FRONTLINE SAFETY: LEADERSHIP, DECISION-MAKING, AND RISK TOLERANCE

FINAL REPORT – PHASE I

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EXECUTIVE SUMMARY

Frontline supervisors play a critical role in construction safety performance. Foremen, superintendents, and other site leaders directly influence worker behavior, hazard recognition, and risk-related decision-making on construction projects. Their leadership traits, communication practices, and tolerance for risk help shape the safety culture experienced by workers in the field. Recognizing the importance of these factors, this study examined how leadership behaviors and decision-making among construction supervisors influence safety practices and worker perceptions of risk.

This research study was conducted as part of the OSU Construction Safety Research Partnership (CSRP). The study used a mixed-methods approach that combined a literature review, an industry survey, and semi-structured interviews with experienced construction leaders. The survey collected responses from construction professionals representing a range of organization types, leadership roles, and levels of industry experience. Survey responses were analyzed to identify patterns in leadership behaviors, communication practices, and safety management approaches. Semi-structured interviews were conducted to provide additional insights into how construction leaders perceive risk, communicate safety expectations, and balance safety responsibilities with production demands.

The research findings suggest that frontline supervisors are widely recognized as key drivers of safety culture on construction projects. According to the survey respondents, supervisory leadership behaviors—including communication, visibility in the field, and consistent enforcement of safety expectations—strongly influence worker safety outcomes. Supervisors serve as the primary link between organizational safety policies and day-to-day work activities, making their leadership practices critical to effective safety management.

Communication is perceived as one of the most important leadership behaviors influencing safety performance. Daily safety meetings, pre-task planning discussions, and informal jobsite conversations are commonly described as mechanisms for reinforcing safety expectations and identifying hazards before work begins. Interview participants also emphasized the importance of creating an environment where workers feel comfortable reporting hazards and exercising stop-work authority when unsafe conditions arise.

The study also found that leadership development and training programs play an important role in supporting effective safety leadership. While many organizations provide some form of leadership or safety training for supervisors, the structure and consistency of these programs vary widely. Industry leaders interviewed for the study emphasized that training is most effective when it combines classroom instruction with field-based mentoring and practical problem-solving experiences.

Overall, the findings reinforce the importance of investing in leadership development for frontline supervisors. Organizations that strengthen supervisory skills in communication, hazard recognition, and safety decision-making may improve safety culture and reduce risk across construction projects.

Frontline Safety: Leadership, Decision-Making, and Risk Tolerance

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1. INTRODUCTION

Safety management in construction incorporates a wide variety of practices and controls to create safe work environments and operations. Human behavior and decision-making are highly correlated with safety performance and commonly recognized as the greatest contributors to the occurrence of occupational injury and fatality incidents (Haslam et al. 2025; Jiang et al. 2015). As a result, a focus on human behavior and decision-making is a common underlying aspect of safety management systems on construction projects. That is, safety practices and controls implemented on construction jobsites rely extensively on both utilizing human involvement to maintain safe jobsites and, when humans are at risk, positively affecting their behavior and decisions to optimize safety performance. A lack of attention to working safety, due to distractions, complacency, and absent-mindedness, for example, is a significant contributor to workplace injury and fatality incidents (Hinze 2006).

Research findings show that all who are involved in a construction project, including those both on and off the jobsite, can influence safety on the site. Executive leadership and top management personnel within a construction company set the tone and culture with respect to safety throughout the organization (Lundell and Marcham 2018; Hinze 2003). Their words, decisions, and actions affect project manager, safety manager, and other project-level personnel who oversee and undertake the work. Managers prioritize key performance objectives, e.g., safety, cost, schedule, and quality, in accordance with the goals and objectives established by company leaders. On the construction site, safety culture is highly influenced by those who oversee, manage, and control the work, including project superintendents (Zohar 2003; Hartley and Cheyne 2010). Their attention to, and involvement in, safety and safety culture affect foremen and, in turn, their crew members (Fang et al. 2015; Al-Bayati 2021). Safety leadership at all levels is recognized as an important aspect of safety performance on the jobsite (Maloney 2012; Mitropoulos 2013; Hinze 2003; 2006). There are significant links between leader behaviors and project safety climate, and leaders, through their actions, need to communicate the importance of safety (Maloney 2012). According to the Center for Construction Research and Training, five leadership skills that positively influence safety are: (1) leads by example; (2) engages and empowers team members; (3) actively listens and practices three-was communication; (4) develops team members though teaching, coaching, and feedback; and (5) recognizes team members for a job well done (CPWR 2015).

The importance of leadership with respect to safety reinforces the considerable attention it attracts by construction companies. Site personnel with well-developed and positive leadership skills play an important role in encouraging beneficial behaviors and decisions of others on the project with respect to safety. This influence is especially true of frontline supervisors, i.e., foremen and superintendents (Mitropoulos 2013). Prior research has identified leadership qualities, behaviors, and risk tolerance of frontline supervisors as critical components of creating a culture of safety on a project and motivating good safety behavior amongst field workers (Mitropoulos 2013). Their outward behaviors, decisions, risk perception, and risk-taking directly impact others on the project. Leadership is a foundational element of safety in an organization. Good safety performance demands organizational attention to frontline supervisor leadership.

Successful safety management requires, in part, the presence and involvement of effective leaders. As a result, developing leadership skills amongst project management and site supervisory personnel, and well as lower-level employees aspiring to become supervisors, is a

key concern of construction companies. The extensive influence that risk tolerance has on a person's approach to safety (Salas et al. 2020) moderates the influence of frontline supervisor leadership skills on the safety performance of those who they supervise. The relationship underscores the need to understand the leadership skills, behaviors, and risk-taking propensity that are particularly impactful, both positively and negatively, to safety and how to measure, develop, and accentuate the desired traits amongst frontline supervisors.

These topics were explored in the research study funded by the Construction Safety Research Partnership (CSRP) titled "Frontline Safety: Leadership, Decision-making, and Risk Tolerance." This document is the final report for Phase I of the study. The report describes the research objectives and methodology, documents existing knowledge about the research topic, presents the results of the analysis of the data collected, and provides recommendations for further research on the topics.

2. LITERATURE REVIEW

2.1 REVIEW METHODOLOGY

To identify and characterize current knowledge and practice associated with effective leadership and risk-taking in a work environment, information was compiled from a comprehensive literature review. This review ensures the research and outputs are founded on contemporary theories and concepts about leadership and risk management. The review implemented a four-step procedure of (1) online search for relevant literature contained within academic journals (e.g., ASCE Library and Safety Science publications) and publicly available practice-oriented resources (e.g., AGC, ASSP, NIOSH, NSC publications), (2) assess eligibility of retrieved articles by applicability to the research topic, (3) summary of extrapolated data from relevant articles, and (4) synthesis and organization of extracted data for the interim deliverable. Figure 2.1 displays the flowchart for the review methodology utilized during the review process.

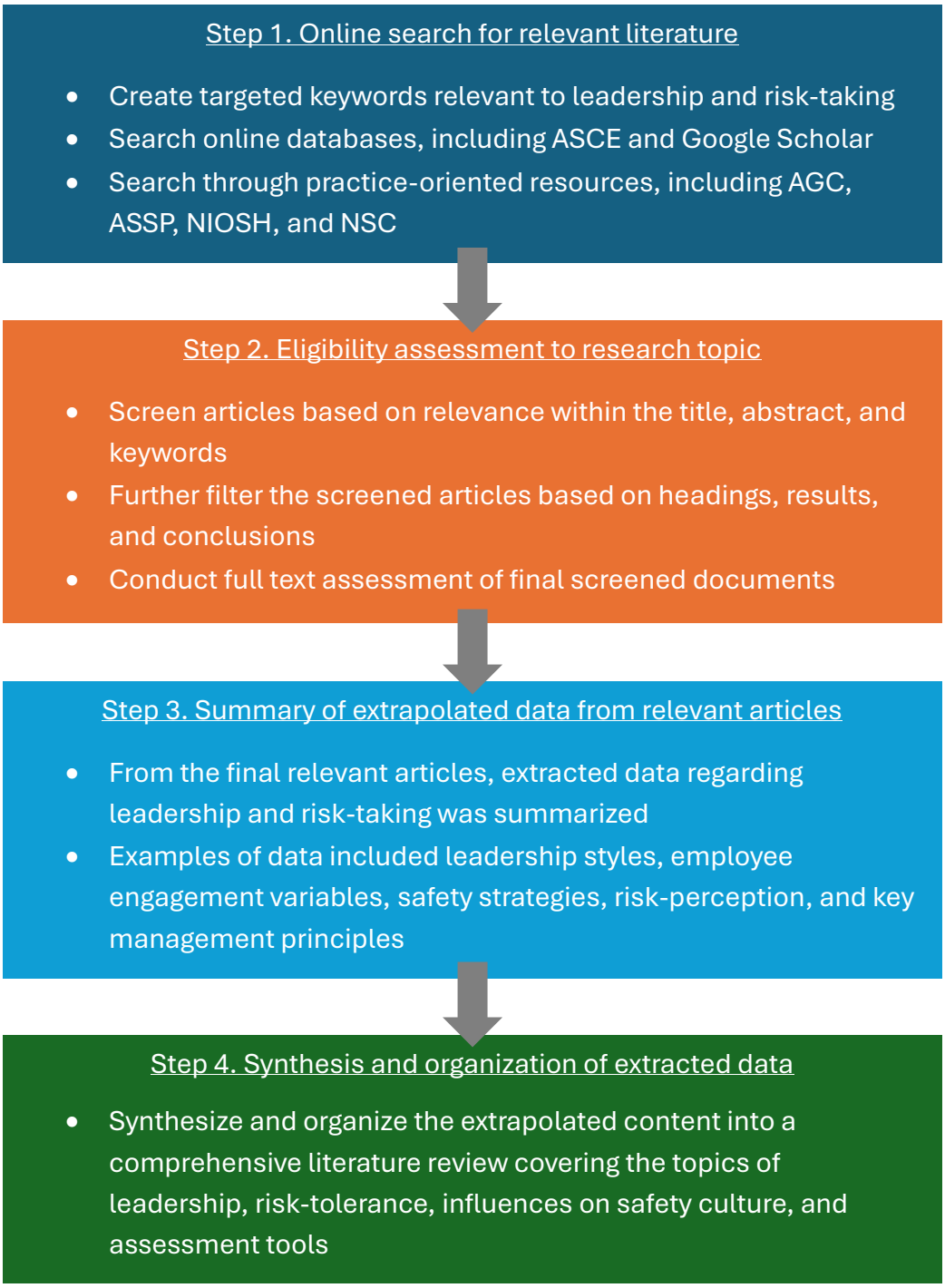

Figure 2.1: Literature Review Methodology

2.1.1 Step 1: Online Search for Relevant Literature

In Step 1, relevant publications were sourced from mainstream databases, such as the American Society of Civil Engineers (ASCE) Library. The ASCE Library is a highly credible source, widely recognized for its peer-reviewed publications in civil engineering and related disciplines, ensuring the reliability and academic rigor of the information it provides. Articles were identified through a targeted keyword search in the ASCE Library, utilizing the terms presented in Table 2.1. A total of 11,936 publications were displayed in the ASCE Library using the following keywords: *Construction* AND *Safety* AND *Leadership Skills* AND *Risk* AND *Assessment*. To ensure thoroughness, an advanced search in Google Scholar within each journal identified by ASCE was conducted. These journals included the *Journal of Construction Engineering and Management*, *Leadership and Management in Engineering*, *Journal of Applied Psychology*, *Journal of Safety Research*, *Safety Science*, *Journal of Management in Engineering*, and *Practice Periodical on Structural Design and Construction*. This subsequent search identified an additional seven articles.

Table 2.1: Keywords Used in Literature Search

Keywords	Boolean Operators	Additional Keywords
Construction Safety	AND	Leadership
Construction	AND	Safety, Leadership skills, Risk, Tolerance, Assessment, Frontline, Worker, Management

2.1.2 Step 2: Eligibility Assessment to Research Topic

In Step 2, the eligibility of the retrieved articles was assessed by relevance to the research topic. To conduct this assessment, several criteria were used for the inclusion and exclusion of indexed studies. Firstly, to ensure the research outputs are founded on contemporary theories and concepts, all studies prior to the year 2000 were excluded. Additionally, any publications found not to be within the topic areas shown in Table 2.2 were excluded from further screening. At this point, 78 publications were included. Secondly, further screening was conducted by examining the headings, results, and conclusions to confirm that each publication addressed topics relevant to our research focus. Finally, each document that passed the preliminary screening underwent a full-text evaluation to confirm its quality and credibility before inclusion in the final review. As a result of this assessment, a total of 78 articles were selected for inclusion in the review.

Table 2.2: Literature Review Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Must have been published after the year 2000	Publications prior to the year 2000
Must be within the topic areas of Construction Management, Safety, Leadership Skills, Risk-Tolerance/Perception, or Safety Assessment	Publications found not to cover specific topic areas of Construction Management, Safety, Leadership Skills, Risk-Tolerance/Perception, or Safety Assessment
Upon full-text evaluation, the publication must be determined to have both credibility and quality of methods and results	Any publications with questionable methodologies, measurements, or inferences that would indicate a lack of validity

2.1.3 Step 3: Summary of Extrapolated Data

In the third step of the review process, a detailed analysis was conducted to extract and synthesize key data from the final set of 78 selected articles. This phase aimed to capture critical insights related to leadership and risk-taking behaviors, both of which are central to the study's research focus. Each article was carefully examined in full, with particular attention given to the results and discussion sections, where the most pertinent findings are typically presented. Extracted data were systematically recorded and categorized based on recurring themes and variables relevant to organizational safety and leadership dynamics.

The types of data collected during this stage included a range of elements, such as leadership styles (e.g., transformational, transactional, supportive, and authoritarian), employee engagement metrics, safety strategy implementation, individual and group-level risk perception, and essential management principles that influence safety behavior in the workplace. By organizing the data in this manner, the review was able to identify commonalities and differences across studies, highlight best practices, and uncover gaps in the existing literature. This process not only ensured that the review remained grounded in evidence-based findings but also provided a strong foundation for drawing meaningful conclusions in later stages of the research.

2.1.4 Step 4: Synthesis and Organization of Extracted Data

For the last step of the review process, the focus transitioned from data collection to critical synthesis and thematic organization. Rather than simply compiling findings, the extracted content was examined collectively to identify overarching patterns, contradictions, and gaps across the literature. This examination involved clustering related concepts and aligning them with the study’s primary areas of interest: leadership, risk tolerance, influences on safety culture, and the application of assessment tools. The goal was to move beyond summary and begin constructing a cohesive narrative that connected various strands of evidence into a meaningful framework. By organizing the literature thematically, this step laid the groundwork for in-depth analysis and interpretation in the final stages of the review process.

Provided below are detailed descriptions of the literature with respect to the study topics and identified themes. The Appendix contains a comprehensive table that summarizes the literature. The table provides a succinct description of each document and identifies the target population and topic(s) discussed in each document.

2.2 LEADERSHIP

Leadership plays a critical role in shaping safety outcomes, particularly in high-risk industries such as construction. Numerous researchers have emphasized that the leadership process is invariably connected to the formation and maintenance of a strong safety climate and, ultimately, the reduction of workplace accidents. Safety leadership has been widely recognized as a pivotal factor in influencing employee attitudes and behaviors toward risk. However, despite growing interest, previous research has offered limited insight into the specific mechanisms by which safety leadership drives improvements in safety behavior.

Recent studies have begun to bridge this gap. Xiao et al. (2025), for example, applied social exchange theory and a multistakeholder perspective to reveal how safety trust mediates the relationship between leadership and employee safety behaviors. Their work also highlighted the amplifying effects of coworker support and family motivation, suggesting that effective safety leadership extends beyond the individual leader to include a broader network of influence. Similarly, Slates (2008) emphasized the importance of management commitment and organizational elements such as employee involvement, training, and hazard control as foundational to effective safety performance. Martin and Lewis (2013) further demonstrated that construction managers who enforce safety standards with authority, sometimes contrary to postmodern expectations, can significantly reduce risk-taking behavior on job sites. Together, these findings underscore the complexity and importance of frontline safety leadership, setting the stage for a deeper exploration of its components, assessment methods, and strategies for improvement.

2.2.1 Frontline Safety Leadership Roles

Frontline supervisors play a pivotal role in shaping the safety climate on construction sites by serving as the essential link between upper management and field workers. Within the framework proposed by Al-Bayati et al. (2019), supervisors are positioned as key actors in translating strategic safety policies into daily, observable actions that directly influence worker perceptions and behaviors. One of their primary responsibilities is implementing safety policies at the site level, ensuring that workers understand and follow procedures consistently. Frontline leaders also reinforce organizational values and demonstrate safety as a non-negotiable priority through their commitment to safety. This reinforcement includes actions such as modeling appropriate behavior, using personal protective equipment, or following site protocols.

Beyond policy enforcement, supervisors are actively engaged in identifying and controlling hazards in real time. Their proximity to evolving site conditions allows them to monitor for unsafe behaviors, conduct inspections, and intervene promptly when issues arise. Communication is another essential component of their role. Effective frontline supervisors maintain open lines of dialogue with their crews, encourage near-miss reporting, and foster a psychologically safe environment where concerns can be raised without fear of retaliation (Xiao et al. 2025). This ongoing feedback loop strengthens the site's responsiveness to risk and promotes trust among workers.

Accountability is also central to the supervisor’s influence. By consistently enforcing safety expectations and addressing noncompliance, supervisors help establish and sustain safety norms. Furthermore, supervisors often serve as informal safety mentors, particularly to newer or less experienced workers. Their ability to provide real-time coaching and on-the-job training

plays a direct role in shaping safety-related behaviors. In this way, frontline supervisors are more than enforcers, they are facilitators of a strong safety climate, guiding workers toward safer practices while reinforcing the broader organizational culture. Their leadership on the ground is fundamental to ensuring that safety values are not only communicated but also practiced, thereby reducing risk-taking behavior and supporting continuous improvement in safety performance (Martin and Lewis 2013; Al-Bayati et al. 2024).

2.2.2 Types of Leadership

Types of safety leadership in construction can take multiple forms, each influencing safety culture and worker behavior in distinct ways. Drawing from recent studies, four primary leadership styles emerge as particularly relevant to construction safety: transformational, transactional, supportive, and authoritarian leadership. These styles differ in characteristics and how they motivate, monitor, and manage workers. Additionally, each style exerts distinct mechanistic effects on safety compliance, participation, and overall incident reduction. The characteristics of each type are summarized in Table 2.3.

Table 2.3: Summary of Leadership Styles, Characteristics, and Effects

Leadership Styles	Core Characteristics	Mechanistic Effects
Transformational	Vision, inspiration, role modeling, innovation in safety practices	Increases risk perception, boosts compliance, and participation
Transactional	Rule enforcement, contingent rewards, monitoring	Maintains baseline compliance, less effective for voluntary behaviors
Supportive	Empathy, personal concern, relationship-building	Builds trust, psychological safety, and improves adherence
Authoritarian	Strict standards, top-down control, high demands	Strong enforcement and immediate accident reduction

Transformational leadership is characterized by a leader's ability to articulate a compelling vision for safety, inspire workers, and encourage them to exceed minimum standards. Leaders employing this style act as role models, promote innovation in safety practices, and foster a shared commitment to safety goals. Guha et al. (2023) found that transformational leadership significantly enhances both safety and quality performance. Similarly, Liu et al. (2021) demonstrated that transformational leadership increases worker risk perception, which in turn drives both safety compliance and voluntary participation in safety activities.

Transactional leadership emphasizes structured control through contingent rewards, active monitoring, and corrective feedback. Leaders exhibiting this style focus on ensuring compliance with established safety procedures and organizational rules. Guha et al (2023) reported that transactional leadership supports baseline compliance but is less effective in promoting discretionary safety behaviors compared to transformational approaches. Liu et al. (2021) similarly found that while transactional leadership can reinforce compliance via improved risk perception, its influence is generally weaker than that of transformational leadership when it comes to fostering proactive safety engagement.

Supportive leadership prioritizes empathy, interpersonal relationships, and concern for worker well-being. Leaders adopting this style actively listen to workers' safety concerns, provide encouragement, and create an environment where individuals feel safe to report hazards. Ma et al. (2020) found a strong link between supportive leadership and safety leadership effectiveness, particularly in contexts where maintaining morale and psychological safety are essential. By fostering trust and demonstrating genuine concern, supportive leaders enhance worker willingness to follow safety protocols and engage in hazard identification.

Authoritarian leadership is directive and control-oriented, relying on strict enforcement of safety standards and demanding adherence from workers. While often viewed less favorably in modern leadership theory, Martin and Lewis (2013) found that managers who "ruled with an iron rod," maintained uncompromising safety standards, and pressed workers for higher performance were more effective at reducing accidents on-site than those who employed more lenient approaches. This finding suggests that in certain high-risk construction contexts, particularly where compliance is non-negotiable, authoritarian leadership may yield immediate and tangible safety benefits.

2.2.3 Assessing Leadership Skills

Assessing leadership skills in construction is a complex endeavor due to the multifaceted nature of leadership and the diverse contexts in which it is exercised. Leadership effectiveness in the construction sector not only determines project outcomes but also influences safety culture, worker engagement, and overall organizational performance (Guha et al. 2025; Ma et al. 2020). Traditional approaches to leadership assessment often rely heavily on qualitative impressions or past experience, which may overlook critical behavioral, emotional, and cognitive dimensions necessary for leading effectively in high-risk, project-based environments. Many recent studies have therefore emphasized the need for structured, data-driven assessment frameworks tailored to the construction context.

One such approach is the Leadership Quality Index (LQI) proposed by Guha et al. (2025). This framework presents five essential factors for effective construction leadership: emotional quotient, spiritual quotient, resilience, democratic leadership, and flow state. The relative importance of these factors was determined using the analytic network process (ANP), which accounts for interdependencies between factors. In their study, emotional quotient emerged as the most significant factor, followed by spiritual quotient, resilience, democratic leadership, and flow state. This weighting reflects the reality that in complex, dynamic construction settings, leaders must excel in emotional intelligence and purpose-driven decision-making while maintaining adaptability and a collaborative approach. The LQI methodology combines these weighted factors with individual leader scores to produce a composite index value. Leaders can then be classified into top-quality, moderate-quality, and low-quality clusters based on their LQI, enabling targeted leadership development interventions. This classification moves beyond rigid typologies by capturing the nuanced interplay of personal traits and leadership behaviors.

Ma et al. (2020) complement this perspective with their Safety Leadership Effectiveness Assessment (SLEA) model, which focuses specifically on behaviors and practices that promote safety performance. Drawing from empirical research across multiple construction projects, the researchers identified a set of owner and contractor safety leadership indicators that can be objectively measured. These indicators capture actions such as establishing authority in safety management, improving trust and collaboration, enhancing safety awareness, ensuring consistent

implementation of safety policies, and increasing worker commitment to safety goals. The indicators are assessed using a Likert-scale questionnaire and analyzed through a fuzzy statistical method, which mitigates the influence of subjective bias. The resulting scores provide a clear benchmark for evaluating a leader's capacity to influence safety-related outcomes and can be compared across projects or organizations to inform leadership improvement strategies.

The research by Fang et al. (2023) on supervisor influence on worker safety behavior, further reinforces the importance of aligning leadership assessment with observable worker outcomes. Their findings demonstrate that a supervisor's safety commitment, communication practices, and role modeling behaviors directly influence both safety compliance and proactive safety participation among workers. Consequently, leadership assessment in construction must account not only for personal attributes and managerial skills but also for the tangible impact a leader has on worker attitudes and behaviors in the field.

Additionally, Mostofi-Togan et al. (2023) add that integrating such qualitative leadership measures with quantitative safety risk profiles derived from predictive analytics can ensure that assessments capture both human and data-driven perspectives. This dual approach not only evaluates how leaders inspire and guide their teams but also links leadership performance to predictive safety outcomes, enabling proactive interventions.

Together, these previous studies point toward an integrated assessment approach that blends trait-based evaluation (as in the LQI), behavioral and outcome-based measurement (as in the SLEA), and worker impact analysis (as in supervisor influence studies). This holistic approach ensures that leadership assessments capture the full spectrum of what makes a leader effective in the construction context, from emotional intelligence and resilience to the consistent enforcement of safety standards, to the ability to inspire and sustain a culture of safety. By combining psychometric measurement with field-based behavioral indicators, organizations can make informed, evidence-based decisions in leader selection, training, and development, ultimately strengthening both leadership capacity and safety performance in the construction industry.

2.2.4 Improving Leadership Skills

The question of how to improve leadership skills remains inherently complex. Many people in the construction industry seek straightforward, one-size-fits-all answers to this question. However, leadership is not a static or easily defined attribute, it is a dynamic and evolving set of skills shaped by context, individual personality, interpersonal dynamics, and organizational culture. Improving leadership skills in the construction industry therefore requires a comprehensive, inclusive, and sustained approach that emphasizes both formal education and experiential learning. According to Skipper and Bell (2006), traditional models of leadership development that focus only on a few high-potential individuals are insufficient. Instead, Skipper and Bell advocate for an "all-hands" approach to leadership development that mirrors the military model where leadership training is integrated throughout all career stages and accessible to all personnel. This broad-based strategy acknowledges that leadership skills can be taught, developed, and refined over time, especially when supported by structured programs and mentoring.

Complementing this perspective, Skipper and Bell (2008) emphasized the importance of integrating leadership development with succession planning. Rather than relying on identifying predictive variables within future leaders, Skipper and Bell argued for embedding leadership

growth opportunities throughout an organization. This approach can be achieved through rotating job assignments, project-based learning, formalized mentorship, and exposure to responsibilities beyond one's current scope. Such strategies cultivate a deep leadership bench, ensure continuity in project execution, and promote a culture of shared responsibility.

In their study, Skipper and Bell noted that creating a culture that values leadership at all levels requires intentional change management. A key finding was that top-performing construction project managers consistently demonstrated superior leadership behaviors when evaluated using the Kouzes-Posner Leadership Practices Inventory (LPI). This 360-degree feedback tool highlights five core practices: modeling the way, inspiring a shared vision, challenging the process, enabling others to act, and encouraging the heart. The top performers scored significantly higher in three of these five areas (modeling the way, inspiring a shared vision, and challenging the process), suggesting that targeted training in these domains could benefit a broader workforce.

Additionally, causal influences that support the development of effective leadership include mentoring and coaching by senior leaders, self-initiated reading and study, and real-world experience managing projects and financial responsibilities. These findings reinforce the idea that leadership development must be multifaceted and include practical, hands-on experiences alongside theoretical training.

The previous studies imply that organizations should normalize leadership training as a continuous process, support it with measurable outcomes, and reinforce it with institutional commitment. The authors suggested that by doing so, the construction industry can foster resilient, adaptable, and emotionally intelligent leaders capable of meeting present and future challenges.

2.2.5 Measuring Improvement in Leadership

Documented metrics for measuring leadership improvement remain a significant research gap. However, many health and safety organizations, including OSHA, NIOSH, and ACGIH, recommend scheduled reassessments of corrective actions as part of continuous improvement. This principle can be applied to leadership development by conducting regular, structured evaluations of leadership competencies over time. Evaluations may include validated assessment tools such as the Kouzes-Posner LPI, employee perception surveys, 360-degree feedback, and performance outcome measures related to safety, quality, and productivity. Additionally, Xiao et al. (2025) emphasize that measurements should go beyond task-level compliance to also track changes in relational factors, such as peer support and safety trust, that sustain long term improvements.

Ultimately, tracking results over successive assessments enables organizations to identify trends, determine the effectiveness of specific development strategies, and make targeted adjustments. By integrating both quantitative indicators such as incident rates, staff retention, and project delivery performance, and qualitative insights such as team morale and communication effectiveness, organizations can establish a comprehensive, ongoing process that aligns leadership growth with both individual and organizational objectives.

2.3 RISK TOLERANCE

Bhandari et al. (2021) define risk tolerance as an individual's willingness to accept uncertainty and potential negative consequences when making decisions in hazardous environments. With respect to occupational safety contexts, risk tolerance reflects the degree to which workers are willing to engage in actions that deviate from established safety protocols based on their own perception of hazard severity, personal skill level, previous experiences, and situational pressures such as deadlines or production demands. This willingness may be intentional in which an individual knowingly takes a calculated risk, or unintentional such as when hazards are underestimated due to overconfidence or lack of hazard awareness.

Furthermore, Salas et al. (2020) framed risk tolerance as a dynamic and context-sensitive psychological construct shaped by cognitive appraisal of hazards, social norms within the workgroup, and the overall organizational safety climate. In this view, risk tolerance is not a fixed personality trait but a flexible, adaptive state that can change rapidly based on prior experiences, peer behavior, management practices, and environmental cues. For example, repeated exposure to high-risk situations without negative consequences can desensitize workers to the hazards present, increasing tolerance over time, whereas witnessing or experiencing an incident can lower tolerance and reinforce safe practices. Factors that have been correlated to workers exhibiting poor risk tolerance include: (1) overestimating capability or experience; (2) familiarity with the task; (3) seriousness of outcome; (4) voluntary actions and being in control; (5) personal experience with an outcome; (6) cost of non-compliance; (7) overly confident in the equipment; (8) confidence in protection and rescue; (9) potential profit and gain from actions; and (10) role models accepting risk (West Fraser Timber, n.d.).

Xiao et al. (2025) indirectly link leadership style to risk tolerance by demonstrating that leaders who build safety trust and encourage peer support can reduce willingness to engage in unsafe acts. This result suggests that interventions aimed at lowering risk tolerance should not focus solely on the individual worker but also address relational and organizational factors.

Importantly, variations in risk tolerance have direct implications on safety performance. Higher levels of risk tolerance are frequently associated with increased rates of unsafe acts, procedural violations, and near misses, as individuals prioritize task completion or efficiency over adherence to safety protocols. Conversely, lower levels of risk tolerance were correlated with proactive hazard avoidance, consistent use of personal protective equipment, and greater compliance with safety systems (Kumar and Bhattacharjee 2023; Bhandari et al. 2021). These findings suggest that understanding the dynamics of risk tolerance is critical for predicting safety behaviors and designing interventions that can shift tolerance levels toward safer norms.

2.3.1 Elements of Risk Tolerance

Risk tolerance in construction is shaped by a complex interplay of individual, task-related, and organizational factors. Wang et al. (2016) categorize these influences into four broad groups: (1) personal subjective perception, (2) work knowledge and experience, (3) work characteristics, and (4) safety management. Personal subjective perception encompasses attitudes toward risk, emotional state, self-confidence, and sensitivity to hazards, while work knowledge and experience reflect a worker's technical expertise, safety knowledge, and familiarity with similar tasks. Work characteristics include environmental conditions, task complexity, time constraints, and workload. Safety management refers to the broader organizational safety culture,

enforcement of safety rules, supervisory practices, and the availability of protective equipment. Among these, external factors, particularly safety management, often have a greater influence on risk tolerance than internal factors (Wang et al. 2016).

Personality traits also play a significant role. Gao et al. (2019) found that workers who score high in conscientiousness and agreeableness typically exhibit lower risk tolerance, aligning with greater adherence to safety procedures. Conversely, traits such as extraversion and openness to experience may be linked with a greater willingness to engage in risk-taking, particularly in environments where such behaviors are socially reinforced. The relationship of neuroticism to risk tolerance is more nuanced. While heightened anxiety can lead to avoidance of hazardous situations, it may also prompt unsafe shortcuts to reduce discomfort or stress. These findings suggest that personality interacts dynamically with environmental and organizational factors, making it one of several important determinants rather than the sole driver of risk tolerance.

Cognitive appraisal, such as a worker's understanding of hazard severity or likelihood, also influences tolerance but is only one component. Alomari et al. (2018) emphasize that differences in risk perception, i.e., the cognitive evaluation of hazard severity and likelihood, can influence risk tolerance thresholds but do not fully explain them. Factors like previous exposure to risk without incident, peer influence, production pressures, and the perceived balance between safety and productivity demands can raise or lower tolerance over time. These elements interact continuously, meaning that risk tolerance is not fixed, it evolves in response to both individual development and changing work environments.

In practice, this multidimensional nature of risk tolerance means that interventions to lower risk tolerance must address multiple domains simultaneously, i.e., strengthen safety management systems, design tasks to minimize unnecessary hazards, enhance individual competencies, and foster positive workplace norms.

2.3.2 Influences of Safety Behaviors and Risk Tolerance

Safety behavior in construction is the observable outcome of the interplay between individual disposition, situational pressures, and organizational context, with risk tolerance serving as a key mediating factor. Workers with high risk tolerance, whether due to personality traits, prior experiences, or environmental cues, are more likely to engage in unsafe acts, procedural violations, and shortcuts, particularly when they perceive the benefits of such actions (e.g., faster task completion) as outweighing the potential consequences (Bhandari et al. 2021; Salas et al. 2020). Such risk tolerance may be reinforced by production pressures, inadequate supervision, normalization of deviance among peers, or previous experiences of "getting away" with unsafe acts without incident (Wang et al. 2016).

Conversely, low risk tolerance is generally associated with positive safety behaviors such as consistent use of personal protective equipment (PPE), adherence to established procedures, and proactive hazard reporting. Gao et al. (2019) link this tendency to personality traits like conscientiousness and agreeableness, which predispose individuals toward compliance and cooperative work practices. Similarly, Alomari et al. (2018) highlight that workers who perceive hazards as both likely and severe are less willing to accept risk, which translates into safer behavioral patterns.

Leadership behaviors also play a role. Xiao et al. (2025) show that leaders who model safety and foster trust can create an environment where even high-tolerance workers are more

likely to act safely. Positive reinforcement, recognition for safe work, and peer accountability mechanisms can help sustain this effect.

A consistent theme in contemporary research is that the drivers of negative or positive safety behavior extend well beyond individual choice and are deeply influenced by broader contextual factors. A strong organizational safety climate, clear and consistent communication, sufficient resources, and visible leadership commitment can reduce individual risk tolerance and encourage safer behaviors, even among workers predisposed to take risks. Conversely, weak policy enforcement, inconsistent supervisory messaging, and poorly designed work environments can undermine even the most safety-conscious workers. These relationships underline the importance of interventions that target both individual predispositions and the systemic conditions that shape safety behavior.

2.3.3 Assessing Risk Perception and Risk Tolerance

Although the terms *risk perception* and *risk tolerance* are sometimes used interchangeably, the literature treats them as distinct yet closely related constructs. Risk perception refers to the cognitive process of interpreting and evaluating the likelihood and severity of an injury associated with a hazard, whereas risk tolerance reflects the behavioral threshold, i.e., the level of risk a person is willing to accept once that perception is formed (Alomari et al. 2018; Bhandari et al. 2021). In most models, perception precedes tolerance. Underestimating a hazard tends to increase willingness to take risks, while heightened hazard awareness generally lowers tolerance. However, this relationship is not strictly linear; organizational culture, peer influence, and prior experiences can moderate or override perception, resulting in tolerance levels that may diverge from objective hazard assessments. Clarifying these definitions is essential for designing accurate measurement tools.

Much like assessing leadership skills, assessing risk tolerance in the construction industry also requires a multifaceted approach that captures both individual dispositions and contextual influences. Bhandari et al. (2021) employed structured questionnaires to quantify personal and work-related risk tolerance, linking these scores to observed safety behaviors. Salas et al. (2020) incorporated behavioral simulations and scenario-based assessments, allowing participants to respond to controlled hazard situations, which helped reveal discrepancies between stated attitudes and actual choices. Alomari et al. (2018) used Delphi-based expert consensus to evaluate risk perception differences among professional roles, which can indirectly inform tolerance thresholds. Personality inventories, such as those measuring conscientiousness, agreeableness, or sensation-seeking, can provide valuable insights into predispositions toward risk-taking (Gao et al., 2019). In addition, organizational safety climate surveys offer context for interpreting individual tolerance levels, as tolerance is often shaped by perceived management commitment to safety, peer norms, and enforcement practices (Wang et al. 2016).

Combining these methods, self-report surveys, behavioral simulations, personality profiling, and climate assessments, can yield a more accurate and actionable picture of both risk perception and risk tolerance. Such comprehensive evaluation enables safety managers to tailor interventions that address the underlying factors driving unsafe behaviors, rather than relying solely on reactive measures after incidents occur.

2.3.4 Improving Safety Behavior and Risk Tolerance

Contemporary literature suggests that improving safety behavior in construction requires a strategy that addresses both the individual determinants of risk tolerance and the systemic factors that shape them. At the individual level, targeted safety training should focus on hazard recognition, decision-making under pressure, and situational awareness, as these skills directly influence a worker's ability to assess and respond to risk. Bhandari et al. (2021) suggest that interventions are most effective when they explicitly link risk-taking tendencies to potential negative consequences, reinforcing safer decision-making patterns.

Additionally, leadership is a critical lever in this process. Xiao et al. (2025) demonstrate that effective safety leadership, characterized by trust-building, clear communication, and role modeling, can reduce risk tolerance by shifting social norms and fostering an environment where safe behavior is expected and reinforced. Leaders who actively engage with workers, address safety concerns promptly, and recognize proactive hazard mitigation efforts help reframe safety compliance as a shared value rather than an imposed rule. Martin and Lewis (2013) similarly found that supervisors who enforce safety standards with consistency, and at times firmness, can counteract normalization of unsafe practices, especially in high-pressure work environments.

On a broader scale, predictive tools such as those described by Mostofi-Togan et al. (2023) can identify patterns of elevated risk tolerance across tasks, crews, or individuals, enabling organizations to deploy targeted interventions where they will have the greatest effect. Interventions may include task redesign to reduce inherent hazards, adjusting work schedules to relieve time pressure, or increasing supervisory presence in high-risk zones. Research also emphasizes tailoring strategies to personality and behavioral profiles. For example, workers high in sensation-seeking may benefit from immersive, scenario-based safety simulations that challenge their assumptions about hazard controllability (Gao et al. 2019).

Finally, improving safety behavior requires a positive and consistent organizational safety climate. Visible top-management commitment, integration of safety into performance evaluations, and alignment of production goals with safety objectives are key elements of such a climate. As Alomari et al. (2018) noted, when workers perceive that management values safety as highly as productivity, their willingness to take risks decreases and positive safety behaviors become the default norm.

2.3.5 Measuring Improvement in Safety Behavior and Risk Tolerance

Measuring improvement in safety behavior and risk tolerance requires a combination of quantitative and qualitative indicators assessed over time (Bhandari et al. 2021; Salas et al. 2020; Alomari et al. 2018). Quantitative measures may include reductions in incident rates, near misses, and safety violations, as well as improvements in compliance scores from site inspections. Behavioral indicators, such as increased rates of hazard reporting and consistent use of PPE, provide direct evidence of safer work practices. Bhandari et al. (2021) highlight the value of longitudinal tracking of individual and work-related risk tolerance scores to determine whether interventions are having a sustained effect.

Qualitative measures, such as worker surveys, structured interviews, and 360-degree peer and supervisor feedback, can reveal shifts in safety attitudes, perceived management commitment, and peer norms, all of which are factors that strongly influence future risk tolerance (Salas et al. 2020; Alomari et al. 2018). Xiao et al. (2025) recommend also monitoring changes

in mediators such as safety trust, coworker support, and family motivation, as these relational elements have been shown to maintain long-term safety gains.

Integrating predictive analytics, as proposed by Mostofi-Togan et al. (2023), can further enhance measurement by identifying early-warning indicators of rising risk tolerance, such as task assignments with elevated hazard exposure or worker groups showing increased deviation from safe work practices. This data-driven layer allows organizations to validate whether leadership and training interventions are not only improving compliance but also reducing the underlying propensity for unsafe acts.

To ensure accuracy, measurement should be cyclical and embedded into routine safety management systems. Comparing results across multiple reassessment periods enables organizations to detect trends, evaluate intervention effectiveness, and refine strategies. When paired with strong leadership engagement, these cyclical assessments can transform safety improvement from a reactive process into a proactive, continuously adaptive system that aligns with both worker well-being and organizational performance goals.

2.4 Influences on Safety Culture

Much like leadership and risk-tolerance, safety culture is also not shaped by a single factor, but instead develops through the interaction of multiple demographic, organizational, and trade-specific influences. Workforce composition, age distribution, firm size, trade practices, and hierarchical role each contribute to the way safety values are formed, communicated, and practiced on site (Al-Bayati et al. 2017; Namian et al. 2022; Alomari et al. 2018, Li et al. 2024). Recognizing these influences is essential for identifying strengths, addressing vulnerabilities, and designing interventions that reflect the realities of the workforce and work environment. The following subsections explore key variables including migrant worker demographics, age, industry characteristics, trade culture, and organizational position, and explain how each variable contributes to the strength and resilience of safety culture in construction settings.

2.4.1 Migrant Workers

Migrant workers, particularly Hispanic laborers, constitute a significant portion of the U.S. construction workforce and play a critical role in shaping site-level safety culture. Al-Bayati et al. (2017) found that language barriers, cultural norms, and differing safety expectations from workers' countries of origin can affect communication, hazard recognition, and adherence to safety procedures. For many migrant workers, limited English proficiency reduces access to training materials, safety meetings, and hazard alerts, increasing reliance on informal translation by bilingual coworkers or supervisors. This dependence can lead to incomplete or delayed communication of critical safety information.

Cultural values also influence safety behavior. Workers from collectivist cultures may be reluctant to challenge authority or report unsafe conditions for fear of disrupting group harmony or appearing disrespectful to supervisors. Similarly, a strong work ethic and a desire to demonstrate productivity may prompt migrant workers to take risks or bypass procedures, particularly when facing production pressure. These patterns are compounded when supervisors lack cultural competence or when safety policies are not adapted to address the linguistic and cultural diversity of the workforce (Al-Bayati et al. 2017). Differences in hazard perception

linked to cultural and experiential backgrounds can further shape these behaviors, influencing how workers evaluate and respond to potential risks (Alomari et al. 2019).

Ultimately, the contemporary literature suggests that improving safety culture among migrant workers requires targeted interventions, including multilingual safety training, culturally tailored communication strategies, and mentorship programs that connect experienced bilingual workers with newer hires. Additionally, fostering a work environment where all workers feel empowered to voice concerns without fear of retaliation can help bridge cultural gaps, reduce misunderstandings, and strengthen overall site safety performance.

2.4.2 Worker Age

Age has also been found to be a significant influencer of construction safety culture and worker safety performance. Namian et al. (2022) found that age correlates to safety outcomes both directly and indirectly through mediating factors such as job experience and fatigue. Older workers often bring extensive experience, which can enhance hazard recognition and safety decision-making. However, older workers may also face declines in physical capacity, reaction time, and endurance, which can increase vulnerability to certain types of accidents, particularly in physically demanding tasks. Younger workers, in contrast, tend to have greater physical stamina and adaptability but may exhibit higher risk tolerance due to limited experience and a tendency toward sensation-seeking.

Complementing this perspective, Li et al. (2024) demonstrated that while older workers often exhibit stronger early-stage hazard awareness (pre-attentive detection), they may show reduced attentive processing of nonfatal hazards, a difference not consistently explained by prior experience. This finding suggests that age-related cognitive changes can affect sustained attention to certain hazards even among seasoned workers, highlighting the importance of tailored safety strategies that support both immediate hazard detection and continuous hazard monitoring.

Collectively, these findings emphasize that safety interventions to improve safety culture and performance should be age-sensitive, leveraging the strengths of each group while addressing potential limitations. For older workers, interventions may involve ergonomic task design, fatigue management, and refresher training focused on attentive hazard processing. For younger workers, strategies should emphasize experiential learning, mentorship, and fostering hazard perception skills to counterbalance lower initial experience levels.

2.4.3 Industry Sector

The characteristics of the construction industry itself have perhaps the most profound influence on safety culture and climate. Al-Bayati (2021) found that industry-wide factors, such as the prevalence of transient workforces, competitive bidding environments, and tight project schedules, can create systemic pressures that shape safety attitudes and behaviors. In sectors of construction where production demands are high and profit margins are narrow, safety may be deprioritized in favor of speed, particularly when leadership commitment to safety is inconsistent or poorly communicated.

Different industry subsegments, such as residential, commercial, and heavy civil construction, also demonstrate distinct safety climates. For example, residential projects, which often rely on smaller crews and subcontracted labor, may have less formalized safety

management systems compared to large-scale infrastructure projects where regulatory oversight and contractual safety requirements are more stringent. Al-Bayati (2021) further highlighted that the perceived importance of safety is closely tied to the maturity of safety programs within a given industry sector, with more established safety management systems contributing to higher levels of safety participation and compliance among workers.

Industry norms, market competition, and regulatory environments therefore interact to shape both organizational and individual safety behaviors. Addressing these systemic influences requires coordinated efforts across the industry, including stronger regulatory enforcement, industry-specific safety campaigns, and cross-sector collaboration to share best practices.

2.4.4 Work Trade

Much like industry sector, the specific trade in which a construction worker is employed can strongly influence both safety culture and climate. Different trades are associated with distinct hazard profiles, work environments, and task demands, which in turn shape worker risk tolerance and safety practices. For example, high-risk trades such as ironworking, electrical work, and roofing often involve elevated heights, live electrical systems, or complex equipment operation, creating a work culture where hazard familiarity can lead to normalization of risk (Wang et al. 2016; Bhandari et al. 2021). Over time, repeated exposure without incident may increase risk tolerance within certain trades, prompting workers to bypass safety procedures in the interest of efficiency or perceived skill mastery.

Personality factors may also contribute to influencing trade-level differences. Gao et al. (2019) observed that certain personality traits, such as higher extraversion or openness to experience, may be more common in trades requiring adaptability, quick decision-making, and comfort with uncertainty, traits that can correlate with higher willingness to take risks. Conversely, trades emphasizing precision and repetitive task execution, such as finish carpentry or painting, may attract workers with higher conscientiousness, which is associated with greater compliance and adherence to safety protocols.

Trade-specific safety behaviors may also be further influenced by hazard perception differences between roles. Similar to the finding of risk normalization in high-risk trades, Alomari et al. (2018) found that professionals' risk perception varies according to their job responsibilities and proximity to hazards, suggesting that some trades may underestimate or overestimate certain risks based on their daily exposure. This variation underscores the importance of tailoring safety training and communication strategies to the unique conditions and behavioral tendencies of each trade (Al-Bayati 2021). Such targeted interventions can address trade-specific risk factors, reinforce hazard awareness, and align safety culture expectations across the broader construction workforce.

2.4.5 Worker Position / Role in Organization

A worker's position within the organizational hierarchy significantly shapes their role in the safety culture and their influence on safety outcomes. Frontline workers are typically the most exposed to immediate hazards, making their personal risk tolerance, hazard perception, and compliance with procedures critical to site safety performance. However, their ability to act safely is often mediated by the clarity of instructions, the availability of resources, and the quality of supervision they receive (Al-Bayati et al. 2024; Fang et al. 2023). Supervisors and

foremen occupy a pivotal position, functioning as the link between management's strategic safety goals and the daily realities of the worksite. Frontline supervisors translate policy into practice, model safe behavior, and enforce safety standards, all of which are actions shown to directly affect both compliance and proactive safety participation among workers (Fang et al. 2023; Martin and Lewis 2013).

At higher organizational levels, managers and safety professionals shape the overall safety climate through decisions related to policy development, hazard control measures, training investments, and enforcement practices. Research by Al-Bayati (2021) indicates that positive safety culture and climate, when modeled consistently by leadership, can motivate workers across all positions to engage more actively in safety behavior. Conversely, when positional authority figures fail to demonstrate commitment to safety, workers may perceive safety rules as secondary to productivity, eroding compliance across the site.

Position also influences the type and frequency of risk encountered. For instance, safety managers and engineers may face fewer direct physical hazards than field workers but bear greater responsibility for hazard anticipation, risk communication, and procedural enforcement (Alomari et al. 2018). This difference in exposure can lead to disparities in risk perception between roles, which, if unaddressed, may result in misaligned safety priorities. Aligning perspectives across positions through targeted communication, cross-level training, and participatory safety planning can strengthen cohesion in safety values and reduce gaps in risk management practices (Al-Bayati et al. 2024).

2.5 TOOLS FOR ENHANCING LEADERSHIP AND RISK TOLERANCE

Enhancing safety in construction requires more than policies and procedures, it depends on the systematic application of tools that assess current conditions, identify weaknesses, and drive targeted improvements. These tools operate at multiple levels, from measuring organizational safety climate to evaluating individual competencies, and from tracking leading indicators and predictive variables to delivering specialized training. When selected and implemented effectively, the tools provide an evidence-based foundation for decision-making, allowing safety managers to move beyond reactive measures toward proactive risk management. As Al-Bayati (2021b) notes, integrating robust safety culture assessments with interventions such as skill development and leadership training can create a reinforcing cycle of improvement, where measured progress informs further action. Similarly, Mostofi-Togan et al. (2023) emphasize that predictive analytics and data-driven tools, when paired with qualitative evaluations of human factors, can optimize the allocation of safety resources and enhance both compliance and engagement across all positions. The following sections outline two critical categories of tools, assessment tools and training tools, that are essential to sustaining high levels of safety performance in the construction industry and are particularly applicable to assessing safety leadership and risk tolerance (Zohar 2000; Al-Bayati 2021b; Salas et al. 2020; CII 2025).

2.5.1 Assessment Tools

Effective enhancement of construction safety culture begins with the ability to measure it accurately. Assessment tools provide organizations with structured methods to evaluate the current state of their safety climate, identify gaps, and track progress over time. Safety climate surveys, such as those based on Zohar's (2000) Group Safety Climate Scale, remain widely used

for capturing workers' perceptions of management commitment, communication, and enforcement of safety policies. Al-Bayati (2021b) demonstrated that these instruments can reliably link safety climate scores to both safety motivation and behavioral outcomes, providing actionable insights for targeted interventions.

In addition to climate and culture surveys, structured behavioral observation systems allow supervisors and safety personnel to monitor compliance with critical safety procedures in real time. When paired with predictive analytics, as suggested by Mostofi-Togan et al. (2023), these observations can feed into safety risk profiles that forecast potential high-risk behaviors and enable proactive intervention. Other assessment approaches include risk tolerance questionnaires (Bhandari et al. 2021), leadership effectiveness evaluations (Guha et al. 2025; Ma et al. 2018), and hazard-specific competency tests that assess worker knowledge of safe work practices.

Recent guidance from the Construction Industry Institute underscores the value of integrating frontline supervisor (FLS) capability assessments into safety performance measurement frameworks. CII's report titled "Owner's Reference Guide for Assessing Contractor's FLS Development" offers a structured approach for evaluating whether contractor organizations have sustainable programs to train and assess key FLS skills, ranging from hazard recognition and communication to technology proficiency and human–automation interaction safety (CII 2025). This tool aligns skill requirements with projected industry scenarios and enables owners to evaluate contractors during the prequalification stage, even when individual supervisors have not yet been assigned.

Combining qualitative measures, such as focus group feedback, with quantitative data from surveys, behavioral audits, incident reports, and FLS skill assessments create a comprehensive view of organizational safety performance. This blended methodology allows organizations to assess not only compliance with safety standards but also the underlying cultural, psychological, and leadership factors influencing worker behavior, while ensuring that supervisory capacity is aligned with future project demands (CII 2025).

2.5.2 Training Tools

Training tools serve as the primary mechanism for translating assessment findings into improved safety performance. Modern construction safety training extends beyond traditional classroom instruction to include interactive and experiential methods designed to engage workers of diverse cultural and educational backgrounds. For example, scenario-based training and simulations can replicate high-risk situations in a controlled environment, enabling workers to practice hazard recognition and decision-making without real-world consequences (Salas et al. 2020).

Culturally tailored safety training, as emphasized by Al-Bayati et al. (2017), improves comprehension and retention among linguistically diverse crews by integrating bilingual materials, culturally relevant examples, and visual aids. Technology-based tools such as virtual reality (VR) and augmented reality (AR) training modules are increasingly used to immerse workers in realistic job site environments, enhancing engagement and knowledge transfer.

Behavior-based safety (BBS) training programs remain a proven approach for reinforcing positive safety behaviors and reducing at-risk actions through observation, feedback, and peer coaching. Additionally, leadership training for supervisors that cover communication skills, cultural competence, and risk tolerance management, have been shown to strengthen safety climate and motivate safer behaviors among crews (Xiao et al. 2025; Gao et al. 2019).

Recent research from CII emphasizes that training programs for frontline supervisors should be built around clearly defined learning objectives linked to the evolving skill requirements of the role. These programs should include multiple delivery methods such as on-the-job training, microlearning, classroom sessions, and VR/AR-based modules to address different competencies effectively. The CII framework also stresses "no regrets" moves, which are universally valuable across all future industry scenarios, including core leadership training, baseline technology literacy, structured mentorship, and inclusive leadership development (CII 2025).

Integrating training with ongoing assessments ensures that safety education is not a one-time event but part of a continuous improvement cycle. By aligning training content with the specific gaps identified through assessment tools, and by incorporating forward-looking competencies such as technological fluency, data-driven decision-making, and human–automation interaction safety, organizations can ensure that resources are directed toward the highest-impact areas for safety performance improvement (CII 2025).

2.6 Gaps in Knowledge and Practice

Despite significant advances in understanding the determinants of leadership, risk tolerance, safety culture, and worker behavior in construction, several gaps remain in both research and practice. A key limitation is the absence of standardized, validated metrics for measuring risk tolerance across different trades, cultural groups, and project types. Without a common framework, as noted by Bhandari et al. (2021) and Alomari et al. (2018), it is difficult to make meaningful comparisons between organizations or industries. Another emerging gap lies in the integration of predictive analytics with safety management systems. While Mostofi-Togan et al. (2023) emphasize the potential of predictive modeling for anticipating risk behavior, practical methods for embedding these tools into routine safety operations remain underdeveloped, particularly in ways that do not overburden site managers.

There is also a need for longitudinal research on leadership interventions. Existing studies, including those by Guha et al. (2025) and Xiao et al. (2025), often use cross-sectional data, limiting understanding of the sustained effects of leadership training over multiple project cycles. Similarly, although cultural and personality factors are recognized as critical influences on safety behavior (Al-Bayati et al. 2017; Gao et al. 2019), few safety programs explicitly integrate these considerations into policy and training design. Field-tested, culturally adaptive safety frameworks that gather longitudinal data remain scarce.

Research on the influence of firm size on safety climate (Al-Bayati 2021a) also reveals a need to investigate the specific mechanisms such as resource allocation, leadership structures, and communication channels, through which firm size impacts safety performance. Additionally, the measurement of safety behavior changes is often reliant on self-reported data, which can be subject to bias. The development of objective monitoring systems, such as sensor-based tracking or structured observational analytics, could provide more accurate assessments of safety performance over time. Finally, while Xiao et al. (2025) highlighted the mediating role of safety trust, coworker support, and family motivation between leadership and safety behaviors, quantitative models capturing the combined effects of these factors on both risk tolerance and incident rates are still limited.

2.7 RESEARCH NEEDS

Addressing the gaps in knowledge and practice will require an interdisciplinary approach that blends behavioral science, engineering, data analytics, and cultural studies. Studies should prioritize the development of universal measurement tools for risk tolerance and perception, integrate predictive analytics into practical safety management processes, and assess the long-term impacts of leadership training across project lifecycles. Moreover, safety interventions should be culturally adaptable, accounting for language, values, and work norms of diverse workforces. Expanding research into firm size effects, incorporating objective behavior monitoring, and building robust models to quantify the influence of safety trust and social support will create more precise and effective safety strategies, ultimately advancing both safety culture and performance in the construction industry.

Insights from the Construction Industry Institute's RT-414 research highlight additional areas for future exploration, particularly in aligning safety culture research with the evolving role of frontline supervisors. Scenario-based workforce planning should be examined as a method to anticipate training and leadership needs under varying levels of technological adoption and labor availability (CII 2025). Further investigation is needed to validate and refine the CII "no regrets" skill set for frontline supervisors, such as inclusive leadership, baseline technology proficiency, and adaptability to human–automation collaboration, ensuring these competencies remain relevant across diverse industry futures.

Research should also explore methods for integrating frontline supervisor skill assessments, such as the CII Playbook, into broader safety performance evaluation frameworks. Longitudinal studies could measure how targeted frontline supervisor development programs influence safety climate, worker engagement, and retention over time. Additionally, emerging training modalities to include AI-driven adaptive learning, VR/AR simulation, and microlearning, may warrant rigorous evaluation for their effectiveness in building both technical and interpersonal skills critical to safety leadership in a rapidly evolving construction environment (CII 2025).

3. RESEARCH DESIGN AND METHODOLOGY

3.1 STUDY DESIGN

The research study employed a mixed-methods research design to examine the relationship between frontline supervisor leadership, risk tolerance, and safety performance within the construction industry. A mixed-methods approach was selected to allow for quantitative measurement of leadership behaviors, communication practices, and organizational influences while also capturing qualitative insights regarding how supervisors shape safety culture in practice. The integration of statistical analysis and thematic interpretation provides a more comprehensive understanding of frontline supervisory influence than either method alone.

The study aligns with the Phase I objectives outlined in the CSRP proposal, which sought to document existing knowledge, refine leadership and risk-related constructs for frontline supervisory application, and identify potential assessment and training resources for future implementation. The present research fulfills these aims through cross-sectional survey data collection, inferential statistical analysis, and qualitative thematic evaluation. No experimental manipulation was conducted, and the study relied on perception-based responses from construction industry personnel representing multiple organizational contexts.

3.2 OBJECTIVES AND RESEARCH QUESTIONS

The primary objective of the study was to determine how frontline supervisors influence construction safety performance through leadership behaviors, communication styles, and risk-related decision-making characteristics. In alignment with the Phase I research framework, the study addressed three core research questions. First, the study examined which frontline supervisor leadership skills and risk-taking behaviors positively or negatively affect safety behavior among construction field workers. Second, it explored how frontline supervisors model safety behaviors in ways that influence safety culture and worker decision-making. Third, the study investigated whether construction organizations currently utilize assessment tools and leadership development mechanisms to evaluate and improve frontline supervisory safety leadership.

The study was guided by the hypotheses that: (1) leadership traits and risk tolerance characteristics influence field worker safety behavior; (2) supervisors who model strong safety commitment and low risk tolerance positively affect safety performance; and (3) organizational use of assessment tools and training programs varies across construction companies. These hypotheses provided the conceptual foundation for the survey questionnaire and subsequent statistical analyses.

3.3 SURVEY QUESTIONNAIRE

The research study included a survey to measure constructs identified in the literature review and grounded in the objectives of the CSRP Phase I proposal. To conduct the survey, a structured survey questionnaire was developed. The questionnaire permitted collecting data that was used to evaluate perceptions of frontline supervisor leadership behaviors, skills, communication practices, organizational influences, and leadership development practices. The questionnaire

incorporated Likert-scale items, ranking questions, multiple-response selections, and open-ended qualitative prompts.

Leadership traits and behaviors were assessed using agreement-based questions incorporating a Likert scale. The questions allowed for evaluating transformational behaviors, safety prioritization, accountability, and modeling of safe practices. Supervisory skills were measured through five Likert-scale questions assessing perceived demonstration of safety-related competencies. Reliability analysis confirmed strong internal consistency for the skill scale, supporting its use as a composite measure.

To examine organizational practices, participants were asked whether their organizations use formal tools to assess leadership skills and whether formal leadership training is provided. Perceived effectiveness of various training formats was also solicited. Finally, open-ended questions invited respondents to describe examples of supervisors improving safety performance, actions demonstrating personal commitment to safety, and the ways supervisors influence their own safety attitudes. The qualitative responses provided contextual depth to complement the quantitative findings.

The questionnaire was uploaded to an online survey platform (Qualtrics) for distribution. A link to the online survey was included in a recruitment email sent to the target sample. A copy of the survey questionnaire is provided in the Appendix along with the recruitment email and the explanation of research included in the survey questionnaire.

3.4 PARTICIPANTS AND SAMPLING

The study sample consisted of construction industry personnel occupying management and executive leadership roles across a range of organizational sizes and industry sectors, including both commercial and non-commercial construction. Participation was voluntary, and no restrictions were imposed based on company size, project scope, trade type, or geographic location, consistent with the Phase I research design.

Because the study was exploratory in nature and designed as an initial Phase I investigation, the sample size was relatively modest. As a result, statistical procedures were selected to accommodate unequal variances and small cell counts. The sample allowed for comparative analysis across industry sector, organization size, and leadership role, although findings must be interpreted within the constraints of the sample size.

3.5 DATA ANALYSIS PROCEDURES

3.5.1 Quantitative Analysis

Quantitative data analysis began with the conversion of Likert-scale responses into numeric values to enable statistical testing. Internal consistency reliability was evaluated using Cronbach's alpha. When reliability met accepted thresholds ($\alpha \geq 0.70$), composite scores were calculated by averaging relevant items. This procedure was applied to scales measuring supervisory skills, safety influence, and leadership training effectiveness.

Distributional assumptions were evaluated using Shapiro–Wilk tests prior to selecting appropriate inferential procedures. When normality assumptions were not met or when group variances were unequal, robust statistical techniques were employed. Group comparisons across industry sector, organization size, and job title were conducted using Welch's two-sample t-tests

and Welch's one-way ANOVA, which do not assume equal variances. Categorical variables were analyzed using Fisher's Exact Test due to small cell counts, and ranking questions were analyzed using Friedman rank-sum tests. Effect sizes, including Cramer's V and Kendall's coefficient of concordance, were calculated to assess practical significance alongside statistical significance.

3.5.2 Qualitative Analysis

Open-ended responses were analyzed qualitatively using thematic coding procedures. Responses were reviewed iteratively to identify recurring patterns related to leadership behaviors, safety modeling, communication practices, accountability, and organizational influences. Themes were grouped into broader conceptual categories reflecting visible leadership presence, coaching and mentorship behaviors, safety prioritization, intervention under pressure, and contextual constraints affecting supervisory effectiveness.

The qualitative analysis was not conducted as a formal grounded theory study but rather as a structured thematic synthesis intended to contextualize quantitative findings. This approach allowed qualitative insights to clarify, support, or explain statistical patterns observed in the survey data.

3.6 ETHICAL CONSIDERATIONS

Participation in the study was voluntary, and responses were analyzed in aggregate form to preserve confidentiality. No personally identifiable information was reported, and the research did not involve intervention or manipulation of workplace conditions. The study focused exclusively on perception-based assessments of frontline supervisory leadership and safety influence within organizational contexts.

4. RESULTS

4.1 SURVEY RESPONSES

A total of 39 construction industry professionals completed the survey questionnaire. Respondents represented a range of organizational types, leadership levels, and construction sectors. Because this study was designed as an exploratory Phase I investigation, the sample size was modest. Accordingly, statistical analyses were conducted using methods appropriate for small samples and unequal variances, including Welch's t-tests, Welch's analysis of variance, Fisher's Exact Tests, and nonparametric rank-based procedures. These approaches allowed for robust group comparisons while minimizing assumptions regarding distributional normality.

4.2 DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

The 39 respondents represented a diverse cross-section of construction industry organizations. Thirty-five of the 39 respondents indicated the type of industry organization they work for. The majority (18 out of 35, 51%) are employed by general contractors, which constituted the largest proportion of the sample. Subcontractors were also well represented (11%). Additional participants work for safety consulting firms (8.5%), construction management companies 5.6%), local or state agencies (2.9%), labor organizations (2.9%), and industry associations (2.9%). Several respondents identified hybrid organizational structures, including companies operating as both general contractor and subcontractor, as well as union halls and multi-category enterprises.

Industry sector representation was similarly broad. Most respondents reported working in commercial building construction (24 out of 35, 69%). Industrial and manufacturing sectors were also frequently reported (49%), along with transportation (49%) and utilities (48%). Residential construction (29%) and marine work (23%) were less represented in the respondent pool. Because respondents were permitted to select multiple sectors, many respondents indicated involvement across more than one construction domain, reflecting the diversified nature of many construction organizations.

Organization size varied considerably across the sample. Respondents represented firms ranging from very small organizations with fewer than 10 employees to large enterprises employing more than 1,000 individuals. The most frequently represented one single category was organizations with more than 1,000 employees (14 out of 35, 40%). Combining multiple size categories, mid-sized firms employing between 51 and 500 individuals were also strongly represented (49%), while smaller organizations employing 11 to 50 individuals comprised a smaller but meaningful portion of the sample (8.6%). This distribution of respondents allows for comparative analysis by organizational scale.

Thirty of the 39 respondents (77%) indicated that their organization employs frontline supervisors, such as foremen and superintendents, on construction projects. Four respondents (10%) represented organizations that do not directly employ such supervisory roles, including consulting or representative organizations.

Thirty-four of the respondents indicated their work title/position. The sample was heavily weighted toward senior leadership roles (17 out of 34, 50%). Executive level job titles included President, Vice President, Chief Operating Officer, Executive Director, Regional Vice President of Environmental Health and Safety, Business Manager, Business Agent, and similar executive-

level positions. Middle management roles were also well represented (38%), including Safety Manager, EHS Director, Construction Manager, and General Superintendent. A small number of respondents (12%) identified hybrid or consultant roles. Overall, the sample reflects perspectives from individuals with substantial authority, organizational oversight, and strategic influence.

Age distribution skewed toward experienced professionals. The majority of respondents (21 out of 33, 64%) were between 45 and 64 years of age, with several participants (12%) reporting ages of 65 or older. A smaller number (21%) fell within the 35–44 age group, and only one respondent (3%) was between 25 and 34 years of age. No respondents reported being under 25.

Industry experience mirrored age distribution. Most participants (24 out of 35, 69%) reported more than 21 years of experience in the construction industry. A smaller group (26%) reported 11–20 years of experience, and only one respondent (3%) reported fewer than five years of experience. This concentration of experience suggests that survey responses reflect insights from seasoned construction professionals.

In terms of current responsibilities, the most frequently reported duty was overseeing and managing safety on jobsites (22 out of 35, 63%). The respondents were allowed to indicate more than one responsibility as part of their work position. Many respondents also reported supervising managing project schedules and budgets (26%), coordinating subcontractors and vendors (23%), supervising field crews or daily jobsite activities (17%), and overseeing material and equipment needs (14%). Several senior leaders described responsibilities focused on strategic planning, operational excellence, and corporate-level safety program management rather than direct field supervision.

Overall, the demographic profile indicates that the sample is composed primarily of highly experienced, senior-level construction professionals working within medium-to-large sized organizations across multiple industry sectors.

4.3 LEADERSHIP TRAITS AND BEHAVIORS

The researchers conducted descriptive and statistical analyses of the survey data to identify patterns and expose correlations between different variables. Summaries of the analyses for selected survey questions are provided below. Detailed descriptions of the statistical analyses conducted are provided in the Appendix.

4.3.1 Transformational Leadership Composite

Survey question Q2.1 asked respondents to indicate the extent to which they agree that the frontline supervisors in their organization/company demonstrate certain personal traits and behaviors. Table 4.1 summarizes the responses. Those behaviors that are predominantly demonstrated are leading by example (mean rating = 1.33), taking responsibility when safety-related issues occur (mean rating = 1.30), and promoting teamwork and collaboration to achieve project safety goals (mean rating = 1.24). Consistently following all safety rules and regulations (mean rating = 0.76) and never sacrificing safety to meet cost or schedule goals (mean rating = 0.76) are perceived as being demonstrated to a lesser extent.

Table 4.1: Extent to which Leadership Behavior Types are Demonstrated (n = 33)

Leadership Types	Rating*			
	Mean	Minimum	Maximum	Std. Dev.
Lead by example	1.33	-2	+2	0.89
Take responsibility when safety-related issues occur	1.30	-2	+2	1.02
Promote teamwork and collaboration to achieve project safety goals	1.24	-2	+2	1.00
Consistently follow all safety rules and regulations	0.76	-2	+2	0.97
Never sacrifice safety to meet cost or schedule goals	0.76	-1	+2	1.03

* Rating scale: -2 = Strongly disagree, -1 = Somewhat disagree, 0 = Neither agree nor disagree, +1 = Somewhat agree, +2 = Strongly agree

To examine whether perceptions of transformational leadership differed by leadership level, a Welch two-sample t-test was conducted comparing respondents in management roles to those in executive leadership roles. The analysis did not identify a statistically significant difference between groups. Although executives demonstrated a slightly higher mean composite score than managers, the confidence interval for the difference in means included zero, indicating substantial uncertainty around the estimated group difference. These findings suggest that perceptions of transformational safety leadership were relatively consistent across leadership levels within this sample.

4.3.2 Ranking of Leadership Behaviors

Participants were asked to rank leadership behaviors according to how consistently they were demonstrated by frontline supervisors (Q2.2). A summary of the results is provided in Table 4.2. Leading by example was ranked as the most consistently demonstrated leadership behavior (mean ranking = 2.13), followed by taking responsibility when safety related issues occur (mean ranking = 2.22). These behaviors were ranked higher than other leadership behaviors demonstrated by a wide margin.

Table 4.2: Consistency of Demonstrated Leadership Behaviors (n = 32)

Leadership Behaviors	Ranking*			
	Mean	Highest	Lowest	Std. Dev.
Leading by example	2.13	1	5	1.16
Taking responsibility when safety-related issues occur	2.22	1	4	1.16
Inspiring workers to take personal ownership of safety and project outcomes	3.31	1	5	1.42
Enforcing work rules and standards consistently	3.38	1	5	1.39
Prioritizing safety over cost and schedule	3.97	1	5	1.03

* Ranking scale: 1 = Most consistently demonstrated and 5 = Least consistently demonstrated

A Friedman rank-sum test indicated statistically significant differences in rankings, suggesting that respondents did not view all behaviors as equally consistent (p-value < 0.001). However, Kendall's coefficient of concordance revealed extremely low agreement among participants (W = 0.008), indicating substantial variability in individual prioritization.

Post-hoc analyses demonstrated that certain behaviors, particularly prioritizing safety over cost and schedule, leading by example, and taking responsibility when safety issues arise, were distinguished from other behaviors at the group level. Although overall consensus was limited, these traits emerged as more consistently differentiated relative to the rest.

4.3.3 Leadership Response to Safety Violations

Survey question Q2.3 asked respondents about the typical response by frontline supervisors when worker safety violations occur. The majority of respondents indicated that frontline supervisors typically address the violations immediately and provide coaching (21 out of 33 responses, 64%). Approximately 18% of the respondents indicated that supervisors typically delegate resolution of the issue to someone else. A small percentage of respondents (9%) stated that supervisors ignore minor safety issues to meet deadlines.

The analysis examined whether typical supervisory responses to safety violations differed by industry sector, organization size, or job title. No statistically significant association was found between response type and industry sector, nor between response type and leadership role. In contrast, organization size demonstrated a statistically significant association with supervisory response patterns (p-value = 0.012). This finding indicates that approaches to addressing safety violations vary meaningfully across small, medium, and large organizations. Effect size estimates suggested that this association was practically meaningful despite the modest sample size.

4.3.4 Leadership Skills

Survey questions Q2.5 and Q2.6 explored the demonstration of safety-related leadership skills amongst frontline supervisors. The results from Q2.5 "Please indicate the extent to which you agree that the frontline supervisors in your organization/company demonstrate the following skills" are shown in Table 4.3. The skill that was rated highest by the respondents on average was

coaching and mentoring workers to build their skills and work safely (mean rating = 0.97). Encouraging group participation in safety decisions and planning, and motivating workers by communicating the project vision and goals, were also rated highly (mean rating = 0.80) for both skills. Developing strategies to improve safety was rated as being less significant.

Table 4.3: Supervisory Skills Demonstrated by Frontline Supervisors (n = 30)

Supervisory Skills	Rating*			
	Mean	Minimum	Maximum	Std. Dev.
Coach and mentor workers to build skills and work safely	0.97	-2	+2	1.03
Encourage group participation in safety decisions and planning	0.80	-2	+2	1.12
Motivate workers by communicating the project vision and goals	0.80	-2	+2	1.06
Ask for input and integrate team perspectives in safety decisions	0.70	-2	+2	1.19
Develop strategies to improve safety	0.63	-2	+2	1.03

* Rating scale: -2 = Strongly disagree, -1 = Somewhat disagree, 0 = Neither agree nor disagree, +1 = Somewhat agree, +2 = Strongly agree

Survey question Q2.6 asked respondents to rank supervisory skills based on how consistently the skills are demonstrated by frontline supervisors in their organization/company. Five examples of supervisory skills were listed for ranking, where 1 represented the most consistently demonstrated skill and 5 represented the least consistently demonstrated skill. Table 4.4 shows a summary of the results. The skills that received the highest mean rankings were coaching and mentoring (mean ranking = 2.43), decision-making under pressure (mean ranking = 2.43), and effective communication of safety expectation and project goals (mean ranking = 2.87).

Table 4.4: Consistency of Demonstrated Supervisory Skills (n = 30)

Supervisory Skills	Ranking*			
	Mean	Highest	Lowest	Std. Dev.
Coaching and mentoring	2.43	1	4	0.85
Decision-making under pressure	2.43	1	5	1.55
Effective communication of safety expectation and project goals	2.87	1	5	1.41
Conflict resolution	3.33	1	5	1.40
Innovation in safety planning	3.93	1	5	1.26

* Ranking scale: 1 = Most consistently demonstrated and 5 = Least consistently demonstrated

The rankings for the five skills were combined into a composite score following reliability testing, which demonstrated excellent internal consistency. The composite score indicated generally positive perceptions of frontline supervisor skill demonstration across the sample. Group comparisons revealed no statistically significant differences in composite skill

scores by industry sector, organization size, or leadership level. Although minor mean differences were observed across groups, confidence intervals indicated substantial overlap. These results suggest broad consistency in perceived supervisory skill levels across organizational contexts.

When participants ranked supervisory skills by consistency of demonstration (Q2.6), an analysis using the Friedman test indicated statistically significant differences in rankings (p-values = 0.001). However, agreement among respondents was extremely low, again reflecting heterogeneous perceptions. Post-hoc comparisons indicated that innovation in safety planning was one of the few skills statistically distinguished from others. Overall, the findings suggest that while respondents collectively differentiate certain skills, there is no uniform consensus regarding a single hierarchy of supervisory competencies.

4.3.5 Leadership Communication Practices

Survey question Q2.7 asked, "Which of the following methods do frontline supervisors in your organization/company use to communicate safety goals?" and offered several example communication methods to select from. Participants reported that frontline supervisors commonly use multiple communication channels to convey safety expectations. Conducting crew huddles/pre-task planning meetings were identified as the most common practice and is practiced by all (100%) of the respondent organizations/companies. Eighty-seven percent of the respondents indicated that written safety plans, checklists, or posted instructions are used for safety communications. Communication techniques are often combined with on-the-job demonstrations (53% of respondents), the use of digital tools (53%), and coaching/mentoring sessions (47%).

Further analysis revealed a statistically significant association between communication method selection and industry sector (p-values = 0.009), suggesting that communication patterns differ meaningfully between commercial and non-commercial organizations. In contrast, no statistically significant differences were observed by organization size or leadership role.

With respect to communication style frequency, direct or authoritative, supportive or collaborative, and proactive or innovative styles were reported as being used most frequently. Minimal or inconsistent communication was reported as substantially less common. No statistically significant group differences were observed across industry sector, organization size, or job title.

4.3.6 Leadership Influence on Safety

The survey questionnaire asked respondents about the ways in which frontline supervisors in their organization influence safety (Q2.9). A list of common ways in which supervisors may influence safety was offered with the question. Similar to previous questions, a five-point rating scale was used from strongly disagree (-2) to strongly agree (+2) with the stated action. Table 4.5 shows a summary of the results from this question. The supervisory action with the highest mean rating (1.52) was "showing concern for workers' safety and well-being." Promoting open communication and encouraging reporting (mean rating = 1.14) and treating all workers fairly and consistently when addressing safety (mean rating = 1.00) were also perceived as having a strong influence on safety.

Table 4.5: Ways in which Supervisors Influence Safety (n = 29)

Supervisory Actions	Rating*			
	Mean	Minimum	Maximum	Std. Dev.
Show concern for workers' safety and well-being	1.52	-2	+2	0.89
Promote open communication and encourage reporting	1.14	-2	+2	0.95
Treat all workers fairly and consistently when addressing safety	1.00	-2	+2	1.07
Ensure workers have the resources to work safely	0.93	-2	+2	0.96
Build a positive team environment through collaboration and support	0.86	-2	+2	1.04

* Rating scale: -2 = Strongly disagree, -1 = Somewhat disagree, 0 = Neither agree nor disagree, +1 = Somewhat agree, +2 = Strongly agree

The five-item composite measuring perceived supervisory influence on safety demonstrated high internal consistency. Composite scores indicated strong overall agreement that frontline supervisors positively influence safety culture and safety performance through their supervisory actions.

Group comparisons showed no statistically significant differences in perceived influence between commercial and non-commercial sectors or between management and executive respondents. However, organization size was significantly associated with perceived supervisory influence (p-value = 0.028), indicating that perceptions of frontline supervisor influence vary by organizational scale.

4.4 Leadership Assessment Tools and Training

Descriptive analysis of the survey responses revealed variability in the use of formal leadership assessment tools across organizations. Based on the responses to survey question Q2.13, approximately half of respondents (14 of 29 respondents, 48%) reported that their organization uses tools to assess frontline supervisor leadership skills, while a substantial portion reported no tool usage (38%) or were unsure (14%). Examples of assessment tools used include employee evaluations and reviews, 4 squares, personality profiles and metrics, surveys, multi-rater feedback and climate surveys, performance review with financial incentive, team observations, semi-annual evaluation of leadership potential, and 360-degree assessments. Organization size was significantly associated with tool adoption (p-value = 0.013), suggesting that larger organizations are more likely to employ formal assessment mechanisms.

Most respondents indicated that their organization provides some form of formal leadership training, whether mandatory (41% of respondents) or optional (31% of respondents). Twenty-one percent of respondents indicated that their organization does not provide leadership training, while 7% were not sure.

For those respondents who indicated that their organization provides leadership training, survey question Q2.15 asked the respondents to rate their agreement that leadership training has influenced the ability of frontline supervisors to manage different aspects of safety management. The results are shown in Table 4.6. Perceived effectiveness of leadership training was generally

positive, with composite scores indicating agreement that training enhances supervisor ability to manage safety. No statistically significant differences in perceived training effectiveness were identified across industry sector, organization size, or leadership level.

Table 4.6: Influence of Leadership Training on Ability to Manage Safety (n = 19)

Leadership Training	Rating*			
	Mean	Minimum	Maximum	Std. Dev.
Training has improved supervisors' ability to manage safety effectively.	1.11	0	+2	0.74
Training has prepared supervisors to communicate safety expectations clearly and consistently.	1.11	0	+2	0.74
Training has increased supervisors' confidence in making safety-related decisions	1.11	-1	+2	0.88
Training includes practical, hands-on activities that have helped supervisors apply safety strategies on the jobsite.	0.84	0	+2	0.69

* Rating scale: -2 = Strongly disagree, -1 = Somewhat disagree, 0 = Neither agree nor disagree, +1 = Somewhat agree, +2 = Strongly agree

Among training formats, survey question Q2.16 asked about the extent to which different types of training formats and elements are effective for developing safety leadership skills. On-the-job coaching (mean rating = 4.18) and in-person workshops (mean rating = 3.96) were rated as most effective. Safety leadership certifications (mean rating = 2.36) and online modules (mean rating = 2.11) received comparatively lower effectiveness ratings. Overall, respondents expressed broad support for structured leadership development approaches.

With respect to leadership training topics, survey question Q2.17 asked the respondents to rank five training topics according to how useful they believe each topic is for training frontline supervisors. A ranking scale was used where 1 = most useful training topic and 5 = least useful training topic. Mean rankings regarding usefulness of leadership training (a lower ranking value indicates greater usefulness) were as follows: communication skills (mean raking = 2.29), safety culture development (2.71), hazard identification (2.96), Leadership and decision-making under pressure (3.25), and risk tolerance assessment (3.79).

A Friedman rank-sum test was conducted to determine whether respondents ranked the five training topics differently in terms of perceived usefulness. The test indicated a statistically significant overall difference in rankings (p-value = 0.028), suggesting that at least one topic was viewed as more or less useful relative to the others. However, Kendall's coefficient of concordance was extremely low ($W \approx 0.004$), indicating very weak agreement among respondents and substantial variability in how individuals prioritized the topics. The results indicate that perceived usefulness of the topics is broadly distributed rather than dominated by a single clearly preferred training topic.

4.5 FRONTLINE SUPERVISOR RISK TOLERANCE

4.5.1 Training on Assessing and Managing Risk

A series of survey questions explored the nature of risk tolerance amongst the respondent organizations. Survey question Q3.6 asked whether the respondent's organization/company provides formal training on assessing and managing risk. Of the 21 responses received from this question, 57% indicated that formal training is provided, 33% responded that no formal training is provided, and 9.5% were not sure.

A follow-up question (Q3.7) asked how effective each risk management tool or training approach is for improving risk tolerance. A Likert-type rating scale was used where 0 = not effective and 5 = extremely effective. The results are shown in Table 4.7. The three types of tools and training that are perceived to be the most effective are hazard analysis training (mean rating = 3.43), incident case study reviews (mean rating = 3.22), and risk perception workshops (mean rating = 3.17). The respondents have a broadly shared perception that risk management tools and training are moderately to highly effective. VR simulations are viewed as less effective than other types of tools and training.

Table 4.7: Effectiveness of Risk Management Tools and Training (n = 23)

Risk Management Tools and Training	Rating*			
	Mean	Minimum	Maximum	Std. Dev.
Hazard analysis training	3.43	0	5	1.31
Incident case study reviews	3.22	0	5	1.38
Risk perception workshops	3.17	0	5	1.27
Virtual reality (VR) hazard simulations	2.74	0	5	1.36

* Rating scale: 0 = Not effective, 1 = Minimally effective, 2 = Somewhat effective, 3 = Moderately effective, 4 = Highly effective, 5 = Extremely effective

Group analyses revealed no statistically significant differences in perceived effectiveness of the risk management tools and training based on project type (commercial vs. non-commercial), organizational size, or job title (manager vs. executive. Collectively, these findings indicate a broadly shared perception across organizational roles and contexts that formal risk management tools and training approaches are moderately to highly effective.

4.5.2 Risk Tolerance Assessment Tools

Survey question Q3.8 asked respondents to indicate whether their organization/company uses any tools to assess the risk tolerance levels of frontline supervisors or craft workers. Most respondents reported their organizations do not use formal tools to assess the risk tolerance levels of frontline supervisors or craft workers (14 out of 23, 61%). Twenty-six percent of the organizations use risk tolerance assessment tools and 13% of the respondents were not sure. Statistical group comparisons showed no significant differences in responses by industry sector, organization size, or job title. Effect size estimates suggested small to moderate practical associations for organization type and organization size, and a small association for job title.

Those respondents who answered "Yes" to Q3.8 were asked to describe the risk tolerance assessment tools. The tools referenced were generally not formal psychometric assessments but instead consisted of operational safety practices embedded in routine work processes. Common themes included the use of Job Hazard Analyses (JHAs), pre-task plans, daily huddles, and structured work plans as primary mechanisms for discussing and evaluating risk before tasks begin. Several participants described periodic or seasonal risk-management training sessions, while others mentioned severity or "hurt-potential" scoring approaches used to align crews on shared risk understanding. Additional responses highlighted behavioral and cognitive frameworks, such as discussing factors that influence individual risk tolerance—including overconfidence, familiarity with tasks, perceived control, and role-model influence—along with collaborative conversations between supervisors and crew leaders to ensure consistent risk perception.

Overall, the combined quantitative and qualitative findings suggest that while standardized or formalized risk-tolerance assessment tools are relatively uncommon, many organizations that implement risk tolerance assessment tools rely on practical, field-based, and discussion-oriented methods integrated into everyday safety management activities rather than standalone measurement instruments.

4.6 Interview Responses

4.6.1 Participant Characteristics

To supplement the quantitative survey findings, three semi-structured interviews were conducted with experienced construction professionals occupying key operational safety leadership roles. One participant with approximately 30 years of experience in the industry serves as an Aggregate Manager overseeing regional operations of a material supply company. The second participant is a Project Superintendent with more than 25 years of experience at a major commercial construction firm, along with additional prior field experience in the trades. The third participant is a Site Safety Manager working on a large-scale construction project, responsible for coordinating daily safety operations, monitoring compliance, and supporting hazard mitigation efforts across multiple trades on an active jobsite.

All three participants have significant responsibility for jobsite safety performance and described safety leadership as a central component of their professional role. Each described their role as involving direct oversight of jobsite safety practices, participation in hazard identification and planning activities, and engagement with workers and supervisors to reinforce safety expectations.

4.6.2 Leadership Philosophy

Across the interviews, the participants described leadership approaches that emphasized modeling safe behavior and maintaining consistent expectations across all levels of the jobsite. The participants stated that supervisors must follow the same safety requirements expected of workers in order to maintain credibility and reinforce safety culture. Additionally, the participants described the importance of demonstrating safe practices in daily activities rather than relying solely on verbal instruction.

The interviewees also discussed the role of decision-making authority on construction projects. While collaborative approaches are generally preferred, they acknowledged that supervisors are sometimes required to make directive decisions, particularly when coordinating multiple trades or managing time-sensitive operations. These situations were described as requiring clear direction to maintain safe work sequencing and avoid conflicts between crews.

Additionally, those interviewed emphasized that safety leadership involves continuous engagement with crews through training, field observation, and communication. They described the importance of being present in the field and maintaining visibility among workers in order to reinforce expectations and address potential hazards as they arise.

4.6.3 Safety Communication

The interviewees described multiple methods used to communicate safety expectations and hazards on construction projects. Daily pre-task planning and safety meetings were identified as primary tools used to discuss upcoming work activities and associated hazards. The participants indicated that these meetings allow crews to review planned tasks, identify potential hazards, and clarify expectations before work begins.

The interview participants also emphasized the importance of open communication between workers and supervisors. All of the interviewees stated that workers on their jobsites are encouraged to raise concerns and report hazards when they are identified. Stop-work authority was described as a key element of safety communication, with the participants indicating that every worker has the authority to stop work if unsafe conditions are observed.

The interviewees described efforts to encourage participation during safety meetings and hazard planning activities. These efforts include asking workers for input during discussions and reinforcing that workers are responsible for identifying hazards and suggesting improvements when necessary.

4.6.4 Risk Perception

The interview participants described several factors that influence how workers perceive hazards on construction sites. A commonly identified issue was the tendency for experienced workers to underestimate hazards associated with routine tasks. The interviewees explained that when workers perform the same task repeatedly, the perceived risk may decrease even though the hazard remains present.

The interviewees noted that new or unfamiliar tasks often receive greater attention from workers because hazards are more apparent during initial planning stages. In contrast, routine tasks may receive less scrutiny over time as workers become more comfortable with the activity. The participants indicated that pre-task planning and daily hazard discussions are intended to address this issue by encouraging crews to review hazards regularly and reassess conditions before beginning work.

4.6.5 Risk Tolerance

The interviewees discussed changes in attitudes toward risk tolerance that have occurred within the construction industry. Several interviewees stated that earlier in their careers it was more common for workers to accept higher levels of risk as part of the job. The participants described

a shift toward greater emphasis on eliminating or controlling hazards rather than accepting them as unavoidable.

The interviewees also described how schedule pressures can influence risk-related decisions on construction projects. They acknowledged that production schedules and deadlines can create pressure to complete tasks quickly. However, they also stated that safety expectations require work to be delayed or modified when hazards cannot be adequately controlled.

The participants indicated that organizational leadership plays a role in supporting these decisions. They reported that when management reinforces the importance of safety over production speed, supervisors and workers are more likely to pause work and address hazards before continuing.

4.6.6 Leadership Challenges

The interview participants identified several challenges associated with maintaining safety on construction projects. One commonly described challenge involves gaining consistent buy-in from workers and supervisors. The participants noted that establishing a safety-focused culture requires ongoing effort and reinforcement.

Another challenge described by the interviewees involves balancing production demands with safety expectations. They explained that supervisors must manage schedules and coordinate multiple trades while also ensuring that safety procedures are followed.

The interviewees also described the difficulty of addressing complacency among experienced workers. Because experienced workers may feel confident performing familiar tasks, supervisors must remain attentive to ensure that established safety procedures continue to be followed.

Finally, the interview participants identified several characteristics they believe are important for effective safety leadership. These characteristics include communication skills, credibility among workers, the ability to solve problems in the field, and a willingness to engage directly with workers to address safety concerns.

5. ANALYSIS AND DISCUSSION

5.1 LEADERSHIP TRAITS AND SAFETY INFLUENCE

The study results suggest that frontline leadership behaviors play an important role in shaping safety culture and influencing worker perceptions of risk. Survey findings indicate generally strong agreement among respondents that supervisors significantly influence safety outcomes through their actions and communication. Composite scores measuring supervisory influence demonstrate consistently positive perceptions across the sample, indicating that leaders are widely viewed as key drivers of safety performance on construction projects.

Another theme emerging from the qualitative data collected during interviews was the importance of credibility in safety leadership. Interview participants consistently emphasized that supervisors must demonstrate safe behavior in their own work practices in order to gain the trust and respect of workers. Interviewees described situations in which safety programs lost effectiveness when supervisors failed to follow the same rules expected of crews. These findings reinforce the survey results indicating strong agreement that supervisors significantly influence jobsite safety culture. When supervisors model safe behavior and consistently reinforce safety expectations, workers are more likely to adopt similar practices.

Although respondents generally agreed that leadership behaviors influence safety culture, statistical analysis did not reveal significant differences between leadership levels in transformational leadership scores. This result suggests that both executive-level leaders and middle managers may share similar perceptions regarding the importance of safety leadership behaviors. Instead of hierarchical differences, safety leadership may be more strongly shaped by organizational culture and expectations.

Key takeaways: Consistent leadership behavior, visible commitment to safety practices, and direct engagement with workers are critical elements of effective safety leadership in construction environments.

5.2 ORGANIZATIONAL FACTORS AND SAFETY LEADERSHIP

Several findings from the survey responses indicate that organizational characteristics influence how safety leadership is implemented on construction projects. Statistical tests identified significant associations between organization size and supervisory responses to safety violations. Larger organizations appear more likely to implement structured approaches to addressing unsafe behavior and enforcing safety expectations.

Interview responses provide additional context for these findings. Interview participants working within larger construction organizations described more formalized safety systems, including structured pre-task planning, documented hazard assessments, and formal leadership training programs. These systems provide supervisors with standardized procedures for identifying hazards and communicating safety expectations.

In contrast, participants in smaller or less formal organizational environments described relying more heavily on informal communication and direct engagement with workers. Although these approaches may still support strong safety culture, the absence of standardized procedures may lead to greater variability in how safety leadership is implemented across projects.

Key takeaways: Organizational structure and resources influence the tools available to supervisors for managing safety. Larger organizations may benefit from formal safety systems

and leadership development programs, while smaller organizations may rely more heavily on interpersonal leadership skills and direct supervision.

5.3 Risk Perception and Risk Tolerance

Both the quantitative and qualitative findings highlight the importance of risk perception in construction safety outcomes. Interview participants consistently identified complacency associated with routine tasks as a major contributor to unsafe conditions. Workers who perform the same activity repeatedly may gradually perceive the task as less hazardous, even when the underlying risk remains unchanged. Survey results support this observation by demonstrating strong agreement among respondents that supervisors influence worker awareness of hazards. Leaders who actively reinforce hazard recognition through communication and planning activities appear to play an important role in maintaining worker awareness of risk.

Participants also described a shift in industry attitudes regarding risk tolerance. Several interviewees noted that earlier construction industry cultures often accepted risk as a normal part of the job. In contrast, current safety practices emphasize hazard elimination and risk control through planning and engineering controls. This shift reflects broader changes in occupational safety management and regulatory expectations.

Another theme emerging from both the survey and interview data is the influence of production pressure on risk-related decision-making. Construction schedules and deadlines can create pressure to complete tasks quickly, which may encourage workers to take shortcuts. However, participants indicated that strong leadership support for safety can reduce this pressure by reinforcing the expectation that work should stop when hazards cannot be adequately controlled.

Key takeaways: Developing situational awareness skills and effective decision-making related to safety risk are top priorities for frontline supervisors. Controls implemented to improve risk perception and risk tolerance should incorporate recognition of both operational and personal influences that can compromise risk perception or risk tolerance and include the necessary redundancy and resilience to ensure high performance safety management systems.

5.4 Communication and Worker Engagement

Communication emerged as a central component of effective safety leadership. Survey responses indicated that supervisors commonly rely on multiple communication channels, including crew meetings, written safety plans, and coaching interactions. These communication methods provide opportunities to reinforce safety expectations and address hazards before work begins.

Interview findings further highlight the importance of open communication between workers and supervisors. The participants consistently emphasized that workers should feel comfortable reporting hazards and raising concerns about unsafe conditions. Stop-work authority was identified as a critical element of effective communication, encouraging workers to intervene when they observe unsafe practices.

Encouraging worker participation in hazard identification also appears to support stronger safety culture. The interviewees described efforts to involve workers in safety discussions during meetings and pre-task planning sessions. When workers contribute to identifying hazards and developing solutions, they may develop a stronger sense of ownership over safety practices.

Key takeaways: Communication practices that encourage dialogue, feedback, and worker participation can strengthen safety awareness and reduce the likelihood of hazardous situations going unreported.

5.5 Leadership Development and Training Implications

The study findings highlight several important implications for leadership development within the construction industry. Both the quantitative survey results and qualitative interview responses suggest that frontline supervisors play a central role in shaping safety culture, influencing worker risk perception, and reinforcing safe work practices. As a result, leadership training programs for supervisors may represent one of the most effective mechanisms for improving safety performance on construction projects.

Survey responses indicated that most participating organizations provide some form of leadership or safety training for supervisors; however, the structure, frequency, and perceived effectiveness of these programs vary considerably across organizations. Composite scores measuring perceptions of leadership training effectiveness were generally positive, suggesting that respondents believe training can enhance a supervisor's ability to manage safety. At the same time, responses indicated that training approaches are not uniform across the industry. Some organizations reported structured training programs that include formal classroom instruction, while others rely more heavily on on-the-job coaching and mentoring.

Interview participants provided additional context regarding the role of training in developing effective safety leaders. Several participants emphasized that traditional classroom-based training alone may not be sufficient to influence field behavior. The participants described situations in which workers completed required training sessions but struggled to apply the concepts in real jobsite conditions. Instead, participants suggested that safety training is most effective when it is reinforced through direct field engagement, coaching, and discussion of real work activities. These observations highlight the importance of combining formal instruction with practical field-based learning experiences.

The survey findings also provide insight into how leadership development may vary across organizational contexts. Statistical analysis identified significant associations between organization size and several safety-related leadership practices, including responses to safety violations and the use of leadership assessment tools. Larger organizations appear more likely to implement formal systems for evaluating leadership performance and monitoring safety behaviors. These systems may provide structured feedback to supervisors and help organizations identify leadership competencies that require further development.

Interview responses further suggest that organizational culture plays a key role in supporting leadership development. The study participants described situations in which supervisors felt empowered to stop work or delay tasks when hazards could not be adequately controlled. In these cases, the participants reported that senior management consistently reinforced the message that safety should take priority over schedule pressures. This type of organizational support was described as essential for enabling supervisors to apply safety leadership principles in practice. Without visible support from upper management, supervisors may feel pressure to prioritize production over safety.

The interviews also highlighted several leadership competencies that participants viewed as essential for effective safety leadership. Communication skills were consistently identified as a critical attribute. Participants explained that supervisors must be able to clearly explain

hazards, listen to worker concerns, and facilitate discussions during safety meetings. The ability to engage workers in two-way communication is viewed as particularly important for identifying hazards and encouraging worker participation in safety planning.

Problem-solving ability was another competency frequently discussed by interview participants. Those interviewed noted that safety professionals must be able to identify practical solutions when hazards are identified in the field. Workers may lose confidence in safety programs if supervisors are unable to provide feasible alternatives for performing tasks safely. As a result, the participants emphasized that safety leaders should not only identify hazards but also work collaboratively with crews to develop workable solutions.

In addition to communication and problem-solving skills, participants emphasized the importance of interpersonal relationships and trust between supervisors and workers. The interviewees described the value of building relationships with crews through regular interaction, field presence, and consistent follow-through on safety concerns. When workers believe that supervisors genuinely prioritize their well-being, the workers may be more willing to report hazards and participate in safety initiatives.

Another implication of the study involves the role of leadership training in addressing risk perception and risk tolerance. Both the survey results and interview responses indicated that workers may underestimate hazards associated with routine tasks. Participants reported that repetitive activities can lead to complacency, which increases the likelihood of unsafe behavior. Training programs that emphasize hazard recognition and encourage workers to reassess routine tasks may help mitigate this issue. Supervisors who regularly reinforce hazard awareness through pre-task planning discussions and field observations may help maintain worker attention to potential risks.

The study findings also suggest that leadership training should address the challenge of balancing production demands with safety expectations. Construction supervisors frequently operate in environments where schedules, budgets, and safety requirements must all be managed simultaneously. Interview participants acknowledged that production pressures can influence decision-making on construction projects, particularly when deadlines are approaching. Training programs that prepare supervisors to manage these competing pressures while maintaining safety standards may improve safety outcomes across projects.

Key takeaways: Effective safety leadership in construction requires a combination of technical knowledge, leadership skills, and organizational support. Training programs that integrate classroom instruction with field-based mentoring, emphasize communication and problem-solving skills, and reinforce the importance of modeling safe behavior may be particularly effective in preparing supervisors to lead safe construction operations. Strengthening these leadership capabilities may ultimately contribute to improved safety culture and reduced injury risk across the construction industry.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

This study examined the relationship between frontline leadership behaviors and worker safety outcomes in the construction industry, with particular emphasis on leadership traits, communication practices, and perceptions of risk. By combining quantitative survey data with qualitative interview insights, the research sought to better understand how supervisory leadership influences safety culture, worker risk perception, and risk tolerance on construction projects.

The results indicate that frontline supervisors play a critical role in shaping safety practices and expectations within construction environments. Survey responses demonstrated strong agreement among respondents that supervisors influence safety outcomes through their actions, communication, and engagement with workers. Participants widely recognized that supervisors serve as the primary link between organizational safety policies and the day-to-day behaviors of workers in the field. Figure 6.1 illustrates the relationships between frontline supervisor leadership, decision-making, and risk tolerance. Leadership influences worker decision-making related to safety and establishes the safety standards to be met. Moreover, decision-making and risk tolerance have reciprocal influences; that is, risk tolerance guides decisions, and decisions made by workers shift their risk tolerance. The aggregate of all three elements (leadership, decision-making, and risk tolerance) is a considerable component of safety climate on a project.

Figure 6.1: Relationships between Leadership, Decision-making, and Risk Tolerance

Qualitative interview findings further reinforced the importance of leadership credibility and visibility. Interview participants consistently emphasized that effective safety leadership requires supervisors to model safe behavior and demonstrate consistent adherence to safety procedures. Participants noted that when supervisors fail to follow the same rules expected of workers, the credibility of safety programs may be undermined. Conversely, supervisors who visibly demonstrate safe practices and actively engage with crews contribute to stronger safety culture and increase worker trust.

The findings also highlight the importance of communication in promoting safe work practices. Both survey respondents and interview participants identified daily pre-task planning, safety meetings, and field-based coaching as essential mechanisms for communicating hazards and reinforcing safety expectations. These communication practices create opportunities for supervisors and workers to discuss potential hazards before work begins and encourage workers to participate in identifying safety concerns.

Risk perception and risk tolerance emerged as additional themes within the findings. Interview participants reported that workers often underestimate hazards associated with repetitive tasks due to familiarity and routine exposure. This phenomenon may contribute to complacency and reduced attention to safety procedures. Participants also described a shift within the construction industry toward greater emphasis on hazard elimination and risk management rather than accepting risk as an inherent part of construction work.

Organizational factors were also found to influence how safety leadership is implemented across projects. Statistical analysis identified significant associations between organization size and supervisory responses to safety violations, suggesting that larger organizations may rely more heavily on formal safety systems and structured leadership development programs. Smaller organizations, in contrast, may depend more on direct supervision and informal communication to manage safety practices.

Finally, the findings suggest that leadership training and development programs may represent an important strategy for improving safety outcomes in the construction industry. Survey responses indicated that many organizations provide some form of leadership training for supervisors, although training structures vary widely. Interview participants emphasized that effective training should combine classroom instruction with field-based mentoring and practical problem-solving experiences.

Figure 6.2 shows an overall summary of the pertinent study findings and recommended actions to ensure frontline supervisory personnel have a healthy foundation for safety management. Consistent and wide-ranging application of the recommended practices are expected to establish strong safety performance on a project.

Figure 6.2: Elements supporting Effective Leadership, Decision-making, and Risk Tolerance

6.2 LIMITATIONS

Several limitations should be considered when interpreting the findings of this study. The limitations primarily relate to sample size, study design, measurement approaches, and potential sources of bias that are common in survey-based and qualitative research.

First, the study relied on a relatively small sample size for the quantitative survey component. Although the participants represented a range of construction organizations, leadership roles, and levels of experience, the limited number of respondents reduces statistical power and may limit generalizability of the findings to a broader population. A small sample size increases the likelihood of Type II errors, meaning that potentially meaningful associations between leadership variables and safety perceptions may not have reached statistical significance due to the small sample size. While the respondents represented several segments of the construction industry, the sample may not fully capture the perspectives of all construction professionals or geographic regions.

Second, the study relied on self-reported survey responses, which introduces the possibility of several forms of information bias. Self-reporting bias may occur when participants provide responses that reflect perceived best practices rather than their actual behaviors or organizational practices. Because the survey addressed safety leadership and safety culture, respondents may have been inclined to provide responses that portray their organizations or leadership practices in a favorable manner. This phenomenon is often described as social desirability bias and is a common concern in occupational safety research involving leadership and safety culture assessments.

Measurement bias may also have occurred due to the subjective nature of the survey questions related to leadership behaviors, perceptions of safety culture, and risk tolerance. Although validated survey constructs and composite scoring methods were used to improve consistency and internal reliability, individual interpretation of survey questions may still vary across respondents. Differences in interpretation could influence how participants evaluated leadership behaviors or safety practices within their organizations.

Several steps were taken to reduce the potential influence of measurement bias. Survey questions were designed to use clear and consistent wording, and composite scores were used to aggregate responses across multiple related items. This approach helps reduce random measurement error by capturing broader patterns in participant responses rather than relying on single survey items. In addition, the inclusion of both quantitative survey data and qualitative interview data provided a form of methodological triangulation, which strengthens confidence in the findings when similar themes emerge across different data sources.

Selection bias is another potential limitation of this study. Participation in the survey was voluntary, which may have resulted in a self-selection effect. Individuals with strong interest in safety leadership or those working in organizations with established safety programs may have been more likely to participate in the survey. As a result, the sample may overrepresent construction professionals who are already engaged in safety leadership initiatives. This influence could potentially lead to an overestimation of positive perceptions regarding leadership influence on safety culture.

Efforts were made to mitigate selection bias by distributing the survey across a range of construction industry stakeholders and organizations representing different company sizes, sectors, and leadership roles. The inclusion of respondents from general contractors,

subcontractors, safety consulting firms, construction management organizations, labor unions, and public agencies helped broaden the range of perspectives included in the study.

Non-response bias may also be present, as individuals who chose not to participate in the survey may systematically differ from those who responded. For example, construction professionals with limited engagement in safety leadership initiatives or those working in organizations with fewer safety resources may have been less likely to participate. Because information about non-respondents was not available, the extent of non-response bias cannot be fully evaluated.

The qualitative interview component also has several limitations. Only three semi-structured interviews were conducted, which limits the ability to capture the full range of leadership perspectives across the construction industry. While the participants represented experienced professionals occupying different leadership roles, additional interviews across a broader set of organizations and trades could provide a more comprehensive understanding of leadership practices. The qualitative findings should therefore be interpreted as exploratory insights that complement the survey data rather than as a comprehensive representation of industry perspectives.

Another potential limitation relates to recall bias during interviews. Interview participants were asked to reflect on their experiences managing safety practices and leadership challenges on construction projects. Because these responses relied on the participant's recollection of past experiences, some details may have been unintentionally omitted or selectively remembered.

Confounding may also influence the relationships observed between leadership variables and safety perceptions. For example, factors such as organizational safety culture, regulatory compliance requirements, workforce experience levels, or project complexity may influence both leadership behaviors and worker safety outcomes. Because the study was not designed to control all potential confounding variables, it is possible that some observed associations reflect the influence of these additional factors rather than leadership traits alone.

Finally, the cross-sectional design of the study limits the ability to establish causal relationships between leadership behaviors and safety outcomes. The survey captured participant perceptions at a single point in time, which makes it difficult to determine whether leadership behaviors directly influence safety culture or whether organizations with strong safety cultures are more likely to promote certain leadership behaviors. Longitudinal research designs that follow organizations or supervisors over time would be better suited to evaluating causal relationships between leadership development initiatives and safety performance outcomes.

Despite these limitations, the use of both quantitative and qualitative methods strengthens the overall validity of the study. The combination of survey data and interview insights allows for a more comprehensive understanding of leadership practices and safety perceptions within construction environments. Consistent themes observed across both data sources provide additional support for the key findings of the research.

6.3 PRACTICAL IMPLICATIONS

Despite these limitations, the study findings provide several practical insights for construction organizations seeking to strengthen safety culture and improve worker safety outcomes. The results consistently highlight the central role that frontline supervisors play in shaping jobsite safety practices. Because supervisors serve as the primary connection between organizational safety policies and daily field operations, investments in leadership development for frontline

supervisors may represent one of the most effective strategies for improving safety performance across construction projects.

A significant implication of this study involves the need in the construction industry for structured leadership training programs that specifically address safety leadership competencies. Survey responses indicated that many organizations provide some form of leadership or safety training for supervisors; however, the availability, structure, and consistency of these programs vary substantially between organizations. The findings suggest that organizations may benefit from implementing more formalized leadership development programs that focus on the skills required to manage safety in complex construction environments. These skills include hazard recognition, effective communication with workers, conflict resolution, and the ability to make safety-focused decisions when production pressures arise.

Interview participants also emphasized that leadership training programs are most effective when they extend beyond traditional classroom instruction. Leaders described the value of field-based mentoring, coaching, and practical problem-solving exercises that allow supervisors to apply safety concepts in real jobsite conditions. Training approaches that integrate classroom learning with field experience may help supervisors develop the confidence and judgment required to address safety challenges in dynamic construction environments.

Another important implication of the study relates to the role of communication in supporting effective safety leadership. Both survey respondents and interview participants identified communication as a critical component of safety management. Daily safety meetings, pre-task planning discussions, and informal field conversations were frequently described as mechanisms for reinforcing safety expectations and identifying hazards before work begins. Organizations may benefit from encouraging supervisors to adopt communication practices that actively involve workers in safety discussions and hazard identification processes.

The findings also suggest that strengthening organizational support for safety-focused decision-making may improve safety outcomes. Interview participants emphasized that supervisors are more likely to intervene when hazards are identified if they believe that senior management prioritizes safety over production speed. Clear organizational messaging that reinforces the importance of safety, combined with consistent enforcement of safety policies, may empower supervisors to make decisions that protect worker health and safety.

In addition, the results highlight the importance of leadership practices that address worker risk perception. Interview participants noted that workers performing routine tasks may become less attentive to hazards over time, which can increase the likelihood of complacency. Supervisors who regularly engage crews in discussions about hazards, encourage workers to reassess routine activities, and reinforce hazard recognition during pre-task planning may help maintain worker awareness of potential risks.

Finally, the findings suggest that leadership development programs may play an important role in strengthening overall safety culture within construction organizations. By equipping supervisors with the skills needed to communicate effectively, identify hazards, and engage workers in safety planning, organizations may create conditions that support safer work practices and improved risk management. As construction projects continue to grow in complexity, strengthening leadership capabilities among frontline supervisors may represent a critical component of long-term safety improvement strategies within the industry.

6.4 Recommendations for Future Research

Future research can build upon the findings of this study by examining safety leadership behaviors across larger and more diverse samples of construction professionals. Expanding the survey population to include additional organizations, geographic regions, and trade specialties may help provide a more comprehensive understanding of leadership influences on construction safety.

Longitudinal research designs could also be used to examine how leadership training programs influence safety outcomes over time. Tracking changes in safety performance before and after implementation of leadership development programs may provide additional insight into the effectiveness of these initiatives.

Additional qualitative research may also be beneficial for exploring the experiences of frontline workers and supervisors in greater depth. Interviews or focus groups involving workers from multiple trades could provide valuable perspectives on how leadership behaviors influence safety perceptions and decision-making on construction projects.

Lastly, future research could explore the relationship between leadership traits and measurable safety outcomes such as incident rates, near-miss reporting, and hazard mitigation practices. Understanding how leadership behaviors translate into measurable safety improvements may help guide the development of targeted training and leadership development programs within the construction industry.

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APPENDIX

A. Literature Review Summary Table
B. Survey Recruitment Email and Explanation of Research Study
C. Survey Questionnaire
D. Statistical Analysis Results

A. LITERATURE REVIEW SUMMARY TABLE

Study Population: O/UM = Owner/Upper Management; FLS = Frontline Supervisor; W = Worker

Study Topic: L = Leadership; RT = Risk Tolerance; RI = Risk Influences; AT = Assessment Tools

Authors(s) (year)	Study Population			Study Topic				Description
	O/UM	FLS	W	L	RT	RI	AT	
Al-Bayati et al. (2017)		X	X			X		This study explores Hispanic workers' perspectives on cultural diversity in U.S. construction, focusing on how cultural and positional differences influence communication, supervision, and safety climate.
Al-Bayati et al. (2019)	X	X	X	X		X	X	Proposes and validates a model differentiating management-level safety culture (MS factor) and site-level safety climate (SS factor) using survey data and Experience Modification Rate (EMR) as validation—offering a practical tool to assess safety culture and climate in construction.
Al-Bayati et al. (2021a)	X	X	X			X	X	Examines how firm size correlates with safety culture, safety climate, and safety behavior using survey-based metrics and statistical analysis, identifying needs for tailored interventions in smaller firms.
Al-Bayati et al. (2021b)	X	X	X	X		X		Validates a practical safety culture–climate framework using survey-based constructs, demonstrating how upper management safety culture influences safety behavior and motivation, and providing measurable tools and metrics for assessing improvement.
Al-Bayati (2024)	X	X	X	X		X	X	Examines how frontline supervisors mediate the effect of safety culture (from upper management) on workers' safety behavior, identifies key factors that enhance supervisor effectiveness (e.g., training, experience, leadership skills), and offers a survey-based quantitative tool to measure that mediation.
Alomari et al. (2018)		X			X			Uses a Delphi method to compare how safety professionals perceive risk factors highlighting both the components of risk perception and their potential influence on safety decision-making.
Bhandari et al. (2021)			X		X			This study models how personal risk tolerance influences work-related risk tolerance and ultimately risk-taking behavior among construction workers; results suggest training should address both personal and work-related risk preferences and account for demographics and social context.

CII (2025)	X	X		X			X	Offers a comprehensive framework and practical guidance for developing and evaluating frontline supervisors, including structured assessment tools, multi-modal training methods, skill-building targets, and mechanisms for measuring leadership improvement.
CPWR (2015)		X	X	X			X	A 2.5-hour interactive training module focusing on five key safety leadership skills—lead by example, engage & empower, active listening, developing others, and recognizing excellence—designed for foremen and supervisors to enhance safety climate through structured, scenario-based learning.
Fang et al. (2015)		X	X	X		X	X	Identifies two key dimensions of supervisory behavior; (a) training and preventive actions; (b) reactive and supportive actions, and models how they directly and indirectly influence worker safety behavior via safety climate, providing both conceptual and empirical measurement tools for assessing supervisory impact.
Fang et al. (2023)	X	X		X			X	Develops a Bayesian network model capturing how owner safety leadership (SL) and safety culture (SC) interact to influence safety management behavior (SMB), and compares intervention strategies involving role modeling combined with safety training for optimizing SMB.
Gao et al. (2020)			X		X	X		Investigates how Big Five personality traits, especially conscientiousness, correlate with safety behavior (e.g., safety compliance), highlighting individual traits as influential components of risk-related behavior.
Guha et al. (2025)		X		X				Proposes a practical framework identifying five critical leadership competencies including resilience, emotional quotient, spiritual quotient, and democratic leadership, and outlines a process for evaluating these traits in construction leaders.
Guha et al. (2025)		X		X				Analyzes how democratic and authoritarian leadership styles positively influence safety and quality performance, offering insights for leadership selection and development strategies.
Hartley and Cheyne (2009)		X	X			X		Explores dynamic formation of safety cultures at site and trade levels, highlighting how site management heavily shapes safety norms and how workers adapt behaviors based on role, conditioned impressions of site safety, and cultural dynamics that vary across industry, trade, position, and possibly worker demographics.
Haslam et al. (2005)		X	X			X		Analyzes multifaceted origins of construction accidents, including organizational,

								environmental, equipment, materials, and human factors. Proposed a systemic model linking distal factors to unsafe acts and conditions.
Hinze (2003)	X	X	X	X		X	X	Identifies nine interdependent best practices, including management commitment, safety training, worker involvement, and incident investigations that collectively drive toward zero accidents, and outlines actionable tools and approaches for assessment, training, and systemic safety improvement.
Hinze (2006)	X	X	X	X		X		Provides a comprehensive, research-informed overview of safety issues from accident causation and supervisory influence to the role of design and contract, underscoring the systemic and leadership dimensions of safety in construction.
Jiang et al. (2015)	X	X	X		X		X	Develops the SD-CUB model, a system dynamics framework that illustrates how management, individual, and environmental conditions interact to cause worker unsafe behaviors; offers a simulation-based assessment tool to explore interventions and leverage points.
Li et al. (2024)			X		X	X	X	Investigates how age influences hazard detection effectiveness using EEG measures (preattentive and attentive) across different hazard types, explores the moderating role of experience, and showcases a novel assessment approach using neurophysiological tools.
Liu et al. (2021)			X	X	X			Investigates how safety leadership and coworker behaviors jointly influence risk perception, safety compliance, and participation, using an integrated survey model to assess how interpersonal dynamics shape worker safety behavior.
Lundell and Marcham (2018)		X	X	X		X		Demonstrates that leadership style, particularly transformational, transactional, and democratic, strongly influences safety culture formation, open communication, and shared safety values, while passive or laissez-faire approaches degrade culture and escalate risk behaviors.
Ma et al. (2020)	X	X		X			X	Proposes an influencing mechanism involving owners' safety leadership, organizational culture, and safety behavior, providing groundwork for measuring how owners' leadership units influence safety culture and performance.
Maloney (2012)		X	X	X		X	X	Uses survey-based methods (e.g., Leadership Practices Inventory and safety climate scales) to assess how frontline leadership behaviors influence safety climate and performance, highlights age- and position-based perceptions

								of safety, and identifies specific leadership actions that reduce incidents.
Martin and Lewis (2013)		X	X	X		X		Uses a leadership-based safety model to analyze how supervisor behaviors and safety leadership correlate with reported accident and near-miss records—highlighting how leadership type and organizational position influence safety outcomes.
Mitropoulos (2013)		X		X			X	Identifies specific production and leadership behaviors displayed by consistently high-performing foremen, offering guidance for system design and training to reduce accidents through reliable leadership practices (high reliability theory).
Mostofi and Togan (2023)		X					X	Proposes machine-learning-based recommendation systems (RARS) that enhance risk assessments by identifying hazard patterns and suggesting risky scenarios, serving both as an advanced tool for assessing safety and as a model that can inform training or decision-support systems.
Namian et al. (2022)			X		X	X		Demonstrates that age changes safety performance indirectly through experience, fatigue, and uses survey-based mediation analysis to assess these relationships.
Salas et al. (2020)			X		X	X		Analyzes individual and sociocultural determinants of risk tolerance, such as beliefs, emotions, and safety culture, across countries, revealing how cultural context shapes workers' risk preferences and informing globally adaptive safety interventions.
Skipper and Bell (2006)		X		X		X		Investigates background, training, and career experience differences between top-performing construction project managers and peers, highlighting factors such as project experience and training opportunities that influence leadership development.
Skipper and Bell (2008)	X	X		X		X		Advocates for an "all-hands" approach to leadership development and succession planning, arguing that leadership capabilities must be cultivated organization-wide and measured systematically while targeting key leadership roles.
Slates (2008)		X		X		X		Argues that injuries and fatalities in high-risk construction environments are more a function of leadership quality than inherent hazard levels, emphasizing how leadership styles influence organizational safety outcomes, especially in high-hazard settings.
Wang et al. (2016)			X		X			Identifies four key groups of factors influencing safety risk tolerance; personal subjective perception, work knowledge & experience, work characteristics, and safety management, and demonstrates via SEM that external factors (especially safety

								management) exert stronger influence over workers' risk tolerance than internal factors.
Xiao et al. (2025)			X	X	X			Reveals that safety leadership, mediated by safety trust, enhances workers' safety behaviors, particularly when supported by coworkers and family motivation, highlighting the mechanisms through which leadership impacts safety.
Zohar (2003)	X	X	X	X		X		Establishes the link between leadership practices and safety climate, showing that leaders influence workers' safety perceptions and behaviors directly. Highlights that leadership style and communication patterns shape organizational safety culture and worker compliance.

B. Survey Recruitment Email and Explanation of Research Study

Survey Recruitment Email:

Dear [insert recipient's first name],

The School of Civil and Construction Engineering at Oregon State University is conducting research titled *"Frontline Safety: Leadership, Decision-Making, and Risk Tolerance."* This study seeks to better understand how leadership, decision-making, and risk tolerance influence safety outcomes on construction projects. The goal is to identify effective leadership traits, strategies, and training approaches that promote safer and more efficient frontline supervision in the construction industry.

We invite you to participate in this online survey because you are a frontline supervisor or a construction professional who regularly interacts with frontline supervisors on construction projects. Your insight and experience will make a valuable contribution to this research.

If you agree to participate, please complete the online survey at the following link: [insert survey link].

The survey is expected to take approximately 15–20 minutes to complete.

Participation in the survey is voluntary. There are no direct benefits to you or your organization; however, your input will help identify leadership practices and risk tolerance factors that can strengthen safety leadership and improve safety outcomes across the construction industry.

This study has been approved by the Oregon State University Institutional Review Board (IRB). There are no foreseeable risks associated with participating in the study, though you may experience mild mental fatigue or frustration when answering complex questions that require thoughtful reflection.

The survey is anonymous. No identifying information will be collected unless you voluntarily choose to provide your name and contact information to participate in potential follow-up interviews. All information collected will be kept confidential and stored on a secure, password-protected OSU server accessible only to the research team.

Publications: "Frontline Safety: Leadership, Decision-Making, and Risk Tolerance" publications or reports resulting from this study will not include any identifying information about you or your organization.

For more information about this study, please contact:

- Dr. John Gambatese, Professor, School of Civil and Construction Engineering, Oregon State University, Tel.: (541) 737-8913, Email: john.gambatese@oregonstate.edu
- Daniel Burns, Graduate Research Assistant, School of Civil and Construction Engineering, Oregon State University, Email: burndani@oregonstate.edu

Best regards,

John Gambatese
Principal Investigator
Study Title: *Frontline Safety: Leadership, Decision-Making, and Risk Tolerance*
School of Civil and Construction Engineering
Oregon State University
101 Kearney Hall
Corvallis, OR 97331

Explanation of Research Study:

Project Name: "Frontline Safety: Leadership, Decision-making, and Risk Tolerance"

Principal Investigator: John Gambatese / Oregon State University

Student Investigator: Daniel Burns / Oregon State University

Why am I being invited to take part in this study?
You are invited to participate in this online survey because you are a frontline supervisor, or personnel who regularly interact with frontline supervisors on construction projects.

What is the purpose of this study?
The purpose of this study is to ascertain the needed leadership skills, effective leadership strategies, the desired level of risk tolerance, factors that influence leadership and risk-taking on construction projects. Additionally, this study means to develop training resources/tools for the purpose of enhancing leadership skills and appropriate risk-taking behavior applicable to frontline supervisors in the construction industry.

What will happen during this study, and how long will it take?
During the survey, you will be asked to answer questions about leadership traits, skills, strategies, levels of risk tolerance, and factors that influence leadership and risk-taking on construction projects. You will also be asked to share your perspectives on training resources or tools that could help enhance leadership and appropriate risk-taking behavior among frontline supervisors. In addition, the survey will collect general demographic information about your work organization/company and your professional background.

The survey is expected to take approximately 15–20 minutes to complete and will be conducted online.

How will my information be used?
The information you provide will be used for research and educational purposes to improve leadership and safety practices in the construction industry. Your responses will help identify needed leadership skills, effective strategies, and levels of risk tolerance, as well as guide the development of training resources and tools for frontline supervisors.

All information will remain anonymous unless you choose to share personal details for the purposes of conducting follow up interviews, and only the research team will have access to your responses. The data may be included in reports, academic publications, and professional guidance documents to support safer and more effective construction practices.

What is the level of anonymity?
The survey is anonymous; no identifying information will be collected from you, unless you choose to provide your name and contact information to share further information about work zone intrusion incident data available to the researchers within your organization/company.

The information you provide during the survey will be kept confidential. Accordingly, nothing you share with us that could be used to identify you or your organization/company will be reported to your organization/company, co-workers, or other organizations, companies, or individuals.

What are the risks of this study to participants?
There are no foreseeable risks associated with participating in the study. However, you may experience feelings of mental fatigue or frustration evoked by decision-making when answering survey questions that are complex or require in-depth consideration.

Internet security: The security and confidentiality of information collected from you online cannot be guaranteed, but we will take steps to ensure safety and privacy. Collected information will be stored on a secure, password-protected server at Oregon State University, and only researchers involved in the study will have access to the collected data. Information collected online can be intercepted, corrupted, lost, destroyed, arrive late or incomplete, or contain viruses.

What are the benefits of this study to the participants?
As a participant, you and your organization will not receive direct benefits from this study. However, your input will contribute to advancing knowledge in the construction industry by helping identify the leadership skills, strategies, and levels of risk tolerance that influence safety and decision-making on job sites. The findings will be used to guide the development of training resources and practical tools to strengthen frontline leadership and support safer, more effective construction practices across the industry.

Do I have a choice to be in the study?
Participation in the study is voluntary. Participants may refuse to answer any questions and/or may withdraw from the study at any time. Participation or non-participation will not affect your relationship with your organization/company.

What if I have questions?
Participants are encouraged to ask any questions at any time about the study and its procedures or about their rights as a participant. The investigators' names and contact information are included below so that you may ask questions and report any study-related problems.

- John Gambatese, Professor, School of Civil and Construction Engineering, Oregon State University, 201b Kearney Hall, Corvallis, OR 97331, Tel.: (541) 737-8913, Email: john.gambatese@oregonstate.edu.
- Daniel Burns, Graduate Research Assistant, School of Civil and Construction Engineering, Oregon State University, 211 Kearney Hall, Corvallis, OR 97331, Email: burndani@oregonstate.edu

In addition, if you have any questions about your rights as a survey participant, do not hesitate to contact the Oregon State University Institutional Review Board (IRB) Office at (541) 737-8008 or by email at: IRB@oregonstate.edu.

Please download or take a screenshot or picture of this informed consent for your records should you want to contact us.

Acknowledgment
I have read the above description of the research. If I had questions or would have liked additional information, I contacted the study team and had all of my questions answered to my satisfaction. I am at least 18 years of age or older, and agree to participate in the research study.

C. SURVEY QUESTIONNAIRE

OSU CSRP Frontline Supervisor Safety Survey

Construction Safety Research Partnership (CSRP): Frontline Supervisor Safety Survey

The OSU Construction Safety Research Partnership (CSRP) is conducting research on frontline supervisor (foremen and superintendents) leadership and risk-taking on construction sites as they relate to the promotion of safe behaviors amongst craft workers on the site. The overall aim of the study is to gather perspectives on issues and conditions typically associated with frontline supervisor leadership and risk-taking to enhance safety culture and performance.

You are invited to participate in this online survey because you are professional within a construction company and are a frontline supervisor or other personnel who regularly interacts with frontline supervisors on construction projects.

The survey is expected to take approximately 10-15 minutes to complete online.

Please review the explanation of the research document and download a copy for your records should you want to contact us about the study: Explanation of research_Frontline Safety_09-30-2025.pdf.

Additionally, the survey will ask respondents if they are willing to participate in a follow-up interview to provide more detailed input. Those who respond that they are available for an interview will be contacted to schedule a day and time for an interview.

Information Requested in the Survey:
The survey includes questions that ask you to provide information and your perspectives about:

- **Organization information:** The organization/company you work for (e.g., type, size, and industry sector)
- **Personal demographics:** Your work position/title, age, years of experience, and role/responsibilities
- **Leadership:** Effective leadership traits, necessary leadership skills, factors that influence leadership on construction sites, and effective assessment and training tools to enhance leadership skills
- **Risk Tolerance:** Desired levels of risk tolerance, factors that influence risk tolerance, appropriate risk-taking behaviors, and effective assessment and training tools to enhance risk tolerance

Survey Notes:
Please provide as much detailed information as possible, including comments clarifying the processes and practices implemented in your organization/company. Definitions of uncommon terms used in the survey are provided on some survey questions.

ACKNOWLEDGEMENT

I have read the above description of the research. If I had questions or would have liked additional information, I contacted the study team and had all of my questions answered to my satisfaction. I am at least 18 years of age or older and agree to participate in the research study.

- ○ Yes
- ○ No

1. PERSONAL AND WORK ORGANIZATION INFORMATION

Q1.0 Please answer the following questions regarding the organization/company you work for.

Q1.1 What type of organization/company do you work for?

- ○ Architectural design firm
- ○ Engineering firm
- ○ General contractor
- ○ Subcontractor
- ○ Construction management
- ○ Owner/developer
- ○ Materials supplier
- ○ Safety consulting firm
- ○ Local/State/Federal agency
- ○ Other - Please specify: _____

Q1.2 Which industry sector(s) does your organization/company conduct work in? Select all that apply.

- ☐ Commercial buildings
- ☐ Residential buildings
- ☐ Industrial/manufacturing
- ☐ Transportation

- [ ] Utilities (power, water, sewer)
- [ ] Marine
- [ ] Other - Please specify: _____

Q1.3 How many employees work in your organization/company?

- ○ 1-10
- ○ 11-50
- ○ 51-150
- ○ 151-250
- ○ 251-500
- ○ 501-1000
- ○ More than 1000

Q1.4 Does your organization/company employ frontline supervisors (foremen and superintendents) on construction projects?

- ○ Yes
- ○ No

Please answer the following questions about your personal background and work experience.

Q1.5 What is your current job title/position?

_____

Q1.6 Which best describes your work role?

- ○ Senior leadership
- ○ Middle management
- ○ Frontline supervisor
- ○ Craft worker
- ○ Other - Please specify: _____

Q1.7 Which of the following represents your age group?

- ○ Under 25
- ○ 25-34
- ○ 35-44
- ○ 45-54
- ○ 55-64
- ○ 65+
- ○ Prefer not to answer

Q1.8 How many years of experience do you have working in the construction industry?

- ○ Less than 1 year
- ○ 1-5 years
- ○ 6-10 years
- ○ 11-20 years
- ○ 21+ years

Q1.9 Which of the following responsibilities are currently part of your work position? Select all that apply.

- ☐ Supervising field crews or daily jobsite activities
- ☐ Managing project schedules and budgets
- ☐ Coordinating subcontractors, vendors, and suppliers
- ☐ Overseeing material and equipment needs
- ☐ Performing hands-on construction or craft work
- ☐ Overseeing and managing safety on jobsites
- ☐ Other - Please specify:

_____

2. LEADERSHIP

Q2.0 Please answer the following questions about leadership with respect to the **frontline supervisors who work in your organization/company**.

For the purposes of this survey, a **frontline supervisor** is defined as an "individual who directly oversees and manages a crew of construction workers on-site, ensuring that daily work is carried out in accordance with project plans, specifications, and established safety standards." Frontline supervisors typically include foremen and superintendents on construction jobsites.

Additionally, **leadership** is defined as the ability of a person in a supervisory role to influence, guide, and motivate others.

Q2.1 Please indicate the extent to which you agree that the frontline supervisors in your organization/company demonstrate the following personal **traits and behaviors**.

	Strongly agree (2)	Somewhat agree (1)	Neither agree nor disagree (0)	Somewhat disagree (-1)	Strongly disagree (-2)
The frontline supervisors lead by example.	○	○	○	○	○
The frontline supervisors never sacrifice safety to meet cost or schedule goals.	○	○	○	○	○
The frontline supervisors take responsibility when safety-related issues or incidents occur.	○	○	○	○	○
The frontline supervisors promote teamwork and	○	○	○	○	○

collaboration among crew members to achieve project goals safely.					
The frontline supervisors consistently follow all safety rules and regulations.	○	○	○	○	○

Q2.2 Please rank the following **traits and behaviors** by how consistently they are demonstrated by the frontline supervisors in your organization/company, with **1 = most consistently demonstrated** and **5 = least consistently demonstrated**. You can drag and drop the items to change the ranking.

_____ Leading by example
_____ Taking responsibility when safety issues arise
_____ Enforcing work rules and standards consistently
_____ Prioritizing safety over cost and schedule
_____ Inspiring workers to take personal ownership of safety and project outcomes

Q2.3 When safety violations occur, the frontline supervisors in your organization/company typically:

- ○ Address the violations immediately and provide coaching
- ○ Delegate resolution to someone else
- ○ Ignore minor issues to meet deadlines
- ○ Unsure / Not applicable
- ○ Other - Please specify: _____

Q2.4 From your perspective, what specific actions best demonstrate a frontline supervisor's personal commitment to safety?

_____
_____
_____
_____
_____

Q2.5 Please indicate the extent to which you agree that the frontline supervisors in your organization/company demonstrate the following **skills**.

	Strongly agree (2)	Somewhat agree (1)	Neither agree nor disagree (0)	Somewhat disagree (-1)	Strongly disagree (-2)
The frontline supervisors develop strategies to improve safety.	○	○	○	○	○
The frontline supervisors encourage group participation in safety decision-making and planning.	○	○	○	○	○
The frontline supervisors coach and mentor workers to build skills and work safely.	○	○	○	○	○
The frontline supervisors ask for input and integrate team perspectives in safety decisions.	○	○	○	○	○
The frontline supervisors motivate workers by communicating the project	○	○	○	○	○

vision and
goals.

Q2.6 Please rank the following **skills** by how consistently they are demonstrated by the frontline supervisors in your organization/company, with **1 = most consistently demonstrated** and **5 = least consistently demonstrated**. You can drag and drop the items to change the ranking.

_____ Conflict resolution
_____ Coaching and mentoring
_____ Innovation in safety planning
_____ Decision-making under pressure
_____ Effective communication of safety expectations and project goals

Q2.7 Which of the following **methods** do frontline supervisors in your organization/company use to **communicate safety goals**? Select all that apply.

- ☐ Crew huddles / pre-task planning meetings
- ☐ Coaching or mentoring sessions
- ☐ On-the-job demonstrations
- ☐ Written safety plans, checklists, or posted instructions
- ☐ Digital tools such as apps, dashboards, or text alerts
- ☐ Other - Please specify: _____

Q2.8 (Optional) Please briefly describe one example where a frontline supervisor's skills directly improved safety performance on one of your projects.

_____
_____
_____
_____
_____

Q2.9 Please indicate the extent to which you agree that the frontline supervisors in your organization/company **influence** safety in the following ways.

	Strongly agree (2)	Somewhat agree (1)	Neither agree nor disagree (0)	Somewhat disagree (-1)	Strongly disagree (-2)
The frontline supervisors	○	○	○	○	○

show concern for workers' safety and well-being.					
The frontline supervisors ensure workers have the resources (training, equipment, time) to work safely.	○	○	○	○	○
The frontline supervisors promote open communication and encourage reporting of safety concerns without fear.	○	○	○	○	○
The frontline supervisors treat all workers fairly and consistently when addressing safety issues.	○	○	○	○	○
The frontline supervisors build a positive team environment by promoting collaboration and mutual support.	○	○	○	○	○

Q2.10 To what extent is each of the following communication styles used by the frontline supervisors in your organization/company when discussing safety on projects?

	Not used (0)	Used minimally (1)	Used occasionally (2)	Moderately used (3)	Often used (4)	Always used (5)
Supportive and collaborative	○	○	○	○	○	○
Direct and authoritative	○	○	○	○	○	○
Minimal or inconsistent	○	○	○	○	○	○
Proactive and innovative	○	○	○	○	○	○
Other - Please specify:	○	○	○	○	○	○

Q2.11 Please rank the following factors by how strongly you think they **influence** the approach to safety taken by the frontline supervisors in your organization/company, with **1 = most influence** and **5 = least influence**. You can drag and drop the items to change the ranking.

_____ Company policies and procedures
_____ Upper management priorities
_____ Peer influence among supervisors
_____ Worker engagement
_____ Availability of safety resources and training

Q2.12 From your perspective, how have frontline supervisors influenced your own attitude toward safety on the job?

_____
_____
_____
_____
_____

Q2.13 Does your organization/company use any tools to assess the leadership skills and traits of frontline supervisors?

○ Yes

- ○ No
- ○ Not sure

Display this question:
If Q2.13 Does your organization/company use any tools to assess the leadership skills and traits of frontline supervisors? = Yes

Q2.13b Please describe the leadership assessment tools used by your organization/company.

_____
_____
_____
_____
_____

Q2.14 Does your organization/company provide formal leadership training for frontline supervisors?

- ○ Yes — mandatory
- ○ Yes — optional
- ○ No training provided
- ○ Not sure

Skip To: Q2.16 If Q2.14 Does your organization/company provide formal leadership training for frontline supervisors? = No training provided
Skip To: Q2.16 If Q2.14 Does your organization/company provide formal leadership training for frontline supervisors? = Not sure

Q2.15 Please indicate the extent to which you agree that **leadership training** has influenced the ability of the frontline supervisor in your organization/company to manage safety.

	Strongly agree (2)	Agree (1)	Neither agree nor disagree (0)	Disagree (-1)	Strongly disagree (-2)	I don't know
Training has improved supervisors' ability to manage safety effectively.	○	○	○	○	○	○

Training has prepared supervisors to communicate safety expectations clearly and consistently.	○	○	○	○	○	○
Training includes practical, hands-on activities that has helped supervisors apply safety strategies on the jobsite.	○	○	○	○	○	○
Training has increased supervisors' confidence in making safety-related decisions	○	○	○	○	○	○

Q2.16 To what extent do you think each of the following training formats and elements is effective for developing safety leadership skills?

	Not effective (0)	Minimally effective (1)	Somewhat effective (2)	Moderately effective (3)	Highly effective (4)	Extremely effective (5)
In-person workshops	○	○	○	○	○	○
On-the-job coaching	○	○	○	○	○	○
Online learning modules	○	○	○	○	○	○

Safety leadership certifications	○	○	○	○	○	○
Other - Please specify:	○	○	○	○	○	○

Q2.17 Please rank the following topics according to how useful you believe each topic is for training frontline supervisors in your organization/company, with **1 = most useful** and **5 = least useful**. You can drag and drop the items to change the ranking.

_____ Hazard identification
_____ Risk tolerance assessment
_____ Communication skills
_____ Safety culture development
_____ Leadership and decision-making under pressure

Q2.18 What additional tools, resources, or training do you think would best support frontline supervisors in leading their teams and improving safety on construction projects?

_____
_____
_____
_____
_____

Q2.19 What leadership skills or traits do you believe are most important for a craft worker to have in order to merit a promotion to frontline supervisor?

_____
_____
_____
_____
_____

3. RISK TOLERANCE

Q3.0 Please answer the following questions about **risk tolerance** on construction projects. For this survey, **risk tolerance** is defined as the degree to which an individual is willing to accept potential exposure to hazards or unsafe conditions when making decisions on the job.

Q3.1 Please indicate the extent to which you agree with each of the following statements related to **risk tolerance**.

	Strongly agree (2)	Somewhat agree (1)	Neither agree nor disagree (0)	Somewhat disagree (-1)	Strongly disagree (-2)
I prefer to minimize risks whenever possible, even if it slows project progress.	○	○	○	○	○
I am comfortable making decisions under uncertain safety conditions.	○	○	○	○	○
I carefully evaluate potential hazards before deciding whether to proceed with a task.	○	○	○	○	○
I decide how much risk to take based on how clear and complete the information is about the situation.	○	○	○	○	○
I am willing to accept certain risks if I believe the benefits to the project	○	○	○	○	○

outweigh the potential hazards.

Q3.2 Please rank the following situations according to your willingness to take a risk in the situation, with **1 = most willing** and **5 = least willing**. You can drag and drop the items to change the ranking.

_____ When project deadlines are tight and delays could affect overall progress
_____ When supervisors or management expect the task to be completed quickly
_____ When I feel highly confident in my own skills and experience
_____ When coworkers are comfortable proceeding despite potential hazards
_____ When safety procedures or hazard information are unclear

Q3.3 Please indicate the extent to which each of the following factors makes you either **increase or decrease your willingness** to take risks on construction sites.

	Strongly increases risk-taking (2)	Somewhat increases risk-taking (1)	No effect on risk-taking (0)	Somewhat decreases risk-taking (-1)	Strongly decreases risk-taking (-2)	I don't know
Pressure to meet deadlines	○	○	○	○	○	○
Management expectations	○	○	○	○	○	○
Peer influence	○	○	○	○	○	○
Personal confidence and experience	○	○	○	○	○	○
Lack of safety resources	○	○	○	○	○	○
Lack of needed materials, equipment, or tools to	○	○	○	○	○	○

perform the work						
Other - Please specify:	○	○	○	○	○	○

Q3.4 Imagine you are working on or supervising a construction task and realize that following all safety procedures will significantly delay completion of the task. How often would you do each of the following actions?

	Never (0)	Infrequently (1)	Sometimes (2)	About half the time (3)	Most of the time (4)	All of the time (5)
Follow all safety procedures, even if it causes delays.	○	○	○	○	○	○
Try to find a faster but still safe alternative.	○	○	○	○	○	○
Take a calculated risk to finish the task on time.	○	○	○	○	○	○
Ask the supervisor for guidance before deciding.	○	○	○	○	○	○

Q3.5 Have you ever been in a situation when taking a calculated safety risk has improved project outcomes? If so, please provide an example situation.

○ Yes. Provide example:

_____

- ○ No

Q3.6 Does your organization/company provide formal training on assessing and managing risk?

- ○ Yes
- ○ No
- ○ Not Sure

Q3.7 Based on your experience, how effective do you think each of the following risk management tools or training approaches is for improving risk tolerance?

	Not effective (0)	Minimally effective (1)	Somewhat effective (2)	Moderately effective (3)	Highly effective (4)	Extremely effective (5)
Hazard analysis training	○	○	○	○	○	○
Risk perception workshops	○	○	○	○	○	○
Virtual reality (VR) hazard simulations	○	○	○	○	○	○
Incident case study reviews	○	○	○	○	○	○
Other - Please specify:	○	○	○	○	○	○

Q3.8 Does your organization/company use any tools to assess the risk tolerance levels of frontline supervisors or craft workers?

- ○ Yes
- ○ No
- ○ Not sure

Display this question:
If Q3.8 Does your organization/company use any tools to assess the risk tolerance levels of frontline supervisors or craft workers? = Yes

Q3.8b Please briefly describe the risk tolerance assessment tools used by your organization/company.

Q3.9 What additional tools, resources, or training do you think would best support improving risk-tolerance on the worksite?

4. ADDITIONAL COMMENTS

Q4.1 What additional strategies or programs do you think your organization/company could introduce to better support frontline supervisors in leading their teams effectively?

Q4.2 Based on your experience, what changes would make leadership assessments or supervisor evaluations more useful and relevant to real jobsite conditions?

Q4.3 What new challenges or trends are emerging on your projects that you feel frontline supervisors and teams need better preparation for?

Q4.4 Are there any technologies, tools, or innovative practices your organization/company has recently adopted that have improved communication, safety, leadership effectiveness, or risk taking on projects?

Q4.5 (Optional) Please share any other information or comments related to frontline supervisor leadership, risk tolerance, and decision-making that you feel is important for safety on construction projects.

5. THANK YOU

Q5.1 We are also conducting short, voluntary follow-up interviews with participants who are willing to share more about their perspectives and experiences. These interviews will help us gain deeper insights into the challenges and opportunities frontline supervisors and construction personnel face.

Would you be willing to participate in an interview?

Participation in an interview is completely voluntary, and your survey responses will remain confidential even if you choose not to participate.

If **yes**, please choose "Yes" below, and you will be taken to another survey where you can provide your name and contact information so that the researchers can contact you to set up an interview.

If **no**, then you have completed this survey, and please choose "No" below. We are incredibly grateful for your participation.

- ○ Yes
- ○ No

Skip To: Q5.2 If We are also conducting short, voluntary follow-up interviews with participants who are willing to share more about their perspectives and experiences. = No

Q5.2 Thank you for taking the time to respond to the survey. Your responses are much appreciated and a vital contribution to our study.

There are no more survey questions.

Please use the back button to return to any unanswered questions before proceeding. Otherwise, please click on "Survey complete" and the forward arrow button below to submit your survey responses.

- ○ Survey Complete

D. STATISTICAL ANALYSIS RESULTS

Q2.1 Please indicate the extent to which you agree that the frontline supervisors in your organization/company demonstrate the following personal **traits and behaviors**.

A Welch two-sample t-test was conducted to examine differences in the transformational leadership composite score between respondents in management and executive leadership roles. The analysis did not identify a statistically significant difference between groups ($t(10.67) = -0.77$, $p = 0.460$). Although the mean composite score was higher among executives ($M = 1.24$) compared to managers ($M = 0.83$), the 95% confidence interval for the difference in means (−1.61 to 0.78) included zero, indicating substantial uncertainty around the estimated group difference. These results suggest that perceived transformational safety leadership did not differ meaningfully by job title in this sample.

Q2.2 Please rank the following **traits and behaviors** by how consistently they are demonstrated by the frontline supervisors in your organization/company, with **1 = most consistently demonstrated** and **5 = least consistently demonstrated**. You can drag and drop the items to change the ranking.

The Friedman test revealed statistically significant differences in the rankings of leadership behaviors ($\chi^2(4) = 22.32$, $p < 0.001$). Additionally, Kendall's coefficient of concordance indicated very low agreement among respondents ($W = 0.008$), suggesting substantial variability in how individuals prioritized these behaviors.

Post-hoc pairwise Wilcoxon signed-rank tests with Holm correction indicated that respondents did not treat all leadership behaviors as equally consistent. Several statistically significant differences were observed, particularly involving the behavior "prioritizing safety over cost and schedule" and those related to "leading by example" and "taking responsibility when safety issues arise." These traits were ranked differently from multiple other behaviors, suggesting that participants perceived them as more distinct in their consistency relative to the rest. In contrast, comparisons such as enforcing work rules versus prioritizing safety, prioritizing safety versus inspiring worker ownership, leading by example versus taking responsibility, and enforcing rules versus inspiring ownership did not reach statistical significance, indicating that respondents tended to rank these pairs similarly.

Overall, while earlier Kendall's W results showed low overall agreement in rankings—meaning individuals varied considerably in how they prioritized leadership behaviors—the post-hoc findings demonstrate that certain traits nonetheless emerged as reliably distinguishable at the group level, especially those emphasizing safety prioritization, responsibility, and leading by example.

Q2.3 When safety violations occur, the frontline supervisors in your organization/company typically: …

The analysis of Q2.3 examined whether the typical supervisory response to safety violations differed across industry sector, organization size, and job title using Fisher's Exact Tests due to small cell counts. Results indicated no statistically significant association between response type and industry sector (Commercial vs. Non-Commercial; $p = 0.080$), suggesting that supervisors in commercial and non-commercial settings reported broadly similar approaches to addressing safety violations. In contrast, there was a statistically significant association between response type and organization size ($p = 0.012$), indicating that the way safety violations are typically handled varies meaningfully across small, medium, and large organizations. No significant association was observed for job title group ($p = 1.00$), implying that managers and executives reported similar typical responses.

Effect size estimates using Cramer's V suggested that, despite the lack of statistical significance for industry sector, the strength of association was large for both industry sector ($V \approx 0.62$) and organization size ($V \approx 0.60$), while the association for job title was small to moderate ($V \approx 0.25$).

Taken together, these findings indicate that organizational size appears to be the most consistent differentiating factor in how safety violations are addressed, whereas differences by sector or leadership level were not statistically reliable in this sample, likely influenced by the relatively small number of respondents.

Q2.4 From your perspective, what specific actions best demonstrate a frontline supervisor's personal commitment to safety? (Qualitative analysis).

Responses to Q2.4 consistently emphasized behavioral modeling and visible leadership actions as the strongest indicators of a frontline supervisor's commitment to safety. The most dominant theme across nearly all responses was "leading by example" or "walking the talk," often expressed through consistent PPE use, adherence to safety rules, and personally demonstrating safe work practices. Closely related to this theme was the idea of safety as a non-negotiable value, with several respondents highlighting prioritizing safety over cost or schedule and embedding safety into daily production planning.

A second major theme involved communication and engagement, including coaching workers in real time, asking open-ended questions, explaining personal motivations ("why"), and setting clear and consistent expectations. Many responses also pointed to accountability and follow-through, such as conducting root-cause analyses, confronting unsafe behaviors directly, and maintaining consistent messaging.

Additional but less frequent themes included collaboration with safety professionals, ownership of mistakes, and building crew buy-in and trust through transparency and care for team members. A small number of responses noted that while leading by example is ideal, it is not always practiced consistently, suggesting a perceived gap between expectations and observed behavior.

Overall, the qualitative data indicate that respondents view personal commitment to safety not as a single action, but as a visible, continuous pattern of leadership behaviors centered on modeling safe practices, clear communication, accountability, and cultural influence rather than compliance alone.

Q2.5 Please indicate the extent to which you agree that the frontline supervisors in your organization/company demonstrate the following **skills**.

The five Q2.5 items were converted to numeric Likert values and analyzed both individually and as a composite measure of perceived supervisory skill demonstration. Item-level Welch t-tests comparing commercial and non-commercial respondents did not identify any statistically significant differences across the five skill items (p values ranged from 0.39 to 0.74). Mean ratings were slightly higher among non-commercial respondents for all items, but these differences were small and not statistically reliable. A composite skills score was then created by averaging Q2.5_1 through Q2.5_5 for each respondent. The composite ranged from −2 to 2, with a mean of 0.77 and a median of 1.00, indicating generally positive perceptions of supervisory skill demonstration overall.

Normality testing using the Shapiro–Wilk test indicated that the composite distribution deviated from normality ($W = 0.899$, $p = 0.024$), suggesting some skew or clustering in responses. Group comparisons of the composite score showed no statistically significant differences by organization size using a Welch one-way ANOVA ($F(2, 4.90) = 2.17$, $p = 0.212$) and no significant differences by job title group using a Welch two-sample t-test ($t(9.90) = -0.31$, $p = 0.764$). Although executives had a slightly higher mean composite score (0.84) than managers (0.65), the confidence interval for the difference in means included zero, indicating substantial uncertainty and no reliable group distinction.

Overall, these findings suggest that respondents generally perceived frontline supervisors as demonstrating safety-related skills at a moderately positive level, and that these perceptions did not vary meaningfully across industry sector, organization size, or leadership level within this sample.

Lastly, Cronbach's Alpha tests were run and the Q2.5 scale demonstrates excellent reliability and coherence, meaning it functions well as a unified measurement of frontline supervisory skills related to safety leadership. The composite score you created is statistically sound, and the items collectively provide a stable, high-quality measure rather than a set of unrelated questions.

Q2.6 Please rank the following **skills** by how consistently they are demonstrated by the frontline supervisors in your organization/company, with **1 = most consistently demonstrated** and **5 = least consistently demonstrated**. You can drag and drop the items to change the ranking.

The Friedman test revealed statistically significant differences in the rankings of leadership behaviors ($\chi^2(4) = 22.32$, $p < 0.001$). Additionally, Kendall's coefficient of concordance indicated very low agreement among respondents ($W = 0.008$), suggesting

substantial variability in how individuals prioritized these behaviors. The ranking analysis for Q2.6 examined how consistently frontline supervisors were perceived to demonstrate five leadership-related skills. A Friedman test indicated a statistically significant difference in the rankings of skills ($\chi^2(4) = 20.17$, $p < 0.001$), meaning respondents did not view all skills as being demonstrated with equal consistency. However, Kendall's coefficient of concordance showed very low overall agreement among respondents ($W \approx 0.01$), suggesting that while differences existed at the group level, individual participants varied widely in how they prioritized or perceived these skills.

Post-hoc pairwise Wilcoxon signed-ran tests with Holm correction revealed that only a small number of specific skill comparisons remained statistically significant after controlling for multiple comparisons. In particular, Coaching and Mentoring (Q2.6_2) differed significantly from Innovation in Safety Planning (Q2.6_3), and Innovation in Safety Planning (Q2.6_3) also differed significantly from both Decision-Making Under Pressure (Q2.6_4) and Effective Communication of Safety Expectations and Project Goals (Q2.6_5). All other pairwise comparisons were not statistically significant following adjustment.

Overall, these findings indicate that although respondents collectively distinguished certain skills—particularly those involving innovation in safety planning—from others, there was minimal consensus on a single consistent ranking order. This pattern suggests heterogeneous perceptions across participants, with only a few skills emerging as reliably differentiated rather than a uniform hierarchy of demonstrated abilities.

Q2.7 Which of the following **methods** do frontline supervisors in your organization/company use to **communicate safety goals**? Select all that apply.

Responses to Q2.7 indicate that frontline supervisors most commonly rely on crew huddles/pre-task planning meetings and written safety plans, checklists, or posted instructions, often in combination with other methods. A large proportion of respondents selected multiple communication channels simultaneously, with the most frequent pattern being the combined use of huddles, coaching or mentoring, on-the-job demonstrations, written materials, and digital tools. Very few respondents selected only a single method, and "other" responses were rare, suggesting that safety communication is generally multi-modal rather than singular. Group comparisons revealed meaningful differences by industry sector.

Fisher's Exact Test indicated a statistically significant association between communication method selection and commercial versus non-commercial organizations ($p = 0.009$), with a very large effect size (Cramer's $V \approx 0.83$). This suggests that the mix of communication channels used by supervisors differs substantially between sectors.

In contrast, no statistically significant differences were observed by organization size ($p = 0.287$) or job title ($p = 0.076$), although the job title comparison approached conventional significance thresholds. Effect size estimates for organization size were numerically large

($V \approx 0.71$) but should be interpreted cautiously given the small sample and sparse category counts.

The Cramer's V for job title returned NaN, which typically occurs when cell counts are too small or uneven to compute a stable estimate.

Overall, the results suggest that frontline safety communication is broadly diverse and typically involves multiple channels, with sector-specific patterns emerging as the primary source of statistical differentiation rather than organizational size or supervisory role.

Q2.8 Please briefly describe one example where a frontline supervisor's skills directly improved safety performance on one of your projects. (Qualitative analysis).

The open-ended responses consistently highlight visible leadership presence, communication, and proactive engagement as the primary mechanisms through which frontline supervisors improve safety performance. A dominant theme is the use of daily huddles or pre-shift planning meetings, where supervisors facilitate hazard discussions, encourage worker input, and reinforce expectations. These routines appear to function as both planning tools and cultural signals that safety is prioritized alongside production.

A second strong theme is coaching and mentorship, often described as one-on-one interactions or real-time interventions. Respondents emphasized supervisors who listen, ask questions, and address issues with empathy—recognizing situational nuances rather than applying rigid rules. This approach was frequently linked to building trust and psychological safety, which in turn supports earlier reporting of hazards and greater crew buy-in.

Another recurring pattern involves decisive action and advocacy, such as initiating stand-downs after serious concerns or pushing back on schedules when risk levels rise. These examples illustrate supervisors exercising authority to protect workers even under client or production pressure, reinforcing the perception that safety is a non-negotiable value. Several responses also described technical competence and innovation, including developing safer equipment configurations, designing ladder-securement methods from available materials, creating controlled access zone boards, and delivering targeted training (e.g., fall protection inspection). These examples suggest that frontline supervisors contribute not only through interpersonal skills but also through problem-solving and process improvement that directly reduces exposure to hazards.

Overall, the qualitative data portray effective frontline safety leadership as a blend of consistent communication rituals, empathetic coaching, willingness to intervene or advocate, and practical technical ingenuity. The common denominator across examples is supervisor presence and intentional engagement, which appears to shift safety from a compliance activity to an integrated, day-to-day practice embedded in team culture.

Q2.9 Please indicate the extent to which you agree that the frontline supervisors in your organization/company **influence** safety in the following ways.

The five Q2.9 items demonstrated high internal consistency (Cronbach's $\alpha = 0.93$), indicating that the questions reliably measured a single underlying construct related to perceived frontline supervisor influence on safety. Item-level statistics and "alpha if item dropped" values showed that no individual item weakened the scale, supporting the decision to compute a composite score. The resulting influence composite had a mean of 1.14 on a −2 to +2 scale (median = 1.40), suggesting that respondents generally perceived frontline supervisors as having a positive influence on safety, with most responses falling in the agreement range. However, the Shapiro–Wilk test indicated non-normal distribution ($W = 0.78$, $p < 0.001$), reflecting skew toward higher agreement.

Group comparisons showed no statistically significant differences in perceived safety influence between commercial and non-commercial organizations ($p = 0.723$) or between management and executive leadership roles ($p = 0.387$). In both cases, mean scores were slightly higher for commercial organizations and executives, but confidence intervals included zero, indicating substantial uncertainty around these differences.

In contrast, organization size demonstrated a statistically significant effect on the influence composite (Welch ANOVA $p = 0.028$), suggesting that perceptions of frontline supervisor safety influence varied meaningfully across small, medium, and large organizations.

Overall, the findings indicate that while respondents broadly view frontline supervisors as positively influencing safety, organizational scale—not sector or job title—appears to be the primary factor associated with variation in these perceptions.

Q2.10 To what extent is each of the following communication styles used by the frontline supervisors in your organization/company when discussing safety on projects?

Question 2.10 examined how frequently frontline supervisors use different communication styles when discussing safety, measured on a 0–5 usage scale. Internal reliability testing indicated poor scale consistency (Cronbach's $\alpha < 0$), driven primarily by one item (Q2.10_3, "minimal or inconsistent") that was negatively correlated with the other items and two items that had no variance (Q2.10_5 and Q2.10_5_TEXT). This pattern suggests the items do not form a single coherent construct and should be interpreted individually rather than as a unified scale. Despite this limitation, a composite score was calculated for exploratory purposes and demonstrated approximate normality (Shapiro–Wilk $p = 0.393$).

Group comparisons using Welch's t-tests and Welch's ANOVA showed no statistically significant differences in communication style usage by industry sector (Commercial vs. Non-Commercial, $p = 0.669$), organization size ($p = 0.735$), or job title ($p = 0.189$). Mean scores indicated that supervisors most frequently reported using direct/authoritative ($M \approx 3.52$), supportive/collaborative ($M \approx 3.35$), and proactive/innovative ($M \approx 3.17$)

communication styles, while minimal or inconsistent communication was substantially less common (M ≈ 1.65).

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Q2.11 Please rank the following factors by how strongly you think they **influence** the approach to safety taken by the frontline supervisors in your organization/company, with **1 = most influence** and **5 = least influence**. You can drag and drop the items to change the ranking.

A Friedman rank-sum test was conducted to determine whether respondents systematically ranked the five influencing factors differently. The test was not statistically significant ($\chi^2(4) = 4.17$, $p = 0.383$), indicating that, at the group level, participants did not demonstrate a consistent pattern in how they prioritized these factors.

Supporting this finding, Kendall's coefficient of concordance showed very weak agreement among respondents ($W = 0.009$), suggesting substantial variability and little shared consensus regarding which factors most strongly influence frontline supervisors' safety approaches.

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Q2.12 From your perspective, how have frontline supervisors influenced your own attitude toward safety on the job? (Qualitative analysis)

Responses to Q2.12 reveal that frontline supervisors are widely perceived as high-impact influencers of individual safety attitudes, primarily through daily visibility, practical knowledge, and leading by example rather than through formal training mechanisms. Many participants emphasized that on-site behaviors—such as proactive hazard communication, collaboration during project planning, and willingness to coach or intervene—carry more weight than online modules or classroom instruction. Supervisors who demonstrated openness, technical competence, and genuine care for crew well-being

were described as strengthening personal commitment to safe practices and reinforcing a "culture of care."

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A second major theme was variability in supervisor effectiveness. Several respondents noted that influence "depends on the supervisor," highlighting differences in communication style, engagement level, and leadership capability across projects. Positive influence was associated with collaboration, simplicity in implementing safety procedures, and early hazard identification, whereas negative or neutral influence emerged when supervisors were perceived as prioritizing schedule or budget pressures, lacking field experience, or being promoted primarily for productivity rather than safety leadership.

A third recurring theme involved structural and organizational pressures, including compressed schedules, workforce qualification gaps, and perceived disconnects between upper management policies and field realities. Some participants expressed concern that these systemic factors can dilute frontline supervisors' ability to champion safety consistently. Despite this, many respondents still characterized supervisors as "key," "eyes and ears," or central drivers of project safety culture.

Overall, the qualitative data suggest that frontline supervisors exert a substantial but highly context-dependent influence on individual safety attitudes. Their impact is strongest when they combine technical credibility, interpersonal engagement, and consistent modeling of safe behaviors, and weakest when organizational constraints or leadership shortcomings undermine their authority or authenticity.

Q2.13 Does your organization/company use any tools to assess the leadership skills and traits of frontline supervisors? If Yes: Q2.13b: Please describe the leadership assessment tools used by your organization/company.

Descriptive analysis indicated that respondents were nearly evenly divided regarding whether their organization uses tools to assess frontline supervisor leadership skills. Approximately 47.8% reported "Yes," 39.1% reported "No," and 13.0% were "Not sure." This distribution suggests moderate variability in organizational practices, with no clear majority consensus.

Group comparison analyses using Fisher's Exact Test showed no statistically significant difference in responses between commercial and non-commercial sectors ($p = 1.00$), and the associated effect size was negligible (Cramer's $V = 0.07$), indicating that industry sector had little to no relationship with whether assessment tools were used.

Similarly, job title groups (manager vs. executive) did not differ significantly ($p = 0.80$). In contrast, organization size demonstrated a statistically significant association with tool usage ($p = 0.013$), suggesting that larger and smaller organizations may differ in their likelihood of employing formal leadership assessment mechanisms.

Overall, the results imply that organizational scale, rather than sector or job role, is the primary factor linked to the presence of leadership evaluation tools in this sample.

Q2.14 Does your organization/company provide formal leadership training for frontline supervisors?

Descriptive results indicate that most respondents reported the presence of some form of formal leadership training within their organizations. Specifically, 43.5% indicated that training was mandatory, 26.1% reported that training was optional, 26.1% reported that no training was provided, and 4.3% were unsure. This distribution suggests that while a majority of organizations offer leadership training in some capacity, a substantial proportion either provide it only optionally or do not provide it at all.

Group comparison analyses using Fisher's Exact Test did not identify statistically significant differences in training availability across industry sector (commercial vs. non-commercial; $p = 0.311$), organization size ($p = 0.121$), or job title group (manager vs. executive; $p = 0.575$).

Despite the lack of statistical significance, Cramer's V effect sizes were in the moderate range (sector $V = 0.44$; organization size $V = 0.43$; job title $V = 0.38$), suggesting that practical or contextual differences may exist but were not detectable as statistically significant within this relatively small sample.

Overall, the findings indicate variability in leadership training practices across organizations, with no clear evidence that these differences are systematically associated with sector, organizational scale, or respondent job role.

Q2.15 Please indicate the extent to which you agree that **leadership training** has influenced the ability of the frontline supervisor in your organization/company to manage safety.

Results for Q2.15 indicate that respondents generally perceive leadership training as having a positive influence on frontline supervisors' ability to manage safety. After converting the four Likert-scale items to numeric values, reliability analysis produced a Cronbach's alpha of 0.79, indicating good internal consistency and supporting the creation of a composite score. The composite mean score was 1.22 on a −1 to 2 scale,

with a median of 1.25 and a range from 0 to 2, showing that overall responses leaned toward agreement that training improves supervisory safety capabilities.

A Shapiro–Wilk normality test was not significant ($p = 0.328$), indicating the distribution did not deviate substantially from normal and that parametric tests were appropriate.

Group comparisons revealed no statistically significant differences by commercial versus non-commercial organizations ($p = 0.714$), organization size ($p = 0.335$), or job title ($p = 0.702$), suggesting that perceptions of leadership training effectiveness were consistent across respondent demographics. Item-level means ranged from 1.00 to 1.33, further reinforcing generally favorable views of training impact.

Overall, the findings indicate that leadership training is broadly regarded as beneficial to frontline safety management, with stable agreement across different organizational contexts rather than effects limited to specific groups.

Q2.16 To what extent do you think each of the following training formats and elements is effective for developing safety leadership skills?

Internal consistency for the Q2.16 scale was acceptable to good (Cronbach's $\alpha \approx 0.76$), indicating that the items generally measured a common underlying concept of perceived training effectiveness. Two variables (Q2.16_5 and Q2.16_5_TEXT) showed no variance and were automatically excluded by the reliability procedure, suggesting they did not contribute meaningful information and should not be included in the composite score. Item-level descriptive statistics indicated that in-person workshops ($M \approx 4.13$, $SD \approx 0.63$) and on-the-job coaching ($M \approx 4.26$, $SD \approx 0.81$) were rated as the most effective training approaches, whereas online learning modules ($M \approx 2.13$, $SD \approx 1.01$) and safety leadership certifications ($M \approx 2.48$, $SD \approx 1.38$) received comparatively lower effectiveness ratings. The overall composite effectiveness score averaged 3.25 ($SD \approx 0.67$), reflecting a generally moderate-to-high perceived effectiveness of training formats overall.

A Shapiro–Wilk test indicated that the composite scores were approximately normally distributed ($p = 0.51$), supporting the use of parametric comparisons. Group analyses revealed no statistically significant differences in perceived training effectiveness by commercial vs. non-commercial sector ($p = 0.90$), organization size ($p = 0.79$), or job title ($p = 0.15$). Although managers reported slightly higher mean effectiveness ratings than executives (3.56 vs. 3.08), this difference did not reach statistical significance.

Collectively, these findings suggest that respondents broadly agree that hands-on and in-person training methods are more effective than passive or credential-based formats, and that these perceptions are relatively consistent across organizational and role-based subgroups.

Q2.17 Please rank the following topics according to how useful you believe each topic is for training frontline supervisors in your organization/company, with **1 = most useful** and **5 = least useful**. You can drag and drop the items to change the ranking.

A Friedman rank-sum test was conducted to determine whether respondents ranked the five training topics differently in terms of perceived usefulness. The test indicated a statistically significant overall difference in rankings, $\chi^2(4) = 10.89$, $p = 0.028$, suggesting that at least one topic was viewed as more or less useful relative to the others. However, Kendall's coefficient of concordance was extremely low ($W \approx 0.004$), indicating very weak agreement among respondents and substantial variability in how individuals prioritized the topics.

Post-hoc pairwise Wilcoxon signed-rank tests with Holm correction were then performed to identify specific differences between topics. Although a few comparisons showed low unadjusted p-values (e.g., Topic 2 vs. Topic 3 and Topic 3 vs. Topic 5), none of the pairwise comparisons remained statistically significant after Holm adjustment (all adjusted $p > 0.05$).

Overall, these results suggest that while the group as a whole demonstrated a statistically detectable difference in topic rankings, there was minimal consensus on which training topics were most useful. The lack of significant post-hoc differences after correction indicates that perceived usefulness was broadly distributed rather than dominated by a single clearly preferred topic.

Q2.18 What additional tools, resources, or training do you think would best support frontline supervisors in leading their teams and improving safety on construction projects? (Qualitative analysis)

Responses to Q2.18 indicate that participants view effective support for frontline supervisors as a combination of practical, field-based leadership development, continuous access to concise training resources, and stronger organizational alignment around safety priorities. A dominant theme was the need for hands-on, on-the-job leadership training and mentorship, with many respondents emphasizing that coaching from experienced supervisors and real-world application are more valuable than classroom instruction alone.

Closely related was the desire for short, easily digestible reference materials and recurring training topics that supervisors can revisit over time to reinforce learning. Several comments highlighted the importance of improved planning skills, situational awareness, and tools that help evaluate worker risk tolerance, suggesting a preference for proactive safety management rather than reactive responses.

Organizational support also emerged as a key factor, with participants noting that upper management messaging, recognition of positive safety behaviors, and reduced production pressure are essential for enabling supervisors to lead effectively. In addition, some respondents expressed a need for greater autonomy and flexibility in safety decision-

making, indicating frustration with rigid, one-size-fits-all policies that may not fit dynamic jobsite conditions.

Technology and innovation, including AI tools and early warning systems, were mentioned as potential enhancers, though generally viewed as supplements rather than replacements for human leadership.

Finally, multiple responses referenced time constraints and accelerated project schedules as barriers to meaningful engagement and coaching, implying that even strong training programs are limited if supervisors lack sufficient time to apply them.

Overall, the feedback portrays safety leadership support as a multidimensional need centered on experiential learning, continuous reinforcement, cultural and managerial backing, and practical tools that enable supervisors to lead confidently and proactively.

Q2.19 What leadership skills or traits do you believe are most important for a craft worker to have in order to merit a promotion to frontline supervisor? (Qualitative analysis)

The responses to Q2.19 show strong consensus that communication ability is the single most important trait for a craft worker to merit promotion to frontline supervisor, with participants repeatedly emphasizing both verbal and written skills as well as the capacity to listen actively and engage meaningfully with team members.

Closely tied to communication was empathy and genuine care for worker well-being, suggesting that effective supervisors are expected not only to direct work but also to build trust and personal connection with their crews. Safety orientation emerged as another dominant theme, with many respondents highlighting the need for a clear safety vision, willingness to prioritize safety over productivity, and the ability to identify hazards and implement mitigations during planning and execution.

Several comments also stressed decision-making capability, consistency, accountability, and ethical integrity—particularly the willingness to “step up and do what is right” even when under pressure. Technical competence and industry knowledge were viewed as important foundations, but respondents often framed these as secondary to soft skills such as teamwork, adaptability, problem-solving, and the ability to forecast resource needs. Respect from peers and leading by example were also frequently mentioned, indicating that credibility and modeled behavior are critical to successful supervision.

Overall, the qualitative feedback portrays the ideal candidate for frontline supervision as a communicator first, a safety advocate second, and a technically competent, emotionally intelligent leader who demonstrates integrity, foresight, and continuous willingness to learn and grow.

Q3.1 Please indicate the extent to which you agree with each of the following statements related to **risk tolerance**.

The Q3.1 risk-tolerance scale demonstrated low to moderate internal consistency, with Cronbach's alpha of 0.40 (standardized alpha ≈ 0.60), indicating that the five items were only weakly to moderately correlated and may not be measuring a single cohesive construct. Item-level statistics showed variability in performance, with Q3.1_5 exhibiting notably lower correlation with the overall scale compared to the other items. Despite this limitation, a composite risk-tolerance score was calculated. The composite had a mean of 1.24 (SD = 0.45) on the response scale, with values ranging from 0.20 to 2.00, suggesting generally moderate agreement with risk-tolerant statements among respondents.

The Shapiro–Wilk test indicated no significant deviation from normality ($p = 0.28$), supporting the use of parametric group comparisons. Group analyses revealed no statistically significant differences in risk-tolerance composite scores between commercial and non-commercial respondents ($p = 0.93$) or between managers and executives ($p = 0.75$), with nearly identical mean scores across these groups. Differences by organization size approached but did not reach statistical significance (Welch ANOVA $p = 0.056$), suggesting a possible but inconclusive trend that larger or smaller organizations may differ slightly in perceived risk tolerance.

Item-level descriptive statistics showed the highest agreement for Q3.1_3 ($M \approx 1.70$) and Q3.1_2 ($M \approx 1.61$), while Q3.1_5 had a substantially lower mean ($M \approx 0.09$) and the largest variability, reinforcing its weaker contribution to the overall scale.

Overall, respondents exhibited moderate average risk tolerance, but the relatively low reliability indicates caution when interpreting the composite as a unified measure.

Q3.2 Please rank the following situations according to your willingness to take a risk in the situation, with **1 = most willing** and **5 = least willing**. You can drag and drop the items to change the ranking.

The ranking analysis for Q3.2 (Willingness to Take Risk Across Situations) indicated clear and statistically significant differences in how respondents prioritized risk across the five scenarios. The Friedman test demonstrated a strong overall effect ($\chi^2(4) = 50.99$, $p < 0.001$), confirming that participants did not view all situations equally in terms of their willingness to accept risk. However, Kendall's coefficient of concordance was extremely low ($W \approx 0.01$), indicating very weak agreement among respondents. In other words, while rankings differed significantly at the group level, individual participants varied widely in how they ordered the scenarios.

Post-hoc pairwise Wilcoxon signed-rank tests with Holm correction revealed several meaningful differences. The scenario involving high personal confidence in one's skills and experience (Q3.2_3) consistently ranked as significantly different from most other situations, indicating that respondents were notably more willing to take risks when they felt personally confident. This scenario had the lowest mean rank ($M = 1.13$, $SD = 0.34$), showing both high willingness and strong consistency across participants.

In contrast, scenarios involving unclear safety procedures or hazard information (Q3.2_5) and tight project deadlines (Q3.2_1) received the highest mean ranks (M = 4.09 and M = 3.70 respectively), indicating lower willingness to take risks in those contexts. Pairwise differences between these higher-risk-avoidance scenarios and the confidence-based scenario were statistically significant even after adjustment.

Overall, the findings suggest that respondents' willingness to accept risk is most strongly influenced by internal confidence factors, whereas ambiguity in safety information and external time pressures are associated with greater caution. Despite this clear pattern in average rankings, the very low Kendall's W highlights substantial heterogeneity in individual decision-making, indicating that perceptions of acceptable risk vary considerably across participants.

Q3.3 Please indicate the extent to which each of the following factors makes you either **increase or decrease your willingness** to take risks on construction sites.

The Q3.3 scale, which measured how different workplace factors influence an individual's willingness to take risks on construction sites, demonstrated high internal reliability (Cronbach's $\alpha \approx 0.89$), indicating that the items generally functioned well together as a coherent construct after automatic reverse-key correction.

Two items (Q3.3_7 and its accompanying text field) showed no variance and were excluded from reliability calculations, which is not unusual when all respondents select the same option or when a text field is inadvertently included in the scale. Item-level descriptive statistics showed that several factors tended to increase risk-taking on average, particularly Q3.3_4 (mean ≈ 1.04) and Q3.3_3 (mean ≈ 0.70), while Q3.3_5 and Q3.3_6 produced negative mean scores (≈ −0.22 each), indicating that these factors more often decreased respondents' willingness to take risks. The overall composite score had a modest positive mean (≈ 0.39), suggesting that, on balance, the listed situational pressures slightly increased perceived risk-taking willingness, although variability across items was substantial.

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The overall composite score had a modest positive mean (≈ 0.39), suggesting that, on balance, the listed situational pressures slightly increased perceived risk-taking willingness, although variability across items was substantial.

Q3.4 Imagine you are working on or supervising a construction task and realize that following all safety procedures will significantly delay completion of the task. How often would you do each of the following actions?

Responses to Q3.4 indicate clear differences in how participants reported they would behave when completing a construction task would be significantly delayed by fully following safety procedures. Internal consistency across the four behavior items was low (Cronbach's $\alpha \approx 0.33$), suggesting that the actions represent distinct decision tendencies rather than a single unified construct.

Descriptively, participants most frequently endorsed continuing to follow all safety procedures and seeking a faster but still safe alternative (both means ≈ 4.04 on a 0–5 scale), followed by asking a supervisor for guidance (mean ≈ 3.13). The least frequently endorsed action was taking a calculated risk to finish on time (mean ≈ 1.83), indicating general reluctance to intentionally accept risk for schedule gains. The overall composite mean was 3.26 (SD ≈ 0.60) and was approximately normally distributed (Shapiro–Wilk $p = 0.15$).

Group comparisons showed no statistically significant differences in composite scores by commercial vs. non-commercial sector ($p = 0.43$), organization size ($p = 0.41$), or job title group ($p = 0.86$), suggesting broadly similar decision patterns across respondent subgroups. However, within-person comparisons across the four actions revealed significant differences (Friedman $\chi^2 = 33.71$, $df = 4$, $p < 0.001$), confirming that participants did not treat all response options equivalently.

Post-hoc paired Wilcoxon tests with Holm correction indicated that "taking a calculated risk" was rated significantly lower than the other behaviors, particularly when compared with following all safety procedures and seeking faster but safe alternatives (adjusted p-values < 0.01). In contrast, following procedures and seeking safe alternatives did not differ meaningfully from each other.

Overall, the pattern suggests a strong preference for maintaining safety compliance or finding safe efficiencies, moderate reliance on supervisory consultation, and clear aversion to deliberate risk-taking when safety rules would delay task completion.

Q3.5 Have you ever been in a situation when taking a calculated safety risk has improved project outcomes? If so, please provide an example situation.

Survey responses indicated that a slight majority of participants reported not having experienced a situation where taking a calculated safety risk improved project outcomes, while a substantial minority reported that they had. Specifically, 57.1% (n = 12) selected "No," and 42.9% (n = 9) selected "Yes."

Statistical comparisons across organizational characteristics showed no statistically significant differences between Commercial and Non-Commercial sectors (Fisher's Exact $p = 1.00$; Cramer's $V = 0.09$, indicating a negligible association), nor between Job Title groupings ($p = 0.62$). Differences by Organization Size approached but did not reach conventional statistical significance ($p = 0.07$), suggesting a possible trend but insufficient evidence to conclude a reliable association within this sample.

Overall, the quantitative findings indicate that experiences with calculated safety risk improving outcomes were relatively common but not strongly patterned by sector, role, or company size. Qualitative analysis of the open-ended "Yes" responses revealed several recurring themes. First, many examples described task-level discretion and adaptive decision-making, such as modifying or bypassing overly broad procedures when hazards could be effectively isolated, or using familiar tools or alternative equipment believed to be safer or more efficient in context. Second, respondents frequently referenced time and schedule pressures, including working extended hours instead of mobilizing a new crew, or temporarily waiving site orientation requirements to avoid delays during critical operations (e.g., concrete pours). Third, several comments highlighted personal protective equipment and fall-protection trade-offs, such as choosing fall-arrest systems over scaffolding or adjusting eye-protection practices based on perceived exposure. A fourth theme involved experience-based judgment, where seasoned workers relied on prior training or situational awareness to select approaches they believed reduced risk while improving efficiency. Finally, a minority of responses expressed ambiguity or skepticism, noting uncertainty about whether the risk truly improved overall outcomes or acknowledging that attention lapses could undermine safety benefits.

Taken together, the results suggest that while calculated safety risks are not universally endorsed, a meaningful portion of practitioners perceive situational flexibility—particularly when informed by experience and hazard isolation—as occasionally beneficial to project performance. However, the narratives also underscore tension between productivity demands and formal safety procedures, indicating that perceived improvements often arise from context-specific trade-offs rather than systematic policy deviations. The absence of strong quantitative group differences implies that these perspectives are broadly distributed across roles and organizational types rather than confined to a particular segment of the industry.

Q3.6 Does your organization/company provide formal training on assessing and managing risk?

A majority of respondents indicated that their organization does provide formal training on assessing and managing risk, with 57.1% ($n = 12$) answering "Yes." Approximately 33.3% ($n = 7$) reported that their organization does not provide such training, while 9.5% ($n = 2$) were not sure. This distribution suggests that although formal risk-related training is common, a substantial minority of organizations either lack structured programs or employees are unaware of their availability.

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Effect size estimates, however, suggest moderate practical associations despite the lack of statistical significance. Cramer’s V values were 0.46 for commercial group, 0.36 for organization size, and 0.27 for job title, indicating small-to-moderate relationships. This pattern implies that while differences were not strong enough to reach statistical significance, likely due in part to the modest sample size, there may still be meaningful variation in how organizations structure or communicate risk training.

Overall, the findings indicate that formal risk training is more common than not, but gaps in provision or awareness remain and may warrant further investigation with a larger sample.

Q3.7 Based on your experience, how effective do you think each of the following risk management tools or training approaches is for improving risk tolerance?

Responses to Q3.7 demonstrated good internal consistency across the effectiveness items, with a Cronbach’s alpha of $\alpha = 0.82$, indicating that the listed tools and training approaches measured a coherent underlying construct of perceived effectiveness. Item-level reliability diagnostics showed that no single item substantially weakened the scale, although one item (Q3.7_5) exhibited no variance and was therefore not informative in differentiating respondents. Overall mean effectiveness ratings fell in the moderate-to-high range (composite mean = 3.14 on a 0–5 scale), suggesting that participants generally viewed the risk management tools and training approaches as beneficial for improving risk tolerance. Individual item means ranged from approximately 2.74 to 3.43, indicating some variation in perceived usefulness but no extreme outliers. The composite effectiveness score was found to be approximately normally distributed (Shapiro–Wilk $p = 0.48$), supporting the use of parametric comparisons.

Group analyses revealed no statistically significant differences in perceived effectiveness based on project type (Commercial vs. Non-Commercial; $p = 0.27$), organizational size ($p = 0.72$), or job title grouping (Manager vs. Executive; $p = 0.30$). Although mean scores were slightly higher among non-commercial respondents and managers, these differences were small and fell within overlapping confidence intervals.

Collectively, these findings indicate a broadly shared perception across organizational roles and contexts that formal risk management tools and training approaches are moderately to highly effective, with minimal evidence of meaningful subgroup variation.

Q3.8 Does your organization/company use any tools to assess the risk tolerance levels of frontline supervisors or craft workers? If Yes: Q3.8b: Please briefly describe the risk tolerance assessment tools used by your organization/company.

Results from Q3.8 indicate that most respondents reported their organizations do **not** use formal tools to assess the risk tolerance levels of frontline supervisors or craft workers, with 60.9% (n = 14) answering *No*, 13.0% (n = 3) answering *Not sure*, and only 26.1% (n = 6) answering *Yes*. Statistical group comparisons showed no significant differences in responses by commercial versus non-commercial organizations, organization size, or job title, as all Fisher's Exact Tests were non-significant; however, effect size estimates suggested small to moderate practical associations for organization type and organization size, and a small association for job title.

Qualitative responses from those who answered "Yes" revealed that the tools referenced were generally not formal psychometric assessments but instead consisted of operational safety practices embedded in routine work processes. Common themes included the use of Job Hazard Analyses (JHAs), pre-task plans, daily huddles, and structured work plans as primary mechanisms for discussing and evaluating risk before tasks begin.

Several participants described periodic or seasonal risk-management training sessions, while others mentioned severity or "hurt-potential" scoring approaches used to align crews on shared risk understanding. Additional responses highlighted behavioral and cognitive frameworks, such as discussing factors that influence individual risk tolerance—including overconfidence, familiarity with tasks, perceived control, and role-model influence—along with collaborative conversations between supervisors and crew leaders to ensure consistent risk perception.

Overall, the combined quantitative and qualitative findings suggest that while standardized or formalized risk-tolerance assessment tools are relatively uncommon, many organizations that reported "Yes" rely on practical, field-based, and discussion-oriented methods integrated into everyday safety management activities rather than standalone measurement instruments.