safety observation on site visits and indicated that if something was noticed it would be corrected. The Higher EMR group also indicated that safety became more of a focus on a site visit when certain activities were taking place. Lower EMR interviewees also indicated more requirements in term of safety of subcontractors. One had a requirement where all subcontractors had to supply a project specific fall protection plan before they were allowed to begin a job.

Table 32: Safety Policies and Operational Procedures

LOW EMR	HIGH EMR	TRENDS
Survey	**Survey**	**Survey** • Averaged just over 3 formal safety policies. • 100% safety glasses, 100% fall protection, and stop-work policies for 2/3rds companies. • Over 60% reported having stop-work policies.
Interview • Safety a priority during site visits • Discipline process includes investigation and corrective action – depending on severity	**Interview** • Site visits for safety during key tasks and activities • Discipline process is to dismiss (fire) unsafe workers	**Interview** • Formal safety policies listed in employee manual • Most have not fired anyone for an unsafe work activity

7 Benchmarking to Prior Research

Since the key factors related to company-level safety were identified from an initial literature review, one goal of the research was to examine how the isolated group in the study (those doing carpentry for residential construction) compared to prior literature. The following is an analysis of where the study does and does not align with findings of previous literature.

7.1 Safety Incentives Program

Safety incentive programs are one of the most common, yet controversial, aspects of a safety program in the construction industry (Gambatese & Hinze, 2003). An effective incentive program was found to improve construction safety performance by rewarding appropriate safety behaviors (Mohammadi, Tavakolan, & Khosravi, 2018), however, Hinze (2002) noted not all construction firms with excellent safety records have safety incentive programs and at times are used as a corrective measure. Additionally, written incentive plans were important to their success (Hinze, Baud, and Hallowell, 2013). This study's findings align with those of Hinze (2002) as the companies with a Higher EMR were more likely to have an incentive program so safety performance does not align with the use of plan. During the interviews, this study found that firms did not view incentives as essential for maintaining a safe jobsite. Most firms did not see value in rewarding behavior that should be expected of a skilled employee who performs quality work. Additionally, none of the firms who used any level of incentives had a formalized written plan. Instead, they provided the incentives when they saw fit or had events for an entire jobsite for completing a job in a safe manner.

7.2 Safety Knowledge, Training, and Orientation

Safety experience as well as quality and competence of worker is significant to the overall safety of the jobsite (Mohammadi, Tavakolan, and Khosravi, 2018). Those with a lower EMR focused more on quality and experience of labor and many expressed the expectation that this quality and experience meant that who they were hiring knew how to complete the work safely. The higher EMR firms were more willing to hire someone with less experience that would fit within their company culture. They were willing to train employees who had little or no experience. The lower EMR group also offered more pre-task training as needed and expressed the value of having workers who knew how to competently complete tasks. There was an expectation from these better performing firms that their employees knew how to work safely.

Aligning with the literature for all firms was the utilization of a formal meeting that included safety-training aspects on the jobsite through a periodic, mostly monthly, basis (Swacha, naoum, and Fong, 1999). The lower EMR firms utilized more third party support materials and formal documentation of who attended these meetings, what was covered by the training, and ensured that training topics were relevant to the type of work being performed. Ensuring that the training was project-specific helps to support better safety performance (Esmaeili and Hallowell, 2012; Findley et al., 2004).

Site-specific safety orientation for all employees has also been documented as beneficial to overall company safety performance (Hinze, Baud, and Hallowell, 2013). There was slightly higher rate of job-site specific safety training in the lower EMR group indicated at the beginning of the job and a significant increase of job-site specific safety training "pre-task". This suggests that no only is job-site safety analysis and training is integrated into the work processes for starting a job but is reviewed periodically through the job as site conditions and hazards change.

Advanced leadership skills among those providing training and management on-site has been identified as having an impact on a company's ability to establish a good safety culture (Ringen et.al, 2018). The lower EMR firms had more upper level leadership or company owners who were directly, or heavily, responsible

for safety training and hiring. More of the higher EMR firms had field-level supervision responsible for safety training. It is possible that the leadership skills of the owners and upper level leadership and their ability to communicate is greater than those of field supervisors. This can correlate with the literature as the firm owners who were more involved had firms that performed better in terms of safety.

7.3 Accident and Incident Investigations and Data Analysis

Tracking of injury costs as well as other direct and indirect costs of accidents has been identified a valuable motivator for better safety performance (Karakhan et al., 2018; Findley et al., 2004; Mohammadi, Tavakolan, and Khosravi, 2018). All companies interviewed collected data required for workers' compensation claims. No companies collected and analyzed data beyond this requirement. The main reason being, due to the size of the company and number of incidents over any period of time, that the frequency of incidents was not enough to influence any work processes based on trend. Due to the low frequency of incidents, the interviewees did not see value in collecting any significant amounts of data beyond what was needed for insurance claims and related investigations. Based on the size and volume of the firms involved in the study and the lack of occurrences they would likely not see the benefit as listed in literature for formalize lessons learned (Mohammadi, Tavakolan, and Khosravi, 2018; Hinze, Baud, and Hallowell, 2013) in order reflect, learn and modify processes based on incident occurrences (Feng, Trinh, and Jin, 2018).

7.4 Safety Resources and Equipment

As part of good safety culture literature identified the importance of having regular inspections and maintenance of tools, full time safety managers (Hinze, Baud, and Hallowell, 2013), provision of safety equipment, and equipment training (Swacha, Naoum, and Fong; 1999). Mostly do the sizes of the firms involved in the study, there was no full time safety manager on site and most often this role was filled by the owner or a field lead. For the companies in the lower EMR group the role of safety manager was most often filled by the owner or a managing partner of the firm. Personal protective equipment was supplied at a consistent rate across both groups of firms. Where the differences were identified was between who was responsible for the safety training and emphasis on equipment safety inspections. The lower EMR firms had indicated the responsibility of safety to be the owner or senior level leader where as the higher EMR firms had indicated this responsibility was a lower level of management. No firms had performed inspections for the sole purpose of safety on the jobsite however the lower EMR firms indicated a more formalized process for checking equipment, reviewing equipment availability, and ensuring that their employees had the right equipment for the job. Lower EMR firms also noted requiring that newer hires prove they understood how to utilize the equipment. Higher EMR firms indicated training for employees on equipment and identification of safety hazards was listed as part of their job-site visit responsibility, however it was not as formalized and forefront in their intentions.

7.5 Written Safety Policy

A documented safety plan/policy was also discussed in the literature as a key safety factor that influenced safety construction performance (Cheng et al., 2015). A majority of the companies with a lower EMR had a documented safety policy consisting of third-party safety manuals of safety education materials assembled by the owner and/or a safety consultant. Additionally, the fact that the owner was more involved with safety meetings and training is aligned with literature that identifies owner visibility in terms of the safety policy has impact on the success of a company's safety plan (Hinze, Baud, and Hallowell, 2013). Many of the higher EMR firms had safety practices but did indicated less of a formal or document nature.

7.6 Safety Culture and Climate

One of the most influential aspects to a positive safety culture and climate that influence the safety performance of an organization was document as involvement of leadership (Mohammadi, Tavakolan, and Khosravi, 2018; Guo and Yiu, 2016). As previously mentioned, the results of this study show that the owners of lower EMR firms were highly involved in safety training and control of safety programs where as in higher EMR firms the role of coordinating safety meetings and training was often on an operational lead or field supervisor. Higher level of leadership provides a more consistent message of safety importance within a company culture.

Another aspect of positive safety culture and climate that can lead to better performance is the performance of job safety audits (Karhan et al., 2018; Cheng, Kelly, and Ryan, 2015). Though none of the firms performed inspections of the jobsite with a specific goal of checking aspects of safety, the lower EMR firms did have more formalized inspection and site visits procedures related to safety.

Companies placing value on safety within the organization is another aspect of a positive safety culture (Feng, Trinh, and Jin, 2018; Mohammadi, Tavakolan, and Khosravi, 2018). The lower EMR group had more formalized checklists and training procedures related to safety. They also indicated a more developed company manual that included safety procedures. When asked what the key drivers of safety were, the lower EMR firms expressed an emphasis on quality and skill. These are all aspects of the organization that relate to a positive safety culture. In contrast, many of the higher EMR firms indicated drivers of safety as “common sense” and “awareness of surrounds.” In and of itself this is a part of safety however key drivers are linked to more formalized processes.

8 Limitations of Study

Because of the focus on one type of work, the number of potential respondents was limited, and future research would need to repeat the study with other groups to check the generalizability of the findings outside of small residential carpentry firms.

One limitation of the research is the response group size when dividing it into groups based on safety performance. Because of the limited responses, breaking them into groups limited the types of statistical analysis that could be performed with any level of confidence. This did not limit the value of the data collected or the trends that were otherwise identified through simple descriptive analysis.

Another limitation is the use of EMR as an indicator of safety. EMR was considered the best indicator for safety based on the quantitative nature of how it is calculated. However, as Jazayeri and Dadi (2017) have identified, a firm's size can greatly influence the EMR because the value is heavily counted on the frequency of injury and not the severity of the injury. Some of the companies may have several smaller incidents that influence that calculation of the EMR in a smaller company that otherwise would not be seen in a larger company that had fewer but more significant claims.

An alternative method for sorting safety performance could have been examining the number of claims over a period of time. Claims data and workers' compensation premiums were examined as potential metrics of safety performance with insurance industry partners. This was limited since those firms that were a higher risk with significant claims data would typically be dropped from coverage. Also, claims could be registered against a company's policy when someone else was at fault. In this case, the claim could eventually be covered by the responsible party's policy but be contraindicative of poor safety performance. Additionally, workers' compensation premiums are highly influenced by the EMR of the company and the type of work being performed. Since the companies perform the same type of work, the indicator of workers' compensation premiums as a measure of safety showed no noticeable difference than just using the EMR.

Another limitation of utilizing EMR is that it is a lagging indicator of safety performance. EMR is calculated by looking at data from the first three years of the past five years. Therefore, significant changes in personnel and company policy can potentially take place to drastically improve a company's actual safety performance, but the EMR would still indicate a less safe company. Consequently, the reverse is also possible where the EMR would indicate a safer firm even if, in the most recent two years of work, the firm exhibited a growing history of claims and accidents. The change in safety performance would not be fully reflected by the EMR in real-time and the EMR would suggest the firm is safer than their most recent performance is.

Despite the noted limitations for utilizing EMR, it was the most appropriate quantitative indicator of safety available. Other qualitative means that require exploring the safety history of firms in more depth could help identify characteristics based on the literature of a safe firm. Some of these characteristics will be explored by discussing the history of a firm's safety performance in the next phase of the research. The use of these qualitative means would require a subjective ranking and not necessarily be transferable from literature due to the nature of work and size of firms participating in this study versus those in the literature. The hope of using a quantitative measure was to provide a direct delineation of safety performance. Determination of differences will require a combination of EMR and other information gained about the firm's historic safety performance and characteristics of a firm's safety culture during the next phase of the research.

Overall, the research intends to gain a better understanding of what smaller firms are doing and how they can improve their safety performance. Though the survey did not show any statistically significant

difference when breaking the respondents into groups based on EMR, there was another value in the data. In examining the data in other ways, there are trends that appear when looking at the age of the firm, distance traveled for work and firm size. There was also data that, in the future analysis, will be utilized as a basis for benchmarking safety practices of small residential carpentry firms in terms of policy types and training practices.

9 Discussion of Key Findings

There were four major themes identified in the analysis of the findings that indicate the current practices of small residential carpentry firms as well as distinguishing factors that can help a company increase their safety performance. These themes include owner/management involvement in safety, hiring practices, worker competency and training, and safety policies and practices. From the findings, several best practices have been highlighted as well as opportunities that can be taken advantage of to help companies increase their safety performance.

9.1 Owner/Management Involvement in Safety

There was a sense of cultural difference between the better performing firms in terms of safety and the perspective of the owners. Firms with a better history of safety performance had owners or upper level management directly involved in jobsite safety through training, safety meetings, jobsite inspections, and equipment quality checks (73%) where higher EMR firms delegated these jobsite safety responsibility to field supervisors (54%). The owners of the lower ERM firms had more structured methods for performing safety audits in terms of inspecting equipment, tools, and jobsites. Most did not have a written checklist or process but had a defined routine they followed. Additionally, these owners identified the key safety drivers for their companies as worker experience (quality), training for those who do not have the experience, and ensuring that the right equipment is on site for the task. In contrast, the owners and managing partners from the higher EMR firms noted common sense and awareness as the key drivers to maintain a safe jobsite. The owners of the higher EMR firms also were less involved in safety with more site superintendents being directly responsible. These firms also did not have as defined practices in terms of conducting safety audits. Lastly, owners of lower EMR firms indicated a perception that safety had more significate impact on worker motivation than higher EMR firms.

9.2 Hiring Practices

Hiring practices was identified in the literature as a key factor to how a company performs in terms of safety. Elements of this include the experience/skill level of the worker, the age of the worker, and how proper training needs are identified and met. The use of common human resource elements such as employment verification, reference checks, drug tests, and review of certifications were all listed as elements that can help identify a good worker. The respondents were surveyed for their use of these methods. Surprisingly, less than half of the firms conducted drug tests for new hires. Only 42% of the firms overall conducted drug screenings for workers and 46% for supervisors. Many larger firms have 100% testing of new workers with random screenings and 0% tolerance so this finding is much less of a use of drug screening than what was expected. The majority of the firms conducted reference checks and employment verifications. A law-enforcement based background check was conducted by 42% of the firms for workers and 38% when hiring new superintendents. Higher EMR firms conducted more drug screening, reference checks, and employment verifications. This can be partially explained by the type of employees that are being hired by each of these groups. The lower EMR firms mostly had owners/top management conducting the hiring process and emphasized looking for skill and experience of their workers to perform quality and safe work. The higher EMR firms delegated more of the hiring process and authority to site supervisors and looked at the right attitude and cultural fit. The higher EMR firms were also more likely to hire someone without experience and were willing to help them learn the necessary skills. Based on the hiring practices of owners of lower EMR firms and the desire for quality and experience, they also expressed an attitude that they expected an experienced worker to be able to complete the job safely. They backed this up with an attitude as noted in the prior section, that if you provide an experienced worker with the right,

and safe, equipment to perform a job they will take ownership and pride in the work they do and this ultimately helps create a safer environment.

9.3 Worker Competence and Training

There were some identified differences in training practices for workers between the groups of respondents. As mentioned in the previous section, the lower EMR firms expressed an emphasis on hiring skilled and quality workers. This can help explain why higher EMR firms provided more types of training at a higher frequency than the lower EMR firms for their site supervisors. The lower EMR firms placed more significance on experience with an understanding that good safety practices should be understood with that experience. This limited training for lower EMR firms to specific tasks, regular reminders in safety meetings, and when new skills were needed.

Related to the skill of the workers, lower EMR firms were also more likely to mitigate safety risk by transferring the work to independent contractors or subcontractors. The lower EMR firms identified practices of ensuring that if their employees were performing a task that they knew they had the right equipment and skill for that task. Some lower EMR firms limited their employees from doing higher risk tasks such as framing at an elevated height and instead subcontracted the work or hired independent contractors. If an employee was not skilled, lower EMR firms emphasized pre-task training to ensure that workers knew how to complete tasks correctly. If a new tool or piece of equipment was being used, someone competent was available to teach the worker how to properly complete the task.

For higher EMR firms, some identified utilizing independent contractors to fill out their workforce but they did not have the same limits on their direct employees. Higher EMR firms offered more general task training and a higher frequency of training when a worker was hired. The lower EMR firms indicated more training "pre-task." This can speak directly to the skill level of workers at the time they are hired.

Also in relation to training, the lower EMR firms offered more site-specific training at the beginning of the job and pre-task than higher EMR firms. This suggests, with some evidence from the interviews, that lower EMR firms are looking for more project-specific hazards and making sure that the workers are aware of those hazards.

9.4 Safety Policies and Practices

All firms indicated having a safety policy of some type. Lower EMR firms had a more formalized and documented policy. Within the formal safety policy, lower EMR firms had 19% more established policies such as 100% hardhat, safety glass, etc. Higher EMR firms indicated the use of a random drug test policy 20% more than lower EMR group. When developing a formal policy lower EMR firms utilized OSHA resources 37% more than higher EMR firms whereas higher EMR firms utilized insurance company resources at a rate of 17% more than lower EMR firms.

Lower EMR firms more often tracked indirect and direct costs of accidents where higher EMR firms documented information required for reportable incidents and workers' compensation claims only. Understanding the full cost of incidents can help motivate change and ensuring that corrections are made to policy and worker practices.

The use of safety incentives is not highly viewed by most firms. 80% of low EMR firms and 45% of high EMR firms never utilize safety incentives. Additionally, lower EMR firms did not look at safety performance in terms of determining bonuses, salary, and promotion as much as high EMR firms. This may be linked back to the type of employee that is hired since owners of lower EMR firms expressed the need to hire quality and experienced workers who are expected to work safe. The use of incentives by some of

the higher EMR firms may be linked to a reactionary need for improving safety behavior and to change the safety culture within the company.

10 Best Practices for Improving Safety Rating Performance

The most defined metric available to indicate company-level safety is the firm's EMR. Since this study looked at company-level performance and not job-site level of performance, the practices identified are linked to a lower EMR. This may not directly relate to job-site safety performance as subcontractor performance and practices were not examined. However many firms utilized independent contractors and subcontractors in completing aspects of their work.

10.1 Company Structure and Skilled Workers

A very prominent trend throughout the study was the types of workers who did the actual work and the type of worker a company was willing to hire.

10.1.1 Mitigating risk through independent and subcontractors

If a company is looking to improve the company-level safety performance and reduce their EMR, then mitigating the risk by transferring performance of high-risk tasks to a qualified subcontractor or independent subcontractor can help achieve this outcome. From a strategic business aspect if there is a need for lowering the company EMR then removing the risk from the types of work performed can be an effective approach to lower the firm's EMR.

10.1.2 Hiring skilled workers

Related to mitigating the risk associated with certain types of work would be to identify workers that are skilled and have the appropriate experience. With the current labor market and lack of skilled labor this can come at a premium and not all types of companies and jobs remain competitive if a premium is needed for higher skilled labor. Sectors of the market that work on thinner margins and are more competitive based on price over quality would have difficulty in hiring a fully skilled workforce. In this case, more success has been seen when ensuring that supervisors have higher levels of technical skill, communication, and leadership ability. Additionally, the owner's direct involvement in education, training, and skill checking for under skilled workers helps improve safety performance. Owners can also be impactful with under skilled workers by testing their skills before allowing them to complete higher risk tasks to ensure they have the proper training. On-the-job training without the owner involvement and skill checking is not as successful.

10.2 Owner Involvement

Owner involvement in terms of safety activities within the company and on the jobsite have an effect on overall safety performance of a company. Owners and upper level leadership must determine which aspects of the business to delegate to lower level management and other employees. The findings of this study suggest that if an owner was to choose between delegating safety responsibility and some other aspect of the business to someone else that they should highly consider options other than safety. Those owners who are directly responsible for, or heavily involved with, onsite safety have companies that perform better in terms of safety. Methods of direct safety involvement that owners of lower EMR firms exhibited include the following.

10.2.1 Site Visits and Safety Audits

Due to the size of the company and number of projects site visits for the sole purpose of safety is not always economical. However, having safety as one of the priorities of a site visit through a formalized process has value to make sure that smaller things that may not be otherwise noticed are addressed. Formalized processes can be documented in the form of a written and printed checklist of items to check or through a

standard process utilized when visiting the site. Additionally, frequency of visits and presence on site where all workers know that site conditions and safety are a concern of the owner influences the safety performance.

10.2.2 Directly responsible for conducting or coordinating safety meetings on site

A more positive safety culture and better safety performance can be achieved when owners and upper level managing partners are responsible for conducting safety meetings and coordinating safety on site. The presence of the owner on the jobsite with a focus on safety has a favorable impact on the company's safety performance.

10.2.3 Direct involvement in making hiring and personnel decisions

Companies where the owner or top level managing partner are directly involved in recruiting and hiring of personnel at the supervisor and worker level perform better in terms of safety. When the task of recruiting labor is delegated to lower level supervision the overall safety performance of the company is not as high. Companies where the owner is directly involved in personnel decisions also tend to focus more on experience of a worker where companies who delegate the personnel decisions more frequently identify a "fit to company culture" as a primary factor when making a decision to hire someone.

10.3 Structured Safety Practices

Formalized safety practices help to make a habit out of the process. The expectations need to be clearly understood by the workers on the site. These structured practices may include:

10.3.1 Safety Audits

Safety audits are effective to help make sure that the right equipment and tools are available and are being used safely. Safety audits can be handled through the creation of a daily checklist for a site lead to review and make sure the job site is safe.

10.3.2 Safety Procedures and Policies

Safety procedures and policies that are written or consistently emphasized to workers can have a positive impact a company's safety culture. Some examples of procedures may include ensuring the right equipment is available for the task being performed. For example, work performed on a ladder can be restricted or minimized to ensure that lifts or other forms of scaffolding are used. This requires upper management to be willing to pay for the correct equipment to ensure a job is done safely. The upfront cost may be more, however this can be regained with productivity, safety, and quality when utilizing the right equipment. Policies can also be implemented for project specific tie-off and fall protection plans where hazards are analyzed and appropriate practices employed for the job.

10.3.3 Safety Training

Regular safety training is common throughout the industry in form of brief meetings periodically on the jobsite. Where these meetings can have more impact is making sure they are specific to the current hazards or types of work being performed on the jobsite. Additionally, tracking who has attended specific meetings can help if issues arise with worker safety performance and task assignment. Both material for training as well as methods for tracking exist in the forms of developed mobile applications, insurance company support, and OSHA publications.

10.4 Opportunities for Improvement of Safety Culture

Commonly in larger industry sectors the promotion, bonuses, and raises of jobsite supervisors are directly tied to measures of safety on the jobsite. This study showed that this is not happening in the residential carpentry sector of the industry. By tying promotions and bonuses to jobsite safety performance and jobsite safety practices (ex: workers participating in training, use of procedures checklist, etc.) it may help create a more positive safety culture and support better safety performance.

11 Conclusions

This study examined the key drivers related to improving company-level safety performance in small residential carpentry firms. Two objectives were targeted as part of this study. The first was to benchmark the findings of this effort against previous research that was conducted related to safety culture and safety practices of larger construction firms. Due to the difference in resources available and methods for managing different size firms, it is possible that certain policies and programs used by larger firms that have shown an increase improvement in safety performance might not be as affective for smaller firms. Additionally, the intent was to isolate key best practices for the small residential carpentry firms that can be linked to improved safety performance.

An in-depth literature review was performed that isolated twelve key drivers related to improving the safety culture and climate of a company. These key drivers consisted of multiple related factors that were then categorized as either a company-level, project-level, or worker-level factor. The company-level factors were then used as a basis for the next steps of the research. To identify which of these factors had a potential impact a Delphi style methodology was used that consisted of an administered survey with follow up interviews. The survey was used to gather higher level data and the interviews were conducted to clarify details of practices as indicated in the survey.

For purposes of comparative analysis, the EMR was utilized as a quantitative measure of safety performance at the company level. Though this measure may be a lagging indicator and some argue it is not the best indicator of a company's safety for smaller firms, it was the most appropriate quantitative measure available. The responding firms were placed onto two groups: those with an EMR lower than a .91 and those with an EMR higher than a .91. In conducting the comparison, lower EMR firms had noticeable differences in terms of how the owner was involved, the firm's hiring practices, company structure, and the level of development of their safety program.

Owner involvement in terms of hiring, conducting/directly coordinating safety meetings, and conducting safety audits of a jobsite was a differentiator between the two groups. Those firms where the owner delegated these responsibilities did not perform as well in terms of safety. As a firm grows, it is understandable that the owner would likely delegate certain duties, but the firms in both groups were similar in size and volume of work. These findings, however, suggest that the owner may want to be more closely involved in terms of recruiting and hiring new workers, not just site supervisors, conducting safety meetings, and having a noticeable presence on site in terms of performing safety audits.

Additionally, there was a difference in how the firms handled hiring practices and the types of work they would allow their employees to complete. Firms that performed better indicated a higher importance of quality of work and experience of the worker when hiring new employees whereas firms with higher EMRs were willing to train employees and were more focused on a cultural fit. Additionally, there appeared to be a trend with the firms with lower EMRs of using independent contractor workers or subcontractors when they did not have workers with the right skill or had higher risk work to complete. Firms with better safety performance were more likely to mitigate risk by transferring high-risk activities to third party independent contractors.

Lastly, lower EMR firms had more developed safety practices that included items like having site-specific hazard analysis plans, job-specific tie-off plan requirements, use of right tools for the right jobs, and more formalized written documentation.

Where the smaller firms seemed to be lacking in terms of benchmarking to other literature is the use of individual and job-site safety records for determining promotion, job assignment, and raises not only for workers, but especially for site supervision.

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Appendix A

Key Studies

Title	Journal/Book	Year	Author(s)	Research Objective(s)
Construction-Safety Best Practices and Relationships to Safety Performance	Journal of Construction Engineering and Management	2013	Hinze, Baud, & Hallowell	Aims to create a comprehensive list of construction-safety strategies implemented by industry-leading companies.
Factors Influencing Safety Performance on Construction Projects: A Review	Journal of Safety Science	2018	Mohammadi, Tavakolan, & Khosravi	Reviews and extracts the factors influencing safety performance on construction projects.
Developing Leading Indicators to Monitor the Safety Conditions of Construction Projects	Journal of Management in Engineering	2016	Guo & Yiu	Presents a conceptual framework for developing leading indicators for the construction industry.
Factors Affecting Safety Performance on Construction Sites	International Journal of Project Management	1999	Swacha, Naoum, & Fong	Discusses the factors that influence safety on construction sites.
Factors That Influence Safety Performance of Speciality Contractors	Journal of Construction Engineering and Management	2003	Gambatese & Hinze	Describes a study conducted to identify factors that significantly influence the safety performance of specialty contractors.
Interrelationships among Highly Efective Construction Injury Prevention Strategies	Journal of Construction Engineering and Management	2011	Hallowell & Calhoun	Describes the result of a Delphi study that quantifies the interrelationships of highly effective and commonly implemented injury prevention strategies.
Proactive Construction Safety Control: Measuring, Monitoring, and Responding to Safety Leading Indicators	Journal of Construction Engineering and Management	2013	Wehle, Hinze, Baud, & Hallowell	Identifies and defines elements of safety management process that can be measured and monitored during the construction phase.
Safety Program Elements in Construction	Journal of Professional Safety	2004	Findley, Smith, Kress, Petty, & Enoch	Identify safety programs, plans, and process commonly used within the construction industry.
Use of Safety Management Practices for Improving Project Performance	International Journal of Injury Control and Safety Promotion	2015	Cheng, Kelly, & Ryan	Tests the effects of safety management practices on project performance.
Construction Safety Risk Mitigation	Journal of Construction Engineering and Management	2009	Hallowell & Gambatese	Describes the results of a recent study to determine the relative effectiveness of safety program elements by quantifying their individual ability to mitigate construction safety and health risks.
Strategies for Achieving Excellence in Constrution Safety Performance	Journal of Construction Engineering and Management	1996	Russell, Anderson, & Jaselskis	Provides strategies for improving construction safety performance through the analysis of numerical profiles of companies and projects with varying levels of safety performance.

Safety Management in Construction: Best Practices in Hong Kong	Journal of Professional Issues in Engineering Education and Practice	2008	Choudhry, Fang, & Ahmed	Describes an exploratory study of site safety management in construction sites' environment.
Risk-Based Framework for Safety Investment in Construction Organizations	Journal of Construction Engineering and Management	2011	Hallowell	Presents a risk-based framework that can be used to evaluate the incremental return on investment of a series of investments in highly effective injury prevention strategies.
Cost-effectiveness of Construction Safety Programme Elements	Journal of Construction Management and Economics	2010	Hallowell	Quantifies and determines the cost and distribution of safety funding of safety program elements in the construction industry.
Diffusion of Safety Innovations in the Construction Industry	Journal of Construction Engineering and Management	2012	Esmaeili & Hallowell	Determines the adoption and diffusion rate of 12 highly effective safety innovations in the construction industry.
Measuring and Evaluating Safety Maturity of Construction Contractors: Multicriteria Decision-Making Approach	Journal of Construction Engineering and Management	2018	Karakhan, Rajendran, Gambatese, & Nnaji	Presents a decision-making framework that can be used to evaluate the safety maturity of construction contractors.
Exploring the Perceived Influence of Safety Management Practices on Project Performance in the Construction Industry	Journal of Safety Science	2012	Cheng, Ryan, & Kelly	Rates the level of importance of 15 safety management practices and criteria in the construction industry.
Development and Initial Validation of Sustainable Construction Safety and Health Rating System	Journal of Construction Engineering and Management	2009	Rajendran & Gambatese	Presents a study to develop and validate a sustainable construction safety and health rating system for projects based on the importance and implementation of safety and health elements.
Effect of Safety Investments on Safety Performance of Building Projects	Journal of Safety Science	2013	Feng	Investigates the effects of contractors' safety investment on safety performance and identify the factors influencing the effects of safety investments on safety performance.
Identifying Behaviour Patterns of Construction Safety using System Archetypes	Journal of Accident Analysis and Prevention	2015	Guo, Yiu, & González	Aims to better understand dynamic complexity of construction safety management by exploring archetypes of construction safety.
Development of a Safety Communication and Recognition Program for Construction	Journal of Environmental and Occupational Health Policy	2015	Sparer, Herrick, & Dennerlein	Provides a leading-indicator-based safety communication and recognition program to incentivize safe work conditions in construction site.

Safety Incentives: Do They Reduce Injuries?	Practice Periodical on Structural Design and Construction	2002	Hinze	Reports on the result of a study in which information is obtained on incentives.
Exploring the Interactive Effects of Safety Investments, Safety Culture and Project Hazard on Safety Performance: An Empirical Analysis	International Journal of Project Management	2014	Feng, Teo, Ling, & Low	Explores the interactive effects of safety investments, safety culture, and project hazard on construction safety performance.
Factors Influencing Workplace Accident Costs of Building Projects	Journal of Safety Science	2015	Feng, Zhang, & Wu	Investigates the magnitude of workplace accident costs to building contractors and identify factors influencing workplace accidents costs of building projects.
Mathematical Models for Determing the Minimum Level of Voluntary Safety Investments for Building Projects	Journal of Construction Engineering and Management	2015	Feng	Investigates the minimum voluntary safety investment through optimization of total controllable safety costs for building projects.
Toward an Understanding of the Impact of Production Pressure on Safety Performance in Construction Operations	Journal of Accident Analysis and Prevention	2014	Han, Saba, Lee, Mohamed, & Peña-Mora	Examines how production pressure relates to safety performance overtime by identifying the feedback processes.
A Hierarchical Factor Analysis of a Safety Culture Survey	Journal of Safety Research	2013	Frazier, Ludwig, Whitaker, & Roberts	Determine the core factors, as well as the structure of those factors that make up a safety culture.
Developing a Model of Construction Safety Culture	Journal of Management in Engineering	2007	Choudhry, Fang, & Mohamed	Presents a robust conceptual model analyze construction safety culture.
Developing a Safety Climate Factor Model in Construction Research and Practice: A Systematic Review Identifying Future Directions for Research	Journal of Engineering, Construction and Architectural Management	2018	Newaz, Davis, Jefferies, & Pillay	Proposes a five-factor model that can be used to diagnose and measure safety climate in construction safety research and practice.
Development of a Safety Culture Interaction (SCI) Model for Construction Projects	Journal of Safety Science	2013	Fang & Wu	Aims to put forward a distinct definition of construction project safety culture and propose a safety culture interaction model to demonstrate the evolvement of construction project safety culture.
Measuring Safety Climate of a Construction Company	Journal of Construction Engineering and Management	2009	Choudhry, Fang, & Lingard	Determines safety climate that enhance safety culture and positively impact perceived safety performance on construction projects.
Multilevel Safety Culture and Climate Survey for Assessing New Safety Program	Journal of Construction Engineering and Management	2013	Jin & Chen	Presents a study that examined the multilevel safety culture and climate to assess a newly launched safety program.

Overview and Analysis of Safety Climate Studies in the Construction Industry	Construction Research Congress	2016	Rowlinson, Leicht, & Niu	Conducts a systematic review of the studies on both safety climate measurement in the construction industry and theoretical safety culture models.
Scorecard Approach to Benchmarking Organizational Safety Culture in Construction	Journal of Construction Engineering and Management	2003	Mohamed	Promotes adopting the balanced scorecard tool to benchmark organizational safety culture in construction.
Conceptual Model for Developing Reselient Safety Culture in the Construction Environment	Journal of Construction Engineering and Management	2018	Feng, Trinh, & Jin	Discusses the concept of resilient safety culture and its application in the construction environment.
Supervisor-Focused Behavior-Based Safety Method for the Construction Industry: Case Study in Hong Kong	Journal of Construction Engineering and Management	2017	Wu, Li, Zhang, & Fang	The paper aims to examine the impact of supervisor behaviors on safety climate and workers' behavioral performance.
Comparative Analysis of Safety Culture Perceptions among HomeSafe Managers and Workers in Resedential Construction	Journal of Construction Engineering and Management	2012	Bigelow et al.	Investigates the measures of safety culture and risk perception among a residential-homebuilding cohort.
Near Miss Reporting Program to Enhance Construction Worker Safety Performance	Construction Research Congress	2014	Marks, Teizer, & Hinze	Identifies best practices associated with a near-miss reporting program for construction companies.
Relationship between Unsafe Working Conditions and Workers' Behavior and Impact of Working Conditions on Injury Severity in U.S. Construction Industry	Journal of Construction Engineering and Management	2013	Chi, Kim, & Han	Aims to understand the relationships between human behavior related and working condition related risks and identify significant factors that impact accidents and injuries in the construction industry.

Appendix B

Hierarchical Framework of Identified Safety Factors

No #	Category	Theme	Safety Factors
1	Safety Incentive Program	Motivation	Job motivators
			Wage
			Peer Pressure (workmate's influence)
			Worker Safety Motivation
			Job Satisfaction
		Safety Incentives and Rewards	Reward and Penalty
			Incentive Programs
			Written safety incentive program
			Evaluation and recognition/reward
2	Safety Training and Orientation	Safety Experience	Competence
			Worker age
			Safety Experience
			Safety Knowledge (Information)
			Hazard/Safety Awareness
			Skill/Quality of worker
			Subcontractor's and Contractor's Prequalification on Safety
		Safety Education	Training and Education
			Learning
			OSHA Fines and Citations
			Safety orientation and training
		Management Level Training	Site-specific safety orientation for all managers
			Safety-orientation test
			Safety and health committees
			Joint safety committee
		Superintendent/Foremen/Supervisor/Employees/Workers Level Training	Monthly H and S training for supervisors
			Jobsite superintendent participation in new-hire orientation
			Subcontractors participation in GC's orientation and training
			Safety leadership training for foremen
			Site-specific safety orientation for all employees
			10-h OSHA training for employees
			Company-specific orientation for all new hires
		Safety Training Participation and Certification	Ongoing Safety Training on Site
			Vendor-safety orientation
			In-person training and certification
			Employee/Worker Safety Certification
			Project-specific training and safety meetings
			Regular scheduled meetings for safety personnel
		Safety Instruction and Control	Safety Instructions
			Safety Control Mechanisms

			Safety Programs
			Safety Policies and Procedures
			Safety Committees/Meetings/organization/Teams/Managers
			Safety goals development and communication
			Safety-training history for all personnel
			Safety Management Systems
			Risk Assessment Implementation/Thoroughness
			Safety Management Practices and Skills
4	**Financial Aspects and Productivity**	**Safety Investment**	Safety Budget
			Return on Investment (ROI)
		Safety Cost Control	Cost of Accidents
			Cost Control
			Track Injury Costs
		Project-based Financial Aspects	Project Cost
			Bidding/Contract Price
			Project Size
			Project Quality
			Cost-plus instead of lump-sum contract
			Company expenditures
		Productivity	Productivity
			Construction and Design Errors
			Rework
5	**Safety Resource and Equipment, Fulltime Safety Manager On-site, Provision of Safety Equipment**	**Safety Resources**	Safety Personnel
			Resource Constraints
			Full-time safety manager on the project
			Safety instructor for the project
			Off-site Fabrication
			Equipment
		Equipment Inspection/Maintenance	Equipment Assessment
			On-site testing and skill evaluation of mobile equipment for craft workers
			Regular inspection and maintenance of all tools
			Regularly scheduled equipment inspections
		Equipment Inspection Program and Training	Maintenance program for all equipment
			Provision of Safety Equipment
			Heavy-equipment inspection and approval program
			Equipment Training
6	**Work Pressure and Condition**	**Work Pressure Variables**	Production Pressure
			Work Overload
			Fatigue and Burnout
			Working Pace
			Working Time
			Overtime Work
			Schedule Delay
			Fatigue-management program
			Work Environment

		Work Condition and Environment	Exposure to Hazard/Unsafe Work Condition
			Project Hazard Level
			Workplace Health and Safety Conditions of Site-resident Workers
			Changing Work Condition
7	**Safety Culture and Climate**	**Safety Culture**	Safety Culture
			Shared Values
			Managements Safety Concerns
			Organization's Safety Policy
			Mindful Organizing Practice
		Safety Environment	Supervisory Environment
			Supportive Environment
			Providing Safety Environment
			Leadership
		Supervisor's Behavior	Supervisor's Behavior
			Supervisor's Attitude
			Supervisor Effectiveness
			Perceived Safety State
			Safety Effort
			Risk Perception
			Supervisors Safety Behavior
		Worker's Behavior	Worker's Attitude
			Perceived Behavior Control
			Behavior Feedback
			Worker's Behavior
			Risk-taking Mindset/Behavior
			Emotional State
			Employees' Work Behavior
		Worker's Involvement in Safety	Participation for Safety Improvement (Worker's Involvement Cognitive and Emotional Engagement)
			Worker involvement
			Involvement of all members
			Workers involvement in pretask safety planning
			Workers involvement in safety committees
			Workers involvement in accident investigations
			Workers involvement in inspections and audits
			Workers involvement in perception surveys
		Foremen's Involvement in Safety	Safe-behavior reward and recognition
			Foremen involvement in jobsite-safety inspections and audits
			Foremen involvement in lessons learned/ knowledge management

			Foremen evaluation in safety performance
			Foremen involvement in safety committees
			Safety-perception surveys completion by foremen
			Participation of all contractors in safety meetings
		Safety Responsibility	Employee involvement and evaluation
			Personal Responsibility for Safety
			Responsibility/Accountability
			Quality requirements of restroom facilities
			Employees' skills
			Safety Compliance
			Trained Safety Representative on Site
			Safety Program Acceptance
			Peer Support
			Job Safety Audits
		Management Involvement	Upper management support
			Limited Management Time
			Management Commitment
			Management Work Pressure
			Management review of craft-worker training
		Management Involvement	Management Talk on Safety
			Management Focus on Safety
			Management Concern/Involvement
			Past safety performance for foremen selection
			Formal interviews for safety personnel
			Safety during the design phase
			Safety during constructability reviews
			Safety in scheduling
			Safety considered during the design phase
			Safety pre-project planning
			Staffing for safety
			Safety Posters Display
			Background check for every new employee
			Site Logistic and layout Plans
			Communication/Information
		Subcontractor's Safety	Subcontract Management
			Specific safety prequalification
			Pre-hire Screening of Employees
			Subcontractors safety standards compared with GC
			Involvement of Subcontractors
			Subcontractors prequalification on safety

			Subcontractor selection and management
			Subcontractor relationships
			Job Experience
			Safety Background
			Worker-Management Relationship
8	**Accident and Incident Investigation**	**Accidents/Incidents Statistics**	Accident Rate (Frequency and Severity)
			Number of Accidents
			Injury (Death) Rate/Type
			First Aid Rate
			Fitness for duty
			First-aid/medical services
			Track First-aid Cases
			Track Near-hits
			Time-Injury Rate
			Lost Work Time Injury Rate
			Zero Injury Techniques
			Experience Modification Rate
		Accidents/Incidents Inspection	Safety Investigation and Inspection
			Accident Investigation and Inspection
			Incidents Control Pressure
			Near-misses' investigation
			Safety inspection
			Frequent worksite inspections
			Record keeping and accident analysis
		Involvement in Accidents/Incidents Investigation	Lesson Learned
			Willingness to Investigate
			Workers involvement in hazard assessment
			Foremen involvement in accident investigation
			Organization's Reflection in Learning form Incidents/Accidents
			Formal lessons learned/knowledge-management program
			GC's involvement in the investigation of management and subcontractors' injuries
		Accidents/Incidents Prevention Policies	Lock-out tag-out policy
			100% hard-hat policy
			Stop-work policy
			Noise measurement and mitigation policy
			100% reflective vest policy
			100% steel-toed boots policy
			On-site medical facilities
			Work-hour restrictions
			PPE inspection and maintenance policy
			100% safety-glasses policy
			Injury reporting and analysis program
			100% fall protection

			First-aid log
			100% gloves policy
9	**Job-hazard analyses**	**Drug/Substance Abuse**	Unannounced random drug and alcohol program
			Hazard Prevention Practice
			Error Management Practice
			Emergency response planning
			Substance abuse programs
			Hazard prevention
			Drug Testing
			Weekly Inspection of site for Hazards
10	**Safety Plan and Policy**	**Company/Organization Overview**	Company's Revenue
			Company's Reputation
			Company's Costs
			Company Size
			Client's Control
			Number of Subcontractors
			Number of Employees/Crew Size
			Project Delivery Method
		Health and Safety Manual	H and S manual
			Provision Safety Booklets
			Review of H and S manual by owner/CEO
			Owner visibility in safety planning
			Owner review of key contract H and S professionals
			Owner's review and approval of safety plan
			Owner review and approval of construction management and GC's safety plan
			Safety program length/detail
		Safety Programs and Policies	Safety-mentoring program for workers
			Root-cause analysis program
			Quality Control Program
			Established disciplinary program
			Worker-hydration program
			Heat- and cold-stress program
			Leadership-development program
			Early-return-to-work policy
			Project health and wellness reviews
			Worker-to-worker-observation program
			Stretch and flex program for workers
			Alcohol and substance abuse program
			Foremen involvement in policy creation and implementation
			Workers involvement in policy creation and implementation

Appendix C

Survey Questionnaire

Company Information

Company Name: Address**:

Approximate Age of Firm: _____ Years ,

Volume of work last year: $_____ ***please correct any errors*

Approximate average annual company growth over the last 5 years:

Less than 0 *0-5%* *5-10%* *10-20%* *20-30%* *> 30%*

The number of employees under your company payroll (including yourself): _____

Approximate percentage of your workforce in each of the following categories:

Residential: _____% *2 stories or less:* _____% *Interior only:* _____%

Commercial: _____% *3 stories or more:* _____% *Exterior (or both):* _____%

How far does your work typically extend from your home office?

< 20 miles *20-39 miles* *40-74 miles* *75-100 miles* *100+ miles*

Hiring Process

Are any of the following included as part of your hiring process?

	Worker	On-Site Supervisor
Drug test	*yes no*	*yes no*
Experience requirements	*yes no*	*yes no*
Employment verification (I-9, Green Card, etc.)	*yes no*	*yes no*
Background check (criminal record)	*yes no*	*yes no*
Reference checks	*yes no*	*yes no*
Task-specific certification/credentials	*yes no*	*yes no*

Safety training

When, if ever, does your company provide safety training for on-site supervisor(s)?

When hired *Beginning of project* *Periodic (i.e. quarterly)* *Pre-task* *Never*

When does your company provide the following safety training for workers? (check all that apply)

	When hired	*Beginning of project*	*Weekly*	*Monthly*	*Pre-task*	*Never*
PPE training						
Toolbox						
General task						
Site specific						

Who is primarily responsible to provide safety training in your company?

Project Manager *Field Supervisor* *Consultant* *Company owner* *Safety Coordinator*

What percentage of their time is dedicated to safety? _____%

Does your company require any of the following certifications for the following personnel?

	OSHA 10	OSHA 30
Worker	*yes no*	*yes no*
Supervisor	*yes no*	*yes no*
Project Manager	*yes no*	*yes no*

Third Party Support

Do you use any of the following third-party support resources for safety training?

Consultant	Insurance company	Trade organization	OSHA
yes no	*yes no*	*yes no*	*yes no*

How often do you request third-party (i.e. OSHA/Consultant) inspection? (select all that apply)

Beginning of job *Pre-task* *Periodic* *Never*

Safety Incentive Program

Do you offer any of the following safety incentives?

Gift card	On-site celebration (e.g. BBQ lunch, etc.)	Monetary bonuses	Raises	Awards of recognition (certificate, plaque, etc.)
yes no	*yes no*	*yes no*	*yes no*	*yes no*

*Please list any other safety incentives:*_____

How often, if ever, are safety incentives given to the following?

	Never	*Randomly*	*Monthly*	*Quarterly*	*Annually*
Worker					
Field Supervisor					
Project Manager					

Does your company have a formal safety incentive program? *Yes* *No*

If yes, how long have you had your formal safety incentive program? _____ *years*

Safety Culture and Climate

To what extent does a worker's safety performance influence their:

	Does not influence	*Slightly important*	*Moderately important*	*Very important*	*Extremely important*
Salary					
Bonus					
Promotions					
Job assignment					

How important are the following criteria in your selection of subcontractors?

	Does not influence	*Slightly important*	*Moderately important*	*Very important*	*Extremely important*
EMR (Experience Modification Rate)					
Financial Stability					
Bond capacity					
References					
Work Experience					
Other: _____					

Do you have a maximum EMR limit when hiring your subcontractors? *Yes No*

If yes, what is the maximum EMR that you allow? _____

Safety Culture and Climate – Continued

Which of the following job site activities are <u>formal</u> policies for your company? (select all that apply)

- ☐ *100% hard-hat*
- ☐ *100% reflective vest*
- ☐ *100% steel-toed boots*
- ☐ *100% safety-glasses*
- ☐ *100% gloves*
- ☐ *100% fall protection*
- ☐ *Pre-hire drug test*
- ☐ *Random drug test*
- ☐ *Stop-work policy (worker authority to stop unsafe activity)*
- ☐ *First-aid log*

Who initially purchases the following Personal Protection Equipment (PPE) for your employees?

	Company	*Worker*
Hard hat		
Reflective vest		
Steel toed boots		
Safety glasses		
Fall protection (Harnesses)		
Safety gloves		

Accident and Incident Investigation

Which of the following does your company track? (select all that apply)

- ☐ *Reportable accidents*
- ☐ *Days away from work*
- ☐ *Restricted work or job transfer*
- ☐ *Near misses*
- ☐ *Direct costs of accidents*
- ☐ *Indirect cost of accidents*

In your opinion, how important is safety for each of the following?

	Not important	*Slightly important*	*Moderately important*	*Very important*	*Extremely important*
Profitability					
Securing work					
Worker productivity					
Company reputation					
Worker motivation					
Other:					

Respondent Data

Would you like a copy of the summarized results of this survey? *Yes* *No*

Name: _____ *Title:* _____

Phone: _____ *Email:* _____

May we contact you for follow up questions? *Yes* *No*

Appendix D

Interview Script

General Company

- Tell us about your company structure.
    - How many employees, what job titles, what types of crews do you have, are any crews specialized in a type of work (framing vs. finishing), what types of work does your company do, do you subcontract any work?
- Tell us about your employees:
    - What level of involvement do you have in hiring employees? Who does the hiring?
    - What are you looking for when hiring? (experience, work ethic, etc.)
    - Are you normally hiring skilled or unskilled employees?
    - How extensive of a background/reference check do you perform?
    - How long do they work for you on average? One job, permanent, etc.
    - Are your employees paid a salary or hourly? Any benefits?
    - What is the turnover rate of employees?

Management Involvement

- What do you consider as the key drivers for good safety results?
- How do you communicate the importance of safety to your personnel?
- How are you directly involved with safety?
- Do you encourage employees to report unsafe practices to you?
- Have you ever fired someone for unsafe practices?
- How often if ever do you or someone do safety inspection on a job where the main focus is safety?
    - What do you do when you find something?

Safety Program

- Do you have a formalized safety program? (versus adhoc or as needed)
- Tell us about the typical safety training that a new employee/worker would receive.
    - Are you directly involved in the training? To what level? Who conducts the training?
    - Are specific policies covered in the training? PPE use, worker authority to stop work?
- What is your discipline process (repercussions) for unsafe practices?
    - is your discipline process covered when hired?
- What other types of safety training do you employee? (general, pre-task, toolbox talks)
- Do your employees know they have the authority to stop-work in the case of unsafe practices?
    - Do they know they have that authority? Is it covered as part of the training they received when hired?
    - What safety violation/practice do you consider important enough to stop work?
- How important is Pre-task safety training (to what extent, what tasks, how beneficial is it
    - What task is considered high risk and needs pre-task training?
- For the average employee how much time is spent related to safety training? (When hired, weekly/monthly)
- Do you provide safety incentives to workers? What/Who? What benefit do you see from the program? (if not, why?)

Tracking of direct and Indirect costs of injuries

- Can you tell us about your past safety performance?
- In terms of accidents and injuries what types of data do you track?
    - Why - what benefit do you get from tracking?
- If you don't track, why?
    - Would you see a benefit in tracking (direct costs, indirect costs, lost time, restricted work days, etc.)?
- What is your process for investigating an incident (data collection, investigations etc.)?
    - Who do you share the information with?
    - Does the information influence future work, training, job selection, etc?