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Mojtaba Nourihamedani

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PERCEPTIONS OF SAFETY AMONG CONSTRUCTION PROFESSIONALS

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BY THE COMMITTEE CONSISTING OF

Dr. Somik Ghosh, Chair

Dr. Matthew Reyes

Dr. Lori Snyder

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Abstract

The health and safety of construction jobsites in the United States has been a concern for a long time among industry practitioners and researchers. Despite all the efforts, the number of construction workplace fatalities has increased in the last decade. Besides that, companies and contractors suffer greatly because of the financial burden imposed as a result of safety accidents. In order to address the problem, recent studies have turned their attention to the more proactive approaches, such as assessing workers' perceptions of safety climate and safety hazards that have been utilized in various industries and yielded positive outcomes. The present study focused on measuring workers' perceptions of safety on commercial construction projects with regard to three distinct variables of safety climate, safety control, and hazard perception. The link between workplace safety performance, injury rates, and each of the aforementioned indicators has been examined in existing studies. However, limited attempts have been made to explore any possible relationship among those factors. Therefore, filling this gap became the goal of this research study. Additionally, the author sought to investigate whether employment type and previous accidents affect perceptions of safety among construction employees. A quantitative research strategy was adopted for the study. Data was gathered from construction workers (n = 118) from two large healthcare construction projects using survey questionnaires. Separate questionnaires were developed for the managerial workers and field workers in English and Spanish. Those who spend most of their time on the jobsite performing direct tasks of construction were categorized as field workers; those whose prime responsibilities include managerial duties and spend most of their time in the jobsite offices such as project engineers, superintendents, and project managers were categorized as managerial workers. Of 118 respondents who completed the survey, 31 were managerial workers and 87 were field workers. Analysis of the data showed that managerial workers had a significantly higher perception of workers' safety than the field workers regarding all three variables considered in this study: safety climate, safety control, and hazard perception. This disparity of the perception of workers' safety can be critical as managerial workers typically make various project-level decisions including safety policies that affect the field workers. Therefore, safety personnel should focus on minimizing the disparity in perceptions of the two groups and improve safety climate. Besides safety climate, a difference in perceptions of hazards and safety control suggests that field workers need to be involved when designing safety programs. Also, the group of workers who were involved in workplace accidents showed significantly higher hazard perception levels. Finally, the correlational analysis between the variables demonstrated a positive correlation between workers' perceptions of safety control and safety climate. It is expected that the findings of this study provide new insights for future studies seeking to improve the safety performance of the construction industry.

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Chapter 1: Introduction

The construction industry in the U.S. has been suffering from large numbers of workplace accidents for many years. According to the U.S. Bureau of Labor Statistics, among all industry sectors, construction accounted for the highest number of fatalities with 1,008 cases in 2018, compared to manufacturing with 343, transportation and warehousing together with 874 deaths for the same year (BLS, 2019). In fact, the number of fatalities in construction has increased from 738 in the early 2010s to the current figure.

The impact of poor safety performance is not solely summarized in physical harms or human losses. Project delays, legal and financial consequences are serious enough to take down the entire project or even a business. Construction accidents are costly; whether it is a fatality with an average cost of 4 million dollars or a case of nonfatal injury resulting in days away from work that can cost as nearly as 42 thousand dollars (Waehrer et al., 2007). Statistically, there have been improvements in some safety performance indicators such as nonfatal occupational injury and illness incidence rates in recent years as shown in Figure 1 (BLS, 2017). However, the current state of safety in the construction industry is unacceptable, calling upon the construction practitioners and organizations to focus their effort on finding better approaches to address the issue.

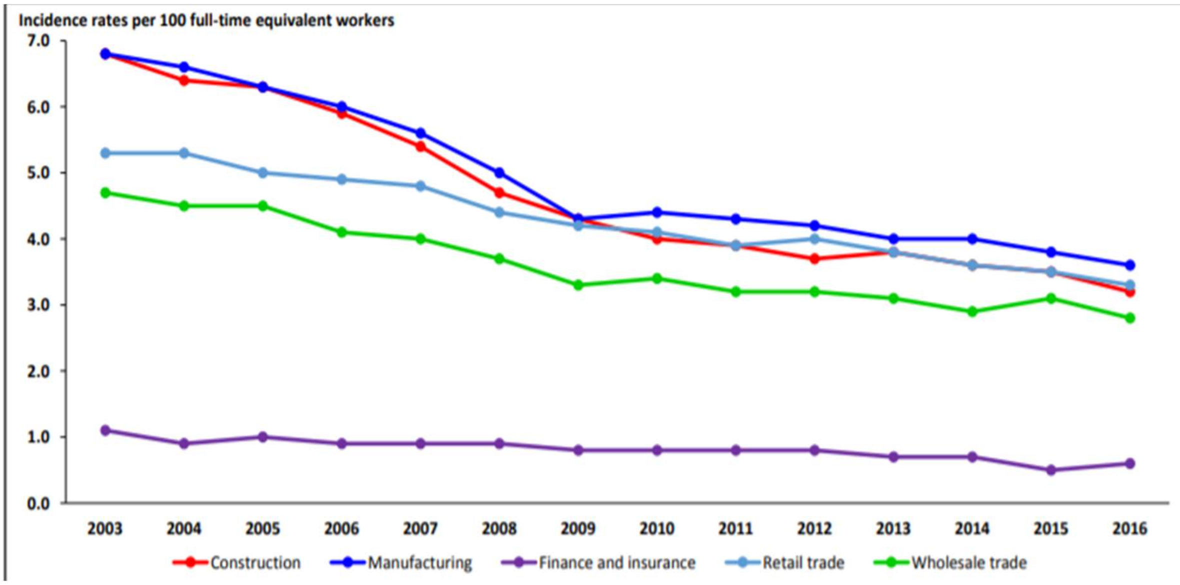

Figure 1. Nonfatal occupational injury and illness incidences rates by selected private sector, 2003-2016 (BLS, 2017)

For many years, historical data, such as fatality rates and lost hours, were the primary source to drive decisions and actions on safety policies and practices (Hinze, Thurman, & Wehle, 2013). This represents a reactive approach since decisions are made based on after-the-fact data, also known as lagging indicators. In this scenario, pitfalls remain unidentified until the system fails. The remedial actions wait for data to be collected after the occurrence of incidents (Flin et al., 2000). The described procedure is reactive since it cannot prevent incidents from happening in the first place. In recent years, safety professionals have turned their attention to proactive methods to measure and improve occupational health and safety. The focus of this strategy is on leading indicators of safety performance such as safety climate and hazard perception of employees (Flin et al., 2000). Several studies including meta-analytic research by Christian et al. (2009), Zohar (2010), and Nahrgang, Morgeson, and Hofmann (2008) demonstrated that safety climate measures can predict workplace injuries in various industry settings, including construction. On the other hand, poor perception of safety risks among workers is considered to be one of the main reasons for workplace accidents. Evidence indicates that improving hazard recognition and risk perception can lead to safer work behaviors and, ultimately, lower injury rates (Fang, Zhao, & Zhang, 2016).

Gaps in Current Literature

The gaps found in the current body of knowledge can be divided into three areas:

A) In the context of safety research, very limited studies have examined the role of safety control in regard to safety performance. According to Huang et al. (2006) the correlation between safety performance and safety climate is mediated by safety control. However, this has not been deeply investigated in the field of construction. This study is one of the few attempts to investigate the correlation between safety control with self-reported injuries/near-miss in the construction workplace.

B) Three variables of (1) safety climate, (2) hazard perception, and (3) safety control were found to play a critical role with regard to the improvement of safety performance and to reduce injury rates .(Huang et al., 2006; Namian et al., 2016; Schwatka, Hecker, & Goldenhar 2016). However, limited studies attempted to reveal the underlying relationship between these three measures not only in the construction literature, but also in other industry sectors.

C) Some researchers, such as Gittleman et al. (2010), conducted between-group comparisons to define whether there is a significant difference in workers' perception of safety climate with respect to their employment type. This multi-level analysis helped them to address the issues related to the safety of the workplace. However, to the best of the author's knowledge, limited attempts have been made to compare employees' perceptions of safety control and hazard across different groups of construction workers.

Research Objectives

The goal of this research study is to investigate whether previous experience with the occupational incident and employment type affect safety perceptions among construction professionals. Also, the author wanted to examine whether there is any association between leading indicators of safety performance. Specific objectives of this research are as follows:

Objective # 1: Investigate if the field workers and managerial workers have different safety perceptions

Objective # 2: Explore the association of previous accident/near-miss experiences on safety perceptions of construction workers.

Objective # 3: Explore the association of safety climate with other safety performance indicators, namely perception of safety control and hazard perception.

Significance of the Study

Construction projects involve a wide variety of professionals ranging from the designers or engineers who prepare the design of the projects, to project managers who plan and control the projects, to field workers who execute the construction of the facilities. Each of these individuals who perform important functions in the overall lifecycle of the projects has varying perceptions of safety risks involved with the construction tasks. The purpose of this study was to capture and compare the differences in the attitudes towards safety between the different groups of construction professionals.

Traditionally, upper-level managers such as the project managers, superintendents, and safety directors have the most inputs while designing the safety procedures and preparing the safety manuals for the construction projects. However, the foremen and field workers who are involved with the safety hazards the most, have minimal inputs in the process. Due to their first-hand involvement with the construction tasks, it is assumed that their perceptions of risks will be more grounded in comparison to the other groups of construction professionals. The results of the research study provided a comparative analysis of the perceptions of safety between different groups of professionals. This may influence the roles of these different groups to plan and prepare the safety procedures of construction projects in the future. In addition, revealing the relationship between safety performance predictors, including safety climate, hazard perception, and safety control, can help practitioners in finding a more effective solution to reduce workplace accidents.

Delimitation

In order to define the scope of work, the author decided to delimit this study to large commercial construction in the region where the investigation was occurring. It is also worth noting that although data were gathered from two separate jobsites, a comparison of safety climate and other safety indicators between these two different jobsites was excluded from the study scope.

A discussion on the current state of safety in the U.S construction industry revealed that occupational health and safety of construction projects had been a primary concern for many years. The negative aftermaths of workplace accidents have urged researchers and practitioners to find a sustainable solution for this issue. A brief review of the current body of knowledge showed that several measures, such as safety climate assessment tools, have been successfully utilized in various industry sectors to mitigate safety accidents. By further investigation of construction literature, several research gaps were found and lead the author to formulate the research objectives that could explain the significance of the present study.

Chapter 2: Literature Review

Introduction

This chapter provides background information relevant to this research study. Scholarly journal articles, industry publications, industry standard organizations (e.g., CPWR and OSHA), and government documents were the primary sources of information that the author used to gain knowledge about occupational health and safety of workplaces in construction. Keywords such as "Safety Climate," "Hazard Perception," "Safety Indicators," etc. were utilized to search through available databases to assess the current body of knowledge on this topic. A comprehensive review of the existing literature helped to identify the gaps. By finding research gaps, the research questions were formulated. Similar studies about safety climate and other safety-related concepts were studied as a guideline in the next steps when developing the research design and methodology. Ultimately, the research findings were tied to several previous works by other researchers.

Current body of knowledge

Safety Climate

Occupational safety has been a major concern across all industries and efforts to improve safety have been undergoing for long. There have been two approaches to deal with occupational safety. The reactive approach relies on lagging indicators such as historical data of accidents to measure the safety of the workplace. Whereas, in the proactive approach, leading indicators are used to predict future incidents. Safety climate is a leading indicator that is measured and studied to prevent accidents (Choudhry, Fang, & Lingard, 2009). It was first introduced by Zohar (1980) to measure workers' perceptions of various aspects of work safety in manufacturing industries.

Since then, this measurement tool has been used across many industries to forecast safety performance. Although there is not a unified definition of safety climate in the literature, it is commonly defined as an employee's perception of overall safety within the workplace (Schwatka et al., 2016). It is affected by safety policies and procedures as well as employees' attitudes towards the actual priorities (Gilkey et al., 2012). This is critical, especially when company goals are in conflict. For example, employees decide whether they bypass safety procedures to meet deadlines, or they choose to work safely and suffer penalties by missing project goals.

Another closely related term to safety climate is safety culture. These two terms are often used interchangeably in the literature, but there are some differences. While safety climate pertains to the actual state of safety in an organization at any given point in time (Huang et al., 2006; Cheyne et al.,1998), safety culture is more focused on the organization's values and ideals with respect to safety (Guldenmund, 2000). It is formed by the managers and decision-makers who design safety policies and procedures. Interactions between employers and employees influence safety culture and safety climate with respect to the varying perception among different job levels (Zohar & Luria, 2005). Zohar (2010) conducted a meta-analytic study based on more than 200 published studies about the assessment of safety climate in various work disciplines. The results of his investigation showed that a correlation between safety climate and injury rates exists. The higher the safety climate score, the better safety outcomes and lower injury and illness rates are likely to be.

Safety Climate in Construction

As mentioned earlier, the concept of safety climate was first introduced about four decades ago by Zohar (1980) in the manufacturing workplace. Since then, safety practitioners from various disciplines around the world started to utilize safety climate surveys to assess the state of their workplace safety. Construction was no exception in this trend. Schwatka et al. (2016) conducted a review of the existing literature with regards to the safety climate in the construction industry and identified 56 articles, of which 80 percent were published after 2008. This implies two facts. First, it demonstrates how research about safety climate has gained attention among safety professionals in construction over the recent years. On the other hand, it leaves space for more work to be done by researchers as this concept was adopted in the construction sector relatively later than the other industries.

In response to what has been done so far, two fairly common themes can be observed among the studies. One approach pertains to the comparative analysis of safety climate perceptions between different groups of construction employees with respect to factors such as union/non-union, ethnicity, trade, job levels, etc. For instance, Gittleman et al. (2010) and Gilkey et al. (2012) compared safety climate scores between workers and managers of residential and commercial projects. Both studies found that managers perceived safety climate significantly more positive compared with workers. Yet, according to Schwatka et al. (2016), only a handful of comparison studies have addressed the job-level differences. Another observed approach in the studies corresponds to the examination of safety climate with other safety-related variables. Fang, Chen, and Wong (2006) conducted a case study on a major commercial construction firm in Hong Kong to explore the relationship between safety climate and workers' personal characteristics and behavior. By analyzing the data and using logistic regression, an existing correlation between safety climate and employees' characteristics was confirmed. Based on the review done by Schwatka et al. (2016), self-reported injury and behavior are the two more commonly investigated variables. However, the relationship between safety climate and other variables requires further research as these investigations can lead to a more advanced safety climate theory (Zohar, 2010)

Construction-Specific Issues

As mentioned earlier, the safety climate concept has been used widely in various sectors, including manufacturing industries. Some unique aspects make construction job sites distinct from manufacturing sites (Schwatka et al., 2016). For instance, construction job sites have a dynamic nature compared to fixed production plants. During a project from beginning to the end, various groups of workers come and go, and they have less time to develop a shared perception of safety climate. This is especially important because, according to Beus, Bergman, and Payne (2010), job tenure has a significant positive correlation with safety climate. The employees who have an opportunity to share their perceptions with coworkers have a more positive attitude towards their workplace safety climate.

On the other hand, subcontracting is another factor that is specific to construction sites and can create some problems. On construction job sites, multiple contractors work together under the supervision of the general contractor, and each of them has their own safety culture, policies, and procedures. According to Lingard, Cooke, and Blismas (2010), foremen play an essential role since the communication between a general contractor and workers occurs through them. Managing occupational health and safety under the subcontract setting is challenging (Ardditi & Chotibhong, 2005). According to Fang et al. (2006), employees of subcontractors usually have a poorer perception of safety climate compared to the employees employed by general contractors. Subcontracting can create problems by reducing levels of worker commitment and control on jobsites. Lingard et al. (2010) suggest that when researchers study safety climate, they should distinguish perceptions with respect to the duties of both the general contractor and the subcontractors.

Instrument to Measure Safety Climate

In order to evaluate the safety climate in the construction industry, several survey instruments have been developed that mostly rely on self-reported data. A content analysis on 15 such survey instruments showed common themes among the instruments (Ghosh, Young-Corbett, & Fiori, 2010). These common themes include but are not limited to role of management and safety rules/procedure as main factors that have repeatedly appeared in safety climate measures along with communication, worker involvement, and work environment (Ghosh et al., 2010). Another study introduced management commitment to safety and workers involvement as the two most important components in measuring safety climate (Dedobbeleer & Béland, 1991). They also identified elements that affected employees' risk perception. Prior experience with injury accounted for the highest impact, followed by control and risk (Dedobbeleer & Béland, 1991).

Further efforts were made to evaluate safety climate by conducting comparison analysis between different job levels in the construction industry. A study conducted by Chen et al. (2013) to evaluate and compare Taiwanese construction managers' perception of safety developed an instrument by reviewing articles to identify the most important variables that influence safety perception. Their instrument was based on six aspects: human error, safety resource and application, safety equipment and training, site culture and external factors, safety inspection and audit, and accident medium and activities. A Likert scale survey questionnaire was distributed among 360 construction management roles, including safety managers, contractor managers, design and audit managers, public work managers, and others. Comparison analysis was done on the responses. The results showed the safety managers perceived safety climate more positively compared to the other groups (Chen et al., 2013).

Gilkey et al. (2012) investigated safety culture and risk perception of 67 residential worksites that participated in a safety pilot program in the Denver metro area. Data was collected from single-family residential construction projects. The analysis based on the group responses of two job levels indicated that managers scored higher than frontline laborers in terms of safety culture. As mentioned earlier, the focus of this paper is commercial construction. One of the aspects that makes the commercial sector different from residential construction pertains to the composition of workers. Residential construction suffers from higher injury rates by operation of many small nonunion contractors, whereas commercial and heavy civil sectors are mostly unionized throughout the US (Gilkey et al., 2012). Gillen et al. (2002) state that nonunion construction laborers hold a poorer safety climate score compared to union workers.

A comprehensive case study on the largest commercial development project in US history until the time of the study represented similar results (Gittleman et al., 2010). In response to the safety concerns following eight fatal accidents on the project, the investigators developed four different versions of survey questionnaires to measure safety climate between four groups with different job levels including, management executives, site superintendents, foremen, and craft workers. The survey consisted of Likert type scale questions as well as open-ended questions to create an opportunity for workers to express their opinions, concerns, and proposed solutions regarding safety issues on the job sites to the upper-level management team. A large number of responses were collected from workers (n=5,268), foremen (n=134), superintendents (n=61), and executives (n= 17), The survey was available in both English and Spanish. However, only 11 % of workers completed the Spanish version, whereas all other groups answered to the English version. Safety climate measures were based on management commitment to safety and safety practices responses as they were found to be the most frequently studied indicators of safety climate. Results of statistical analysis showed that differences in safety climate scores between different group-responses existed. For management commitment to safety, the difference was significant, particularly between workers and the other three groups consisting of senior managers, superintendents, and foremen. On the other safety climate indicator, namely perception of safety practices, the mean differences were significant between workers and two groups of foremen and superintendents. Although managers scored higher compared to workers on this indicator, the difference was not statistically significant. The content analysis on the responses from the open-ended section was helpful in proposing action plans for improvement of safety conditions on the job site by modifying the safety process that required minimal investment of resources and time (Gittleman et al., 2010). The authors concluded that "gauging differences in perception about site safety can provide critical feedback at all levels of a construction organization." Further investigation by Geller (2001) reveals that because construction workers engage in risky environments on a daily basis, their perception of risks will decrease as they get used to the hazards. As a result, they start to bypass the usual precautions to achieve short-term benefits such as getting the job done quickly. There are also some study efforts to compare the different ethnic groups such as Hispanic versus non-Hispanic workers to examine whether their perceptions about safety climate are different (Cigularov et al., 2013; Gilkey et al., 2013).

Other Safety-Related variables

Safety Control

One of the safety-related variables that has been discussed in the literature relates to employee safety control. It is defined as an individual's perception of his/her own capability to take measures to prevent or minimize safety risks or change an unsafe circumstance (Anderson et al., 2004). Similar to safety climate, employee safety control is a perception-based concept, but in fact, it is distinct from other similar safety variables such as safety understanding or safety performance (Snyder et al., 2011).

Researchers have sought to explore and establish the relationship between safety control and other safety indicators. For instance, Snyder et al. (2011) proposed a model in which safety understanding would impact safety performance through safety control. In response to whether safety control is correlated with workplace injury incidence, Huang et al. (2006) conducted a survey on a large number of workers from various industry sectors, including construction, manufacturing, service, and transportation. The overarching goal of their investigation was to identify the process through which safety climate can predict safety outcomes such as self-reported occupational injury. The results of this cross-sectional study showed two things. First, employee safety control was negatively correlated with injury rates, meaning that higher safety control relates to lower injury incidence. This particular finding is aligned with the theoretical models noting employee safety control as a predictor of safety outcomes, such as self-reported injuries. Albert, Hallowell, and Kleiner (2014) explain that employees who fail to perceive hazards accurately may not be able to make effective decisions to avoid safety accidents. Similarly, Namian et al. (2016) proposed a conceptual model that describes the role of safety control in preventing injuries with respect to hazard perception.

The second finding of the study by Huang et al. (2006) showed that safety control mediates the correlation between safety climate and workplace injury. This research was one of the very few attempts to examine a relationship between employee safety control and safety climate. In fact, it seems future studies should further investigate this association using other samples of workers (e.g., construction workers) as the potential findings may provide safety professionals with useful implications for improving workplace safety.

Safety Risk Perception

Efforts have been made by occupational health researchers to find out the root causes of the accidents taking place in the working environment. Among the factors that could lead to occupational accidents, human errors and unsafe behaviors were found to be the major causes for most of the accidents (Haslam et al., 2005; Rasmussen, 1977). Further analysis by Fang, Zhao, and Zhang (2016) on construction workers led to the introduction of a cognitive model in which inaccurate perception of safety and hazard recognition are linked to unsafe behaviors. This is conformable with the findings of the studies conducted by Tixier et al. (2014), and Carter and Smith (2006), that risk-taking behaviors have a positive correlation with inaccurate safety perception. According to Shin et al. (2014), underestimation of safety risks is very common among construction workers. Part of this underestimation can be attributed to the fact that many hazards are still unidentifiable for frontline workers. Even experienced workers who are able to identify safety risks may underestimate hazards (Perlman, Sacks, & Barak, 2014). In fact, when workers do not face negative consequences when they engage in risky activities on a regular basis, they become less sensitive to those risks, and over time their safety perception would gradually decrease (Geller, 2001). In contrast, workers who had previous experience with injury showed a better perception of safety hazards (Shin et al., 2014). Not only poor safety perception can lead to unsafe behaviors, but it may also prevent workers from abiding by safety policies and decisions, which is troublesome in terms of implementing safety practices (Zhang et al., 2014).

As indicated in the literature, the worker's ability to recognize and accurately perceive safety risks relevant to their daily tasks are extremely important. According to Arezes and Miguel (2008), occupational accidents can be effectively avoided by recognizing safety hazards. On the other hand, accurate perception of safety risks plays a vital role in effective safety programs (Hallowell, 2010).

In summary and based on the current body of knowledge that exists in safety literature, safety climate, hazard perception, and safety control are considered leading indicators of safety performance. All these factors are based on the perception of employees. Researchers have used theoretical models to develop survey instruments that can measure workers' attitudes about workplace safety with respect to several indicators such as management commitment to safety, safety policies, practices, etc. Multi-level group comparisons are utilized widely to reveal issues related to the safety of the workplace. Most of the comparisons are based on the worker's job position. The review of the current construction literature revealed very limited efforts that attempted to explore the association between the three discussed variables in this study. To the author's view, this was a gap in the body of knowledge that calls for more attention.

Research Questions and Hypotheses:

Based on the research goal and objectives outlined in the first chapter, the following research questions and hypotheses were formed:

Research Question # 1: Does safety perception of the field workers differ from managerial workers?

Hypothesis 1: There is a difference in the mean "safety climate" scores between different groups of construction professionals (field workers versus managerial workers). Field workers will report a lower safety climate score compared to the managerial workers.

Hypothesis 2: There is no significant difference in the mean scores of workers' perception of hazards between the two groups.

Hypothesis 3: There is no difference in the mean scores of "workers' perception of safety control" between the two groups.

Research Question # 2: Does prior experience with workplace incidents have any correlation with safety perceptions of construction workers?

Hypothesis 4: There is a negative correlation between the safety climate score and workers' most recent experience with accidents/near-miss. Those workers who experienced accidents or near-miss incidents will demonstrate a lower safety climate score.

Hypothesis 5: There is a positive correlation between "experience with accidents/near-miss" and "perception of fatal four hazards." Those workers who have been involved in safety-related incidents will have a higher mean score for the perception of the fatal four fatal hazards.

Hypothesis 6: There is a negative correlation between "experience with accidents/near miss" and the perception of "safety control." Those workers that have been involved in safety-related incidents will report higher mean scores of safety control perception.

Research Question # 3: Is there any correlation between safety climate and other leading indicators of safety performance, namely, hazard perception and safety control?

Hypothesis 7: There is a positive correlation between safety climate scores and "perception of four fatal hazards."

Hypothesis 8: There is a positive correlation between perceptions of "safety climate" and "safety control."

Chapter 3: Methodology

Introduction

Based on the outlined research questions in Chapter 1 of this document, the focus of this study was to explore the relationships between three perception-based variables and to examine whether employment type or prior experience with workplace incidents can predict those measures. It is worth mentioning that the research questions were the primary determinant of what methodology and research design could appropriately direct this study. In this regard, a quantitative approach was selected to allow the investigator to measure workers' perception of safety using survey research design. Survey research is appropriate to collect quantitative data to draw significant conclusions on opinions or attitudes of a population by studying a sample of the population (Creswell, 2009). The purpose of utilizing a survey questionnaire was to collect data from a sample set of construction professionals. Subsequent hypothesis testing was performed by conducting inferential statistical analysis on the collected data with the intent to generalize the results to a larger population. This research approach was expected to help the author in finding answers to the research questions of this study.

The following sections provide details pertaining to the procedures used for participant selection, development of survey instrument, data collection process, and analysis procedures.

Participant Recruitment

The primary objective of the research study was to explore the perception of safety among construction workers working on commercial projects in the US. This represents a large pool of individuals as the population for any study. To avoid the common issues that could result from sampling procedures such as regional bias and company size bias, it was decided that the population should be limited to a particular project type and geographical region. Additionally, the author looked for samples from a population that would be considered harmonious in terms of project size.

With respect to the constraints, two ongoing healthcare projects in the Oklahoma City Metropolitan area were selected. Using the personal industry contacts that the researchers had, the management teams of the two projects were asked to participate in the research study, and they both agreed. At the time of data collection, the COVID-19 global pandemic affected the region, and one of the projects refused to provide access to the jobsite due to health concerns. As a result, another healthcare project management team was contacted through contacts held by the author. The alternative project located in the Colorado Springs Metro area agreed to participate in the study.

Convenience sampling strategy was used to collect data from construction professionals (n = 118) working on the two projects mentioned above. It should be acknowledged that the relatively small sample size for the research study was not sufficient to generalize the findings of this study to the population of the commercial projects located in the Southwestern US. Rather, this attempt should be viewed as a case study that can be added to the larger pool of studies about safety climate and relevant concepts in the literature.

To answer the research questions and hypotheses formed earlier in the study, a research design was required that could gauge workers' perception of safety. As mentioned earlier, a quantitative method was chosen in this respect. In fact, this work falls in the field of safety climate and related theories in which the author sought to examine its relationship with other variables. A review of the literature by the author confirmed that a quantitative methodology is a common approach to evaluate employees' perceptions about safety-related issues. In this regard, Denison (1996) explains why a quantitative approach is more favorable compared to a qualitative method. According to Schwatka et al. (2016), some researchers have developed a new safety climate survey; however, the majority of studies used pre-developed instruments and modify them with respect to the specific characteristics of construction jobsites. Several studies have discussed the theoretical background of the safety climate indicators in detail (Zohar, 2000; Dedobbeleer & Beland 1991; Mohamed, 2002). For this study, the items to measure safety climate were based on existing surveys that have been previously validated.

Developing survey

The framework of the survey used in this study corresponds to the variables the author intended to investigate. As shown in Figure 2, the survey questionnaire was comprised of three main parts. Part A included questions about general demographic information, such as age, education, trade, etc. Part B consisted of three self-reported questions about direct and indirect experience with recent workplace incidents (six months before the study). It was expected that the number of injury cases would not be sufficient to accommodate the analysis later on. Therefore, other types of workplace incidents such as near-miss and indirect experiences (witnessing of workplace incidents to a colleague) were included in the survey. Each of the three questions was followed up by a multiple-choice item to discover the causes of the incidents.

Part C contained 28 Likert type scale statements that evaluate three variables: “perception of specific fatal hazards,” “safety control perception,” and “safety climate.” As mentioned earlier, although these variables are distinct, they are similar in the sense that they relate to employee’s perceptions.

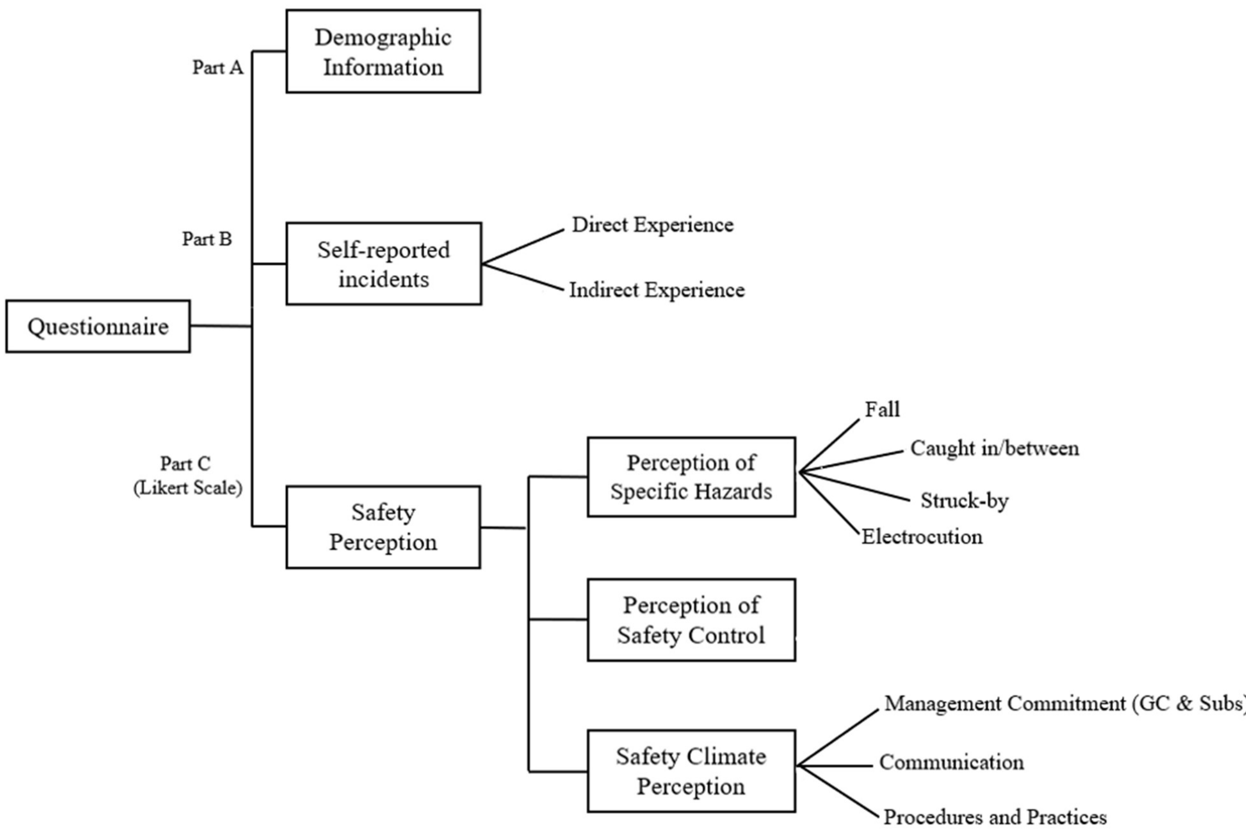

Figure 2. Overview of survey instrument

Instrument

A survey was used to collect data from construction workers. Items pertaining to the three variables were measured using a Likert type scale of 1 through 5, with score 1 (strongly disagree) corresponding to lowest perception and score 5 (strongly agree) representing the highest perception. Two versions of questions were prepared with minimal differences in format to allow comparison between two groups; (1) Field workers: those who spend most of their time on the jobsite performing direct tasks of construction (examples include general laborers, journeymen, foremen, etc.) and (2) Managerial workers: those whose prime responsibilities include managerial duties such as project engineers, superintendents, and project managers who spend most of their time in the jobsite offices. In addition to paper copy surveys, an online platform (Qualtrics survey) was arranged so that respondents could easily use their phone/computer to complete the online survey by either scanning a QR code or clicking on a weblink.

There was a total of 40 questions in each version: nine questions about demographic information, three multi-part questions relevant to self-reported incidents, and 28 Likert type scale questions to measure safety perceptions. All versions of the instrument can be found in Appendix A.

Variables

Perception of Specific Hazards

The Occupational Safety and Health Administration (OSHA) has identified the top leading causes of construction fatal incidents as: Falls, Struck-By, Caught-In/Between and Electrocutions. These hazards are referred to as the 'fatal four' and are the focus of safety training programs promoted by OSHA (2011). As mentioned in chapter one, the number of construction workplace fatalities has increased in the last decade (BLS, 2019). That's the reason the author focused on these specific hazards for this study. Table 1 presents four statements that weighed perceptions about OSHA fatal four hazards. As can be seen in the table, a field worker answered to these items about him/herself, while for managerial workers, the questions referred to field workers. The score of this variable will be calculated by adding up individual scores of all items. Ideally, a higher perception of these risks was more favorable, and any gaps between perceptions of the two worker groups need to be addressed.

Table 1. Likert scale statements measuring perception of the specific hazards

*On this project, there is a high likelihood that I will be injured or harmed due to a fall from height, slip, or trip **if I don't follow safety procedures***
*On this project, there is a high likelihood that I will be injured or harmed due to cave-ins, by unguarded machinery, or caught in between equipment **if I don't follow safety procedures***
*On this project, there is a high likelihood that I will be injured or harmed due to falling/flying objects or struck by vehicles/equipment **if I don't follow safety procedures***
*On this project, there is a high likelihood that I will be injured or harmed due to electrocution **if I don't follow safety procedures***

Safety Control

Table 2 presents seven questions that assessed safety control perceptions of construction workers. These items were in the instrument developed and used in the study by Snyder et al. (2011). Like the previous variable, for managerial group statements referred to field workers whereas field workers answered the questions about self.

Table 2. Likert scale statements measuring perception of safety control

I am able to change unsafe practices at work
I am able to modify work conditions in order to make them safer
I am capable of taking action to prevent injuries or accidents to myself at work
I am able to change the unsafe behavior of others at work
I have control over whether I use safety equipment (e.g., hard hat, safety goggle, etc.)
I have control over whether or not to engage in safe work behaviors
I am able to report safety hazards that I see

Safety Climate

This variable includes 17 items with respect to three common indicators of safety climate: “management commitment,” “communication,” and “safety procedures and practices.” Statements corresponding to each construct can be seen in Table 3. This questionnaire is a modified version of the instrument used in the study by Gittleman et al. (2010). Unlike the two previous parts, items were completely identical for both groups. The safety climate scale was calculated by adding all individual item scores.

Table 3. Likert scale statements measuring perception of safety climate

Safety climate Indicators	
Management Commitment (GC)	*The management of this project is concerned for the safety of employees*
	The management of this project believes safety is more important than schedule and deadlines
	The management team follows up when there is a problem or concern about safety
	The management of this project works well with other subcontractors to ensure the safest possible working conditions on this jobsite
Management Commitment (Subcontractors)	*Safety is important to my company, even when the job runs behind schedule*
	Employees from various companies work well together to address safety concerns on this project
	Foremen make sure that workers follow site safety rules and procedures very closely
	Foremen think safety is more important than productivity
Communication	*Workers are able to discuss their concerns about safety with the foremen*
	Employees are regularly consulted about workplace health and safety issues
	There is open communication about safety issues in this workplace
Safety Procedures and Practices	*Toolbox talks about safety are given regularly and they are effective.*
	Safety issues are given a high priority in training programs.
	Workplace health and safety training covers the types of situations that employees encounter in their jobs.
	Employees receive enough training in workplace health & safety issues
	Safety procedures and practices are sufficient to prevent incidents occurring.
	The safety procedures and practices in this project are useful and effective.

Internal Validity and Consistency

Several measures were taken into consideration to ensure the internal validity and consistency of the study. Lengthy questionnaires can be harmful to the reliability of any instrument. The author limited the number of questions to 40 items, and they were contained within two sides of one sheet to encourage higher participation and timely completion by respondents. Since a considerable portion of construction workers are Hispanic, a Spanish version of the questionnaire was prepared. This enabled the researcher to capture the opinions of majority of workers with various backgrounds. A Spanish translator was hired, and the translation was reviewed by a bilingual faculty member at the University of Oklahoma to verify the accuracy with respect to the special terms in the construction industry.

Furthermore, workers were made aware that their responses would remain confidential and anonymous. This was especially important for vulnerable groups so that they were not concerned about any retaliation while answering questions truthfully, and no one could misuse their responses to punish them. The draft version of the questionnaire was shared with a few faculty members at the University of Oklahoma as well as some industry professionals from the participating jobsites to correct any ambiguity in wording and to incorporate their input into the work. After review of the comments, several changes were made to the format and wording of the questions. Lastly, Cronbach's alpha was calculated to test the internal consistency of the scores of the three main domains, including "Safety Control," "Safety Climate" and "Specific Hazard Perception." The results of Cronbach's alpha test are reported in Chapter 4.

Data Collection Procedure

Data was gathered from two large healthcare projects over a course of four months during the first half of the year 2020. The participating projects were located in Oklahoma and Colorado. The author initiated contacts with the project-level management teams on the intended jobsites to obtain their permission for the purpose of data collection on their ongoing projects. To encourage the decision-makers to take part in this study, the author explained the objectives of the research and how the industry could benefit from the possible findings. Additionally, it was essential to ensure them there was no harm to the research participants as confidentiality is a major source of concern for large organizations. In this matter and prior to collecting data, the study, along with the survey questionnaire and the proposed data collection procedure were approved by the Institutional Review Board (IRB) at the University of Oklahoma – Norman Campus.

During multiple jobsite visits, the author asked the potential respondents whether they would spend most of their time in the field or in the jobsite office (Managerial) to decide which version of surveys needed to be handed out. Both groups were given the option to take either an online survey or a paper copy questionnaire. Additionally, Spanish surveys were available for Spanish speaking field workers, and a bilingual companion helped the researcher in this regard. The time needed to answer the questions was approximately 10 minutes. This process took place during work breaks to avoid interference with workers' tasks. All responses were anonymous, and the researchers did not disclose the individual responses with the employers.

Data Analysis Procedures

Once data collection was done, the individual responses were compiled and sorted in Microsoft Excel. Excel and RStudio were used to process the data. Preliminary descriptive statistics was performed for demographic analysis and to report means and standard deviation of all questions. Before running the hypothesis tests using inferential statistics, analysis of Cronbach's alpha was performed to ensure the internal consistency of Likert scale items pertaining to three distinct variables of "safety climate," "hazard perception," and "perception of safety control." Inferential statistics were used to test three hypotheses seeking to discover any differences in perception of safety between field workers and managerial workers. The relationships between the three intended variables were examined with correlation tests. In addition, the author investigated whether prior experience with work incidents could predict those variables. Analysis of the data and the test results will be discussed in more detail in Chapter 4.

In summary, this chapter discusses the cross-sectional methodology that was utilized by the author to conduct the study in connection with the research question developed earlier. Using a convenience sampling strategy, participants were selected from the two healthcare projects that were harmonious in project size. In order to measure workers' perception of safety, the author adapted existing survey instruments found in other similar studies. The survey contained Likert type scale items pertaining to the three intended variables of safety climate, safety control, and hazard perception. According to the participants that were divided into two groups of managerial workers and field workers, two versions of the survey were prepared. The researchers took several measures to ensure the internal consistency of survey instruments. Data was gathered using paper questionnaires and an online platform to increase the response rate. Computer software was used to store and process the data. By conducting descriptive and inferential analyses, the researcher tested the hypotheses. The next chapter will report the findings and analysis in detail.

Chapter 4: Analysis

Introduction

The analysis of the data was broken down into five main parts, and the results are presented in the following order: (1) report on the demographics of the participants, (2) analysis of Cronbach's Alpha, (3) between-group comparison of safety perceptions across workers with different employment types, (4) study of the possible correlation between workers' safety perceptions and previous incident/accident experience, and (5) correlation analysis of the three variables of safety perception. The statistical analysis of quantitative data was employed in order to test the pre-developed hypotheses. In each part, a summary of the results is presented objectively to minimize misinterpretation of the data when discussing the findings and drawing conclusions later in Chapter 5.

Participants and Demographics

Respondents were selected from two participating healthcare projects. As mentioned earlier, one in the Oklahoma City metro area (hereinafter referred to as Jobsite 1), and the other one was located in the Colorado Springs metro area (hereinafter referred to as Jobsite 2). Separate versions of survey questionnaires were distributed to two groups of construction professionals working on the aforementioned projects: managerial workers ($n = 31$) and field workers ($n = 87$). A summary of demographic information about participants is provided in Tables 4 and 5 below. Of the total 118 participants, 56% were from Jobsite 1 ($n = 66$), whereas 44% were from Jobsite 2 ($n = 52$). The majority ($n = 105$, 89%) of respondents completed paper questionnaires, while 11% ($n = 13$) used online surveys. All the field workers were given a choice to take the survey either in English or Spanish, 60 (69%) of them completed the English version, and 27 (31%) answered to the Spanish version. All the managerial workers responded to the survey in English as it was the only available option for them. The mean age of all the respondents was 36 years (standard deviation = 10.6). Both the groups came close when it came to the average age and average years of working in the construction industry and for the current company. But the managerial workers spent more time on the projects under consideration (mean = 16 months) compared to the field workers (mean = 8 months).

Table 4. Demographics of the Participants

Demographics	Managerial Workers N = 31	Field Workers N = 87
Jobsite 1	15 (48%)	51 (59%)
Jobsite 2	16 (52%)	36 (41%)
	Mean (SD)	Mean (SD)
Age	37 (12.4)	36 (9.8)
Years worked in construction	14.5 (10.4)	13 (9.2)
Years worked for current company	7 (6.1)	6 (5.3)
Months worked on the project	16 (8.1)	8 (6.5)

In response to what race/ethnicity the respondents belonged to, the majority of the managerial workers were Caucasian. However, among the field workers, more than half were Caucasian, and a considerable portion (39%) were Hispanic. More than 95% of the field workers were male, which confirms that the construction industry is male dominated. The gender distribution among the managerial group was relatively less skewed, with females consisting of approximately one-fifth of the group. In terms of education level, most of the managerial workers had some college or above education. In return, less than one-third of field workers had some college/college degree. Close to half (45%) of managerial workers were affiliated with the general contractors and 99% of the field workers were affiliated with the subcontractors. Main subcontractors that had participants in this study include mechanical, electrical, plumbing, drywall, and paint trades.

Table 5. Demographics of the Participants – Race, Education, Gender, Trade

Demographics	Managerial Workers N = 31 N (%)	Field Workers N = 87 N (%)
Race/Ethnicity		
Caucasian	30 (97%)	46 (53%)
Hispanic	0	34 (39%)
African American	0	7 (8%)
Native American	1 (3%)	1 (1%)
Other	0	0
Missing	0	2 (2%)
Education Level		
High School Diploma & Below	2 (6%)	38 (44%)
GED Certification	0	2 (2%)
Vocational/Technical School	3 (10%)	20 (23%)
Some College/College Degree	23 (74%)	26 (30%)
Graduate Degree	3 (10%)	0
Missing	0	1 (1%)
Gender		
Male	25 (81%)	83 (95.5%)
Female	6 (19%)	3 (3.5%)
Missing	0	1 (1%)
Trade		
General Contractor	14 (45%)	1 (1%)
Mechanical	6 (19%)	1 (1%)
Electrical	4 (13%)	15 (17%)
Plumbing	1 (3%)	8 (9%)
Concrete	0	3 (3.5%)
Carpentry/Drywall	0	22 (25%)
Tile/Flooring	0	6 (7%)
Paint	0	8 (9%)
Other	5 (16%)	16 (18.5%)
Missing	1 (3%)	7 (8%)

The managerial workers consisted of a diverse group of employees including 11 (35.5%) project managers, 4 (13%) superintendents, 9 (29%) project engineers, and 7 (22.5%) with other job titles such as assistant superintendent, project executive, etc. Among field workers, 7 (8%)

were foremen, and the rest (92%) were workers with various job titles consisting of apprentices, journeymen, technicians, operators, etc.

Analysis of Cronbach's Alpha

Twenty-eight Likert type scale items were used to measure workers' perception of safety with regard to the three variables of "perception of specific hazards," "safety control," and "safety climate." Scale scores for each of the three variables were calculated by adding up scores of individual items. As mentioned earlier in Chapter 3, the majority of the questions were adapted from existing surveys found in other similar studies with minor modifications. In order to ensure the internal consistency between the individual items representing a specific variable, Cronbach's Alpha was computed. Cronbach's Alpha was calculated separately for all three variables, both on the entire dataset and each study group. The results are presented in Table 6.

The highest α value ($\alpha > 0.9$) belonged to the safety climate measure, for both groups, as well as on the entire sample set. The alpha values for the two variables of safety control and perception of specific hazards were relatively lower for managerial groups in comparison with field workers and the entire sample set (0.71 and 0.77, respectively). The author believes that the lower α values for managerial workers are due to a relatively smaller sample size of this group ($n = 31$). Yet, as can be seen below, for all variables, Cronbach's α values are greater than the threshold of 0.7, indicating that the internal reliability of the survey was acceptable for this study (DeVellis, 1991).

Table 6. Cronbach's Alpha Analysis

	Variable	α
The entire sample set N = 118	Perception of Specific Hazards	0.93
	Safety Control	0.88
	Safety Climate	0.95
Field Workers N = 87	Perception of Specific Hazards	0.94
	Safety Control	0.89
	Safety Climate	0.96
Managerial Workers N = 31	Perception of Specific Hazards	0.77
	Safety Control	0.71
	Safety Climate	0.92

Statistical Analysis

All statistical analyses were performed using Microsoft Excel and RStudio. For hypothesis testing, a 95% confidence level (p-value = 0.05) was set as the threshold to decide whether the results were significant or not. The presentation of the results follows the order that was outlined earlier in the introduction section:

Between-Group Comparison

This section is comprised of three parts to test hypotheses h_1, h_2, and h_3. The results could answer the first research question formed at the beginning of this study: whether the safety perception of the construction workers working at site offices differs from those that work at job sites. In this regard, mean group differences were compared with an independent sample t-test. Individual items and mean scores that represent each variable are presented first, followed by a summary of test results pertaining to the relevant hypothesis.

Hypothesis 1: There is a significant difference in the "safety climate" scores between two groups of construction professionals (field workers versus managerial workers). Field workers will report a lower safety climate score compared to the managerial workers.

Table 7 presents individual items pertaining to the safety climate variable and the corresponding mean score of each item for managerial and field workers. As shown, managerial workers had a more positive perception of all the items compared to the field workers. It is worth noting that the lowest mean score among both groups belongs to the question stating that *"Foremen think safety is more important than productivity"* ($Mean_{Field}$ = 3.91, $Mean_{Managerial}$ = 4.19). On the other hand, the highest mean score among the two groups pertains to general contractor's management commitment to safety: For the managerial workers, this item was *"The management team follows up when there is a problem or concern about safety"* (M = 4.61, SD = 0.72), and for the field workers, "*The management of this project is concerned for the safety of employees"* (M = 4.33, SD = 0.82). Finally, the safety climate score was calculated by summing up the scores of individual questions and each respondent received an aggregated safety climate score.

Table 7. Comparison of responses about items representing perception of safety climate

Questions	Managerial Workers Mean (SD)	Field Workers Mean (SD)
The management of this project is concerned for the safety of employees	4.55 (0.62)	4.33 (0.82)
The management of this project believes safety is more important than schedule and deadlines	4.23 (0.99)	4.01 (1.02)
The management team follows up when there is a problem or concern about safety	4.61 (0.72)	4.16 (0.87)
The management of this project works well with other subcontractors to ensure the safest possible working conditions on this jobsite	4.45 (0.89)	4.06 (0.99)
Safety is important to my company, even when the job runs behind schedule	4.48 (0.68)	4.13 (0.92)
Employees from various companies work well together to address safety concerns on this project	4.42 (0.67)	3.99 (0.99)
Foremen make sure that workers follow site safety rules and procedures very closely	4.32 (0.65)	4.16 (0.89)
Foremen think safety is more important than productivity	4.19 (0.70)	3.91 (0.86)
Workers are able to discuss their concerns about safety with the foremen	4.53 (0.57)	4.10 (0.95)
Employees are regularly consulted about workplace health and safety issues	4.26 (0.77)	4.00 (0.95)
There is open communication about safety issues in this workplace	4.45 (0.77)	4.10 (0.95)
Toolbox talks about safety are given regularly and they are effective	4.52 (0.51)	4.09 (0.87)
Safety issues are given a high priority in training programs.	4.48 (0.51)	4.28 (0.92)
Workplace health and safety training covers the types of situations that employees encounter in their jobs.	4.48 (0.57)	4.20 (0.93)
Employees receive enough training in workplace health & safety issues	4.39 (0.72)	4.23 (0.92)
Safety procedures and practices are sufficient to prevent incidents occurring.	4.48 (0.57)	4.11 (1.00)
The safety procedures and practices in this project are useful and effective.	4.52 (0.57)	4.22 (1.03)
Safety Climate Score	75.37 (7.69)	70.08 (12.21)

An independent sample t-test was used to examine the mean group differences related to the aggregated safety climate scores. Based on Levene's test, the variances of the two groups were homogenous. The test results are provided in Table 8 below. There is a significant difference between the two groups, $t(116) = 2.33$, $p = 0.02$. The safety climate perceived by managerial workers was significantly more positive compared with what the field workers perceived. Therefore, the result supported h_1.

Table 8. Test results for h1

Independent Sample t-Test (under $\sigma_1 = \sigma_2$)		
t	df	**p**
2.33	116	**0.02**

Hypothesis 2: There is no significant difference in the mean scores of "workers' perception of specific hazards" between the two groups.

Table 9 presents individual items about workers' perception of OSHA fatal four hazards and the corresponding mean score of each item for both groups. As can be seen, managerial workers had a relatively higher perception of all the four hazards compared to the field workers. The highest and lowest scores for both groups belong to the same hazards. Electrocution was perceived highest by both groups compared to the other three risks ($Mean_{Field} = 3.62$, $Mean_{Managerial} = 4.58$). On the other hand, the lowest mean scores between the two groups were related to caught in/between ($Mean_{Field} = 3.23$, $Mean_{Managerial} = 3.74$). Similar to the safety climate, an independent sample t-test was run based on aggregated scores that each respondent received.

Table 9. Comparison of responses about items representing perception of OSHA four fatal hazards.

Questions	Managerial Workers Mean (SD)	Field Workers Mean (SD)
On this project, there is a high likelihood that I/site workers will be injured or harmed due to a fall from height, slip, or trip if I/they don't follow safety procedures.	4.1 (0.98)	3.51 (1.51)
On this project, there is a high likelihood that I/site workers will be injured or harmed due to cave-ins, by unguarded machinery, or caught in between equipment if I/they don't follow safety procedures.	3.74 (1.12)	3.23 (1.61)
On this project, there is a high likelihood that I/site workers will be injured or harmed due to falling/flying objects or struck by vehicles/equipment if I/they don't follow safety procedures.	4.13 (0.99)	3.50 (1.45)
On this project, there is a high likelihood that I/site workers will be injured or harmed due to electrocution if I/they don't follow safety procedures.	4.58 (0.56)	3.62 (1.45)
Specific Hazard Perception Score	16.55 (2.88)	13.85 (5.54)

Table 10 presents the test result for testing the second hypothesis using an independent sample t-test. According to Levene's test, the variances of the two groups were not homogenous ($p < 0.05$). Therefore, the t-test was run by using the appropriate formula under the assumption of $\sigma_1 \neq \sigma_2$. There is a significant difference between the two groups in terms of specific hazard perception, $t(116) = 3.56$, p-value = 0.0005. Managerial workers had a significantly a higher score compared to the field workers. A higher score indicates higher levels of safety risk perception with regard to the four fatal hazards. Thus, the result rejected the null h_2.

Table 10. Test results for h2

Independent Sample t-Test (under $\boldsymbol{\sigma_1 \neq \sigma_2}$)		
t	df	**p**
3.56	116	**0.0005**

Hypothesis 3: There is no significant difference in the mean scores of "workers' perception of safety control" between the two groups.

Questions about workers' perception of safety control and the relevant mean scores can be found in Table 11. Like the other two variables discussed earlier, managerial workers had a relatively higher perception of all items compared to the field workers. The highest scores for both groups belong to the last statement *"I (Site workers) am (are) able to report safety hazards that I (they) see"* ($Mean_{Field} = 4.32$, $Mean_{Managerial} = 4.42$).

Table 11. Comparison of responses about items representing perception of safety control.

Questions	Managerial Workers Mean (SD)	Field Workers Mean (SD)
I/Site workers am/are able to change unsafe practices at work	4.35 (0.61)	3.67 (1.23)
I/Site workers am/are able to modify work conditions in order to make them safer	4.16 (0.69)	3.76 (1.19)
I/Site workers am/are capable of taking action to prevent injuries or accidents to myself/themselves at work	4.35 (0.80)	3.93 (1.14)
I/Site workers am/are able to change the unsafe behavior of others at work	4.00 (0.73)	3.52 (1.25)
I/Site workers have control over whether I/they use safety equipment (e.g., hard hat, safety goggle, etc.)	3.81 (1.25)	3.76 (1.25)
I/Site workers have control over whether or not to engage in safe work behaviors	4.16 (0.86)	3.95 (1.12)
I/Site workers am/are able to report safety hazards that I/they see	4.42 (0.72)	4.32 (0.81)
Safety Control Score	29.26 (3.5)	26.9 (6.3)

Table 12 shows the test result for testing the third hypothesis. There is a significant difference between the two groups, $t(116) = 2.71$, p-value = 0.008. This result suggests that managerial workers had a significantly higher perception of safety control in comparison with field workers. Hence, the null h3 is rejected.

Table 12. Test results for h3

Independent Sample t-Test (under $\sigma_1 \neq \sigma_2$)		
t	df	**p**
2.71	116	**0.008**

Previous Incident Experience

This section relates to the first research question of whether there is an association between workers' perceptions of safety and prior experience with work-related accidents/incidents (h_4, h_5, and h_6). A summary of self-reported data is presented in Table 13 and Figure 3. Workers were asked to report their recent experience with any type of safety incident on the job site for six months preceding the data collection. Fifty-nine workers (50%) reported at least one encounter with accident/incident within six months of completing the questionnaires, while 58 workers (49%) had no exposure to safety incidents during the same period. Experience with incidents was divided into two categories of direct and indirect. One group consisted of 45 people who had direct involvement with incidents by experiencing personal injury (n = 13) or near-miss (n = 32). The other group was 44 workers who witnessed an incident happening to a colleague.

Table 13. Summary of Self-reported Incidents

Direct Experience		Indirect Experience
Personal Injury	Personal Near-Miss	Witness of incident to colleague
13 (11%)	32 (27%)	44 (38%)

Analysis of the causes of the incidents showed that the top four fatal hazards in construction accounted for 81% of total incidents reported by the respondents in the survey. Among the four specific risks, fall had the highest share (32%) while, caught in/between had the lowest frequency (11%). Other causes (19%) include burn, inattention, improper use of equipment, etc.

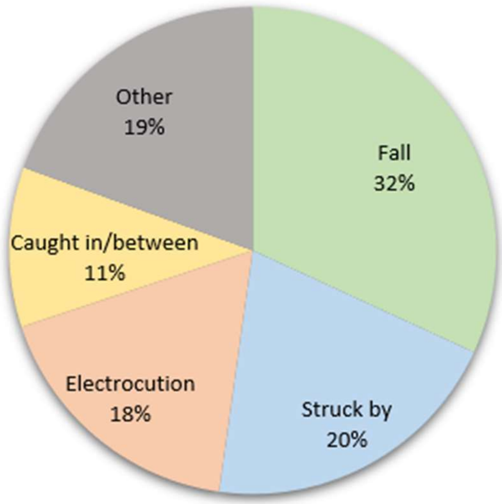

Figure 3. Causes of workplace incidents reported by participant

Hypothesis 4: There is a negative correlation between the safety climate score and workers' most recent experience with accidents/near-miss. Those workers who experienced accidents or near-miss incidents will demonstrate a lower safety climate score.

Respondents who directly experienced personal injury or near-miss were combined to form an adequate number of samples for hypothesis testing on the entire sample date (direct experience). In return, those who observed an incident to a colleague were grouped separately (indirect experience). Point-Biserial Pearson correlation tests were performed to reveal any possible association between workers' perceptions of safety climate and previous accident/incident experience (Accident group = 1, No accident group = 0). The results are reported in Table 14. The correlations were negative for both direct and indirect incident experience; however, p-values were greater than 0.05, indicating that the association is not significant. Therefore, the result partially rejected h_4.

Table 14. Test results for h4

Point-Biserial Pearson Correlation test				
Group	r_{pb}	df	t	p
Direct experience with incident (0,1)	- 0.11	115	-1.14	0.26
Indirect experience with incident (0,1)	-0.10	113	-1.08	0.28

Hypothesis 5: There is a positive correlation between “experience with accidents/near-miss” and “perception of fatal four hazards.” Those workers who have been involved in safety-related incidents will have a higher mean score for perception of the fatal four fatal hazards.

The hypothesis testing was performed similarly to the previous test on the entire sample data. The results are provided in Table 15. For direct experience, ($r_{pb} = 0.43$, $p < 0.05$) a stronger correlation exists in comparison with indirect experience ($r_{pb} = 0.26$, $p<0.05$). Yet, both correlations are positive and significant. Thus, h_5 is retained.

Table 15. Test results for h5

Point-Biserial Pearson Correlation test				
Group	r_{pb}	df	t	p
Direct experience with incident (0,1)	0.43	115	5.15	0.000001
Indirect experience with incident (0,1)	0.26	113	2.82	0.006

Hypothesis 6: There is a negative correlation between “experience with accidents/near miss” and the perception of “safety control.” Those workers that have been involved in safety-related incidents will report higher mean scores of safety control perception.

The test results are shown in Table 16. Similar to the two previous tests, correlation tests were performed for both direct and indirect experience. Both correlations were weak and $P > 0.05$.

No significant correlation found between the perception of safety control and previous accident experience. So, h_6 is rejected.

Table 16. Test results for h6

Point-Biserial Pearson Correlation test				
Group	r_{pb}	df	t	p
Direct experience with incident (0,1)	-0.02	115	-0.18	0.86
Indirect experience with incident (0,1)	0.1	113	1.09	0.28

Association Between Safety Perception Variables

Pearson partial correlation tests were used to reveal any possible association between the intended variables of safety perception (h_7 and h_8). The hypothesis testing was performed on the entire sample data.

Hypothesis 7: There is a positive correlation between safety climate and perception of fatal four hazards scores.

Table 17 provides the results of the partial correlational test between the two intended variables while controlling the effect of safety control. The result partially rejects h_7. The correlation between safety climate and perception of specific hazards is positive; however, it is not significant, $t(116) = 0.67$, $p = 0.67$.

Table 17. Test results for h7

Test	r	df	t	P
Pearson Correlation test	0.1	116	1.13	0.26
Partial Correlation test (Controlled variable=safety control)	0.04	116	0.42	0.67

Hypothesis 8: There is a positive correlation between perceptions of "safety climate" and "safety control."

According to the tests results in Table 18, workers' perception of safety climate is significantly positively correlated with their perception of safety control, t(116) =5.22, P=0.0000007.

Table 18. Test results for h8

Test	r	df	t	P
Pearson Correlation test	0.45	116	5.38	0.0000004
Partial Correlation test (Controlled variable=Hazard Perception)	0.44	116	5.22	0.0000007

Although there was no hypothesis regarding the association between two variables of safety control and perception of specific hazards, and additional test was run to examine all possible correlations between any pair of variables. According to the partial correlation test results provided in Table 19, there is no significant correlation between the two variables of safety control and hazard perception, t(116) = 1.55, p = 0.13.

Table 19. Correlational test, Safety Control and Specific Hazard Perception

Test	r	df	t	P
Pearson Correlation test	0.16	116	1.71	0.09
Partial Correlation test (Controlled variable=Safety Climate)	0.12	116	1.55	0.13

Results Overview

Overall, eight hypotheses were successfully tested to answer the two pre-developed research questions. A summary report of demographics provided a better insight about the specific background characteristics of the participants. Analysis of quantitative data showed that there is a significant gap between field workers and managerial workers in terms of the perceptions of safety pertaining to the three variables studied in this paper. Finally, the correlations between multiple factors were examined. Based on the results, the following model was developed that demonstrates the association between several factors that were studied in this paper. It is worth noting that the correlations in this model do not imply any causal relationship between the variables. Additionally, the tests conducted in this paper do not show the direction of the relations.

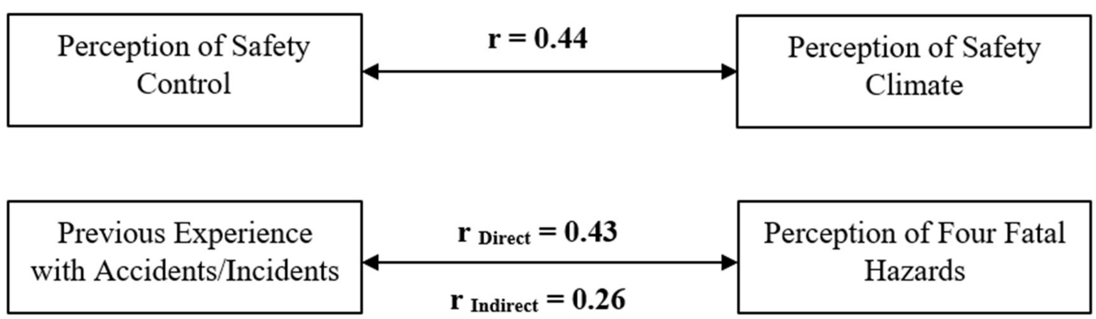

Figure 4. Research model based on the correlation statistical analysis.

Chapter 5: Conclusions

This study started with three main research questions to explore more about construction workers' perception of safety as it relates to safety climate and other associated concepts found in the existing literature with respect to commercial construction. In fact, the author attempted to investigate possible links between different pieces of a puzzle that each had been studied in various industries and they were found to be part of the overall picture of workplace occupational health and safety. These pieces include hazard control, hazard perception, and safety climate. In recent years, researchers have relied on these leading indicators not only to predict, but also to improve workplace safety performance. In this chapter, the author discussed the study findings, limitations, and offered some suggestions for future studies.

Study Findings and Implications

One of the primary objectives of this paper was to examine whether there is an association between three perception-based variables, namely safety climate, safety control, and hazard perception. The results of the correlational tests revealed a significant positive correlation between safety climate and safety control. This major finding implies that workers' attitude towards safety climate is linked to the extent to which they have the power to control safety in their workplace. To the best of the author's knowledge, very limited studies have investigated the relationship between safety control and safety climate, especially in construction. For instance, a study by Huang et al. (2006) on samples, including workers from various industry sectors, concluded that safety control mediates the correlation between safety climate and workplace injury. Although the mediation analysis between factors was not discussed in this paper, the significant positive correlation between safety climate and safety control can be viewed as the main takeaway that suggests researchers should further investigate this relationship and its type (mediation, moderation, causal effect, etc.) using a variety of samples from the construction workforce. According to Hardy and Leiba-O'Sullivan (1998), organizations are able to improve workers' perception of safety control by empowering them through practices that delegate power and authority to the workers in the workplace. It will be both informative and practical to examine if empowerment policy can positively influence the workplace safety climate. Such investigations can lead to novel ideas about how to enhance the safety climate and, ultimately, the safety performance of jobsites more effectively.

Another major finding of this research pertains to the between-group comparison based on the employment type. The results of the comparative analysis between the two groups of managerial and field workers confirmed that a significant gap existed in terms of their perception of all three safety-related variables. This reality signifies one of the issues in construction jobsites that have been captured by several other studies that compared safety climate perceptions of different groups of workers based on job level (Glendon & Litherland, 2001; Tholen, Pousette, & Törner, 2013; Biggs & Banks, 2012). The majority of these studies found that laborers' perceptions of safety climate were less positive compared to the other groups such as project managers and superintendents. Besides the safety climate, a difference in perceptions of hazards and safety control implies the fact that organizations and safety practitioners should focus on addressing the perception gaps between the field workers and the managerial workers. The study findings also suggest that the role of field workers in planning and preparing the safety procedures of construction projects should be reconsidered in the future. Traditionally, upper-level managers such as the project managers, superintendents, and safety directors have the most inputs while designing the safety procedures and preparing the safety manuals for the construction projects.

However, field workers who are involved with the safety hazards the most, have minimal inputs in the process. According to Grawitch et al. (2009), safety policies and programs exclusively designed by upper-level managers are deemed to fail, and they cannot encourage change at the level of employees. In fact, management teams rely on their own understanding of what actions are necessary to improve the safety of the organization and do not consider other perspectives. On the other hand, Grawitch et al. (2009) further explain that managers will get better results if they focus on actions that promote workers' involvement, such as communication. By implementing this approach, employees will take more ownership of their actions with regard to the decisions being made within the organization.

It seems an appropriate solution to the disparity in perceptions requires both managerial workers and field workers to have contact with each other and to be involved in the process. In this regard, the author proposes several practical suggestions for industry professionals. One of them is that general contractors can form a safety committee consisting of both the managerial and field workers with proper work experience who reflect the voice of the majority of the construction workers when making decisions about safety. Another recommendation that might be considered is that organizations can create a system by which field workers have an opportunity to share their thoughts about safety with the management group. Various incentives would encourage workers to engage in this system actively. Lastly, carrying out periodic safety assessment surveys, like the one that was utilized in this study, can be beneficial in several ways. Through using surveys, workers will have a chance to influence on safety decisions. Moreover, it provides the management group an insight into how their perceptions differ from the field workers' viewpoints about various aspects of worksite safety. Experts agree that utilization of safety assessment surveys is a cost-effective approach for improvement of safety that requires minimal investment by organizations.

For example, Gittleman et al. (2010) have successfully used this method to address safety concerns and to improve the safety performance of a large commercial construction project.

In addition to the advantages mentioned above, safety assessment instruments can reveal potential pitfalls with respect to safety issues. For instance, analysis of individual items in this study showed that the lowest mean score in the safety climate scale for both managerial workers and field workers was related to the item stating, *"Foremen think safety is more important than productivity."* This item refers to management commitment to safety (by subcontractors), which is an indicator of safety climate. An action plan for the participating companies should address this important issue that pertains to the foremen. According to Lingard, Cooke, and Blismas (2009), supervisory positions (e.g., foremen) play a key role in shaping the safety performance of front-line workers. In fact, foremen are the link between the general contractor and subcontracted workers. As mentioned before, subcontracting is one of the key differences that makes safety climate in construction different from other industries. The general contractors can influence on the workers' safety climate perceptions by developing leadership capabilities in first-line supervisors. Organizations should consider the foremen's role in this regard, as they are the communication channel between the management team and workers (Lingard et al., 2009).

Another example that clearly demonstrates how general contractors can benefit from the safety assessment tool is related to the hazard perception survey items. Both groups of workers had a relatively lower perception of caught-in/between. This finding suggests that more focus needs to be allocated to the risk of caught-in/between during safety meetings or training programs in order to improve workers' perception of this particular hazard.

No significant correlation was found between perception of hazard and safety control. Similarly, no association was observed between perception of hazards and safety climate. Lacking correlation between these factors does not mean that the role of these factors should be underrated by construction professionals. But rather, it suggests that each of these variables has its own path to overall safety of the worksite. For instance, many studies have confirmed that increasing risk perception is effective in improving safety performance (Howard, 1987; leather, 1987). According to Tixier et al. (2014), those who have higher hazard perception levels are less likely to show risky behaviors. It should be noted that the findings do not show cause and effect relationships since this study was based on a cross-sectional design.

Analysis of data showed that previous incident experience was positively correlated with hazard perceptions. This suggests those workers who experienced work-related incidents were more alert about major risks. The correlation was stronger for the groups who had direct interactions with safety incidents. As mentioned before, an accurate hazard perception is very critical in preventing work-related injuries. Improving hazard perception levels is achievable through safety training (Namian et al., 2016). In the author's view, one lesson that can be learned from this investigation is that safety practitioners should use new methods in safety training programs to provide workers with a more realistic experience of risks. For instance, workers who were involved with work accidents on a jobsite can be invited to share their encounters with other coworkers. According to the study results, even those who had indirect experience by witnessing an accident to a colleague showed a relatively higher perception of hazards compared to the non-accident group. Of course, this suggestion is subject to further investigation since it may have other side effects, whether negative or positive. No correlation between previous accident and safety climate was not a surprise for the researcher since studies are not inconsistent about the result.

Martin and Lewis (2014) found a similar result, no difference found between safety climate perception between the accident and non-accident groups.

While the focus in measuring hazard perception was summarized to the OSHA fatal four hazards, the scope can go beyond to include other types of risks in future studies. However, the causes of incidents on the two studied jobsites showed that about 80% of incidents resulted from four hazards of fall, caught-in/between, electrocution, and struck-by. This study finding is aligned with the focus program pioneered and promoted by the Occupational Safety and Health Administration (OSHA, 2011). As mentioned earlier, although non-fatal occupational injury and illness rates have dropped in recent years, the number of construction fatalities has increased. Therefore, more attention needs to be devoted to fatal-four hazards compared to non-fatal risks.

Limitations

The present study offers some key findings to the current body of knowledge. However, like many other studies, it contains several limitations that need to be acknowledged, as well. This research was conducted with a relatively small sample size (N=118) from only two participating projects. Measuring perceptions of safety based on a small group of workers may not fully represent the entire population of employees working on commercial construction projects. Hence, the scope of inference cannot be generalized to the larger population. It should be noted the coincidence of the COVID-19 global pandemic and data collection was a major issue for the researchers since accessibility to the jobsites was restricted.

Moreover, the selection of sample jobsites and respondents was based on the convenience sampling strategy, which is classified as a non-random sampling (Leedy & Ormrod, 2013). Due to the author's time limitation and restricted accessibility of jobsites, data collection was administered at certain stages of the construction process. The fact that many workers from various trades who were not present during data collection and were left out from the study could be a source of bias that might alter the findings. Lastly, data collected solely using self-reporting survey tools may be prone to problems arising out of perception differences and memory restrictions (Leedy & Ormrod, 2013). For instance, it was assumed that respondents were able to rightly recall what type of incident they were involved with during the six months prior to taking the survey. The author attempted to address the perception differences about questions by asking for feedback from a group of industry professionals from participating jobsite. It is worth noting the number of survey items was also limited to allow timely completion and a high response rate by the respondents.

Recommendations for Future Studies

It is suggested that future studies perform the analysis on a larger sample size to provide more robust results about the occupational health and safety of construction jobsites. Researchers may use the findings of this study to expand their knowledge about the type of relationship between safety climate and perception of safety control in construction. With regard to the dynamic nature of projects, it is recommended safety climate studies capture the opinions of all groups of workers from various trades. While the majority of studies, including the present paper have used cross-sectional design (Schwatka et al., 2016), a longitudinal research design might be an alternative approach to assess safety climate as it was used in very few previous studies. (Han et al., 2014; Tholen et al., 2013). One advantage of using longitudinal research is that workers from different trades will have a chance to share their opinions about safety conditions. It is important to hear the voices of as many workers as possible. On the other hand, a longitudinal approach may provide a better insight into the relationship between safety climate and other similar concepts and how they might change over the lifecycle of a project.

The construction workforce is comprised of a very diverse group of people with different backgrounds. Based on the finding of this study that confirmed group differences in perceptions of safety among workers, the author believes the safety programs should be designed by considering all these differences (e.g., age groups, ethnicities, employment type). In this respect, the common goal needs to concentrate on minimizing gaps in perception levels among different groups (Zacharatos, Barling, & Iverson, 2005). Moreover, utilizing mixed-method surveys can help management teams at organizations to gain a better understanding of the issues related to jobsite safety.

Concluding Remarks

Despite all the limitations outlined earlier, the present study offers several important findings to the current body of knowledge. Leading indicators of safety performance, such as workers' perceptions of workplace safety climate, hazard perception levels, and safety control, were studied to answer the research question with respect to the knowledge gaps found in the current literature. The results demonstrated that a significant gap in safety perception levels existed across two groups: managerial workers and field workers. Thus, safety practitioners should pay attention to employment type as a key factor in developing safety programs. Additionally, the fact that previous accident experience could predict workers' perception level about hazards could be used in designing more effective safety training to reduce workplace accidents. Lastly, a significant correlation between safety climate and perception of safety control confirms that the relationship between these two variables needs to be further investigated in future works, as it may provide more insight on safety performance improvement. Although the results here in this document may not be generalizable to the construction industry, even in the commercial sector, the author believes it provides researchers with new ideas and a framework for future studies.

References

Albert, A., Hallowell, M. R., & Kleiner, B. M. (2014). Experimental field testing of a real-time construction hazard identification and transmission technique. *Construction Management and Economics*, *32*(10), 1000-1016.

Anderson, L., Chen, P. Y., Finlinson, S., Krauss, A. D., & Huang, Y. H. (2004, April). Roles of safety control and supervisory support in work safety. In *th Annual Conference of the Society for Industrial and Organizational Psychology, Chicago, IL* (Vol. 20).

Arditi, D., & Chotibhongs, R. (2005). Issues in subcontracting practice. *Journal of construction engineering and management*, *131*(8), 866-876.

Arezes, P. M., & Miguel, A. S. (2008). Risk perception and safety behaviour: A study in an occupational environment. *Safety science*, *46*(6), 900-907.

Beus, J. M., Bergman, M. E., & Payne, S. C. (2010). The influence of organizational tenure on safety climate strength: A first look. *Accident Analysis & Prevention*, *42*(5), 1431-1437.

Biggs, S. E., & Banks, T. D. (2012). A comparison of safety climate and safety outcomes between construction and resource functions in a large case study organization.

Carter, G., & Smith, S. D. (2006). Safety hazard identification on construction projects. *Journal of construction engineering and management*, *132*(2), 197-205.

Chen, W. T., Lu, C. S., Liu, S. S., & Wang, M. S. (2013). Measuring the perception of safety among Taiwan construction managers. *Journal of civil engineering and management*, *19*(1), 37-48.

Cheyne, A., Cox, S., Oliver, A., & Tomás, J. M. (1998). Modelling safety climate in the prediction of levels of safety activity. *Work & Stress*, *12*(3), 255-271.

Choudhry, R. M., Fang, D., & Lingard, H. (2009). Measuring safety climate of a construction company. *Journal of construction Engineering and Management*, *135*(9), 890-899.

Christian, M. S., Bradley, J. C., Wallace, J. C., & Burke, M. J. (2009). Workplace safety: a meta-analysis of the roles of person and situation factors. *Journal of applied psychology*, *94*(5), 1103.

Cigularov, K. P., Lancaster, P. G., Chen, P. Y., Gittleman, J., & Haile, E. (2013). Measurement equivalence of a safety climate measure among Hispanic and White Non-Hispanic construction workers. *Safety science*, *54*, 58-68.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approach*. Sage publications.

Dedobbeleer, N., & Béland, F. (1991). A safety climate measure for construction sites. *Journal of safety research*, *22*(2), 97-103.

Denison, D. R. (1996). What is the difference between organizational culture and organizational climate? A native's point of view on a decade of paradigm wars. *Academy of management review*, *21*(3), 619-654.

DeVellis, R.F. (1991). *Scale Development: Theory and Applications*. Sage Publications

Fang, D., Zhao, C., & Zhang, M. (2016). A cognitive model of construction workers' unsafe behaviors. *Journal of Construction Engineering and Management*, *142*(9), 04016039.

Fang, D., Chen, Y., & Wong, L. (2006). Safety climate in construction industry: A case study in Hong Kong. *Journal of construction engineering and management*, *132*(6), 573-584.

Flin, R., Mearns, K., O'Connor, P., & Bryden, R. (2000). Measuring safety climate: identifying the common features. *Safety science*, *34*(1-3), 177-192.

Geller, E. S. (2001). *Working safe: How to help people actively care for health and safety*. CRC Press.

Ghosh, S., Young-Corbett, D., & Fiori, C. M. (2010). Emergent themes of instruments used to measure safety climate in construction. In *Construction Research Congress 2010: Innovation for Reshaping Construction Practice* (pp. 1010-1019).

Gilkey, D. P., del Puerto, C. L., Keefe, T., Bigelow, P., Herron, R., Rosecrance, J., & Chen, P. (2012). Comparative analysis of safety culture perceptions among home safe managers and workers in residential construction. *Journal of construction engineering and management*, *138*(9), 1044-1052.

Gilkey, D., del Puerto, C. L., Rosecrance, J., & Chen, P. (2013). *Comparative Analysis of Safety Culture & Risk Perceptions Among Latino and Non-Latino Workers in the Construction Industry* (Doctoral dissertation, American Society of Safety Engineers).

Gillen, M., Baltz, D., Gassel, M., Kirsch, L., & Vaccaro, D. (2002). Perceived safety climate, job demands, and coworker support among union and nonunion injured construction workers. *Journal of safety research*, *33*(1), 33-51.

Gittleman, J. L., Gardner, P. C., Haile, E., Sampson, J. M., Cigularov, K. P., Ermann, E. D., ... & Chen, P. Y. (2010). [Case Study] CityCenter and Cosmopolitan Construction Projects, Las Vegas, Nevada: Lessons learned from the use of multiple sources and mixed methods in a safety needs assessment. *Journal of Safety Research*, *41*(3), 263-281.

Glendon, A. I., & Litherland, D. K. (2001). Safety climate factors, group differences and safety behaviour in road construction. *Safety science*, *39*(3), 157-188.

Grawitch, M. J., Ledford Jr, G. E., Ballard, D. W., & Barber, L. K. (2009). Leading the healthy workforce: The integral role of employee involvement. *Consulting Psychology Journal: Practice and Research*, *61*(2), 122.

Guldenmund, F. W. (2000). The nature of safety culture: a review of theory and research. *Safety science*, *34*(1-3), 215-257.

Hallowell, M. (2010). Safety risk perception in construction companies in the Pacific Northwest of the USA. *Construction management and economics*, *28*(4), 403-413.

Han, S., Saba, F., Lee, S., Mohamed, Y., & Peña-Mora, F. (2014). Toward an understanding of the impact of production pressure on safety performance in construction operations. *Accident analysis & prevention*, *68*, 106-116.

Hardy, C., & Leiba-O'Sullivan, S. (1998). The power behind empowerment: Implications for research and practice. *Human relations, 51*(4), 451-483.

Haslam, R. A., Hide, S. A., Gibb, A. G., Gyi, D. E., Pavitt, T., Atkinson, S., & Duff, A. R. (2005). Contributing factors in construction accidents. *Applied ergonomics*, *36*(4), 401-415.

Hinze, J., Thurman, S., & Wehle, A. (2013). Leading indicators of construction safety performance. *Safety science*, *51*(1), 23-28.

Howarth, C. I. (1987). Perceived risk and behavioural feedback: Strategies for reducing accidents and increasing efficiency. Work & Stress, 1(1), 61-65.

Huang, Y. H., Ho, M., Smith, G. S., & Chen, P. Y. (2006). Safety climate and self-reported injury: Assessing the mediating role of employee safety control. *Accident Analysis & Prevention*, *38*(3), 425-433.

Leather, P. J. (1987). Safety and accidents in the construction industry: a work design perspective. *Work & Stress*, *1*(2), 167-174.

Leedy, P. D., & Ormrod, J. E. (2013). Practical research: Planning and design, Boston, MA: Merrill.

Lingard, H. C., Cooke, T., & Blismas, N. (2010). Safety climate in conditions of construction subcontracting: a multi-level analysis. *Construction Management and Economics*, *28*(8), 813-825.

Lingard, H. C., Cooke, T., & Blismas, N. (2009). Group-level safety climate in the Australian construction industry: within-group homogeneity and between-group differences in road construction and maintenance. *Construction management and economics*, *27*(4), 419-432.

Martin, H., & Lewis, T. M. (2014). Pinpointing safety leadership factors for safe construction sites in Trinidad and Tobago. *Journal of Construction Engineering and Management*, *140*(2), 04013046.

Mohamed, S. (2002). Safety climate in construction site environments. *Journal of construction engineering and management*, *128*(5), 375-384.

Nahrgang, J. D., Morgeson, F. P., & Hofmann, D. A. (2007, April). Predicting safety performance: a meta-analysis of safety and organizational constructs. In *22nd annual conference of the society for industrial and organizational psychology, New York*.

Namian, M., Albert, A., Zuluaga, C. M., & Behm, M. (2016). Role of safety training: Impact on hazard recognition and safety risk perception. *Journal of construction engineering and management*, *142*(12), 04016073.

Occupational Safety and Health Administration (OSHA). (2011). UNITED STATES DEPARTMENT OF LABOR. Retrieved June 12, 2020, from https://www.osha.gov/dte/outreach/construction/focus_four/

Perlman, A., Sacks, R., & Barak, R. (2014). Hazard recognition and risk perception in construction. *Safety science*, *64*, 22-31.

Rasmussen, J. (1997). Risk management in a dynamic society: a modelling problem. *Safety science*, *27*(2), 183-213.

Schwatka, N. V., Hecker, S., & Goldenhar, L. M. (2016). Defining and measuring safety climate: a review of the construction industry literature. *Annals of occupational hygiene*, *60*(5), 537-550.

Shin, M., Lee, H. S., Park, M., Moon, M., & Han, S. (2014). A system dynamics approach for modeling construction workers' safety attitudes and behaviors. *Accident Analysis & Prevention*, *68*, 95-105.

Snyder, L. A., Krauss, A. D., Chen, P. Y., Finlinson, S., & Huang, Y. H. (2011). Safety performance: The mediating role of safety control. *Work*, *40*(1), 99-111.

Tholén, S. L., Pousette, A., & Törner, M. (2013). Causal relations between psychosocial conditions, safety climate and safety behaviour–A multi-level investigation. *Safety Science*, *55*, 62-69.

Tixier, A. J. P., Hallowell, M. R., Albert, A., van Boven, L., & Kleiner, B. M. (2014). Psychological antecedents of risk-taking behavior in construction. *Journal of Construction Engineering and Management*, *140*(11), 04014052.

U.S. Bureau of Labor Statistics (BLS) (2017). News Release – "Employer-Reported Workplace Injuries and Illnesses – 2016" Retrieved on June 12, 2020 < https://www.bls.gov/news.release/archives/osh_11092017.pdf>

U.S. Bureau of Labor Statistics. (2019). Charts related to the latest "Census of Fatal Occupational Injuries" news release. Retrieved June 12, 2020, from https://www.bls.gov/charts/census-of-fatal-occupational-injuries/number-and-rate-of-fatal-work-injuries-by-industry.htm

Waehrer, G. M., Dong, X. S., Miller, T., Haile, E., & Men, Y. (2007). Costs of occupational injuries in construction in the United States. *Accident Analysis & Prevention*, *39*(6), 1258-1266.

Zacharatos, A., Barling, J., & Iverson, R. D. (2005). High-performance work systems and occupational safety. *Journal of applied psychology*, *90*(1), 77.

Zhang, P., Lingard, H., Blismas, N., Wakefield, R., & Kleiner, B. (2015). Work-health and safety-risk perceptions of construction-industry stakeholders using photograph-based Q methodology. *Journal of Construction Engineering and Management*, *141*(5), 04014093.

Zohar, D. (1980). Safety climate in industrial organizations: theoretical and applied implications. *Journal of applied psychology*, *65*(1), 96.

Zohar, D. (2010). Thirty years of safety climate research: Reflections and future directions. *Accident Analysis & Prevention*, *42*(5), 1517-1522.

Zohar, D., & Luria, G. (2005). A multilevel model of safety climate: cross-level relationships between organization and group-level climates. *Journal of applied psychology*, *90*(4), 616.

Appendix A

Managerial Workers

1. Age: _______ 2. Job title: ________________ 3. Total years working in construction: _________

4. Trade (e.g. concrete, masonry, painter, etc.): ____________________

5. Sex: ☐Male ☐Female ☐Prefer not to answer

6. Race/Ethnicity:

Caucasian	Hispanic	African American	Native American	Asian	Other	Prefer not to answer

7. How many years have you been working for your current company? __________

8. Education Level:

☐Did not graduate from High School ☐High School Diploma ☐GED Certification

☐Vocational/Technical School ☐Some College ☐College Degree ☐Graduate Degree

9. How many months have you been working on this project? _________

10. Have you been personally injured at work <u>in the last 6 months</u>? ☐Yes ☐No

- If YES, please specify the reason(s) for the injury from the list below:

☐ Due to Fall from Height

☐ Due to Cave-ins, Unguarded Machinery or Caught in/between Equipment

☐ Due to Hit by Flying Objects & Struck by Vehicles/Equipment

☐ Due to Electrocution

☐ Other (Please briefly describe): ________________________________

- Did you seek medical attention/first aid following the accident? ☐Yes ☐No

- Did you lose work time because of the accident? ☐Yes ☐No

11. Have you personally experienced a near-miss incident at work <u>in the last 6 months</u>? ☐Yes ☐No

- If YES, please specify the reason(s) for the near-miss incident from the list below:

☐ Due to Fall from Height

☐ Due to Cave-ins, Unguarded Machinery or Caught in/between Equipment

☐ Due to Hit by Flying Objects & Struck by Vehicles/Equipment

☐ Due to Electrocution

☐ Other (Please briefly describe): ________________________________

12. Please mark any type of incident that you have witnessed on this jobsite <u>in the last 6 months</u>?

☐Injury to someone else on the jobsite ☐Property damage ☐Near-miss to someone else ☐None

- Please specify the reason(s) for the incident that you witnessed from the list below:

☐ Due to Fall from Height

☐ Due to Cave-ins, Unguarded Machinery or Caught in/between Equipment

☐ Due to Hit by Flying Objects & Struck by Vehicles/Equipment

☐ Due to Electrocution

☐ Other (Please briefly describe): ________________________________

- Did the victim of the incident that you witnessed have to seek medical attention/first aid? ☐Yes ☐No ☐NA (No Victim)

- Did the victim of the incident that you witnessed lose work time? ☐Yes ☐No ☐NA (No victim)

Please rate how strongly you disagree or agree with each of the following statement by circling the appropriate number. (1=Strongly Disagree; 2=Somewhat Disagree; 3=Neutral; 4=Somewhat Agree; 5=Strongly Agree)	Strongly Disagree	Somewhat Disagree	Neutral	Agree	Strongly Agree
On this project, there is a high likelihood that site workers will be injured or harmed *due to a fall from height, slip, or trip* **if they don't follow safety procedures**	1	2	3	4	5
On this project, there is a high likelihood that site workers will be injured or harmed *due to cave-ins, by unguarded machinery, or caught in/between equipment* **if they don't follow safety procedures**	1	2	3	4	5
On this project, there is a high likelihood that site workers will be injured or harmed *due to falling/flying objects or struck by vehicles/equipment* **if they don't follow safety procedures**	1	2	3	4	5
On this project, there is a high likelihood that site workers will be injured or harmed *due to electrocution* **if they don't follow safety procedures**	1	2	3	4	5
Site workers are able to change unsafe practices at work	1	2	3	4	5
Site workers are able to modify work conditions in order to make them safer	1	2	3	4	5
Site workers are capable of taking action to prevent injuries or accidents to themselves at work	1	2	3	4	5
Site workers are able to change the unsafe behavior of others at work	1	2	3	4	5
Site workers have control over whether to use safety equipment (e.g., hard hat, safety goggle, etc.)	1	2	3	4	5
Site workers have control over whether or not to engage in safe work behaviors	1	2	3	4	5
Site workers are able to report safety hazards that they see	1	2	3	4	5
The management of this project is concerned for the safety of employees	1	2	3	4	5
The management of this project believes safety is more important than schedule and deadlines	1	2	3	4	5
The management team follows up when there is a problem or concern about safety	1	2	3	4	5
The management of this project works well with other subcontractors to ensure the safest possible working conditions on this jobsite	1	2	3	4	5
Safety is important to my company, even when the job runs behind schedule	1	2	3	4	5
Employees from various companies work well together to address safety concerns on this project	1	2	3	4	5
Foremen make sure that workers follow site safety rules and procedures very closely	1	2	3	4	5
Foremen think safety is more important than productivity	1	2	3	4	5
Workers are able to discuss their concerns about safety with the foremen	1	2	3	4	5
Employees are regularly consulted about workplace health and safety issues	1	2	3	4	5
There is open communication about safety issues in this workplace	1	2	3	4	5
Toolbox talks about safety are given regularly and they are effective.	1	2	3	4	5
Safety issues are given a high priority in training programs.	1	2	3	4	5
Workplace health and safety training covers the types of situations that employees encounter in their jobs.	1	2	3	4	5
Employees receive enough training in workplace health & safety issues	1	2	3	4	5
Safety procedures and practices are sufficient to prevent incidents occurring.	1	2	3	4	5
The safety procedures and practices in this project are useful and effective.	1	2	3	4	5

Field Workers

1. Age: _______ 2. Job title: _________________ 3. Total years working in construction: _________

4. Trade (e.g. concrete, masonry, painter, etc.): _____________________

5. Sex: ☐Male ☐Female ☐Prefer not to answer

6. Race/Ethnicity:

Caucasian	Hispanic	African American	Native American	Asian	Other	Prefer not to answer

7. How many years have you been working for your current company? __________

8. Education Level:

☐Did not graduate from High School ☐High School Diploma ☐GED Certification

☐Vocational/Technical School ☐Some College ☐College Degree ☐Graduate Degree

9. How many months have you been working on this project? _________

10. Have you been personally injured at work in the last 6 months? ☐Yes ☐No

- If YES, please specify the reason(s) for the injury from the list below:

☐ Due to Fall from Height

☐ Due to Cave-ins, Unguarded Machinery or Caught in/between Equipment

☐ Due to Hit by Flying Objects & Struck by Vehicles/Equipment

☐ Due to Electrocution

☐ Other (Please briefly describe): ___________________________________

- Did you seek medical attention/first aid following the accident? ☐Yes ☐No

- Did you lose work time because of the accident? ☐Yes ☐No

11. Have you personally experienced a near-miss incident at work in the last 6 months? ☐Yes ☐No

- If YES, please specify the reason(s) for the near-miss incident from the list below:

☐ Due to Fall from Height

☐ Due to Cave-ins, Unguarded Machinery or Caught in/between Equipment

☐ Due to Hit by Flying Objects & Struck by Vehicles/Equipment

☐ Due to Electrocution

☐ Other (Please briefly describe): ___________________________________

12. Please mark any type of incident that you have witnessed on this jobsite in the last 6 months?

☐Injury to someone else on the jobsite ☐Property damage ☐Near miss to someone else ☐None

- Please specify the reason(s) for the incident that you witnessed from the list below:

☐ Due to Fall from Height

☐ Due to Cave-ins, Unguarded Machinery or Caught in/between Equipment

☐ Due to Hit by Flying Objects & Struck by Vehicles/Equipment

☐ Due to Electrocution

☐ Other (Please briefly describe): ___________________________________

- Did the victim of the incident that you witnessed have to seek medical attention/first aid? ☐Yes ☐No ☐NA (No Victim)

- Did the victim of the incident that you witnessed lose work time? ☐Yes ☐No ☐NA (No Victim)

Please rate how strongly you disagree or agree with each of the following statement by circling the appropriate number. (1=Strongly Disagree; 2=Somewhat Disagree; 3=Neutral; 4=Somewhat Agree; 5=Strongly Agree)	**Strongly Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Strongly Agree**
On this project, there is a high likelihood that I will be injured or harmed *due to a fall from height, slip, or trip* **if I don't follow safety procedures**	1	2	3	4	5
On this project, there is a high likelihood that I will be injured or harmed *due to cave-ins, by unguarded machinery, or caught in between equipment* **if I don't follow safety procedures**	1	2	3	4	5
On this project, there is a high likelihood that I will be injured or harmed *due to falling/flying objects or struck by vehicles/equipment* **if I don't follow safety procedures**	1	2	3	4	5
On this project, there is a high likelihood that I will be injured or harmed *due to electrocution* **if I don't follow safety procedures**	1	2	3	4	5
I am able to change unsafe practices at work	1	2	3	4	5
I am able to modify work conditions in order to make them safer	1	2	3	4	5
I am capable of taking action to prevent injuries or accidents to myself at work	1	2	3	4	5
I am able to change the unsafe behavior of others at work	1	2	3	4	5
I have control over whether I use safety equipment (e.g., hard hat, safety goggle, etc.)	1	2	3	4	5
I have control over whether or not to engage in safe work behaviors	1	2	3	4	5
I am able to report safety hazards that I see	1	2	3	4	5
The management of this project is concerned for the safety of employees	1	2	3	4	5
The management of this project believes safety is more important than schedule and deadlines	1	2	3	4	5
The management team follows up when there is a problem or concern about safety	1	2	3	4	5
The management of this project works well with other subcontractors to ensure the safest possible working conditions on this jobsite	1	2	3	4	5
Safety is important to my company, even when the job runs behind schedule	1	2	3	4	5
Employees from various companies work well together to address safety concerns on this project	1	2	3	4	5
Foremen make sure that workers follow site safety rules and procedures very closely	1	2	3	4	5
Foremen think safety is more important than productivity	1	2	3	4	5
Workers are able to discuss their concerns about safety with the foremen	1	2	3	4	5
Employees are regularly consulted about workplace health and safety issues	1	2	3	4	5
There is open communication about safety issues in this workplace	1	2	3	4	5
Toolbox talks about safety are given regularly and they are effective.	1	2	3	4	5
Safety issues are given a high priority in training programs.	1	2	3	4	5
Workplace health and safety training covers the types of situations that employees encounter in their jobs.	1	2	3	4	5
Employees receive enough training in workplace health & safety issues	1	2	3	4	5
Safety procedures and practices are sufficient to prevent incidents occurring.	1	2	3	4	5
The safety procedures and practices in this project are useful and effective.	1	2	3	4	5

Trabajadores Directos

1. Edad: _______ 2. Puesto: _________________ 3. Años trabajando en la construcción: _________
4. Profesión/Oficio (por ejemplo: concreto, albañilería, pintor, etc.): _____________________

5. Sexo: ☐Hombre ☐Mujer ☐Prefiero no contestar

6. raza/étnica:

caucásico	Hispano	Afroamericano	Nativo Americano	Asiático	Otro	Prefiero no contestar

7. Cuántos años tienes trabajando para esta compañía? __________
8. Nivel de educación:

☐ No se graduó de la Escuela Secundaria ☐ el bachillerato ☐Certificado GED

☐ Escuela Vocacional/Técnica ☐colegio incompleto ☐título universitario ☐título de posgrado

9. Cuántos meses tienes trabajando en esto proyecto? _________

10. ¿Ha sido herido personalmente en el trabajo <u>en los últimos 6 meses</u>? ☐SI ☐NO

- En caso si, por favor especificar el(los) motivo(s) de la(s) lesión de la siguiente lista:
  - ☐ Debido a la caída de la altura
  - ☐ Debido a derrumbe, maquinaria sin vigilancia o atrapado en /entre equipo
  - ☐ Debido a golpe por objetos voladores y golpeados por vehículos/equipos
  - ☐ Debido a electrocución
  - ☐ Otra razón (por favor describe brevemente): ___________________________________
- Busco a atención medica/primeros auxilios después del accidente? ☐SI ☐NO
- Perdió tiempo del trabajo por el accidente? ☐SI ☐NO

11. ¿Ha experimentado personalmente un incidente casi-perdido en el trabajo en <u>los últimos 6 meses</u>? ☐SI ☐NO

- En caso si, por favor especificar el (los) motivo(s) de la(s) incidente(s) casi-perdido de la siguiente lista:
  - ☐ Debido a la caída de la altura
  - ☐ Debido a derrumbe, maquinaria sin vigilancia o atrapado en /entre equipo.
  - ☐ Debido a golpe por objetos voladores y golpeados por vehículos/equipos
  - ☐ Debido a electrocución
  - ☐ Otra razón (por favor describe brevemente): ___________________________________

12. Por favor marque cualquier tipo de incidente que haya estado presente en este sitio de trabajo en <u>los últimos 6 meses</u>?

☐ Lesión a otra persona en el lugar de trabajo ☐Daño a la propiedad ☐Casi-perdido a alguien más

☐Ninguno

- Por favor, especifique el(los) motivo(s) del incidente que presenció en la siguiente lista:
  - ☐ Debido a la caída de la altura
  - ☐ Debido a derrumbe, maquinaria sin vigilancia o atrapado en /entre equipo.
  - ☐ Debido a golpe por objetos voladores y golpeados por vehículos/equipos
  - ☐ Debido a electrocución
  - ☐ Otra razón (por favor describe brevemente): ___________________________________
- ¿La víctima del incidente que usted fue testigo tuvo que buscar atención médica/primeros auxilios?

  ☐SI ☐NO ☐NA (No Víctima)
- La víctima del incidente que usted fue testigo tuvo que perder trabajo? ☐SI ☐NO ☐NA (No Víctima)

Por favor, califique la firmeza con la que no está de acuerdo o esté de acuerdo con cada una de las siguientes declaraciones dando círculos al número apropiado. (1=Completamente en Descuerdo; 2=Algo En Desacuerdo; 3=Neutral; 4=Algo De Acuerdo; 5=Completamente de Acuerdo)	Completamente en Descuerdo	Algo En Desacuerdo	Neutral	Algo De Acuerdo	Completamente de Acuerdo
En este proyecto, existe una alta probabilidad de sufrir lesiones o daños debido *a una caída de altura, resbalón o tropiezo* **si no sigo los procedimientos de seguridad**	1	2	3	4	5
En este proyecto, existe una alta probabilidad de que resulte lesión o daño debido *a derrumbe de zanjas o excavaciones, por maquinaria sin protección o atrapado entre equipos* **si no sigo los procedimientos de seguridad**	1	2	3	4	5
En este proyecto, existe una alta probabilidad de que resulte lesión o daño debido *a objetos que caen/vuelan o ser golpeado por vehículos/equipo* **si no sigo los procedimientos de seguridad**	1	2	3	4	5
En este proyecto, existe una gran probabilidad de que resulte lesión o daño debido *a la electrocución* **si no sigo los procedimientos de seguridad**	1	2	3	4	5
Yo puedo cambiar practicas inseguras en el trabajo	1	2	3	4	5
Yo puedo modificar las condiciones de trabajo para que sean más seguras	1	2	3	4	5
Yo estoy capaz de tomar medidas para prevenir lesiones o accidentes en el trabajo	1	2	3	4	5
Yo puedo cambiar el comportamiento inseguro de otros en el trabajo	1	2	3	4	5
Yo tengo control sobre si usa equipo de seguridad (cascos, lentes de seguridad, etc.)	1	2	3	4	5
Yo tengo control sobre practicar o no practicar conductas de trabajo seguras	1	2	3	4	5
Yo puedo reportar riesgos de seguridad que yo veo	1	2	3	4	5
La gerencia está preocupada por la seguridad de los empleados	1	2	3	4	5
La gerencia de este proyecto cree que la seguridad es más importante que el calendario y la fecha limite	1	2	3	4	5
La gerencia realiza un seguimiento cuando hay un problema o preocupación sobre la seguridad	1	2	3	4	5
La gerencia de este proyecto funciona bien con otros subcontratistas para garantizar las condiciones de trabajo más seguras posibles en este lugar de trabajo	1	2	3	4	5
La seguridad es importante para mi compañía, incluso cuando el trabajo se ejecuta atrasado	1	2	3	4	5
Empleados de varias compañías trabajan bien juntos para dirigir los problemas de seguridad en este Proyecto	1	2	3	4	5
La gerencia se asegura de que los trabajadores sigan muy de cerca las reglas y procedimientos de seguridad del sitio	1	2	3	4	5
La gerencia piensa que la seguridad es más importante que la productividad	1	2	3	4	5
Los empleados pueden discutir sus preocupaciones sobre la seguridad con la gerencia	1	2	3	4	5
Hay suficiente oportunidad para discutir y tratar los problemas de seguridad en las reuniones	1	2	3	4	5
Hay comunicación abierta sobre asuntos de seguridad dentro de este lugar de trabajo	1	2	3	4	5
Los empleados son consultados regularmente sobre cuestiones de salud y seguridad en el lugar de trabajo	1	2	3	4	5
Se da alta prioridad a los problemas de seguridad en los programas de capacitación	1	2	3	4	5
La capacitación en salud y seguridad abarca los tipos de situaciones a las que los empleados se enfrentan en sus trabajos	1	2	3	4	5
Los empleados reciben capacitación completa en temas de salud y seguridad para su trabajo	1	2	3	4	5
Los procedimientos y las prácticas de seguridad son suficientes para evitar incidentes	1	2	3	4	5
Los procedimientos y prácticas de seguridad en esta organización son útiles y efectivos	1	2	3	4	5