

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

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John Gambatese, PhD, PE(CA)

Principal Investigator

Professor, School of Civil and Construction Engineering

and

Daniel Burns

Research Assistant

Oregon State University, Corvallis, OR

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Literature Review

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

Prepared by:

John Gambatese, Phd, PE(CA)
Principal Investigator
and
Daniel Burns
Research Assistant

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CONSTRUCTION SAFETY RESEARCH PARTNERSHIP (CSRP)

OREGON STATE UNIVERSITY

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TABLE OF CONTENTS

LIST OF FIGURES	iii
LIST OF TABLES	iii
1. INTRODUCTION AND BACKGROUND.....	1
2. REVIEW METHODOLOGY.....	3
2.1 Online Literature Search (Step 1)	5
2.2 Eligibility Assessment (Step 2).....	5
2.3 Summary of Extrapolated Data (Step 3).....	6
2.4 Synthesis and Organization of Data (Step 4).....	6
2.5 Literature Review Contents	7
3. LEADERSHIP	8
3.1 Roles of Frontline Safety Leadership	8
3.2 Types of Leadership.....	9
3.3 How to Assess Leadership Skills	10
3.4 How to Improve Leadership Skills	12
3.5 How to Measure Leadership Improvement.....	13
4. RISK TOLERANCE.....	14
4.1 Elements of Risk Tolerance	14
4.2 Influences of Safety Behaviors and Risk Tolerance	15
4.3 How to Assess Risk Tolerance	16
4.4 How to Improve Safety Behaviors and Risk Tolerance.....	17
4.5 How to Measure Improvement in Risk Tolerance	18
5. INFLUENCES ON SAFETY CULTURE	19
5.1 Migrant Workers	19
5.2 Worker Age	20
5.3 Construction Industry Sector	20

5.4	Work Trade.....	21
5.5	Title/Position (Role in Organization).....	22
6.	TOOLS FOR ENHANCING SAFETY PERFORMANCE.....	23
6.1	Assessment Tools.....	23
6.2	Training Tools	24
7.	GAPS IN KNOWLEDGE AND PRACTICE.....	26
7.1	Future Directions	26
	REFERENCES	28
	APPENDIX.....	32
	Literature Summary	32

LIST OF FIGURES

	<u>Page</u>
Figure 2.1: Review Methodology	4

LIST OF TABLES

	<u>Page</u>
Table 2.1: Keywords Used in Literature Search	5
Table 2.2: Inclusion and Exclusion Criteria.....	6
Table 2.3: Study Population(s) and Study Topic Area(s) in the Literature Cited	7
Table 3.1: Summary of Leadership Styles, Characteristics, and Effects	9

1. INTRODUCTION AND BACKGROUND

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-way communication; (4) develops team members through 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 and risk tolerance.

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.

This document presents a comprehensive literature review on the topic of frontline supervisor leadership, decision-making, and risk tolerance with respect to safety. The review is intended to document what is known about the topic, and support and inform further research on the topic. The overall aims of the research are to develop an understanding of how to assess and develop frontline supervisor leadership skills and risk tolerance, and to create resources to support construction companies in their efforts to develop and train frontline supervisors and improve safety performance on projects.

2. 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 consisting of: (1) an online search for relevant literature contained within academic journal databases, e.g., American Society of Civil Engineers (ASCE) Library and Safety Science publications, and publicly available practice-oriented resources, e.g., Associated General Contractors (AGC), American Society of Safety Professionals (ASSP), National Institute for Occupational Safety and Health (NIOSH), and National Safety Council (NSC) publications; (2) assessment of the eligibility of retrieved articles by applicability to the research topic; (3) summary of extrapolated data from the relevant articles; and (4) synthesis and organization of the extracted data for the interim deliverable. Figure 2.1 displays the flowchart for the review methodology utilized to guide the review process.

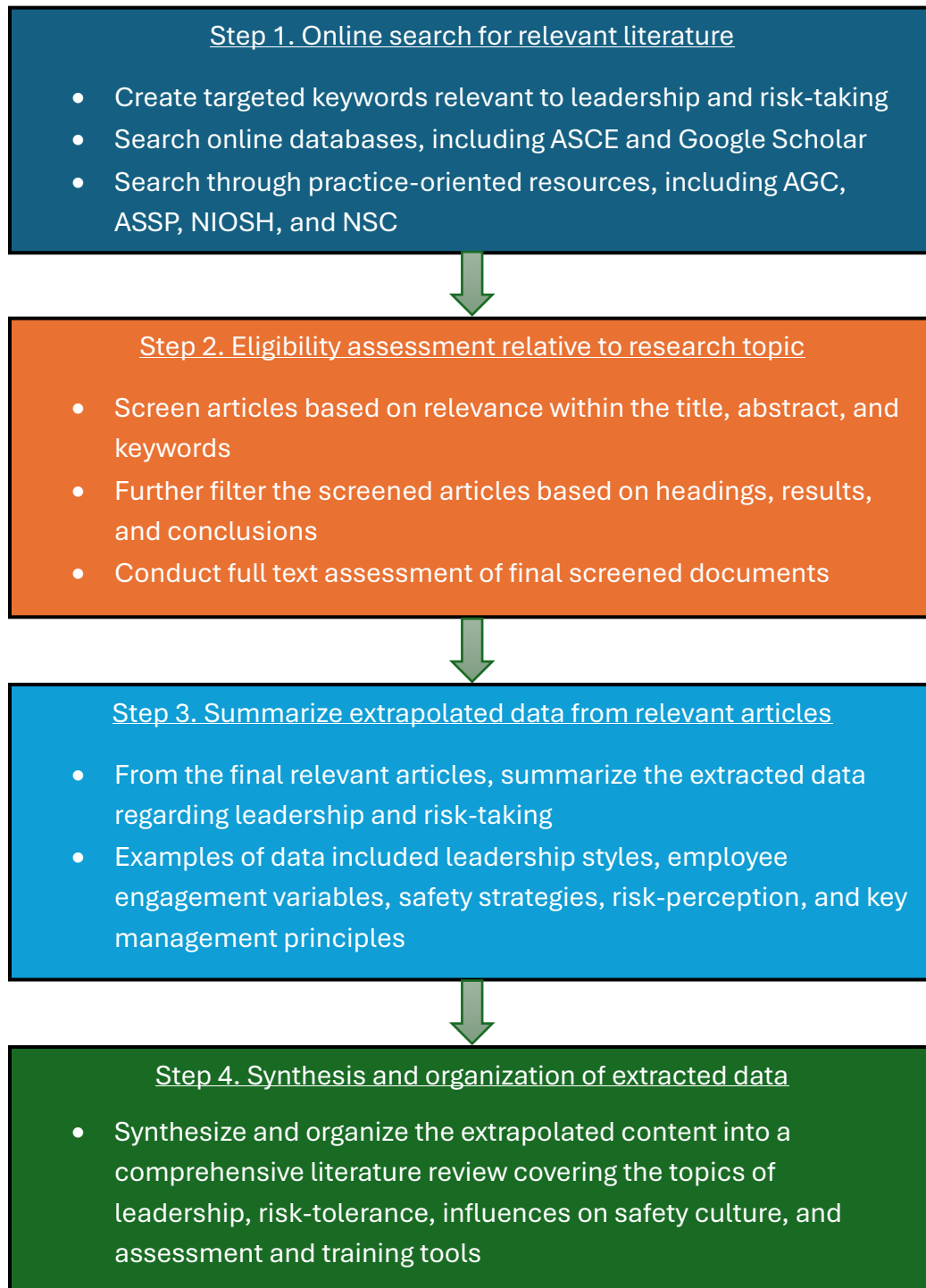


Figure 2.1: Review Methodology

2.1 ONLINE LITERATURE SEARCH (STEP 1)

In Step 1, relevant publications were sourced from mainstream databases, such as the 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	Additional keywords
Construction Safety	AND	Leadership
Construction	AND	Safety, Leadership skills, Risk, Tolerance, Assessment, Frontline, Worker, Management

2.2 ELIGIBILITY ASSESSMENT (STEP 2)

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 the 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: Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Must have been published in or after the year 2000	Publications prior to the year 2000
Must cover the topic areas of Construction Management, Safety, Leadership Skills, Risk-Tolerance/Perception, or Safety Assessment	Publications found not to cover the 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, and which are based solely on personal opinion and experience

2.3 SUMMARY OF EXTRAPOLATED DATA (STEP 3)

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 researchers were 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.

2.4 SYNTHESIS AND ORGANIZATION OF DATA (STEP 4)

In this last step, 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 process 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 and training tools. The goal was to move beyond a summary level and begin constructing a

cohesive narrative that connected various strands of evidence into a meaningful framework. By organizing the literature thematically, this phase laid the groundwork for in-depth analysis and interpretation in the final stages of the review process.

2.5 LITERATURE REVIEW CONTENTS

The following sections provide detailed descriptions of the literature review results after completing all of the four steps described above. The current knowledge and practice related to leadership and risk tolerance are presented with special focus given to the construction industry and to frontline supervisors. The literature cited represents the papers, reports, and other documents amongst the 78 articles identified that are most relevant to the research topic ($n = 35$ articles).

Additional details about the relevant literature cited in the literature review are summarized in the Appendix. Specifically, for each of the 35 articles cited, the Appendix provides a detailed description of the article content, the study population, and the specific topic addressed in the article. The study population which the research targets is indicated as being in one or more of the following categories: company owner/upper management (O/UM), frontline supervisor (FLS), and worker (W). Similarly, the summary indicates the topic area(s) which the articles focus on. The possible topic areas are leadership (L), risk tolerance (RT), influences on risk tolerance (IRT), and assessment tools (AT). Table 2.3 provides a summary of the literature with respect to each study population and topic area. As shown in the table, most of the literature targets frontline supervisors and workers, and focuses on leadership and risk influences.

Table 2.3: Study Population(s) and Study Topic Area(s) in the Literature Cited

Category	Number of Articles Cited*	Percent of Articles Cited*
Study Population:		
Company owner/upper management (O/UM)	12	34%
Frontline supervisor (FLS)	27	77%
Worker (W)	24	69%
Topic Area:		
Leadership (L)	22	63%
Risk tolerance (RT)	10	29%
Influences on risk tolerance (IRT)	21	60%
Assessment tools (AT)	14	40%

* Based on 35 articles cited. Some articles address more than one study population and focus on more than one topic area. Therefore, the number of articles and the percent of articles do not sum to 35 and 100%, respectively.

3. 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.

3.1 ROLES OF FRONTLINE SAFETY LEADERSHIP

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 role includes actions such as modeling appropriate behavior, using personal protective equipment, and 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 the work operations 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, they 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 & Lewis 2013; Al-Bayati et al. 2024).

3.2 TYPES OF LEADERSHIP

Safety leadership in construction can take multiple forms, each influencing safety climate 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 (Table 3.1). 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.

Table 3.1: Summary of Leadership Styles, Characteristics, and Effects

Leadership Style	Core Characteristics	Mechanistic Effects
Transformational	Vision, inspiration, role modeling, innovation in safety practices	Increases risk perception, boosts compliance, and encourages participation
Transactional	Rule enforcement, contingent rewards, monitoring	Maintains baseline compliance; less effective for voluntary behaviors
Supportive	Empathy, personal concern, relationship-building	Builds trust, promotes psychological safety, and improves adherence to safety protocols
Authoritarian	Strict standards, top-down control, high demands	Strong enforcement and immediate incident 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 workers' 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 with 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 is essential. By fostering trust and demonstrating genuine concern, supportive leaders enhance workers' 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 safety-related incidents 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.

3.3 HOW TO ASSESS 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 climate, 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 identified 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 model, which focuses specifically on behaviors and practices that promote safety performance. Drawing from empirical research across multiple construction projects, they 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 questionnaire requesting Likert-scale responses 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 studies point toward an integrated assessment approach that blends trait-based evaluation (as in the LQI), behavioral and outcome-based measurement (as in the Safety Leadership Effectiveness Assessment), 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.

3.4 HOW TO IMPROVE LEADERSHIP SKILLS

The question of how to improve leadership skills remains inherently complex. Many 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, they recommend 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.

The study by Skipper and Bell (2008) revealed 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 (Skipper and Bell 2008). These findings reinforce the idea that leadership development must be multifaceted and include practical, hands-on experiences alongside theoretical training.

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

3.5 HOW TO MEASURE LEADERSHIP IMPROVEMENT

Documented metrics for measuring leadership improvement remain a significant research gap; however, many health and safety organizations, such as the Occupational Safety and Health Administration (OSHA), NIOSH, and the American Conference of Governmental Industrial Hygienists (ACGIH), recommend scheduled reassessments of control measures and corrective actions as part of continuous improvement (for example, see OSHA 2015). 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, which 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, 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.

4. 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. In occupational safety contexts, risk tolerance reflects the degree to which workers are willing to engage in actions that deviate from their personal level of acceptable risk and established safety norms and protocols. Workers assess their willingness based on their own perception of hazard severity, nature of the safety controls present, personal skill level, previous experiences, and situational pressures such as deadlines and production demands. This willingness may be contemplated and intentional such that an individual knowingly takes a calculated risk, or unintentional, where hazards are underestimated or not recognized due to overconfidence or a 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, increasing tolerance over time (i.e., risk normalization), whereas witnessing or experiencing an injury, fatality, or near miss incident can lower tolerance and reinforce safe practices.

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 finding 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 for safety performance. Higher levels of risk tolerance were frequently associated with increased rates of unsafe acts, procedural violations, and near misses, as individuals may 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.

4.1 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) group these influences into four broad categories: personal subjective perception, work knowledge and experience, work characteristics, and 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 climate, enforcement of safety rules, supervisory practices, and the availability of protective equipment. Among these influences, 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 possess high levels of 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. Neuroticism's relationship to risk tolerance is more nuanced. While heightened anxiety can lead to avoiding 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 the presence of a hazard and the corresponding severity and likelihood of an injury, also influences tolerance, but is only one piece of a broader puzzle. Alomari et al. (2018) emphasize that differences in risk perception, i.e., the cognitive evaluation of the hazard, injury severity, and injury likelihood, can influence tolerance thresholds but do not fully explain them. Factors like previous exposure to risk without experiencing an injury or near miss 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 means that interventions to lower risk tolerance must address multiple domains simultaneously, including strengthening safety management systems, designing tasks to minimize unnecessary hazards, enhancing individual competencies, and fostering positive workplace norms.

4.2 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 tolerance may be reinforced by production pressures, inadequate supervision,

normalization of deviance among peers, and/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, 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. This dynamic underlines the importance of interventions that target both individual predispositions and the systemic conditions that shape safety behavior.

4.3 HOW TO ASSESS 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 incident occurring due to 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 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.

4.4 HOW TO IMPROVE SAFETY BEHAVIORS 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, with 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. These 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 these 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. Creating a positive safety climate involves ensuring visible top-management commitment, integration of safety into performance evaluations, and alignment of production goals with safety objectives. 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.

4.5 HOW TO MEASURE IMPROVEMENT IN 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 personal protective equipment, 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.

5. 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). Safety culture, and therefore the factors related to safety culture, influence the way frontline supervisors perceive and exhibit leadership and risk tolerance. 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 the influence of key variables on safety culture, including migrant worker demographics, age, industry characteristics, trade culture, and organizational position, and explain how each contributes to the strength and resilience of safety culture in construction settings.

5.1 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, 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. Performing these activities

and establishing these conditions are largely dependent on the frontline supervisors who oversee the migrant workforce. Additionally, those migrant workers who are promoted to frontline supervisory roles will possess viewpoints and tendencies driven by the cultural values they adhere to and cultural markers they see and experience. Knowledge of how frontline supervisors experience and drive safety culture is important to understanding their effectiveness as leaders and willingness to take safety risks.

5.2 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 affects 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 injury incidents, 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, this aim 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. Frontline supervisors play a significant role in ensuring that safety messages are communicated in a way that is effectively received and implemented by workers of all ages.

5.3 CONSTRUCTION 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

construction sectors 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.

Given the differing demands and work environments within different industry sectors, frontline supervision leadership and risk tolerance may take different forms depending on the industry sector. Leadership and risk tolerance assessments and training, therefore, must take into account the characteristics of the industry sector in which they are deployed.

5.4 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 workers' risk tolerance and safety practices. For example, high-risk trades such as steel erection, 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, all of which are 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 targeted at field workers and frontline supervisors 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, and enhance the leadership qualities of frontline supervisors.

5.5 TITLE/POSITION (ROLE IN ORGANIZATION)

A worker's position within an 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 & 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 assessment and 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).

6. TOOLS FOR ENHANCING SAFETY PERFORMANCE

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 (2021) 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 potentially beneficial for frontline supervisory roles (Zohar 2000; Al-Bayati 2021; Salas et al. 2020; CII 2025).

6.1 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 (2021) demonstrated that these instruments can reliably link safety climate scores to both safety motivation, leadership, 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 workers' knowledge of safe work practices.

Recent guidance from the Construction Industry Institute (CII) underscores the value of integrating frontline supervisor (FLS) capability assessments into safety performance measurement frameworks. Their 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). The CII 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 creates 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).

6.2 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 without putting them at risk of injury. 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 covers 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).

7. GAPS IN KNOWLEDGE AND PRACTICE

Despite significant advances in understanding the determinants of safety culture, leadership, risk tolerance, 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) emphasizes the potential of predictive modeling for anticipating risk-taking 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), typically 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 2021) 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.

7.1 FUTURE DIRECTIONS

Addressing these gaps will require an interdisciplinary approach that blends behavioral science, engineering, data analytics, and cultural studies. Future 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 (FLS). 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 FLS, 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 FLS skill assessments, such as the CII Playbook, into broader safety performance evaluation frameworks. Longitudinal studies could measure how targeted FLS development programs influence safety climate, worker engagement, and retention over time. Additionally, emerging training modalities that 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).

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APPENDIX

LITERATURE SUMMARY

Provided below is a summary of the literature identified and cited in the literature review.

Authors(s) (year)	Study Population			Topic				Description
	O/UM	FLS	W	L	RT	IRT	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. (2021) (A)	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. (2021) (B)	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 & 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	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 & 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 & 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 & Togan (2023)		X				X	Proposes machine-learning-based recommendation system (RARS) that enhances 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 & 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 & 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.

Notes: Study Population: O/UM = Company Owner/Upper Management, FLS = Frontline Supervisor, W = Worker

Topic: L = Leadership, RT = Risk Tolerance, IRT = Influences on Risk Tolerance, AT = Assessment Tools