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[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

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ABSTRACT

Problem: The present study describes a response to eight tragic deaths over an eighteen month times span on a fast track construction project on the largest commercial development project in U.S. history. *Methods:* Four versions of a survey were distributed to workers, foremen, superintendents, and senior management. In addition to standard Likert-scale safety climate scale items, an open-ended item was included at the end of the survey. *Results:* Safety climate perceptions differed by job level. Specifically, management perceived a more positive safety climate as compared to workers. Content analysis of the open-ended item was used to identify important safety and health concerns which might have been overlooked with the qualitative portion of the survey. *Discussion:* The surveys were conducted to understand workforce issues of concern with the aim of improving site safety conditions. Such efforts can require minimal investment of resources and time and result in critical feedback for developing interventions affecting organizational structure, management processes, and communication. *Summary:* The most important lesson learned was that gauging differences in perception about site safety can provide critical feedback at all levels of a construction organization. *Impact on the Industry:* Implementation of multi-level organizational perception surveys can identify major safety issues of concern. Feedback, if acted upon, can potentially result in fewer injuries and fatal events.

1. Objective

The purpose of this case study is to: (a) provide a general background on how researchers utilized a multi-faceted assessment approach and collaborated with different stakeholders to respond to eight tragic deaths at the largest privately owned commercial construction development project in U.S. history, the CityCenter and Cosmopolitan construction projects in Las Vegas, Nevada; (b) describe the theoretical framework of safety climate that guided researchers to develop a safety needs assessment survey to assess the perceptions, attitudes, and behaviors of project workers, foremen, superintendents, and senior management executives; (c) provide a descriptive analysis of survey data obtained from project employees at four organizational levels with the goal of providing feedback to improve safety on the project; and (d) describe how multiple data sources and mixed methods were used to provide deeper insights into the safety issues on the site.

2. Background

In June of 2008, CPWR the Center for Construction Research and Training (formerly The Center to Protect Workers' Rights)[1] was asked to participate as an independent third party evaluator to conduct a safety needs assessment survey and other worksite assessments of safety

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[1] Over the past 20 years, CPWR has operated a National Center for Construction Safety and Health (Construction Center). The Center is dedicated to improving safety and health performance in the industry by having built a multi-disciplinary, integrated research team, (2) being an integral part of the construction industry, and (3) having an extensive record of major achievements (National Academies Press, 2009).

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programs and practices on the CityCenter and Cosmopolitan construction projects. The site consisted of a massive workforce spanning a wide variety of trades, which grew from 5,200 workers to over 7,000 workers by the end of 2008. Twenty-four separate buildings were under construction on a 45-acre site, with a combined price tag of $12.7 billion dollars. The General Contractor ran all aspects of the project on the first jobsite, which consisted of 22 buildings. The second jobsite, which included two additional buildings, was managed by the Construction Owner. A distance of only 50 feet separated the two sites.

The construction project began in 2006, with an expected completion date of December 2009. Worksite safety had come into question after eight fatal incidents had occurred on the sites over 18 months. Workers had walked off the job in June of 2008 to protest their concerns, and the alarming number of deaths, injuries, and near-misses that had occurred at these jobsites was brought to the public's attention by Alexandra Berzon (2008) in her Pulitzer Prize-winning articles published in the *Las Vegas Sun*. Both the General Contractor and the Southern Nevada Building Trades Council sought help from CPWR to provide training, a worksite assessment, and a safety needs assessment survey that could help identify problems and provide recommendations to improve safety on the site.

3. Introduction

Construction workers suffer a disproportionate share of occupational fatalities and lost time injuries (CPWR the Center for Construction Research and Training, 2008; Ringen, Seegal, & Englund, 1995) and construction continues to be one of the most dangerous industries. Based on data from the Bureau of Labor Statistics (BLS, 2006), the construction industry accounts for a substantial percentage of the occupational injuries and fatalities (21.2% of all occupational injuries in 2006) relative to other industries, although it comprises approximately 6% of the workforce in the United States. Occupational injuries and fatalities within the construction industry have also been associated with considerable financial costs. It has been estimated that occupational injuries within the construction industry cost over $10 billion per year (Waehrer, Dong, Miller, Haile, & Men, 2007). To exacerbate the risks endured by the industry, work progresses on most construction projects with fast track schedules that offer big financial payoffs in completion incentives. Millions of dollars are awarded for getting the job done on time, or as quickly as possible (Berzon, 2008).

Recent articles in the *Journal of Safety Research* have focused on the issue of safety in construction. For example, Torner and Pousette (2009) looked at characteristics of safety from the perspectives of supervisors and experienced workers to identify what elements determine high levels of safety. Interviews with members at different organizational levels within the construction workforce revealed that safety management, organizational structures, defined roles, procedures, and resources are some of the key components in executing projects with high levels of safety. The difficulty arises in moving these concepts from research to practice. It is a complex process that involves understanding organizational cultures as well as individual perceptions and attitudes. Integrating the lessons learned from research into the sector is a slow, continuous process requiring multifaceted approaches and tactics. This study documents the efforts of one such attempt to integrate research into practice in addressing safety concerns.

3.1. Research Approach

At the time CPWR was invited to provide technical assistance on the site, a team of investigators from Nevada OSHA was already investigating the fatal incidents. Data collection on the fatality investigations was ongoing and the construction company was unable to share this information with CPWR. CPWR invited subject matter experts in the fields of industrial hygiene, occupational health psychology, and ergonomics from the National Institute for Occupational Safety and Health, Colorado State University, Illinois Institute of Technology, and West Virginia University to join the assessment team and develop an assessment strategy and protocol.

After the initial site visit in June of 2008, CPWR's Worksite Assessment Team determined that its assessment would include the following six components: (a) observations of safety orientation training programs; (b) observations of safety staff while observing interactions with personnel on site; (c) observations of safety management programs and practices; (d) face-to-face interviews with selected personnel; (e) fall hazard identification and control audit of selected buildings on site, and (f) safety needs assessment surveys. This study focuses on the development and administration of these surveys, which were a key component of the overall worksite assessment.

Four different safety needs assessment surveys were developed and distributed to craft workers, foremen, superintendents, and executives with the aim of assessing safety climate perceptions, safety behaviors, and other safety-related issues. The surveys were used as tools to gauge the "temperature" or "pulse" of safety on the jobsites following the eight tragic fatalities. The surveys were tailored to the site-specific conditions and needs of the clients – the General Contractor and the Southern Nevada Building Trades Council. Both management and labor representatives were interested in knowing about the workforce perceptions of safety as they related to the General Contractor managing the sites, the subcontractors hired by the General Contractor, and the individuals working on the sites. In addition, workers were given an opportunity to express their concerns in an open-ended format that asked them to describe what they perceived the safety-related issues were and what they believed the solutions should be. This approach is consistent with the performance feedback literature, which suggests that in order to gain a more accurate and in-depth understanding of the status of safety in an organization, feedback should be sought from multiple sources (e.g., workers, supervisors, and senior management; Borman, 1997) and with multiple methods (e.g., quantitative and qualitative; Hancock, Windridge, & Ockleford, 2007).

By means of this multi-level survey, potential problems were identified and recommendations were provided in order to resolve them. The survey provided an independent, objective assessment by the third party evaluation group led by CPWR. The use of multiple sources of data provided a unique lens through which the organization could identify its developmental needs and undertake appropriate organizational changes related to workplace safety. The open-ended section of the survey allowed for identification of problems and concerns that the safety needs assessment survey items may have overlooked or that were unable to be asked due to the practical constraints of survey length. Furthermore, it provided workers the opportunity to voice their concerns and suggestions in their own words. Adopting a qualitative approach to occupational safety research is based on the premise that qualitative research can provide a deeper understanding of social factors in the workplace that may play a role in the occupational safety and health of workers in high-risk industries, such as construction (National Institute for Occupational Safety and Health [NIOSH], 2008).

3.2. Defining Safety Climate and its Importance to Construction

Although the importance of safety in construction should be evident, there are many barriers to safety and health management systems (Mohamed, 2002). For example, it is tempting for management to emphasize speed and schedules in the short term in order to increase productivity. However, prioritizing and valuing safety (i.e., having a positive safety climate) have been shown to enhance safety performance and decrease employee injuries (Zohar, 2002).

Consequently, safety researchers have started to recognize the critical role of safety climate in workplace safety because of its consistent relationships with important safety-related outcomes (Hofmann & Stetzer, 1996; Johnson, 2007). Safety climate is a term used by safety professionals to describe employee perceptions regarding overall safety within the workplace (Clarke, 1999, 2003; Cooper, 2000). It differs from the term safety culture, which is used to describe the underlying beliefs, values, and attitudes about safety toward work and the organization in general. Over the past 30 years, both terms have been confused and intermingled (Glendon, Clarke, & MCKenna, 2006; Mearns, Whitaker, & Flin, 2003). Specifically, safety climate is said to describe safety culture in action in that it "reflects the perception of how we do things around here" (Cox & Cox, 1991). Safety climate assessment can be considered as "taking the temperature of" or "pulse of" the workforce to determine perceptions and attitudes toward safety on a site. The need to improve understanding of construction safety culture and climate was recognized by researchers and stakeholders via inclusion as Strategic Goal 8 of the National Occupational Research Agenda (NORA) National Construction Agenda (National Institute for Occupational Safety and Health [NIOSH], 2008).

Measuring safety climate is a relatively new endeavor (Yule, 2003). Prior to Zohar's (1980) study of the Israeli manufacturing sector, the assessment of an organization's safety climate had never specifically focused on assessing the attitudes of employees in relation to safety. Since then, there have been numerous studies that have aimed at developing a reliable measure of safety climate. The construct of safety climate has been conceptualized to include factors such as management commitment to safety, supervisor support for safety, safety systems/practices, and priority of safety over production, among others (Flin, Mearns, O'Connor, & Bryden, 2000; Griffin & Neal, 2000). Recent meta-analytic evidence has confirmed that safety climate is associated with greater safety performance and decreased rates of accidents and injuries (Christian, Bradley, Wallace, & Burke, 2009; Clarke, 2006). Furthermore, the Occupational Safety and Health Administration (OSHA, 2009) has also suggested that the development of a strong safety climate has the most influence on accident reduction of any process.

Consistent with the above, emerging empirical evidence from construction research has linked positive safety climate with increased safe work behaviors (Larsson, Pousette, & Tőrner, 2008; Mohamed, 2002; Pousette, Larsson, & Torner, 2008), lower injury severity (Gillen, Baltz, Gassel, Kirsch, & Vaccaro, 2002), and lower rates of injury underreporting (Probst, Brubaker, & Barsotti, 2008). As a result, safety climate has become a desired target of organizational development initiatives aiming to improve the occupational safety and health of construction workers (Mohamed, 2002).

A key phase of safety interventions is the assessment and identification of developmental needs pertaining to safety (Cummings & Worley, 2005). Hellervik, Hazucha, and Schneider (1992) point out that developmental need identification begins with some type of assessment, such as surveys, focusing on what should be changed. In fact, a number of safety climate measures have been developed and used for organizational assessment purposes in the construction industry (e.g., Dedobbeleer & Beland, 1991; Fang, Chen, & Wong, 2006; Jorgensen, Sokas, Nickels, Gao, & Gittleman, 2007; Pousette et al., 2008; Siu, Phillips, & Leung, 2003). These measures most often take the form of self-report surveys that are completed by employees (Guldenmund, 2000). The use of safety climate measures has offered several advantages, such as predicting safety behaviors and injuries, diagnosing safety issues and providing feedback to organizational decision-makers, helping organizations guide action and change, and being easy and cost-effective to administer (Seo, Torabi, Blair, & Ellis, 2004; Johnson, 2007).

As the concept receives more recognition and importance, there has been a growing increase in the number of safety climate measures reported in the literature. However, there is no consensus on key aspects of the concept of safety climate (Glendon et al., 2006; Guldenmund, 2000; Flin et al., 2000). Other concerns focus on the lack of consistency in what is considered an appropriate set of metrics for determining the nature of a given workplace safety climate. Safety climate surveys vary widely in the kind and number of issues assessed. The present study compared employee perceptions at different job levels (i.e., workers, foremen, superintendents, and executives) of management commitment to safety and safety practices responses, which have been identified as two of the most frequently studied indicators of safety climate (Flin et al., 2000; Neal & Griffin, 2004).

3.3. Benefits of Using Multiple Sources of Data to Assess Safety Climate and Hypotheses

Research in the performance feedback realm has pointed to the need to include perspectives from multiple sources (or levels) of raters when trying to understand and improve behavior. It is assumed that multi-source feedback provides unique information from different perspectives, adding incremental validity to performance assessment (Borman, 1997). In practice, many organizations implement multi-source ratings to provide managers with performance feedback from different perspectives (e.g., subordinates, peers, and supervisors; Brutus, Fleenor, & London, 1998). Research on multi-source ratings of managers' performance has shown to be beneficial for managers by increasing awareness of their strengths and weaknesses, fostering constructive dialogue with other sources of raters (e.g., subordinates or superiors), and motivating them to change (Atwater, Roush, & Fischthal, 1995; Reilly, Smither, & Vasilopoulos, 1996; Waldman, & Atwater, 1998).

In addition, studies of multi-source feedback (Borman, 1997; Brutus et al., 1998; London & Wohlers, 1991) and performance ratings from different sources (Conway & Huffcutt, 1997; Harris & Schaubroeck, 1988) have consistently shown discrepancies among different groups of raters (e.g., supervisors, subordinates). These differences may be attributed to varying perspectives on performance and/or diverse opportunities to observe performance (Lawler, 1967). In this study, it was expected that feedback about safety climate from the four organizational levels would be different, and therefore, each source would provide a unique perspective to facilitate the change needed. Management groups have been considered key agents in organizations (Eisenberger, Huntington, Hutchison, & Sowa, 1986) and thus, their ratings could be considered the Construction Management Company's "self-ratings." In contrast, workers' and, to a lesser degree, foremen ratings could be considered as "upward ratings" for the organization, a term conventionally used in the performance feedback literature. By administering the surveys to all levels, discrepancies between the "self-ratings" and "upward ratings" can be identified, which in turn can be used to motivate the needed organizational changes.

The importance of examining differences in perceptions between employees and management has been noted by other researchers. For instance, differences in beliefs have been linked to various negative consequences such as quality (Howard & Foster, 1999), perceived fairness

(Niehoff & Moorman, 1996), and organizational commitment (McElroy & Morrow, 1995). Prussia, Brown, and Willis (2003) found that workers and managers at a steel company shared similar perceptions regarding the factors that influence safe behavior decisions, although the workers and managers held different views regarding factors such as safety climate.

Based on prior research (e.g., Conway & Huffcutt, 1997; Borman, 1997), it was expected that workers, foremen, superintendents, and senior managers would have varying perspectives about workers' safety behaviors and worker fatigue as the reason for their mistakes at work. Superintendents and senior management are actively involved in construction projects; however, they tend not to be present on the jobsite daily. Therefore, their views about workers' safety behaviors and interpretation of workers' mistakes being due to fatigue might be different than the workers' views. Workers and foremen may also have different views on the above factors because of the different roles they play. Because ratings from these sources could capture different perspectives, we expected that their ratings on these factors would be different. Based on the above review, we hypothesized that safety climate and safety-related outcomes would be viewed similarly by respondents within the same group, but would be viewed differently by respondents across groups. Additionally, it was expected that safety climate would predict safety-related outcomes across the four organizational levels.

Hypothesis 1. Workers, foremen, superintendents, and senior management were expected to have similar views about safety climate (i.e., management commitment to safety and safety practices) and safety-related outcomes (i.e., safety performance, safety knowledge, and fatigue) within the correspondent group, but hold different views from each other.

Hypothesis 2. It was expected that safety climate (i.e., management commitment to safety and safety practices) would predict safety-related outcomes (i.e., safety performance, safety knowledge, and fatigue) across the four organizational levels (i.e., workers, foremen, superintendents, and senior management).

3.4. Benefits of Qualitative Methodology and its Applications in Workplace Safety

The benefits of qualitative research have been demonstrated in many realms. Although a qualitative approach has been less common than other methods in safety research, researchers have found that qualitative methods were useful for understanding workers' perceptions of safety and risk. Mullen (2004) conducted a qualitative study using interview data with the goal of identifying factors affecting individual safety behavior. Results of the study pointed to important social and organizational factors that may lead to unsafe behavior beyond the job design and engineering systems that are typically studied. Additionally, qualitative methods provided researchers with a deeper understanding of construction workers' perceptions of risk control related to falls from height and skin disease (Holmes, Lingard, Yesilyurt, & De Munk, 1999).

Other investigations of workplace safety have integrated qualitative and quantitative methods to gain additional information about safety issues. In their research on Hazmat logistics and industrial risk, Pezzullo and De Filippo (2009) asked a group of tanker drivers to explain important safety terms and processes in their own words. They used this information to create categories from the workers' responses and integrated the data with additional quantitative data. Pezzullo and De Filippo concluded that this integration of qualitative and quantitative approaches allowed them to obtain a better understanding of workers' conceptualizations about risk, safety behaviors, and attitudes toward safety. Furthermore, McDonald, Corrigan, Daly, and Cromie (2000) utilized qualitative and quantitative methodology, in the form of management interviews and survey data, in order to obtain a better understanding of safety culture across various aircraft maintenance organizations.

The rationale for taking a qualitative, open-ended response approach as part of the needs assessment survey had three facets. First, including an open-ended item was an acknowledgement that workers might be aware of additional issues that survey developers did not think to ask. Second, it was a recognition of the constraints placed on the length of the survey. It would not be practical for the assessment team to ask about every possible issue on these jobsites and maintain a reasonable survey length. Third, a qualitative approach could provide the assessment team with a deeper understanding of the workers' perspectives of their environment. As suggested by Kidd (2002), a qualitative approach to research is conducted without preconceived expectations for how people will respond. Furthermore, as noted by Hancock et al. (2007), qualitative research is essential if the goal is to understand individuals' perceptions of their experiences, their interpretations of the problems, their ideas for solutions, and to capture all of this in their own words. Thus, to truly understand what was occurring at these jobsites, workers needed to be allowed and encouraged to use their own words to describe what was happening in addition to endorsing responses to Likert-type survey items.

4. Method

4.1. Participants

Separate safety needs assessment surveys were administered to four groups of employees working on the above-described construction project: executives ($n = 17$; 100% response rate), superintendents ($n = 61$; 43% response rate), foremen ($n = 134$; 96% response rate), and workers ($n = 5{,}268$; 87% response rate). Responses to the safety-related open-ended item included in the workers' survey were obtained from 1,219 construction workers (23% of the total 5,268 workers).

All persons who agreed to participate were given the option of completing either an English or Spanish version of the survey. Of the workers completing the survey 4,704 (89%) completed the English version and 564 (11%) completed the Spanish version. All of the foremen, superintendents, and executives completed the English version of the survey.

Of the 5,268 construction workers, two thirds (68%) worked at the main construction site (hereafter referred to as Jobsite 1), whereas 25% worked on an adjacent site (hereafter referred to as Jobsite 2). All 61 superintendents who completed the survey worked on Jobsite 1. Nine hundred and eighty two workers (19%) who responded to the survey were apprentices and 3,967 (75%) were journeymen. Of the foremen, 43% of those completing the survey were general foremen, and 55% were classified as foremen. There were 43 superintendents and 12 assistant superintendents who completed the survey. Table 1 displays information about participants' age, race/ethnicity, job experience, and trade affiliation by job level.

Table 1
Demographics of Workers, Foremen, Superintendents, and Executives.

	Workers N = 5,268	Foremen N = 134	Superintendents N = 61	Executives N = 17
Age Categories				
14-19	88 (2%)	0%	0%	0%
20-24	445 (9%)	3 (2%)	0%	0%
25-34	1,380 (28%)	31 (24%)	3 (5%)	0%
35-44	1,415 (28%)	47 (36%)	16 (28%)	4 (24%)
45-54	1,123 (24%)	41 (31%)	24 (41%)	7 (41%)
55-64	405 (8%)	9 (7%)	15 (26%)	5 (29%)
65+	40 (1%)	0%	0%	1 (6%)
Race / Ethnicity				
Caucasian	2,341 (45%)	70 (52%)	44 (72%)	15 (88%)
Hispanic	1,850 (34%)	46 (34%)	3 (5%)	0%
African-American	376 (7%)	2 (1%)	1 (2%)	0%
Native American	164 (3%)	3 (2%)	3 (5%)	0%
Asian	65 (1%)	3 (2%)	0%	1 (6%)
Other	188 (4%)	9 (7%)	5 (8%)	0%
Missing	284 (6%)	1 (1%)	5 (8%)	1 (6%)
Experience on the Job				
< 3 Months Worked	1,976 (38%)	15 (11%)	19 (31%)	NA
>= 3 Months Worked	2,840 (54%)	118 (88%)	36 (59%)	NA
Missing	452 (9%)	1 (1%)	6 (10%)	NA
Trade				
Carpenter	1,120 (21%)	80 (60%)	NA	7 (64%)
Electrician	840 (16%)	0%	NA	0%
Plumber / Pipefitter	825 (16%)	0%	NA	0%
Sheet Metal Worker	559 (11%)	0%	NA	0%
Laborer	379 (7%)	35 (26%)	NA	3 (27%)
Insulator	202 (4%)	0%	NA	0%
Operating Engineer	152 (3%)	5 (4%)	NA	0%
Cement Mason	81 (2%)	8 (6%)	NA	0%
Iron Worker	50 (1%)	0%	NA	1 (9%)
Painter	45 (1%)	0%	NA	0%
Missing	209 (4%)	2 (1%)	NA	0%

4.2. Measures

Four separate safety needs assessment surveys were developed by a team of occupational safety and health experts from CPWR, the National Institute for Occupational Safety and Health, Colorado State University, and Illinois Institute of Technology. The surveys were divided into three sections: questions about the General Contractor (GC) (e.g., management commitment to safety), questions about the sub-contractor (e.g., safety program, foreman safety management), and questions about individuals' perceptions of safety (e.g., safety practices, safety knowledge, safety behaviors, and media coverage). Each survey contained up to a total of 44 questions. Except for the open-ended question, which is described below, all survey items used a 6-point Likert-type scale, with response categories ranging from 1 ("strongly disagree") to 6 ("strongly agree"). The surveys were created in English and Spanish. A bi-lingual staff member of CPWR translated the survey into Spanish and this version was pilot tested with bi-lingual trainers to ensure its accuracy. Although the surveys administered to each organizational level were similar, not all the items were the same across the surveys. Tables 2, 3, and 4 present the items that were the same across at least three of the four surveys. Descriptions of the specific measures used to examine Hypotheses 1 and 2 (i.e., of management commitment to safety, safety practices, safety behaviors, safety knowledge, and fatigue) follow. Scale scores for management commitment to safety, safety practices, and safety behaviors were computed by summing up individual items.

Management commitment to safety was assessed with four items, measuring the extent to which the General Contractor's top management and safety personnel placed high priority on safety and communicated and acted on safety issues effectively. These items included, "Safety is visible on this job – for example, I have seen safety personnel or site supervisors or site management doing daily safety checks," "The GC thinks that jobsite safety is more important than job schedules and deadlines," "GC safety personnel step in to stop unsafe operations," and "The GC safety staff follows up when there is a problem - it gets fixed right away and stays that way." Alpha coefficients ranged from .75 to .84 for the four surveys.

Safety practices were assessed with four items, measuring the extent to which safety-related training, toolbox talks, and site-specific information, as well as personal protective equipment were adequate and available. Items included "There is always enough personal protective equipment available to allow work to be done safely," "Toolbox talks about safety are given regularly," "I always get enough site-specific information about a job to do it safely," and "I have received enough training to do my work safely." On the foremen, superintendent, and senior management surveys, the last two items referred to workers rather than self. Alpha coefficients ranged from .61 to .78 across the four surveys.

Although the focus of the surveys was safety climate perceptions, several important safety outcome variables were also measured, including safety performance, safety knowledge, and fatigue (Christian et al., 2009). For the foremen, superintendents, and executives, all items referred to workers rather than self.

Two items assessed workers' safety performance. These included "I always report safety hazards that I see" and "I assist others to make sure they perform their work safely." Alpha coefficients for this scale ranged from .56 to .91 across the four groups. One item assessed whether workers knew how to report hazards at work (i.e., safety knowledge): "I know who to report a hazard to when I see one on the job." Fatigue was

Table 2
Comparison of item-specific responses about safety management by the general contractor across the four organizational levels.

Questions	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Missing	Mean± std. dev.
Safety is visible on this job–for example, I have seen safety personnel or site supervisors or site management doing daily safety checks.								
Construction Workers	161 (3%)	245 (5%)	291 (6%)	919 (17%)	2198 (42%)	1024 (19%)	430 (8%)	**4.62±1.22**
Foremen	0 (0%)	1 (1%)	3 (2%)	9 (7%)	59 (44%)	61 (46%)	1 (1%)	**5.32±0.76**
Superintendents	0 (0%)	0 (0%)	0 (0%)	4 (7%)	18 (30%)	38 (62%)	1 (2%)	**5.57±0.62**
Executives	0 (0%)	0 (0%)	0 (0%)	0 (0%)	5 (29%)	11 (65%)	1 (6%)	**5.69±0.48**
The GC thinks that job site safety is more important than job schedules and deadlines.								
Construction Workers	278 (5%)	383 (7%)	495 (9%)	1177 (22%)	1620 (31%)	886 (17%)	429 (8%)	**4.27±1.40**
Foremen	0 (0%)	4 (3%)	3 (2%)	13 (10%)	58 (43%)	55 (41%)	1 (1%)	**5.18±0.92**
Superintendents	0 (0%)	0 (0%)	0 (0%)	4 (7%)	24 (39%)	31 (51%)	2 (3%)	**5.46±0.62**
Executives	0 (0%)	1 (6%)	0 (0%)	1 (6%)	5 (29%)	10 (59%)	0 (0%)	**5.35±1.06**
GC safety personnel step into stop unsafe operations.								
Construction Workers	163 (3%)	277 (5%)	368 (7%)	1078 (20%)	1941 (37%)	922 (18%)	519 (10%)	**4.50±1.25**
Foremen	1 (1%)	4 (3%)	2 (1%)	9 (7%)	50 (37%)	67 (50%)	1 (1%)	**5.29±0.97**
Superintendents	1 (2%)	0 (0%)	1 (2%)	0 (0%)	23 (38%)	34 (56%)	2 (3%)	**5.47±0.84**
Executives	0 (0%)	0 (0%)	0 (0%)	1 (6%)	8 (47%)	7 (41%)	1 (6%)	**5.38±0.62**
The GC safety staff follows up when there is a problem- it gets fixed right away and stays that way.								
Construction Workers	199 (4%)	328 (6%)	481 (9%)	1414 (27%)	1598 (30%)	627 (12%)	621 (12%)	**4.24±1.26**
Foremen	1 (1%)	1 (1%)	6 (4%)	19 (14%)	61 (46%)	45 (34%)	1 (1%)	**5.05±0.92**
Superintendents	1 (2%)	0 (0%)	2 (3%)	3 (5%)	25 (41%)	29 (48%)	1 (2%)	**5.30±0.93**
Executives	0 (0%)	0 (0%)	0 (0%)	0 (0%)	6 (35%)	10 (59%)	1 (6%)	**5.63±0.50**
GC's safety program works well together with other sub contractor safety programs–it is clear to me who is responsible for what.								
Construction Workers	191 (4%)	342 (6%)	492 (9%)	1189 (23%)	1744 (33%)	711 (14%)	599 (11%)	**4.30±1.29**
Foremen	(1%)	5 (4%)	6 (4%)	21 (16%)	63 (47%)	37 (28%)	0 (0%)	**4.86±1.09**
Superintendents	(2%)	0 (0%)	2 (3%)	8 (13%)	28 (46%)	20 (33%)	2 (3%)	**5.07±0.94**
Executives	(0%)	0 (0%)	0 (0%)	4 (24%)	8 (47%)	4 (24%)	1 (6%)	**5.00±0.73**

Reponses that were statistically significantly different between the 4 groups are indicated in shades of gray. For example, for the first question, worker responses were significantly different (light gray) from foremen, superintendent and top management executive responses (dark gray).

assessed with one item about whether workers' mistakes were due to their fatigue. For workers, the item read, "Fatigue is an issue for me – I have caught myself making mistakes on the job when I was tired."

The following open-ended item was included at the end of only the workers' survey, to provide respondents with an opportunity to give additional feedback about the status of safety on their worksite: "Please add any additional comments about safety on this job and actions you think would improve safety."

The coding scheme for the open-ended item was created through an iterative content analysis process. Spanish responses were translated into English by a research associate fluent in both English and Spanish and knowledgeable about the construction industry. Members of the research team read through the responses and constructed initial categories. These categories were then combined or integrated with other categories with the goal of creating a coding scheme of categories that were exhaustive and mutually exclusive.

The responses of 285 workers were eliminated from the qualitative analysis data because the respondent simply wrote in this section that he/she did not have a comment or it was determined that the information provided was not relevant to health or safety. Each of the remaining 934 open-ended responses was coded by four independent coders, and Krippendorff's alpha (Krippendorff, 2004) assessment of inter-coder reliability yielded an agreement coefficient $\alpha = .74$ with a 95% confidence interval (.73, .75). Coding disagreements were resolved through group discussion until consensus was reached.

4.3. Process for Administering the Surveys

Worker surveys were conducted during a 10-hour OSHA Hazard Awareness program, which was provided to all workers, foremen, superintendents, and executives on the sites between July 2008 and December 2008. All workers who had not previously received OSHA 10-hour training (70% of workers on site) were required to participate in a two-day, 10-hour hazard awareness training program. This program is referred to as SMART MARK for the building trades. These classes were staffed by CPWR trainers, who have been certified by OSHA to conduct hazard awareness training nationwide. Trainers were recruited from a pool of 5,000 members. Of the 9,300 workers on the two sites (as of December 19, 2008), it was initially estimated that 70% of the workforce had not received OSHA 10-hour training. This survey was only distributed to those workers who had not previously received OSHA 10-hour training. Workers who had not previously received such training were identified by subcontractors on the site.

Foremen received the survey during a day-long safety culture training session. At the time of the fatal incidents, the General Contractor hired a consultant to address the impact of these events on the safety culture of the site. Superintendents had an opportunity to complete the survey during their weekly superintendent meetings, and top management executives were individually provided the survey and a self-addressed envelope to return to CPWR during the same time frame as the 10-hour training.

Prior to implementation, the four surveys were shared with the General Contractor and the head of the Southern Nevada Building Trades Council as part of the participatory process to evaluate safety on the sites. Several questions were added based on input from both labor and management.

The protocol for administering the surveys was complicated by the nature of the sites. A construction site is not a training facility. Makeshift classrooms were identified in trailers and workspaces on the sites to accommodate the need for immediate 10-hour hazard awareness training.

Table 3
Comparison of item-specific responses about safety management by the subcontractors across the four organizational levels.

Questions	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Missing	Mean± std. dev.
My subcontractor's safety program works well together with other subcontractor's safety programs								
Construction Workers	90 (2%)	179 (3%)	272 (5%)	1118 (21%)	2066 (39%)	825 (16%)	718 (14%)	**4.62±1.09**
Foremen	0 (0%)	11 (8%)	9 (7%)	13 (10%)	66 (49%)	29 (22%)	6 (4%)	**4.73±1.15**
Superintendents	0 (0%)	0 (0%)	2 (3%)	7 (11%)	27 (44%)	24 (39%)	1 (2%)	**5.22±0.78**
Executives	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Safety is important to the GC/ my subcontractor – he or she mention sit often when talking to crews on site.								
Construction Workers	111 (2%)	148 (3%)	210 (4%)	842 (16%)	1973 (37%)	1408 (27%)	576 (11%)	**4.84±1.14**
Foremen	0 (0%)	1 (1%)	1 (1%)	5 (4%)	68 (51%)	59 (44%)	0 (0%)	**5.37±0.67**
Superintendents	0 (0%)	0 (0%)	0 (0%)	0 (0%)	23 (38%)	37 (61%)	1 (2%)	**5.62±0.49**
Executives	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
My foreman has the safety knowledge needed for th ehazards we face on this job.								
Construction Workers	115 (2%)	130 (2%)	161 (3%)	682 (13%)	2040 (39%)	1576 (30%)	564 (11%)	**4.94±1.12**
Foremen	1 (1%)	2 (1%)	0 (0%)	4 (3%)	66 (49%)	61 (46%)	0 (0%)	**5.35±0.79**
Superintendents	0 (0%)	0 (0%)	1 (2%)	7 (11%)	22 (36%)	30 (49%)	1 (2%)	**5.35±0.76**
Executives	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
My foreman makes sure we follow site safety rules and procedures very closely.								
Construction Workers	109 (2%)	111 (2%)	189 (4%)	679 (13%)	1973 (37%)	1661 (32%)	546 (10%)	**4.97±1.11**
Foremen	1 (1%)	1 (1%)	0 (0%)	6 (4%)	62 (46%)	63 (47%)	1 (1%)	**5.38±0.75**
Superintendents	0 (0%)	0 (0%)	0 (0%)	3 (5%)	21 (34%)	36 (59%)	1 (2%)	**5.55±0.59**
Executives	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
My foreman thinks that safety is more important than productivity.								
Construction Workers	140 (3%)	207 (4%)	260 (5%)	841 (16%)	1865 (35%)	1310 (25%)	645 (12%)	**4.73±1.23**
Foremen	2 (1%)	4 (3%)	4 (3%)	13 (10%)	61 (46%)	44 (33%)	6 (4%)	**5.02±1.05**
Superintendents	0 (0%)	0 (0%)	3 (5%)	6 (10%)	19 (31%)	31 (51%)	2 (3%)	**5.32±0.86**
Executives	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Reponses that were statistically significantly different between the 4 groups are indicated in shades of gray. For example, for the first question, worker and foremen responses were significantly different (light gray) from superintendent responses (dark gray) *N/A applies to questions not asked and therefore do not apply to that specific group.

Workers were cycled into the training for two days, and received half of the 10-hour course the first day and half on the second. The hazard awareness course was provided as part of on-the-job training, so workers returned to their jobs after their classes.

First, a CPWR trainer/training coordinator provided background information describing the purpose of the surveys – to collect information about safety on the sites. The trainer then explained the voluntary nature of the surveys and noted that there were no personal identifiers collected. Participants were then provided the surveys and asked to complete them in 10 minutes. Once completed, the surveys were collected by the trainer/coordinator and put in a sealed self-addressed envelope and sent directly back to CPWR for data entry and analysis. Once the surveys were received by CPWR, individual surveys were given a unique identifier for data entry.

The survey was pilot tested with workers only on the site for two weeks to evaluate the specificity and sensitivity of the questions and the viability of the protocol for integration into the OSHA 10-hour training classes.

4.4. Statistical Analyses

Quantitative analyses of the safety-related perceptions of the General Contractor, subcontractor, and individuals are presented at both the item and scale levels. Mean group differences were examined with *t*-tests, analysis of variance, and multivariate analysis of variance. In addition, multiple regression analysis was employed to study the extent to which management commitment to safety and safety practices predicted safety behavior, safety knowledge, and fatigue across the four job levels (i.e., workers, foremen, superintendents, and executives). All statistical analyses were performed using SAS for Windows Version 9.1 (SAS Institute Inc, 2004).

5. Results

Analyses of demographic and background characteristics of participants are presented first. These are followed by results from mean group comparisons of safety perceptions across organizational levels (i.e., Hypothesis 1). Then, multiple regression analyses results are described (i.e., Hypothesis 2). Lastly, results from the content analysis of the qualitative data are presented.

5.1. Demographic Analyses

Table 1 shows and compares the demographics of workers, foremen, superintendents, and executives.

Of all survey respondents ($n = 5{,}480$), the average number of years worked in the construction industry was 15 ± 11 years for workers, with a range from 1-57 years. A majority of the foremen (86%) had over 10 years of experience and had an overall average of 18 ± 9 years. All of the superintendents had worked 10+ years in construction, with an average of 27 ± 8 years. Executives had the most years worked in construction, with an average of 29 ± 8 years and a range of 15 to 47 years.

The distribution of workers by age shows that workers were younger than the other organizational groups (foremen, superintendents, and management executives). Thirty-three percent of the workers were aged>45, whereas 50% of foremen, 67% of superintendents, and 76%

Table 4
Comparison of item-specific responses about safety on the job across the four organizational levels.

Questions	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Missing	Mean± std. dev.
Fatigue is an issue for me…I have caught myself making mistakes on the job when I was tired.								
Construction Workers	1491 (28%)	1653 (31%)	431 (8%)	438 (8%)	385 (7%)	190 (4%)	680 (13%)	**2.38±1.44**
Foremen	36 (27%)	60 (45%)	9 (7%)	13 (10%)	6 (4%)	1 (1%)	9 (7%)	**2.17±1.15**
Superintendents	8 (13%)	17 (28%)	5 (8%)	15 (25%)	0 (0%)	0 (0%)	4 (7%)	**3.11±1.41**
Executives	1 (6%)	3 (18%)	5 (29%)	4 (24%)	4 (24%)	0 (0%)	0 (0%)	**3.41±1.23**
Doing the work safely on this job has definite priority over getting it done on schedule.								
Construction Workers	186 (4%)	261 (5%)	349 (7%)	727 (14%)	1678 (32%)	1417 (27%)	650 (12%)	4.67±1.35
Foremen	5 (4%)	10 (7%)	7 (5%)	14 (10%)	62 (46%)	30 (22%)	6 (4%)	4.63±1.33
Superintendents	0 (0%)	3 (5%)	1 (2%)	10 (16%)	22 (36%)	24 (39%)	1 (2%)	5.05±1.05
Executives	0 (0%)	0 (0%)	0 (0%)	3 (18%)	8 (47%)	6 (35%)	0 (0%)	5.18±0.73
Sometimes I can't do my job safely because other trades are in my way.								
Construction Workers	548 (10%)	920 (17%)	470 (9%)	932 (18%)	1081 (21%)	635 (12%)	682 (13%)	**3.65±1.63**
Foremen	31 (23%)	43 (32%)	10 (7%)	18 (13%)	14 (10%)	10 (7%)	8 (6%)	**2.77±1.61**
Superintendents	16 (26%)	20 (33%)	6 (10%)	4 (7%)	9 (15%)	4 (7%)	2 (3%)	**2.69±1.63**
Executives	4 (24%)	7 (41%)	0 (0%)	1 (6%)	4 (24%)	0 (0%)	1 (6%)	**2.63±1.59**
There is always enough personal protective equipment available to allow work to bed one safely.								
Construction Workers	195 (4%)	250 (5%)	318 (6%)	708 (13%)	1919 (36%)	1229 (23%)	649 (12%)	**4.64±1.32**
Foremen	3 (2%)	3 (2%)	6 (4%)	7 (5%)	59 (44%)	51 (38%)	5 (4%)	**5.09±1.10**
Superintendents	1 (2%)	0 (0%)	3 (5%)	2 (3%)	24 (39%)	30 (49%)	1 (2%)	**5.30±0.96**
Executives	0 (0%)	0 (0%)	0 (0%)	3 (18%)	4 (24%)	9 (53%)	1 (6%)	**5.38±0.81**
I have received enough training to do my work safely.								
Construction Workers	79 (2%)	110 (2%)	152 (3%)	529 (10%)	2201 (42%)	1630 (31%)	567 (11%)	5.03±1.03
Foremen	1 (1%)	2 (1%)	6 (4%)	16 (12%)	64 (48%)	40 (30%)	5 (4%)	5.02±0.94
Superintendents	1 (2%)	1 (2%)	1 (2%)	5 (8%)	39 (64%)	12 (20%)	2 (3%)	4.97±0.89
Executives	0 (0%)	0 (0%)	2 (12%)	3 (18%)	8 (47%)	3 (18%)	1 (6%)	4.75±0.93
I always get enough site-specific information about a job to do it safely.								
Construction Workers	107 (2%)	169 (3%)	297 (6%)	865 (16%)	2027 (38%)	1133 (22%)	670 (13%)	**4.73±1.15**
Foremen	0 (0%)	2 (1%)	4 (3%)	14 (10%)	74 (55%)	34 (25%)	6 (4%)	5.05±0.80
Superintendents	0 (0%)	0 (0%)	1 (2%)	7 (11%)	27 (44%)	25 (41%)	1 (2%)	**5.27±0.73**
Executives	0 (0%)	0 (0%)	2 (12%)	1 (6%)	11 (65%)	2 (12%)	1 (6%)	4.81±0.83
I know what my safety responsibilities are at work.								
Construction Workers	51 (1%)	49 (1%)	75 (1%)	373 (7%)	2185 (41%)	1901 (36%)	634 (12%)	**5.22±0.88**
Foremen	0 (0%)	1 (1%)	1 (1%)	8 (6%)	72 (54%)	47 (35%)	5 (4%)	**5.26±0.68**
Superintendents	0 (0%)	2 (3%)	0 (0%)	5 (8%)	29 (48%)	24 (39%)	1 (2%)	**5.22±0.87**
Executives	0 (0%)	0 (0%)	1 (6%)	4 (24%)	10 (59%)	2 (12%)	0 (0%)	**4.76±0.75**
Sometimes I ignore a safety rule or policy in order to carry out an assignment to meet the schedule.								
Construction Workers	1447 (27%)	1431 (27%)	460 (9%)	551 (10%)	526 (10%)	193 (4%)	660 (13%)	**2.53±1.52**
Foremen	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Superintendents	31 (51%)	20 (33%)	3 (5%)	0 (0%)	3 (5%)	1 (2%)	3 (5%)	**1.74±1.13**
Executives	5 (29%)	10 (59%)	0 (0%)	1 (6%)	0 (0%)	1 (6%)	0 (0%)	**2.06±1.25**
I always report safety hazards that I see.								
Construction Workers	113 (2%)	180 (3%)	270 (5%)	732 (14%)	2026 (38%)	1339 (25%)	608 (12%)	**4.80±1.17**
Foremen	2 (1%)	2 (1%)	11 (8%)	22 (16%)	58 (43%)	34 (25%)	5 (4%)	**4.81±1.07**
Superintendents	0 (0%)	2 (3%)	3 (5%)	19 (31%)	24 (39%)	11 (18%)	2 (3%)	**4.66±0.96**
Executives	0 (0%)	0 (0%)	5 (29%)	5 (29%)	5 (29%)	2 (12%)	0 (0%)	**4.24±1.03**
I know who to report a hazard to when I see one on the job.								
Construction Workers	92 (2%)	101 (2%)	123 (2%)	402 (8%)	2245 (43%)	1671 (32%)	634 (12%)	5.08±1.03
Foremen	0 (0%)	1 (1%)	0 (0%)	15 (11%)	65 (49%)	48 (36%)	5 (4%)	5.23±0.71
Superintendents	0 (0%)	1 (2%)	0 (0%)	7 (11%)	28 (46%)	23 (38%)	2 (3%)	5.22±0.79
Executives	0 (0%)	0 (0%)	0 (0%)	4 (24%)	8 (47%)	5 (29%)	0 (0%)	5.06±0.75
I assist others to make sure they perform their work safely.								
Construction Workers	70 (1%)	81 (2%)	134 (3%)	679 (13%)	2290 (43%)	1361 (26%)	653 (12%)	**4.98±0.98**
Foremen	0 (0%)	2 (1%)	1 (1%)	13 (10%)	75 (56%)	38 (28%)	5 (4%)	**5.13±0.74**
Superintendents	0 (0%)	1 (2%)	1 (2%)	14 (23%)	30 (49%)	13 (21%)	2 (3%)	**4.90±0.82**
Executives	0 (0%)	0 (0%)	0 (0%)	7 (41%)	7 (41%)	2 (12%)	1 (6%)	**4.69±0.70**
Toolbox talks about safety are given regularly.								
Construction Workers	142 (3%)	167 (3%)	165 (3%)	437 (8%)	1914 (36%)	1720 (33%)	723 (14%)	**4.97±1.20**
Foremen	0 (0%)	2 (1%)	1 (1%)	7 (5%)	60 (45%)	59 (44%)	5 (4%)	**5.34±0.76**
Superintendents	0 (0%)	0 (0%)	2 (3%)	2 (3%)	23 (38%)	32 (52%)	2 (3%)	**5.44±0.73**
Executives	0 (0%)	0 (0%)	0 (0%)	0 (0%)	7 (41%)	9 (53%)	1 (6%)	**5.56±0.51**
Toolbox talks are helpful to me.								
Construction Workers	112 (2%)	128 (2%)	184 (3%)	693 (13%)	1959 (37%)	1493 (28%)	699 (13%)	4.91±1.13
Foremen	0 (0%)	2 (1%)	1 (1%)	10 (7%)	60 (45%)	56 (42%)	5 (4%)	5.29±0.77
Superintendents	0 (0%)	0 (0%)	1 (2%)	6 (10%)	27 (44%)	25 (41%)	2 (3%)	5.29±0.72
Executives	0 (0%)	0 (0%)	0 (0%)	1 (6%)	10 (59%)	5 (29%)	1 (6%)	5.25±0.58
I believe tha tsafety committees for the project would be very beneficial.								
Construction Workers	74 (1%)	113 (2%)	151 (3%)	754 (14%)	1885 (36%)	1631 (31%)	660 (13%)	4.99±1.06
Foremen	1 (1%)	2 (1%)	5 (4%)	25 (19%)	47 (35%)	48 (36%)	6 (4%)	5.02±1.00

Table 4 *(continued)*

Questions	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Missing	Mean± std. dev.
I believe tha tsafety committees for the project would be very beneficial.								
Superintendents	1 (2%)	1 (2%)	2 (3%)	9 (15%)	31 (51%)	15 (25%)	2 (3%)	4.92±0.99
Executives	0 (0%)	0 (0%)	0 (0%)	3 (18%)	9 (53%)	5 (29%)	0 (0%)	5.12±0.70
Media attention has portrayed safety on the site accurately								
Construction Workers (N = 3,661)	305 (8%)	329 (9%)	457 (12%)	719 (20%)	743 (20%)	360 (10%)	748 (20%)	3.79±1.52
Foremen	47 (35%)	26 (19%)	14 (10%)	8 (6%)	22 (16%)	9 (7%)	8 (6%)	2.67±1.74
Superintendents	36 (59%)	11 (18%)	3 (5%)	2 (3%)	5 (8%)	3 (5%)	1 (2%)	1.97±1.54
Executives	9 (53%)	5 (29%)	1 (6%)	0 (0%)	1 (6%)	1 (6%)	0 (0%)	1.94±1.48

Reponses that were statistically significantly different between the 4 groups are indicated in shades of gray. For example, for the first question, worker and foremen responses were significantly different (light gray) from superintendent and top management executive responses (dark gray).

of executives were>45 years of age. The average age of workers who responded was 38.7 years ±11.1 years; for foremen, this average was 41±9 years; for superintendents – 48±8 years; and for executives – 51±8 years. We were unable to identify the trade or employer of the youngest worker, a 14-year-old apprentice who worked for a sub-contractor. The oldest worker was a 87-year-old journeyman plumber with 50 years of experience in the construction industry.

Forty-five percent of the workers were Caucasian, compared to half (52%) of foremen, 72% of superintendents, and almost all (88%) executives. A third (34%) of the workers and foremen were Hispanic, whereas only 5% of the superintendents and none of the executives were Hispanic, respectively. Over one third (38%) of the workers were on the job less than three months, similar to 31% of superintendents. On the other hand, foremen had much more experience, with only 11% on the job less than three months. The average number of months on the job was 5±6 months for workers, 15±10 months for foremen, and 12±11 months for superintendents. This background characteristic was not relevant to executives and was not included in their survey.

Carpenters, electricians, plumbers/pipefitters, sheet metal workers, and laborers represented 71% of trades among workers. Sixty percent of foremen were carpenters and 26% were laborers, followed by (6%) cement masons and (4%) operating engineers. Among executives, 64% had been carpenters, 27% laborers, and 9% ironworkers. Superintendents were not asked about trade affiliation and thus could not be compared with the other organizational groups.

The mean age of those responding to the open-ended item included in the workers' survey was 39.2 years. These individuals described their ethnicity as Caucasian (52.0%), Hispanic (28.8%), African-American (6.3%), Native American (3.6%), Asian (1.1%), and other (3.6%). This information was not provided by 4.6%. The average number of years of experience in the construction industry was 16.6 years.

In addition, Fig. 1 displays the distribution of the 5,268 workers by their home Union Local. Workers on the two jobsites came from states across the country, with the majority of workers coming from Nevada, California, and Arizona.

5.2. Differences in Percent of Agreement to Safety Needs Assessment Survey Questions between Jobsites 1 and 2

Fig. 2 shows the significant differences between the two jobsites in the percent of agreement to the survey questions. Overall, workers on Jobsite 2 reported more positive responses to some of the survey items than their counterparts on Jobsite 1. More specifically, workers on Jobsite

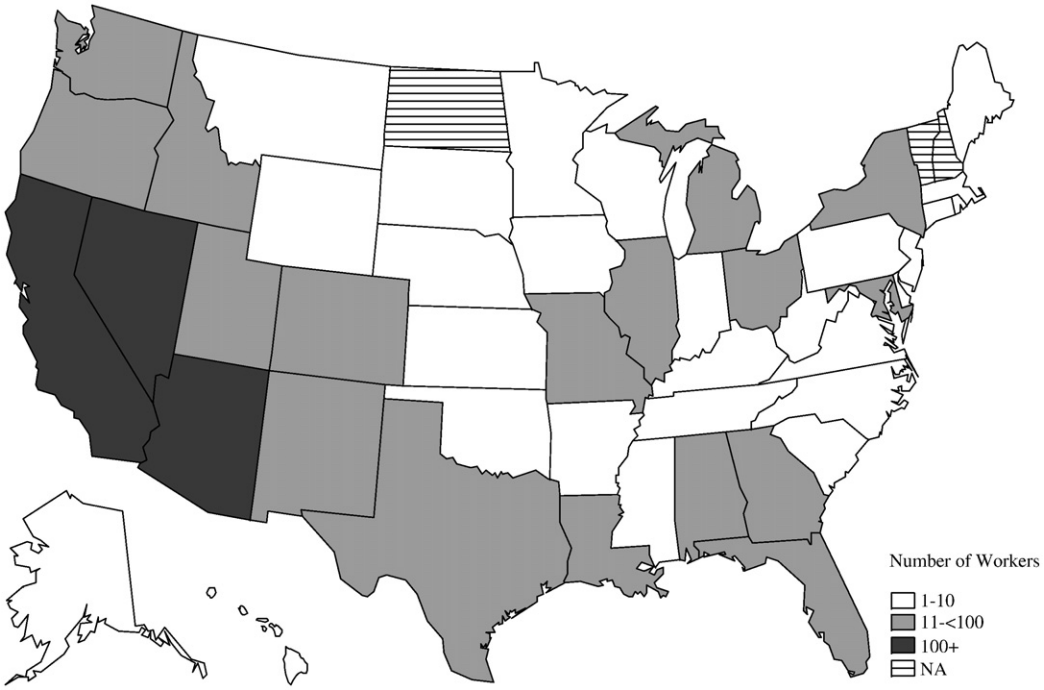

Fig. 1. Distribution of Workers by Home Local.

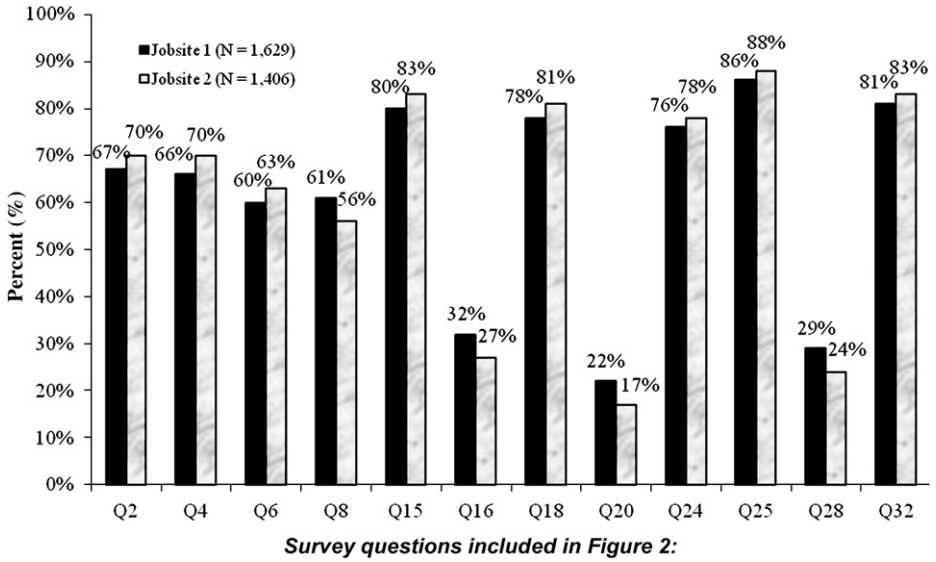

Fig. 2. Percent Agreement (somewhat agree, agree and strongly agree) on selected needs assessment questions between Jobsite 1 and Jobsite 2.

2 felt that safety was more important than schedules, deadlines, and productivity compared to workers on Jobsite 1. Workers on Jobsite 2 also felt that their feedback on safety was more appreciated than those on Jobsite 1, and they ignored safety rules less frequently. In addition, workers on Jobsite 2 reported less fatigue, greater availability of personal protection, and more regular toolbox talks.

Q2. The General Contractor (GC) thinks that job site safety is more important than job schedules and deadlines
Q4. The GC thinks that safety is more important than productivity
Q6. The GC likes to get safety reports/feedback from workers like me
Q8. The GC believes that schedule is the most important issue on this project
Q15. My foreman thinks that safety is more important than productivity
Q16. My foreman thinks that productivity is more important than safety
Q18. My foreman stops work if working conditions are unsafe, even if we have a deadline
Q20. Fatigue is an issue for me – I have caught myself making mistakes on the job when I was tired
Q24. There is always enough personal protective equipment available to allow work to be done safely
Q25. I have received enough training to do my work safely
Q28. Sometimes I ignore a safety rule or policy in order to carry out an assignment to meet the schedule
Q32. Toolbox talks about safety are given regularly

5.3. Examination of Individual Item Responses Among the Four Organizational Levels

Tables 2, 3, and 4 display the results of the comparisons of individual items between workers, foremen, superintendents, and executives. Overall, there were significant differences between the four groups for 19 of the 24 comparable items in the surveys.

5.3.1. Perceptions about Safety Management by the General Contractor

Table 2 shows the responses to survey questions directed at how safety was managed on the site by the General Contractor. The questions focused on (a) whether safety personnel were visible on the site, (b) to what extent safety was viewed as more important than schedules and deadlines, (c) whether work stopped when hazardous conditions were prevalent, and if so, (d) whether the problem was remediated (and how quickly), and (e) the ability of the General Contractor to work with different subcontractors. The mean results in Table 2 suggest that more positive responses were associated with higher job levels. More specifically, average worker responses on all five questions were significantly lower than the other three organizational groups. On the other hand, foremen, superintendents, and executives did not differ significantly among each other, except in relation to the item "The GC safety staff follows up when there is a problem - it gets fixed right away and stays that way," on which executives responded significantly more positively than foremen and superintendents.

5.3.2. Perceptions about Safety Management by the Subcontractors

Table 3 provides the responses to the survey questions directed at how safety was managed on the site by subcontractors. The questions focused on (a) the ability of different subcontractors to work well with one another, (b) whether the subcontractor viewed safety as important and mentioned it to work crews, (c) whether the subcontractor safety personnel had sufficient knowledge needed for conditions faced on the site, (d) whether safety rules and procedures were followed, and (e) whether safety was more important than productivity.

The average responses of workers and foremen regarding how well subcontractors worked together were significantly lower (4.62 ± 1.09 and 4.73 ± 1.15, respectively) compared with superintendents' average responses (5.22 ± 0.78). The majority of workers (80%), compared with 99% of foremen and superintendents, agreed that safety is important to their subcontractors. Moreover, workers' and foremen responses to this question showed statistically significant lower means (4.84 ± 1.14 and 5.37 ± 0.67, respectively) compared with superintendent mean responses (5.62 ± 0.49). Overall, the worker responses to questions about foremen safety knowledge, site safety rules and procedures, and the importance of safety over productivity were all significantly lower compared to responses of foremen and superintendents.

5.3.3. Perceptions About Safety on the Job

Table 4 describes responses to survey questions directed at how safety on the job was perceived by the individual responding to the survey. Workers responded to the questions on their own behalf. Foremen, Superintendents, and Executives responded to questions about their workers rather than themselves. The questions in this section focused on (1) fatigue, (2) scheduling, (3) crowding, (4) personal protective equipment, (5) training, (6) safety responsibilities, (7) rules and regulations, (8) hazard reporting, (9) communication, (10) performing work safety, (11) toolbox talks, (12) safety committees, (13) lost time injuries, and (14) media coverage.

In contrast to either superintendents or executives, both workers and foremen were less likely to report that fatigue is an issue for them that has caused mistakes ("Fatigue is an issue for my workers – they have made mistakes on the job because they were tired"). Nineteen percent of workers and 15% of foremen agreed that fatigue is an issue for them, whereas 25% of superintendents and 48% of executives agreed that fatigue is an issue for their workers.

Approximately three-quarters of workers (73%) and foremen (78%) agreed that doing work safely on the job had definite priority over getting it done on schedule, compared to superintendents (91%) and executives (100%). It should be noted that the mean difference between workers/foremen and superintendent/executives, favoring the latter group, was noticeable, although it was not statistically significant. Cohen's *d*, a measure of the size of the observed mean differences was calculated between workers and each of the other three groups. Although there is no agreed upon standard, Cohen suggested that 0.2 to 0.3 is a small effect, around 0.5 is a medium effect, and 0.8 and larger is a large effect. Using workers as a reference, Cohen's *d* was 0.03 for foremen, 0.3 for superintendents, and 0.5 for executives.

About half of the workers (51%) agreed that sometimes they could not do their job safely because other trades were in their way, compared to 30% of foremen, 29% of superintendents, and 30% of executives. Workers' responses were significantly higher than the other three groups.

Similarly, workers' responses about availability of personal protective equipment were significantly higher than those of foremen, superintendents, and executives. Fifteen percent of the workers disagreed that there was always enough personal protective equipment available to allow work to be done safely, whereas 8% of foremen, 7% of superintendents, and no executives disagreed with this statement. A similar trend in mean differences was observed for perceptions about the regularity of toolbox talks. Seventy-seven percent of the workers, compared to 94% of foremen, 93% of superintendents, and 94% of executives, agreed that toolbox talks about safety were given regularly.

Furthermore, workers reported significantly more positive perceptions of media coverage of safety on the project (3.79 ± 1.52), compared to foremen (2.67 ± 1.74), superintendents (1.97 ± 1.54), and executives (1.94 ± 1.48). Fifty percent of the workers, compared with 29% of foremen, 16% of superintendents, and 13% of executives, agreed that the media portrayed safety on the site accurately.

5.4. Within- and Between-Group Analyses of Safety Climate and Safety-Related Outcomes

To examine if responses were similar within each organizational level, the homogeneity of group ratings or the agreement among respondents within each organizational level, r_{wg}, was calculated for both safety climate dimensions and three safety-related outcomes based on the procedure outlined by James, Demaree, and Wolf (1984, 1993). For management commitment to safety, r_{wg} for the workers was .76; whereas r_{wg} for the three other organizational levels was above .91. For safety practices, r_{wg} ranged from .81 (workers) to 1.00 (superintendents). Agreement within the organizational levels for the safety outcomes was lower than the agreement within the organizational levels on the safety climate dimensions. None of the organizational levels demonstrated high agreement for fatigue, with the least amount of agreement among the workers (r_{wg} ranged from .29 to .55). For safety knowledge and safety performance, r_{wg} was .64 and .75 for the workers, and r_{wg} averaged .81 and .84 for the other three organizational levels, respectively. Overall, the results suggest moderate to high agreement among the foremen, superintendents, and executives; whereas the workers demonstrated moderate agreement for most of the variables. These results overall support similar assessments by individuals within each organizational level.

Two approaches were used to examine mean differences on safety climate dimensions and safety-related outcomes across the four organizational levels. First, we examined the correspondence between ratings of any combination of two groups with intra-class correlation coefficients (ICCs), based on mean ratings of the safety climate dimensions and safety-related outcomes. Considering the size of ICCs found in this study (ranging from 0 to 0.21), the variance of ratings can be explained by differences between the four organizational levels.

We further examined mean differences in management commitment to safety, safety practices, and safety performance among the four organizational levels using a MANOVA. Mean differences in fatigue and safety knowledge were reported in the previous section. As shown in Table 5, management commitment to safety was perceived differently among the four organizational levels. Post-hoc comparisons revealed that the workers perceived a significantly poorer management commitment to safety compared to foremen, superintendents, and executives, which did not differ among each other. In the present study, Cohen's *d*s for management commitment to safety varied from 0.85 (foremen), 1.1 (superintendents), to 1.2 (executives), which indicated large mean differences between workers' perceptions of management commitment to safety and the perceptions at the other organizational levels.

Table 5
Mean Comparisons for Safety Climate Dimensions and Safety Outcomes Among Four Organizational Levels (N = 4149).

	Management commitment to safety			Safety practices			Safety performance		
Job Level	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
Workers	3963	17.56[bcd]	4.17	3963	19.41[bc]	3.56	3963	9.77	1.85
Foremen	120	20.82[a]	2.74	120	20.49[a]	2.60	120	9.97	1.51
Superintendents	50	21.86[a]	2.51	1454	20.94[a]	5.40	50	9.58	1.67
Senior Management	16	22.25[a]	1.73	16	20.50	2.45	16	8.94	1.73
$F_{(3, 4145)}$		47.90*			7.10*			1.720	
Eta_p^2		0.03			0.01			0.00	

Note. $^*p < .05$.

[a]group that is significantly different from workers. [b]group that is significantly different from foremen. [c]group that is significantly different from superintendents. [d]group that is significantly different from Senior Management.

It was also found that safety practices were perceived differently among workers, foremen, superintendents, and executives. Safety practices perceived by workers were significantly poorer than safety practices perceived by foremen and superintendents. Although the difference in perceptions between workers and executives was not significantly different, the results indicated that the executives perceived safety practices more positively than the workers. Cohen's *d*s, again calculated using the workers as the reference group, varied from 0.32 (foremen or executives) to 0.46 (superintendents).

No significant mean differences between the groups were found for safety performance.

Overall, the above findings indicated that the size of the observed mean differences between the perceptions of workers and those of the other three groups was large for management commitment to safety and medium for safety practices. In addition, our findings show significant differences in fatigue, but no differences in safety knowledge and performance across the four groups. Thus, Hypothesis 1 was partially supported.

5.5. Safety Climate Predicting Safety-Related Outcomes

Means, standard deviations, and correlations between management commitment to safety, safety practices, fatigue, safety knowledge, and safety performance are reported in Table 6. The zero-order correlations across the four organizational levels showed that, in general, positive perceptions of safety practices were consistently associated with greater safety knowledge and safety performance. Management commitment to safety was negatively related to fatigue, but only in the foremen and superintendents' groups. In addition, management commitment to safety was positively related to safety knowledge among workers, foremen, and superintendents, and also positively related to safety performance among the foremen and superintendents. Thus, it appears that there is some variability in the relationships between the two safety climate dimensions and safety-related outcomes across the four organizational levels.

Multiple regression analyses were conducted to examine if management commitment to safety and safety practices significantly predicted safety performance, safety knowledge, and fatigue within each organizational level. Within the worker group, both management commitment and safety practices predicted all three outcomes, as shown in Table 7. However, it should be noted that the significant effect of management commitment to safety on fatigue was due to a suppression effect, a statistical artifact that should not be interpreted. Management commitment to safety and safety practices predicted a significant positive increase in safety knowledge and safety performance. In addition, positive safety practices were significantly associated with a decrease in perceptions of fatigue.

In contrast, the pattern of significant results among the three other organizational levels was not so consistent. Within the foremen group, management commitment to safety only predicted an increase in safety performance; whereas safety practices predicted an increase of safety performance and safety knowledge. For superintendents, management commitment to safety and safety practices predicted an increase in safety knowledge. Furthermore, safety practices predicted an increase of workers' safety performance. For executives, only safety practices predicted an increase in safety knowledge and safety performance. Overall, these results suggest that management commitment to safety and safety practices are positively related to the three safety-related outcomes, which partially support Hypotheses 2.

To explore whether the associations of management commitment to safety and safety practices with safety performance, safety knowledge, and fatigue were different between the workers and the three other organizational levels, six moderated regression analyses were conducted using the workers as the reference group. Due to the small sample size of the senior management executive group, the foremen, superintendents, and executives were combined for these analyses into a group labeled as "management." This was justified, since it was found that the foremen, superintendents, and executives tended to hold more similar views compared to the workers.

Table 6
Descriptives, Coefficients Alpha, and Correlations of Variables by Organizational Level.

Variable	*N*	*M*	*SD*	Range[a]	1	2	3	4	5
Workers									
1. Management commitment to safety	4,497	17.90	4.19	4-24	(.84)				
2. Safety practices	4,390	19.39	3.28	4-24	.40*	(.76)			
3. Fatigue	4,588	2.28	1.44	1-6	.01	-.15*	(n.a.)		
4. Safety knowledge	4,634	5.08	1.03	1-6	.26*	.48*	-.11*	(n.a.)	
5. Safety performance	4,563	9.78	1.87	2-12	.29*	.51*	-.10*	.60*	(.66)
Foremen									
1. Management commitment to safety	130	20.85	2.71	4-24	(.75)				
2. Safety practices	128	20.49	2.55	4-24	.45*	(.66)			
3. Fatigue	125	2.17	1.15	1-6	-.22*	-.16	(n.a.)		
4. Safety knowledge	129	5.23	0.71	1-6	.39*	.59*	-.19*	(n.a.)	
5. Safety performance	129	9.95	1.53	2-12	.48*	.59*	-.06	.49*	(.56)
Superintendents									
1. Management commitment to safety	58	21.78	2.42	4-24	(.79)				
2. Safety practices	58	21.02	2.28	4-24	.65*	(.61)			
3. Fatigue	57	3.11	1.41	1-6	-.30*	-.22	(n.a.)		
4. Safety knowledge	59	5.22	0.76	1-6	.56*	.57*	-.18	(n.a.)	
5. Safety performance	58	9.53	1.57	2-12	.45*	.55*	-.26	.65*	(.71)
Executives									
1. Management commitment to safety	16	22.25	1.73	4-24	(.77)				
2. Safety practices	16	20.50	2.45	4-24	0.77*	(.78)			
3. Fatigue	17	3.41	1.23	1-6	-0.31	-0.16	(n.a.)		
4. Safety knowledge	17	5.06	0.75	1-6	0.74*	0.79*	-0.30	(n.a.)	
5. Safety performance	16	8.94	1.73	2-12	0.58*	0.73*	-0.14	0.80*	(.91)

* $p < .05$. Alpha coefficients are reported in the diagonal of the above matrix where appropriate. n.a. = Not Applicable.
Note. [a]Range refers to observed range of scores. n.a. = non-applicable.

Table 7
Regression Results for Safety Climate Predicting Safety Outcomes by Organizational Level.

Safety Climate Dimensions	Fatigue	Safety knowledge	Safety performance
Workers			
Management commitment to safety (β)	.08*	.09*	.11*
Safety practices (β)	-.18*	.45*	.47*
F	59.28*	651.77*	762.96*
R2	.03	.24	.27
n	4053	4082	4064
Foremen			
Management commitment to safety (β)	-.19	.15	.35*
Safety practices (β)	-.06	.53*	.31*
F	3.08	36.44*	27.24*
R2	05	38	31
n	120	124	124
Superintendents			
Management commitment to safety (β)	-.28	.36*	.12
Safety practices (β)	-.04	.35*	.50*
F	2.62	18.19*	13.27*
R2	.10	.41	.34
n	53	55	54
Senior Management			
Management commitment to safety (β)	-0.42	0.31	0.05
Safety practices (β)	0.17	0.56*	0.69*
F	0.72	13.05*	7.50*
R2	.10	.67	.54
n	16	16	16

*$p < .05$.

Interaction terms were created for each of the safety climate dimensions and group level (i.e., group × management commitment to safety, and group × safety practices). The findings revealed that two out of the six interaction effects were significant. Specifically, the relationships of management commitment to safety with safety knowledge ($\Delta R^2 = 0.00$, $p < .05$; $\beta = 0.26$, $p < 0.05$) and safety performance ($\Delta R^2 = 0.00$, $p < .05$; $\beta = 0.30$, $p < 0.05$) were significantly different between the workers and management. Specifically, there was a stronger positive relationship between management commitment and both safety knowledge and safety performance for workers as compared to management. However, the associations between safety practices and safety-related outcomes appear to be the same for workers and management. Thus, it appears that the safety climate dimensions predict the safety-related outcomes, but some of these relationships appear to vary by organization level.

5.6. Results for Qualitative Data

Content analysis results revealed 10 distinct safety-related themes. These included: lack of management action, health hazards, unsafe procedures, no safety problems, lack of coordination/planning, individual responsibility, lack of appropriate safety equipment, need for improved communication, need for improved training/hiring practices, and problems with housekeeping. The most frequently mentioned theme was a lack of management action (27.8%), which refers to a lack of appropriate monitoring, enforcement, or action regarding safety and an emphasis on productivity over safety on the part of management. Presence of health hazards (13.5%), which covers a variety of health-related issues such as toxic dust in the air, lack of ventilation, issues with the heat, as well as a lack of access to water and reasonably clean bathroom facilities, was the second most frequently mentioned theme. The next most frequent theme, unsafe procedures (10.2%), primarily focused on unsafe actions on the part of fellow employees. Table 8 presents all 10 themes along with a definition of the theme, example statements, and frequency of theme emergence.

6. Discussion

Workplace safety remains a significant concern in the construction industry (Ringen & Englund, 2006). Such was the case at the largest commercial construction development project in U.S. history, particularly on the heels of eight fatalities and a large number of injuries reported on the adjacent jobsite over a period of 18 months. The results of the surveys among the four organizational levels provided a glimpse into the minds of the workforce (including workers, foremen, superintendents, and senior management executives) on this project.

There were numerous stakeholders involved in this project. Both management and labor invested a great deal of time and resources ($1.2 million dollars alone was allocated for OSHA 10-hour hazard awareness training) toward making improvements on the site. CPWR, Colorado State University, Illinois Institute of Technology, University of West Virginia, and researchers from the National Institute for Occupational Safety and Health applied their expertise in occupational health psychology, occupational hygiene, epidemiology, and communications to develop the components of the assessment. The team of safety officers for the General Contractor were fully engaged in facilitating and recruiting participation in the worksite assessment (which included the survey), provided total access to the site and personnel, and suggested questions for inclusion on the survey. This level of engagement and involvement by the wide range of stakeholders created an environment conducive to

Table 8
Categories Identified by Content Analysis of Responses to the Open-Ended Question.

Category	Definition	Examples	% of Responses
Lack of management action	Management's lack of monitoring or enforcement of safety rules, ignoring safety concerns, and emphasizing working quickly at the expense of working safely.	"Safety gets ignored for productivity"; "There are many safety hazards which are ignored"; "It seems that contractors and companies go through the motions in order to cover themselves, but the bottom line is production and whatever it takes to do that."	27.8%
Health hazards	Health concerns such as dust and chemicals in the air or lack of ventilation, water, hand-washing areas and sufficiently clean portable toilets.	"This job has monocoat and dust for us to breathe all day every day. We have at least 4 men who have gone to the doctor's office for this problem"; "We have made complaints about exhaust fumes"; "Rooms are at 120+ degrees and manlift operators aren't provided any heat relief (fans)."	13.5%
Unsafe procedures	Other workers are conducting procedures improperly and engaging in unsafe behavior.	"When the cranes are lifting stuff people only blow the horns at the start of the lift or right before landing. They should constantly sound the horn"; "When some of the iron workers are cutting, welding, etc. above they do not follow safety rules, such as taping the area below and they don't have firewatch!"; "Forklifts drive way too fast in the basement area."	10.2%
No safety problems	Safety is handled properly at these job sites.	"Excellent safety procedures. Keep up the good work!"; "What I have seen of this job they take safety very seriously"; "I have no issues that would involve improving safety."	9.1%
Lack of coordination/ planning	Crowded workspaces, too many people on site, or a lack of appropriate scheduling/coordination.	"It is difficult, with the sheer numbers of workers on this site, to get all hands on the same page"; "Too many workers in a small space"; "Better scheduling to prevent overlapping trades."	7.7%
Individual responsibility	Individuals should take care of themselves and safety is the responsibility of each person (not the company.	"There is a responsibility on the individual to make safety a priority"; "Safety starts with the individual. Can't blame the company for all accidents"; "Majority of deaths on this site were preventable if people used common sense."	7.6%
Lack of safety equipment	Lack of adequate equipment needed to work safely.	"I still have not been provided safety glasses by my employer"; "There are no standing eyewash stations on every floor"; "Lighting is poor in most areas I've been."	7.1%
Need for Improved Communication	Need to improve communication, including described English-Spanish language barrier issues.	"The language barrier: English/Spanish is the number one hazard on this job"; "Toolbox talks are too general and commonly do not pertain to the specifics of the job";	5.8%
Need for Improved training/hiring practices	Need for more training or better hiring practices by the company.	"We need more training for our brothers who don't have much construction experience"; "It seems to me the majority of people getting hurt have little commercial jobsite experience";	5.8%
Problems with housekeeping	Problems with workers not cleaning up trash, materials, or equipment.	"Housekeeping on this job is terrible. In my opinion it is the biggest problem on this job"; "Too much clutter – material scattered everywhere – need to clean up walkways."	5.5%

asking and answering difficult questions. In addition, it promoted an atmosphere supportive of negotiations, compromises, and a willingness to change based upon the information identified, regardless of the intense media scrutiny and regulatory attention.

While the main focus of the safety needs assessment surveys was to better understand perceptions of safety on the site, we also learned about the nature of the workforce through collection of demographic information. The majority of the workforce consisted of Caucasian and Hispanic workers. The issue of barriers and challenges to communication became apparent after learning from the General Contractor that many of the work crews spoke predominantly Spanish on the jobsites, and were guided in the daily work by bi-lingual foremen. This communication barrier clearly emerged from the content analyses of the qualitative data.

Overall, the findings from this study indicated that: (a) workers, on average, reported poorer safety climate and outcomes compared to management; (b) safety climate dimensions were associated with safety outcomes across the four organizational levels; and (c) an open-ended question was helpful in validating the results based on the quantitative data and in identifying additional safety issues, which might have been overlooked otherwise.

6.1. Key Findings from Individual Item Analyses Across the Four Organizational Levels

This project, like most major commercial construction projects in the United States, was considered a fast-track construction activity. In the case of the CityCenter (i.e., Jobsite 1), a $100 million bonus was attached to the timely completion of the project (Audi, 2008). Work on the project was conducted in round-the-clock shifts. The impact of this deadline was clearly reflected in a number of specific responses of the workforce as well as in the overall perception of safety climate.

The General Contractor for the sites maintained a safety team responsible for monitoring site conditions, tracking incidents, and inspecting to ensure safety and health standards were met and communicated across the sites. Interestingly, the workers perceived these activities differently than the foremen, superintendents, and executives. More specifically, workers perceived the General Contractor's safety personnel on-site as doing daily safety checks less frequently than the other respondents. They reported less positive perceptions about the General Contractor intervening to stop unsafe operations and doing follow-ups to ensure that the safety issues were resolved in a timely fashion. In his article on construction site safety roles, Toole (2002) emphasized that entities other than those actually performing the work have an important role in enforcing proper safety standards. He reported that monitoring work on a frequent basis, knowing the relevant safety standards for the task being performed, and controlling behavior were key elements to site safety. The size of the site and the magnitude of the workforce may have contributed to deficient enforcement of safety. Workers and foremen also felt that personal protective equipment was less available than management of the operation. Requirements for personal protective equipment are described in OSHA regulations under subpart E of the code of federal regulations for construction (29 CFR 1926.95). Enforcement in the use of this equipment was a major issue on the site. The GSC's safety

crew was perceived by workers as "Safety Cops," a label they felt was inaccurate. Further, responses indicated that, in some cases, workers ignored safety rules and policies in order to carry out work assignments to meet schedules and productivity requirements. Between workers and management, there were clearly different perceptions of the importance of site safety vis-à-vis job scheduling and deadlines.

Another important indicator of site safety is the extent to which it is addressed and re-enforced on a regular basis on the site. In addition, communications among workers, foremen, superintendents, and management were also viewed differently on this project, with workers perceiving these conversations to happen less frequently than management. Communication is facilitated when systems are in place to share information. The idea of using a participatory approach to improve communications on construction sites has been tested by Hecker, Wilhette, and Barsotti (2000). An outcome of discussions with the GC, based on the survey, indicated the need for better two-way communications from workers to management and management to workers. A safety feedback card system was put into place to identify hazards and bring them to the attention of the safety crew for more timely remediation. Workers also perceived fatigue as less of an issue of concern than management. However, compared to management, they felt the pace of work scheduling required different trades to work in too-close proximity to one another, which created safety problems.

6.2. Safety Climate, Safety-Related Outcomes, and Motivation to Change

The findings from the multiple perspectives also demonstrated some perceptual gaps in safety climate dimensions between workers and the other three organizational levels. Specifically, the management groups, especially superintendents and executives, tended to hold more positive views about the safety climate of their organization than those of the workers. Although one may be interested in finding out which data source is more or less accurate, the purpose of our multi-source approach was not to seek out the "truth." Instead, the purpose was to identify discrepancies among data sources since the awareness of such discrepancies was likely to motivate the organization to change. For instance, Atwater and Brett (2005) found that leaders who received low ratings from others, but overrated themselves, reported stronger motivation to change. Based on the findings and multi-source feedback literature (Borman, 1997), it is recommended that multiple sources of safety information be utilized when developing strategies and actions for improving safety.

The results on the differences among the groups regarding workers' fatigue and whether workers' mistakes were due to fatigue suggested that attributions regarding workers' mistakes varied between workers and management. Management tended to perceive fatigue as more of a safety problem that may lead to mistakes on the job than workers did. This is consistent with DeJoy (1994), who argued that blaming individuals for occupational injuries is inherent in safety management. Based on the attribution theory, which describes how people infer causes of events (Kelly, 1973), it is in the best interest of each party to attribute the cause of injuries to other parties. Applied to the context of the current study, the attribution theory suggests that different groups on a construction site will likely hold different views about the causal factors that lead to unsafe behaviors. The recognition of this is important, since it is likely to force management to reconsider the causes of mistakes. Additionally, it will hopefully motivate management to try to identify the actual cause of mistakes instead of assuming the workers' fatigue is the culprit.

Overall, it was found that safety climate predicted safety-related outcomes, but these relationships varied by organizational level. Specifically, management commitment predicted safety knowledge among the workers and superintendents. Management commitment also predicted safety performance for the foremen. Safety practices predicted safety performance and safety knowledge for all four organizational levels. Additionally, safety practices predicted fatigue for the workers. The findings regarding safety climate predicting safety outcomes are consistent with prior research (Christian et al., 2009; Clarke, 2006). This study extends previous research by demonstrating that safety climate is predictive of outcomes not only among workers but also among supervisors and management. However, these relationships were not consistent in the current study.

The interaction results suggested stronger relationships between management commitment and safety-related outcomes for workers than for management. The reason for the inconsistent prediction from safety climate is unclear, but possible explanations can be identified from the literature. First, it is possible that management's ratings of their own commitment to safety, which would be considered self-ratings, are subject to a positive response bias. This could lead to an inflated mean or restriction of range, which would make it more difficult to find significant relationships with other variables. Morgeson and Campion (1997) discussed how self-presentation processes, such as impression management and social desirability, may influence ratings in a job analysis context. Both of these self-presentation processes would lead an individual to present themselves (e.g., their behaviors and/or attitudes) more favorably. Although in this case the context is different (i.e., reporting one's commitment to safety), the same processes apply. With regard to their commitment to safety, management might be motivated to present themselves in a more positive light than is truly accurate.

6.3. Key Findings from Qualitative Data

We believe there were several benefits of including a qualitative portion in the workers' safety needs assessment survey. First, the findings from the qualitative portion converged with the quantitative portion of the survey on some of the safety issues. Certain themes, which emerged from the qualitative analysis, were analogous to dimensions or items on the survey. For example, lack of management action, which was the most frequently mentioned theme, was conceptually similar to the management commitment to safety dimension of safety climate. Both emphasize the issue of whether management makes safety a priority over schedules and takes appropriate actions to correct safety problems. The emergence of categories comparable to the safety climate dimensions could be interpreted as validity evidence for the safety climate items used in the study and the coding scheme, which strengthens the credibility of our findings.

A second benefit of the qualitative portion of the survey was the identification of safety and health issues, which were not part of the safety needs assessment survey items. Some themes provided unique information that did not correspond to survey items. For example, serious issues, such as toxic chemicals in the air, the extent of crowding in workspaces, and language barrier problems, were not directly assessed by the survey items. A substantial number of workers identified a variety of hazards, which could have potential aversive effects on their health. The large number of workers who specifically mentioned problems with ventilation, heat, lack of water, inadequate bathrooms, and toxic dust in the air led us to conclude that these health concerns were a pervasive problem on these jobsites and not simply the complaints of a few workers. Additionally, many workers mentioned that their work areas were overcrowded, which is consistent with the quantitative survey results indicating safety problems due to interferences between different trades on the same site.

Furthermore, many workers mentioned the language barriers between English-speaking and Spanish-speaking workers. From reviewing these responses, it became clear to us that this was an issue of great tension and, at times, hostility among the workers, which has not been properly addressed at the jobsites. This is also an important issue in the construction industry at large, where ethnic disparities in safety and health outcomes for construction workers have been observed and need to be addressed (National Research Council, 2003). In fact, the construction safety literature indicates that Hispanic construction workers are more likely to experience fatal and non-fatal injuries at work than any other ethnic group (Anderson, Hunting, & Welch, 2000; Dong & Platner, 2004).

A third benefit of the qualitative portion of the survey was that workers often identified specific problems and provided specific ideas for solutions. As an example related to health hazards, a worker said, "I think you need fans to get the exhaust out of the basement." Another worker stated, "Water should be available at all manlifts and on every floor." Statements such as these offered the organization some actionable steps for intervention. The research team found it quite striking that some of the issues mentioned by the workers could have such quick and simple solutions with significant return of investment in the long run. These were problems that the organization could easily address, and the resulting changes could have a real impact on the quality of work-life for their employees, as well as on production and financial gains. It is the willingness to learn from this feedback and act pro-actively that presents the biggest challenge.

Overall, the above-discussed results suggested that the inclusion of the open-ended portion of the safety survey allowed the research team to gather additional critical information and gain a better understanding of the workers' experiences and make recommendations for appropriate safety interventions.

6.4. Implications and Impact on Industry

The current study has important practical implications for the construction industry and other industries. The safety needs assessment surveys were developed so the research team could provide informed recommendations to the company's management team about safety concerns requiring attention. The findings support the importance of reducing the attribution bias, including the need to minimize the distance in perceptions about the work environment between the management groups and workers (Zacharatos, Barling, & Iverson, 2005). This could be achieved by providing the management exposure to specific job tasks and conditions, which could ultimately strengthen the work systems (DeJoy, 1994). Zohar (2002) demonstrated the importance of management involvement by showing that frequent interactions between management and workers regarding safety issues resulted in increased safety behaviors that were maintained 20 weeks after the intervention ended. It is important for management to be involved and to have contact with workers on any construction site, since it sends a strong message to all parties that safety is important and is everyone's responsibility, rather than responsibility of one particular group.

Our study design, which included the utilization of an open-ended question for workers and multiple sources of data, not only offered employees the opportunity to influence decisions made at higher levels of the organization regarding safety and management practices, but it also provided the management group insights into how their views were different from workers' views. Our approach to worksite assessments was guided by the notion of the participatory decision making (PDM), which has been related to employee satisfaction (Miller & Monge, 1986), productivity (Hung, Rundall, Cohen, Tallia & Crabtree, 2006), and lower turnover rates. As discussed by Grawitch, Ledford, Ballard and Barber (2009), while there are many possible organizational interventions available, employee involvement is critical to the success of any workplace health and safety initiative. Employee involvement can include seemingly simple practices such as input in decision making; yet, interventions or programs that are solely determined by management can fail to promote change at the level of front-line workers. Ludwig and Geller (2000) conducted a series of safety intervention studies aimed at increasing safety behaviors of delivery drivers. They found that employee involvement, in the form of participation in goal setting, was related to the drivers engaging in safety behaviors beyond those that were targeted in the intervention. For example, while the intervention targeted the behavior of coming to a complete stop at stop signs, they found that employee involvement also increased safety behaviors such as safety-belt use and turn-signal use. Ludwig and Geller further concluded that providing opportunities to involve employees was a critical factor for program success.

Allowing employees' opinions to be heard during the decision making process is important in enhancing perceptions of organizational fairness (Lind, Kanfer & Earley, 1990; Bies & Shapiro, 1988). Research has consistently shown that providing employees with a voice in the decision making process is related to perceptions that the organization is carrying out procedures in a fair and just manner (Lind & Tyler, 1988). The effect of giving voice is especially strong when employees gave their voice before a decision was made (Lind et al., 1990). Giving voice allows an opportunity to provide one's input to a decision maker, and people perceive these procedures as having greater fairness even when a decision does not favor them (Bies & Shapiro, 1988).

Thus, in an environment of great worker discontent, which culminated in workers walking off the job on June 3, 2008 over their safety concerns, providing workers with an opportunity to have their voices heard may have benefits beyond the knowledge obtained from the open-ended responses. In sum, this study demonstrated the utility of integrating both quantitative and qualitative approaches to measuring safety climate, and verified perceptions of safety climate shared by workers and the management groups to assist the organization to further advance its safety-related policies, procedures, and practices. The implementation of multi-level safety needs assessment surveys can identify major safety issues of concern. Feedback, if acted upon, can potentially result in fewer injuries and fatal events. It is worth noting that following the involvement of CPWR and its partners (i.e., OSHA training and worksite assessments), there were no additional fatal incidents reported on the two jobsites.

6.5. Recommendations to Management

The results from the safety needs assessment surveys led the research team to offer management four main recommendations and steps to achieve them.

First, it was clear that the General Contractor needed to augment its efforts to demonstrate the organization's commitment to safety and its willingness to assume responsibility and solve safety problems in action (i.e. talk the talk, and walk the walk). Five specific suggestions were offered to achieve this:

1. Provide workers with timely feedback for improvement and recognition of their safety behaviors;
2. Provide clearly defined organizational safety goals and policies;

3. Develop and distribute quality toolbox talks;
4. Conduct regular workplace hazard analyses to identify safety improvement opportunities;
5. Provide detailed safety reports to all employees (i.e., including injuries and near miss incident reports).

The second recommendation called for greater involvement of both the General Contractor's and sub-contractors' senior and mid-level management in safety by providing them with training on proactive management skills. Three specific suggestions were offered to achieve this:

1. Senior and mid-level management need to frequently communicate to their employees and show their genuine concern for safety through participation in day-to-day activities;
2. Explicitly include safety as senior and mid-level management's responsibility and in performance standards. Promotion and/or merit raises should also be evaluated based on efforts and strategies in promoting safety;
3. Senior and mid-level management need to serve as role models and get involved in critical safety activities (e.g., safety seminars, training, and critical operations).

The third recommendation encouraged foremen to display positive and constructive attitudes, actions, expectations and communications about safety. Four specific suggestions were offered to achieve this:

1. Both the General Contractors and sub-contractors are encouraged to provide training to foremen on pro-active management skills;
2. Provide immediate, constructive, and specific feedback to workers when they demonstrate poor performance;
3. Promote and engage in open communications about safety errors and near misses with workers to prevent future injuries and accidents;
4. Consider providing, at a minimum, an OSHA 30-hour training course to all foremen.

The fourth and final recommendation was to empower workers to become actively involved in safety. Three specific suggestions were offered to this end:

1. Periodically conduct anonymous short safety needs assessment surveys or informal interviews to allow employees the opportunity to voice their opinions and provide suggestions on the current status of safety programs and practices;
2. Establish a formal reporting system including weekly information and emergency reporting for issues that need to be conveyed to all site personnel that is easily accessible (e.g., blast text messages);
3. Establish labor/management safety committees with appropriate experience and skills who have a voice in organizational safety decisions.

Follow-up with the company's management team five months after the delivery of our research findings indicated that a plan of action steps to meet the recommendations was developed and underway. It is likely this type of project will be replicated elsewhere in the future.

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