

WORKtoZERO

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The State of Rigging and Signaling in Crane Operations



Executive Summary

Rigging and signaling are fundamental to safe crane operations, yet there is no standardized, enforceable system to verify competency in these roles. As a result, training, qualification and execution vary widely across jobsites, contributing to communication breakdowns, inconsistent rigging practices and increased risk during crane operations. To better understand this variability, the [Work to Zero](#) program at the National Safety Council (NSC) partnered with the [NCCCCO Foundation](#) to examine current rigging and signaling practices across the industry. This study draws on existing research, an industry survey and interviews with crane personnel to assess how variability across technical, human and organizational factors influences jobsite safety.



Key Findings



Lack of industry standardization is a core risk. Survey responses were widely polarized on issues such as what proportion of lift crews are certified, how lifts are planned and frequency of refresher training, reflecting wide variability in how organizations approach crane safety.



Communication challenges are routine in crane operations. Virtually all respondents (98%) have encountered a communication challenge in the last 90 days. These challenges included weather interference, technology limitations, unclear or nonstandard signals, language barriers and lack of pre-lift expectations, most often resulting in minor clarifications or operational delays.



Nonstandard signaling persists despite established standards. Fifty-nine percent of respondents identified inconsistent signaling as a common communication challenge. Qualitative and focus group findings indicate that jobsite norms, experience hierarchies and power dynamics frequently override standardized signaling protocols in practice, highlighting a need for stronger reinforcement of standard signaling practices through supervision, training and pre-lift planning.



Human and organizational factors drive unsafe rigging practices. Respondents cited inattention and distraction (49%), production pressures (48%) and poor supervision (47%) as top contributors to rigging errors, exceeding technical failures like load estimation or equipment selection. These factors often stem from larger systemic challenges, such as inadequate planning, competing production demands and insufficient oversight.



A gap exists between stated safety priorities and day-to-day practice. While 77% of respondents agreed that their organization does not compromise safety for production schedules, production pressure was simultaneously a frequently reported contributor to unsafe rigging practices, suggesting a meaningful disconnect between policy and operational reality.



Training gaps remain a persistent safety risk. Knowledge and skills gaps were reported as recurring challenges for both riggers and signalpersons. Certified personnel were consistently rated as more effective across nearly all core competencies, indicating a meaningful difference in preparation between formally certified and informally “qualified” workers.

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Background and Objectives

Rigging and signaling are central to safe crane operations, yet they are performed within a system characterized by significant variability in training, communication practices and organizational conditions. Unlike crane operators, who must meet standardized certification requirements, riggers and signalpersons are typically qualified through employer-driven processes. In practice, this results in wide variation in how workers are trained, how signals are interpreted, and how lifts are planned and executed across jobsites.

This study establishes a baseline understanding of current rigging and signaling practices, examining how variability across technical, human and organizational factors contributes to risk. Findings reveal that communication challenges, nonstandard signaling practices and gaps in training remain common issues in crane operations, ultimately impacting safety and efficiency on site. These issues are compounded by organizational factors like production pressures, inconsistent supervision and unclear accountability, which shape how work is performed in the field. Taken together, the results indicate that risk in crane operations is driven less by isolated technical failures and more by inconsistent application of standards in practice.

Crane Safety: Injury and Fatality Trends

Crane-related fatalities have declined substantially since the late 1990s (see Figure 1), driven in part by regulatory actions, industry-led safety initiatives and the gradual expansion of training and certification programs. Despite these improvements, cranes were a primary or secondary cause of death in 405 fatal incidents between 2015 and 2024, averaging roughly 41 deaths per year (BLS, 2025). Notably, crane and tower operators accounted for only 29% of these fatalities, underscoring that risk extends well beyond the cab to riggers, signalpersons, and other personnel working near suspended loads and moving equipment.

Patterns in how these incidents occur are well established. Struck-by events, particularly those involving swinging or dropped loads, consistently account for the largest share of crane-related fatalities, followed by electrocution and crushing incidents (Beavers et al., 2006; McCann et al., 2009). While much of the literature focuses on direct incident causes, available evidence also points to underlying contributors linked to how work is coordinated in the field. Rigging-related issues have been identified in approximately 20% of crane accidents, often involving unbalanced or improperly secured loads (Kumar & Thatoad, 2023), while signaling errors appear in roughly 16% of incidents involving injury or fatality (Raviv et al., 2017). This report examines why these failures persist by exploring how rigging, signaling and organizational conditions interact in practice to shape crane safety outcomes.

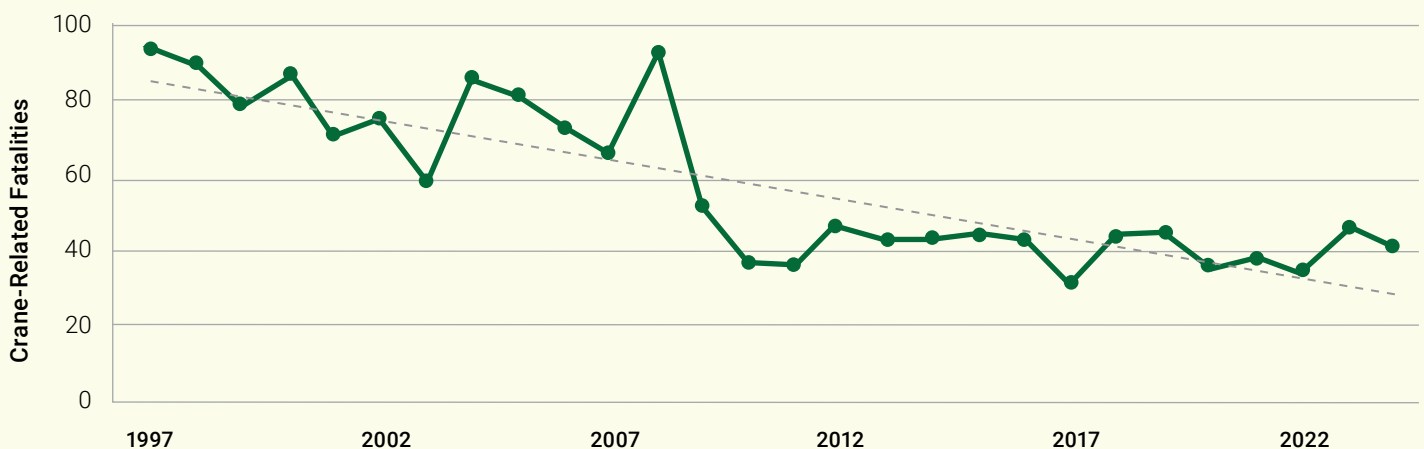


Figure 1. Fatal Work Injuries Involving Cranes (All Industries), 1997-2024 (BLS, 2025)



Research Approach

The methodology of this study consisted of three main parts:

- 1. A comprehensive literature review of existing academic, industry and grey literature;**
- 2. An industry survey of 376 crane professionals, including operators, riggers, signalpersons, supervisors and safety leaders; and**
- 3. Semi-structured interviews with crane industry professionals to capture perspectives from those working in the field.**

A comprehensive review of existing literature was conducted to establish a baseline understanding of current rigging and signaling practices. The review drew on peer-reviewed academic literature, industry publications and grey literature, such as technical reports and standards documentation from organizations such as OSHA and the American Society of Mechanical Engineers (ASME).

Next, an industry-wide survey was conducted to capture perspectives on jobsite practices. The survey was distributed in March 2026 to the National Commission for the Certification of Crane Operators (NCCCO) mailing list (approximately 42,500 certified recipients) and promoted through NSC email lists, NSC communities and LinkedIn, including an NCCCO crane safety group. To qualify, participants were required to be actively involved in crane operations and based in the United States, and had to pass an attention check to ensure data quality. In total, 376 responses were included in the final sample.

Crane operators made up a majority of the sample (71%), followed by site supervisors or lift directors (10%), riggers (6%), safety professionals (4%), trainers and instructors (3%) and signalpersons (3%). The most common certification held was Mobile Crane Operator (78%), followed by Rigger (Level I or II) and Signalperson certifications, each held by approximately 44% of respondents. Over 72% held multiple certifications, averaging three each. Respondents were also highly experienced, with over 70% of respondents reporting 10 years of experience or more.

In addition to the survey, in-depth interviews were conducted with five experienced crane professionals to provide qualitative context for the survey findings. Collectively, interview participants represented more than 90 years of experience across crane operations, training and supervision. While not intended to be representative of the broader workforce, these interviews were used to surface recurring themes, explain patterns observed in the survey data, and illustrate how certification and training play out in real world jobsites.

Results are organized by theme and draw jointly on survey data, interviews and existing research to present a cohesive view of how current rigging and signaling practices influence crane safety.

Findings and Results

Variability in Crane Safety Practices

Crane operations rely on a high degree of coordination between roles, often under time pressure and changing site conditions. **Research consistently shows that crane incidents rarely stem from a single failure point; rather, they reflect broader breakdowns in how lifts are planned, communicated and executed. For example, many crane incidents stem from breakdowns in expected versus actual performance of work, such as improper load handling or rigging failures (Beavers et al., 2006; Kumar and Thatoad, 2023; Milazzo et al., 2017), unclear or erroneous signaling (Raviv et al., 2017; Sruthy and Xavier, 2024) or poor lift planning (Kumar and Thatoad, 2023; Kim & Kang, 2022). This gap between expected and actual performance is often driven by organizational and systematic variability in training, communication, supervision and jobsite conditions.**

A central contributor of this gap is variability. Crane safety practices are not applied uniformly across jobsites, and expectations around training, communication, supervision and planning differ widely by employer and project. This variability is most visible in how crane personnel are qualified. Crane operators must meet standardized certification requirements, including written and practical examinations administered by third-party certifying bodies. Riggers and signalpersons, by contrast, need only be “qualified,” a designation OSHA defines broadly and delegates to employer discretion. In practice, this approach produces substantial variation in the depth and rigor of training across jobsites.

Survey results illustrate the extent of this inconsistency. One-third of respondents reported that fewer than 10% of their lift crews held current third-party certification, while another 32% reported that at least three-quarters were certified, with the remaining few falling in between (see Table 1). Refresher training showed a similarly uneven distribution: while 33% of respondents reported receiving role-specific training at least annually, 12% reported receiving it less than once every five years or never. As a result, the level of competency and preparation that workers encounter depends largely on the employer, rather than on shared industry standards.

Table 1. Proportion of Certified Lift Crew and Frequency of Refresher Training

Proportion of Lift Crew Certified		Refresher Training Frequency	
0-10%	33%	More than once a year	10%
11-25%	9%	About a year	23%
26-50%	8%	Every 2-3 years	17%
51-75%	7%	Every 4-5 years	36%
76-100%	32%	More than every five years	5%
Unsure	12%	Never	7%

Variability also extends to how work is organized and prioritized. For example, rigging planning practices ranged from formal, pre-task planning to decisions made immediately before a lift, with 52% of respondents describing planning as last-minute, inconsistent or absent, which can introduce uncertainty into the operation, increasing the potential for incidents, injuries or near-misses. Notably, safety culture displayed similar tension. Although 77% of respondents agreed that their organization does not compromise crane safety for production schedules, production pressure was simultaneously identified as a common contributor to unsafe rigging practices. Rather than reflecting deliberate disregard for safety, these findings suggest that production pressures may operate indirectly through deadlines, workload expectations and schedule demands, influencing worker behavior even in organizations that formally prioritize safety. As a result, workers may face competing priorities during lifting operations, where the need to maintain productivity can undermine planning, communication and other critical safety practices.

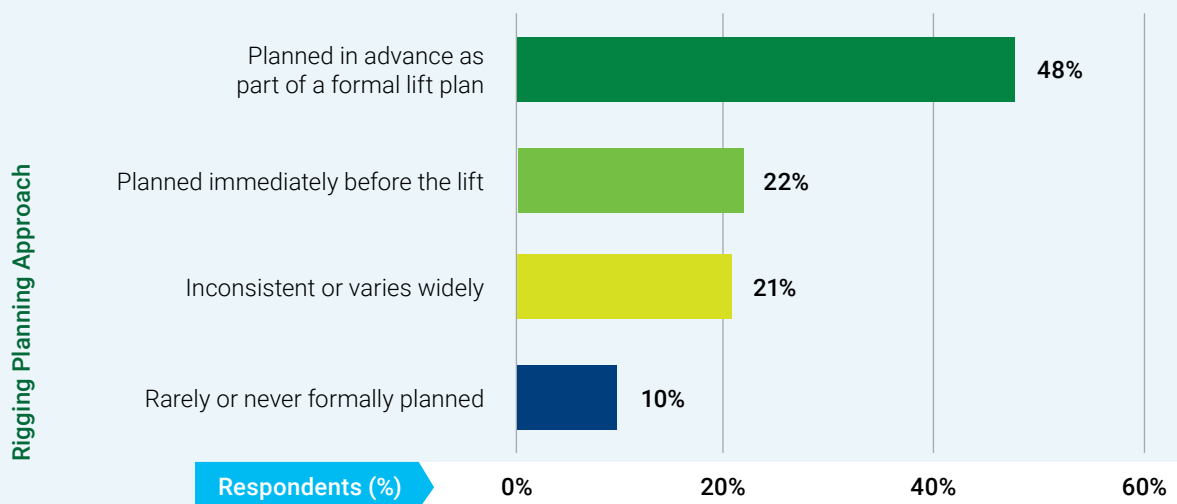


Figure 2. *Rigging Planning for Crane Lifts*

Standards such as OSHA’s Cranes and Derricks in Construction rule (OSHA, 2010) and ASME consensus standards (ASME, 2025) attempt to reduce this variability by establishing a common framework for safe operations. However, the existence of these standards does not guarantee their consistent application. In practice, this results in variability in how lifting operations are planned, communicated and executed, particularly in areas such as signaling, coordination and on-site decision making.

Communication Challenges

Communication remains a persistent challenge in crane operations, where blind lifts and changing site conditions can shift the risk of a lift in moments. Even under controlled conditions, safe lifting depends on accurate coordination between operators, riggers and signalpersons. However, results show that communication is often compromised by factors such as environmental conditions, technological limitations, nonstandard practices and language barriers, introducing variability into even routine lifting operations.

Survey results show that these challenges are not just occasional but are often a part of routine operations. **Ninety-eight percent of survey respondents reported encountering communication challenges at least “sometimes” in the last 90 days, with weather interference (64%), noise interference (63%), and line-of-sight limitations (61%) as the top challenges in the past 90 days.** A majority also identified organizational and procedural factors, such as inconsistent signaling practices (59%), signalperson training gaps (57%), language barriers (55%) and the absence of a designated signalperson (46%), suggesting that communication during lifts is frequently shaped by competing environmental and organizational conditions, rather than being consistently planned and controlled.

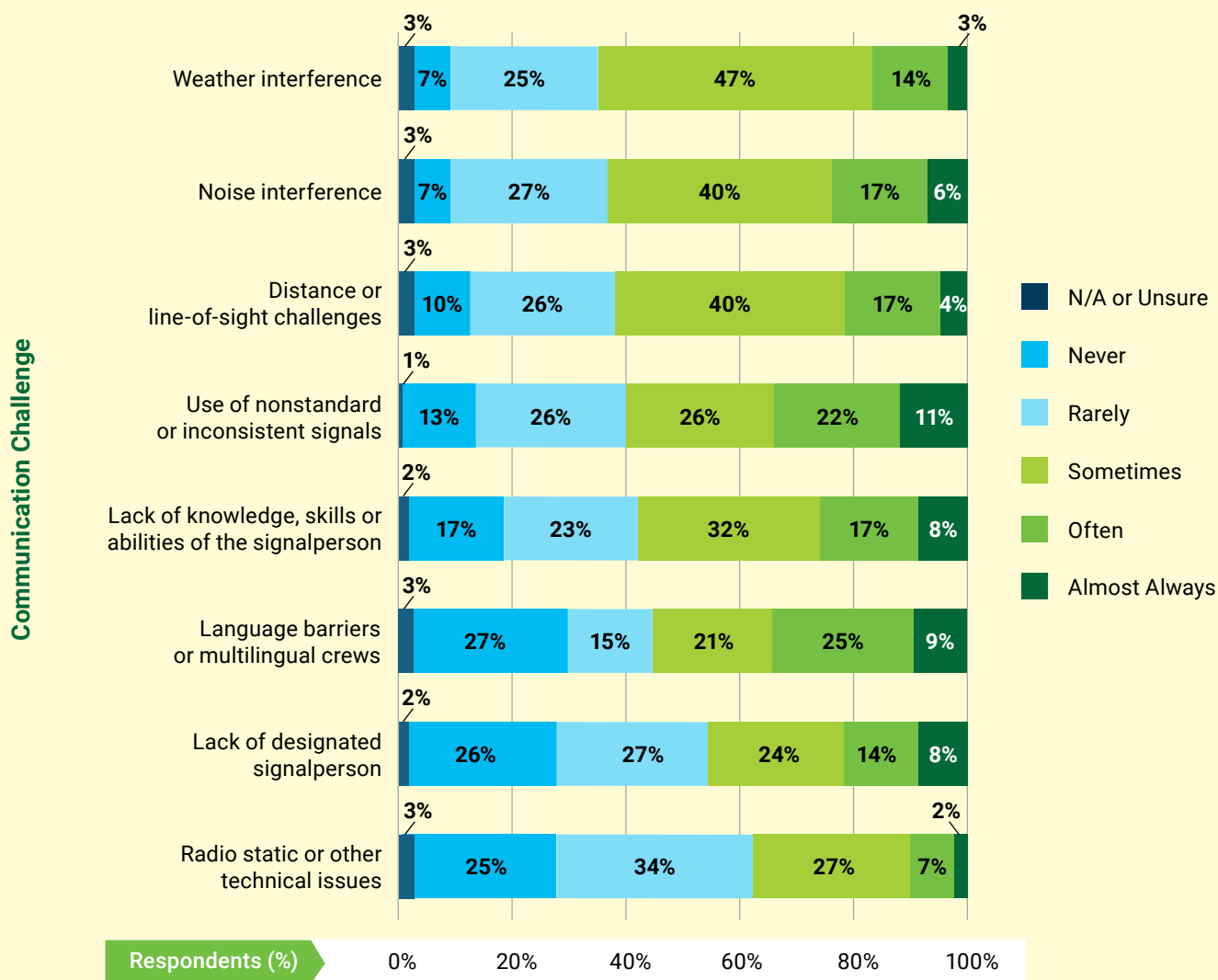


Figure 3. Communication Challenges occurring in the Past 90 Days

Percentages may not add up to 100% due to rounding and omitting of N/A responses.

According to these results, communication breakdowns result in operational disruptions rather than near-misses or incidents. Respondents commonly reported slowed or delayed movements (69%) or minor clarifications (70%) as the most common outcomes (see Figure 4). However, nearly half (47%) indicated that communication failures lead to full stops of lifting operations at least sometimes, demonstrating that breakdowns often reach a point where work cannot safely continue. Less frequent but more severe outcomes, including near-misses (10%) and incidents involving injury or property damage (4%), further show that when communication failures are not resolved, they can escalate into more serious safety events.

Taken together, these findings show that communication breakdowns are not rare, but a persistent challenge in crane operations. They introduce variability into how lifts are performed and require workers to rely on judgment, experience and workarounds to maintain control. The following sections examine how this variability manifests in practice, including through nonstandard signaling, language barriers and gaps in training and coordination.

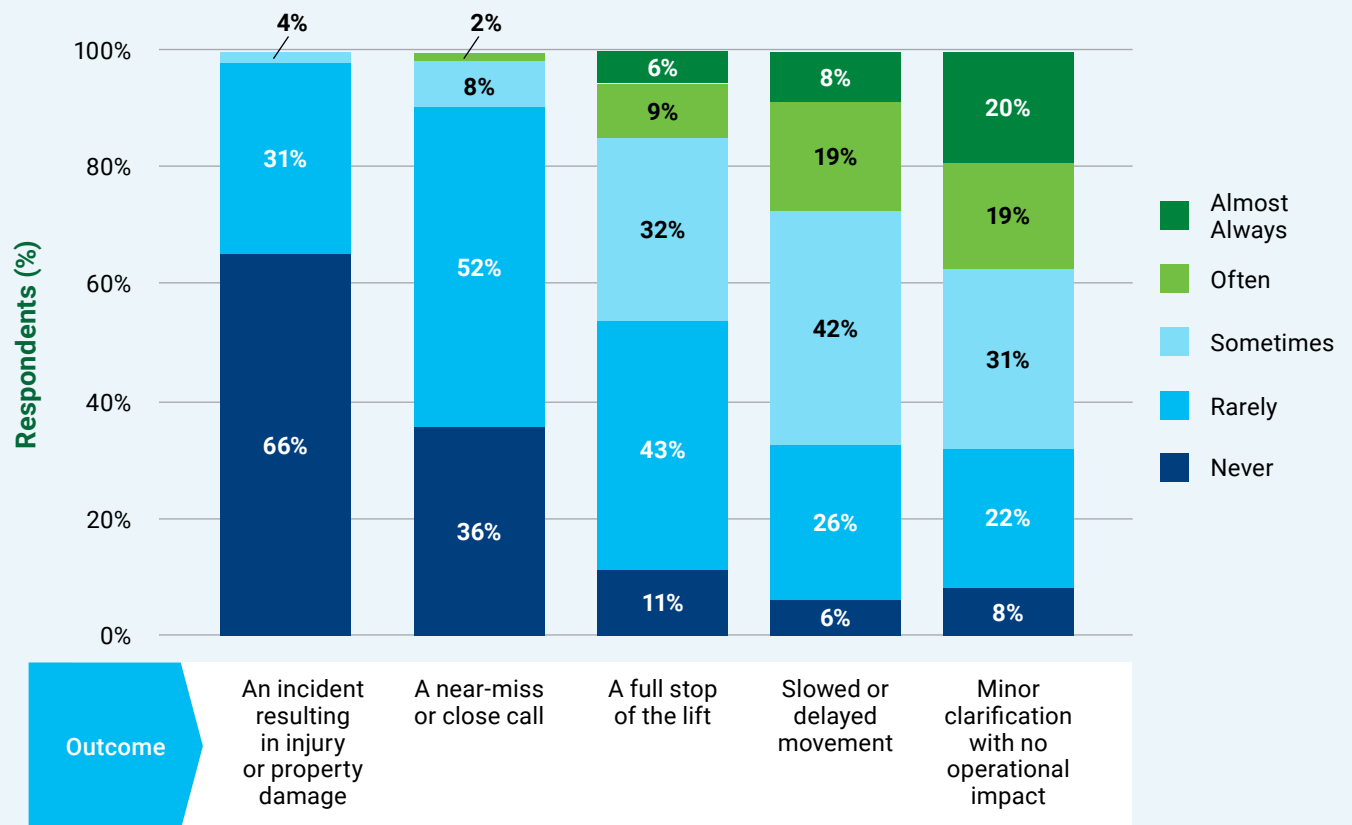


Figure 4. Self-Reported Outcomes of Communication Challenges

Percentages may not add up to 100% due to rounding and omitting of N/A responses.

Nonstandard Signaling Practices

Standard signals are designed to provide consistent, shared language between crane operators and signalpersons, reducing ambiguity during complex or blind lift operations. OSHA requires the use of standardized hand signals for most lifting scenarios, allowing deviations only when standard methods are genuinely infeasible and alternative signals are clearly defined and agreed upon prior to the lift (OSHA, 2010). The use of nonstandard signals introduces ambiguity into crane operations by replacing a shared, universally understood communication system with signals that may be interpreted differently by operators and signalpersons. This increases the potential for miscommunication, delayed responses, incorrect crane movements and other errors that can compromise the safety of lifting operations.

Evidence from both research and practice highlights these consequences. A review of crane-related fatalities from 1992 to 2006 found that 14% involved workers being struck by loads while flagging, directing or guiding the lift (McCann et al., 2008). Similarly, an analysis of international tower-crane incidents identified signaling errors in 11% of reported incidents, rising to 16% among those involving injury or fatality (Raviv et al., 2017). Survey findings further reinforce this pattern, where 59% of respondents identified nonstandard or inconsistent signals as a common challenge during lifting operations (see Figure 3).

When signaling deviates from standard practice, operators described two consistent outcomes: individual interpretation of the signals or interruptions to the lift until signals are verified. In several interviews, operators described scenarios where they received an incorrect or unknown signal but used experience and knowledge of the lift to interpret the "correct" meaning. In others, lifts are slowed or stopped to regain clarity, introducing operational disruption and time pressures to already high-stress operations. Both outcomes increase risk by forcing operators into positions where decisions must be made quickly and without certainty.

"I was in the middle of a lift, picking a well house over a live well head, where hand signals were the best form of communication and was given non-NCCCO hand signals. They made absolutely no sense at all. So, I made no crane movements until they got mad and came and talked to me personally."

–Mobile Crane Operator, Oil & Gas



Survey and interview findings further suggest that jobsite culture and experience hierarchies contribute to the persistence of nonstandard signaling practices. Newly trained signalpersons may enter the field with a clear understanding of standardized signals but encounter environments where informal, site specific methods are normalized. Over time, less experienced workers may defer to these norms, replacing standardized communication with learned behavior.

Importantly, these challenges are not confined to small operations or inexperienced crews. **Respondents reported similar issues on projects with formal safety programs, indicating that the problem is not the absence of standards, but inconsistent adherence to them.** Accordingly, efforts should focus on strengthening compliance with standardized signaling practices rather than accommodating nonstandard methods. Employers and site supervisors play a central role in encouraging and reinforcing the use of standard signals whenever possible, with deviations reserved only for exceptional circumstances where standard signals cannot be effectively applied.

Certification and training programs can further support this effort by reinforcing mastery and the consistent application of standard signals while preparing workers to recognize and respond to situations where nonstandard signaling practices are being used. These programs should emphasize that deviations from standard signals are exceptional measures, appropriate only when standard methods are genuinely infeasible. By promoting the consistent use of a shared signaling system across crews, employers and jobsites, these efforts can reduce communication variability and strengthen one of the most fundamental yet often overlooked safety controls in crane operations.

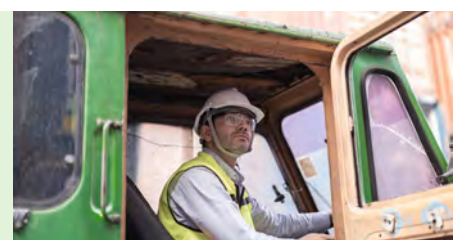
Signalperson Training Gaps

Studies consistently point to deficiencies in training (Beavers et al., 2006; McCann et al., 2008; Kumar & Thatoad, 2023; Raviv et al., 2015) and limited opportunities for hands-on experience (Lingard et al., 2021) as underlying contributors to crane incidents. According to Shapira & Lyachin (2009), while operators are often the focus of safety, those in supporting roles, particularly signalpersons and riggers, are often comparatively undertrained and inexperienced.

Signalpersons play a critical role in directing crane movements and preventing incidents, yet they remain outside of mandatory certification requirements. Like riggers, signalpersons are only required to be “qualified” by employers, with no independent or standardized mechanism for verifying competency. Survey responses, written comments, and focus group discussions indicate that this employer driven approach results in wide variability in training quality and preparedness, with workers entering the role through both formal and informal pathways that differ substantially in rigor.

"You teach them properly and they understand what the signal means, and then they get on the job site and they're dealing with a crane operator who's been in the seat for 20, 25 years... next thing you know, they're just doing it the way the crane operator wants them to do it."

–Industry Trainer, Former Operator



This variability is reflected in survey results. Signalperson knowledge, skills and abilities were identified as a recurring challenge by 57% of respondents, the highest proportion across all human factors assessed. Focus group discussions described the qualification gap directly, noting that some individuals are deemed “qualified” after minimal exposure to signaling instruction, with little opportunity for practical assessment or reinforcement on the jobsite. As a result, signalpersons working side by side may hold the same designation while demonstrating very different levels of actual competency.

“We’re accepting people that are ‘qualified’ to signal a crane. They took a 15-minute course in their facility with a safety person and is now qualified, and he’s directing the crane operator.”
–Operator, Construction



To better understand how this gap translates into performance, respondents were asked to compare certified and non-certified signalpersons across six core competencies aligned with ASME B30 standards (see Table 2).

For five of the six competencies, certified signalpersons were rated as more effective by a clear majority of respondents, ranging from 69% – 78%. These areas include hazard anticipation, maintaining clear communication, providing accurate signals, and stopping crane movement when communication becomes unclear, tasks that rely on standardized procedures and shared expectations.

One competency, however, stood apart from the rest: the use of nonstandard or site specific signals. In this area, only 37% of respondents rated certified signalpersons as more effective, compared to 69% for the use of standard ASME B30.5 signals. A substantial share of respondents rated certified and non-certified signalpersons as equally effective, and one in five rated certified signalpersons as less effective. This finding likely reflects the intended focus of certification programs, which emphasize the use of standardized signaling practices rather than site-specific or informal alternatives. As a result, certified signalpersons would be expected to demonstrate the greatest advantage when using standard signals, where training and assessment are aligned with established industry standards. Certification and training programs may further strengthen this advantage by preparing workers to recognize and appropriately respond to nonstandard signaling practices, including seeking clarification, ensuring signal alignment and exercising stop-work authority when communication is unclear.

These findings further highlight the challenges that are created when nonstandard signaling practices become normalized on jobsites. As exemplified, the benefits of certification are strongest when crews rely on a common set of standardized signals. When workers encounter informal or site-specific alternatives, communication becomes more dependent on local knowledge and individual interpretation, reducing consistency across the jobsite. Accordingly, efforts should focus on reinforcing the use of standard signals, establishing clear pre-lift communication expectations and limiting deviations to situations where standard signals are genuinely infeasible.

Table 2. Effectiveness of Certified Signalpersons Compared to Non-Certified

Competency	Less Effective	About the Same	More Effective
Anticipating and communicating potential unsafe movements or hazards	5%	17%	78%
Maintaining continuous and clear communication with the operator	4%	19%	77%
Providing accurate and unambiguous signals that result in the intended crane movement	5%	21%	74%
Stopping or pausing crane movements if communication is lost or unclear	4%	21%	74%
Using standard hand and voice signals per ASME B30.5 standards	6%	25%	69%
Using nonstandard hand and voice signals per ASME B30.5 standards	20%	43%	37%

Language Barriers

Language barriers emerged consistently across the literature, survey responses and focus group discussions, reflecting broader demographic shifts within the construction workforce. From 2000 to 2023, the proportion of Hispanic workers in construction increased from 16.5% to 34% (Trueblood et al., 2024). This growing segment of the workforce also experiences disproportionately higher rates of fatal injuries, a pattern attributed to multiple interacting factors, including language barriers, cultural dynamics and greater representation within smaller organizations that may lack robust safety systems (Trueblood et al., 2024). These risks are magnified during irregular lifts or situations requiring rapid decision making and clear communication (Shapira & Lyachin, 2009).

Survey findings indicate that language barriers are a frequent operational challenge rather than an occasional exception. Nearly six in ten respondents (55%) reported encountering language barriers “sometimes” to “almost always” within the previous 90 days. Unlike other communication challenges, responses showed substantial variability across respondents, suggesting that language barriers are strongly influenced by regional workforce composition and jobsite-specific conditions rather than uniformly experienced across all projects.

“Many of the personnel that work in this region are Spanish-speaking... the signaller, the rigger on the job... they speak Spanish, can’t communicate well with the crane operator because he speaks English. And you have that whole breakdown. And it’s a mess.”

–Industry Trainer, Former Operator

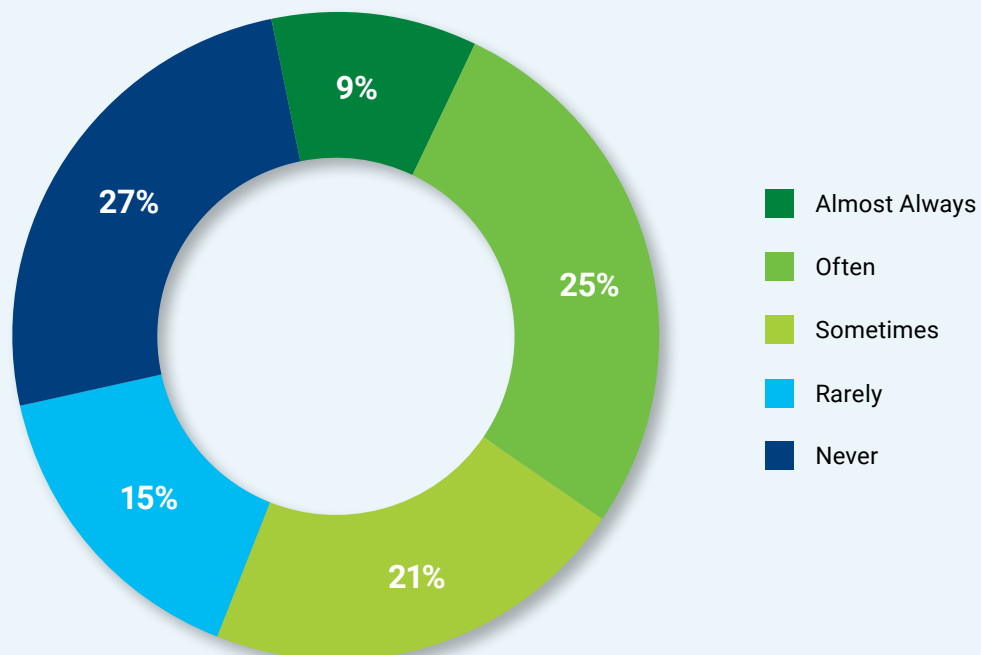


Figure 5. In the past 90 days, how often have you experienced challenges related to language barriers or multilingual crews?

Percentages may not add up to 100% due to rounding and omitting of N/A responses.

Qualitative responses and interviews illustrated how language differences can undermine safe crane operations when communication extends beyond standardized hand signals. Respondents described situations where verbal clarification, radio communication or pre-lift coordination became difficult or ineffective, leading to delayed actions, confusion or unsafe load handling. These accounts align with existing research showing that workers facing language and cultural barriers may be less likely to seek clarification or challenge unclear instructions, particularly in environments shaped by power distance, production pressure or job insecurity (Al-Bayati et al., 2017).

“He [the signalperson] only knew ‘cable up’ and didn’t stop me from shock loading the hooks. Had to full stop the crane for fifteen minutes to get someone who spoke English and Spanish to communicate how he needed to direct a crane in the blind spot of an operator.”

–Tower Crane Operator, Construction



In the absence of formal solutions, operators described developing improvised workarounds to bridge communication gaps on the fly, ranging from inferring signals from context to relying on technology to fill the gap. For example, one interviewee described reading the situation rather than the signal: *“Once I understood what they wanted by the meeting we had before, I kind of knew what they wanted, even though they gave me the wrong signal.”* A few operators also described using technology, such as Google Translate or translation apps, to communicate in real time. Critically, these workarounds depend entirely on the experience and resourcefulness of the individual operator, meaning the same breakdown that one veteran navigates successfully could result in a near-miss or worse in the hands of someone less experienced. Others, such as translation applications, may also provide incorrect information or fail to replicate cultural jargon. Notably, the use of these workarounds signals a clear gap in established processes and an opportunity for learning and improvement.

Addressing language barriers in crane operations requires a coordinated and multilayered approach. At the jobsite level, existing research supports the need for detailed and accessible step-by-step instructions for all workers. Others have found success employing bilingual personnel to serve as translators between workers and identifying safety leaders within Hispanic workgroups to help reinforce understanding and trust across crews and sites (Al-Bayati et al., 2017). Expanding access to Spanish-language training materials and incorporating real-time interpretation (e.g., translators or technology aids) into safety training can further support a consistent understanding across workers (Trueblood et al., 2024).

At the industry level, certifying bodies and training providers are well positioned to strengthen communication competency within certification frameworks. In addition to evaluating technical knowledge, programs can incorporate explicit communication-focused expectations, including proficiency with standardized signals, effective radio communication and the ability to operate safely across communication breakdowns. This effort can be further supported through the development of multilingual signaling resources aligned with ASME standards, such as validated terminology, standardized radio phrases and visual training tools, to promote consistent interpretation across crews. Expanding bilingual certification pathways, including exams, preparatory materials and continuing education offered in multiple languages, would help ensure that certified personnel are equipped to meet both the technical and communication demands of crane operations.

Ultimately, the goal is a shared operational language across crane crews. Standardized signals are especially important because they provide a common means of communication that can bridge language barriers and reduce reliance on verbal instructions. Without this shared system, communication becomes reliant on interpretation rather than standardization, increasing variability and risk. Reinforcing pre lift planning, signal alignment and shared expectations is therefore essential to ensuring that language differences do not translate into safety failures.

Rigging Challenges

Rigging has consistently been identified in the research as a significant contributor to crane incidents, not because of a single technical failure, but due to the interaction of technical, human and organizational factors. More than half of crane-related injuries involve workers being struck by loads or equipment, with outcomes closely tied to how loads are secured and controlled during lifts (BLS, 2019). A review of 75 North American crane accidents found that rigging-related issues contributed to approximately 20% of incidents, most often involving unbalanced or improperly secured loads (Kumar & Thatoad, 2023). OSHA (2008) outlines the most common rigging errors, including:

- Center of gravity miscalculation
- Improperly selected and/or damaged wire rope
- Improper hitch configuration
- Synthetic sling compression or contact with sharp objects
- Improper load weight determination

However, survey findings from the current study suggest that these technical errors rarely occur in isolation. Respondents more frequently identified organizational and human factors, such as lack of knowledge, skills or abilities (54%), inattention or distraction (49%), time pressure (48%) and inadequate supervision (47%), as more common contributors to unsafe rigging practices than purely technical mistakes (see Figure 6). While failures to inspect equipment, errors in load estimation and incorrect rigging configurations do occur, they were reported less often, suggesting that technical rigging failures are often symptoms of broader systemic pressures rather than stand-alone causes.

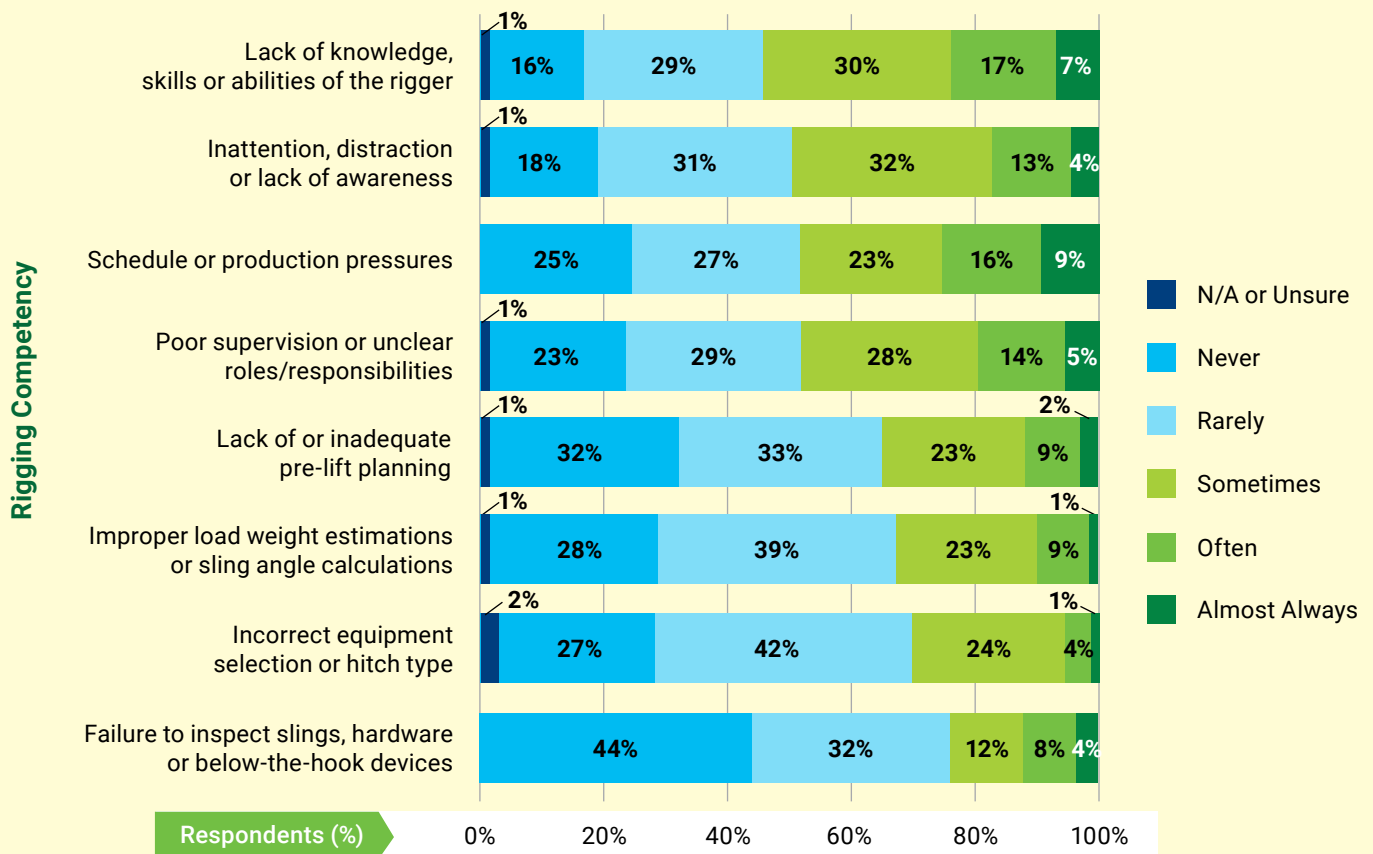


Figure 6. Factors Contributing to Unsafe Rigging Practices

Percentages may not add up to 100% due to rounding and omitting of N/A responses.

When these conditions are present, their consequences become most visible in operational outcomes. Improper rigging most often results in minor disruptions, such as slowed movements or corrective adjustments, but these events can escalate. Nearly 16% of respondents reported experiencing near misses at least occasionally due to improper rigging, and 7% reported incidents involving injury or property damage (see Figure 7).

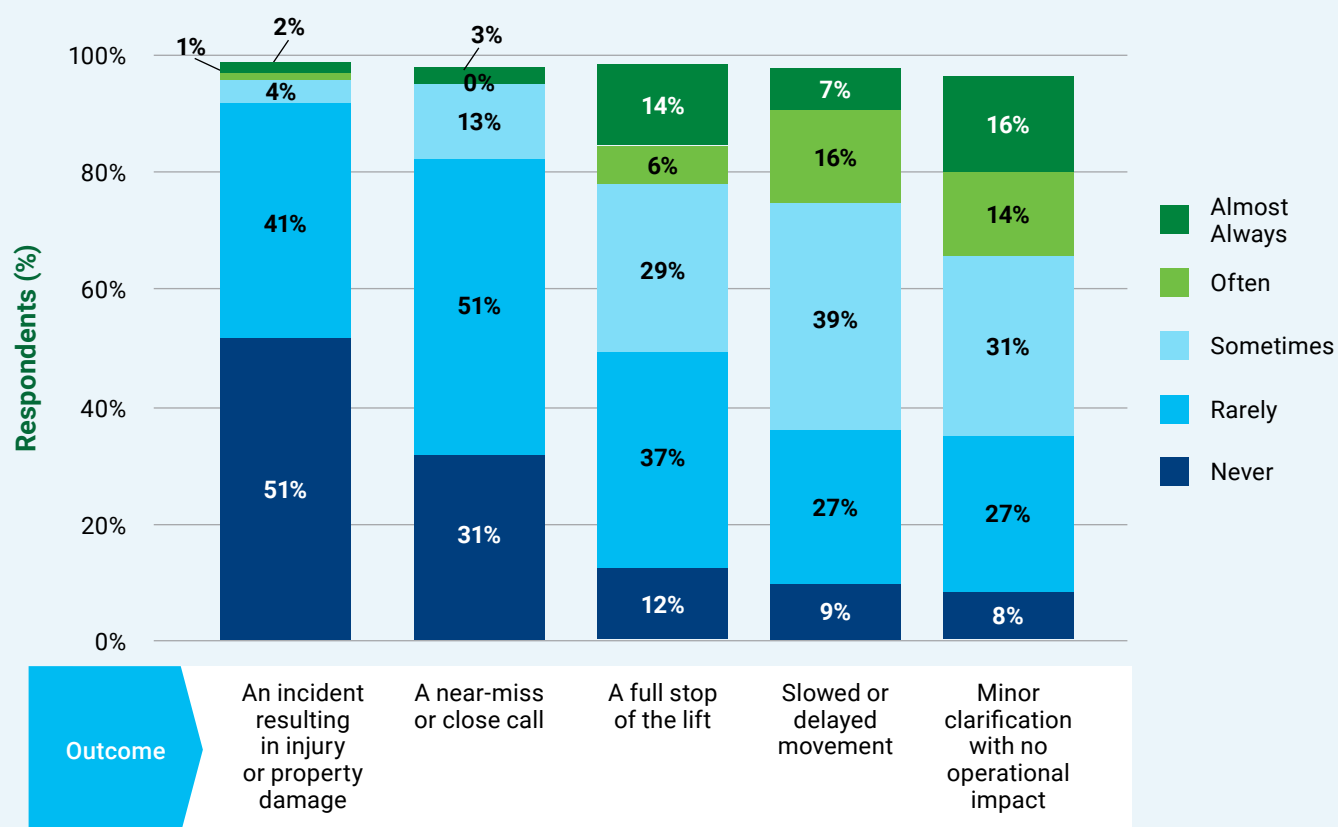


Figure 7. Common Outcomes of Unsafe or Improper Rigging

Percentages may not add up to 100% due to rounding and omitting of N/A responses.

Rigger Training Gaps

As discussed earlier, prior research consistently identifies training deficiencies and limited hands on experience as contributing factors in crane incidents (Beavers et al., 2006; McCann et al., 2008; Lingard et al., 2021). This pattern is reflected in survey findings, where rigger knowledge, skills and abilities were identified as the top contributors to improper or unsafe rigging (see Figure 6).

When asked to compare, respondents consistently perceived certified riggers as more effective than their non-certified peers. Across eight competencies aligned with the ASME B30.5 framework, roughly three in four respondents (73% – 78%) rated certified riggers as more effective in areas such as equipment inspection, load estimation and hitch application (see Table 3). Support for mandatory rigger certification was similarly strong, with nearly three in four respondents favoring required certification for complex lifts, rising to 86% among riggers themselves.

Table 3. Effectiveness of Certified Riggers Compared to Non-Certified

Competency	Less Effective	About the Same	More Effective
Inspection requirements for rigging components	4%	19%	77%
Anticipating and addressing rigging issues/ unsafe conditions	5%	18%	77%
Proper selection and use of rigging hardware	4%	18%	78%
Proper selection and use of slings	5%	18%	77%
Application of standard hitches (e.g., vertical, choker, basket)	4%	22%	73%
Proper selection and use of below-the-hook lifting devices	5%	20%	75%
Effect of sling angles on rigging loads	6%	18%	77%
Estimation of load weight and center of gravity	6%	22%	73%

These findings suggest that certified riggers are perceived as better prepared across the full range of competencies their role requires. Importantly, these are the same competencies respondents identified as among the leading contributors to unsafe rigging practices. Given that deficiencies in rigger knowledge, skills and abilities were cited as a major source of rigging errors, the strong perceived advantage of certified riggers suggests that broader adoption of certification could directly address one of the most identified risk factors in crane operations. However, the absence of mandatory certification means there is currently no consistent mechanism for verifying that level of preparation. Without an independent standard, qualification varies widely and is shaped by employer resources, training culture and individual experience rather than a shared benchmark.

Given the strong association between certification and perceived effectiveness, expanding the use of third-party certification for riggers, particularly for complex lifts, offers a clear opportunity to reduce variability in training quality and establish a more consistent baseline of competency across the workforce. Standardizing competency requirements would strengthen rigging performance by ensuring that workers possess both the knowledge and skills necessary to carry out rigging tasks safely and effectively.

"[I think] all riggers and signal persons should be required to have certifications, pass a written and a practical test. If they are not certified, they think that the crane has no limits or it can do anything. If they don't understand the basic principles of the crane and rigging, they are going to be a hazard on a job site."

—Tower Crane Operator



Organizational Factors Shaping Crane Safety

While individual competence is necessary for safe crane operations, safety outcomes are largely shaped by organizational conditions that determine how work is planned, supervised and executed. A substantial body of research emphasizes that safety is not governed by individual skill alone, but by the organizational culture that establishes priorities, expectations and acceptable tradeoffs under real-world conditions. Safety culture develops through shared norms and behaviors, influencing how consistently procedures are followed when crews operate under pressure or uncertainty (Bisbey et al., 2019).

Production Pressure and Planning Breakdown

Production pressure emerged as a central organizational factor shaping unsafe crane practices, where time constraints may influence workers to bypass safety controls, expedite planning or proceed with incomplete information to meet deadlines (Lingard et al., 2021). Accelerated schedules also increase workload and cognitive demand, heightening the likelihood of error during complex, coordinated tasks (Garrett & Teizer, 2009). Structural features of the construction industry can further amplify these risks, where multilayered subcontracting arrangements can blur accountability and create gaps in communication and safety expectations across organizations (Gharaie et al., 2015).

Survey results reflect these dynamics. Although 77% of respondents reported that their organization does not formally compromise safety for production deadlines, nearly half (48%) identified production pressure as a contributor to unsafe rigging practices. This apparent contradiction suggests that production pressure often operates indirectly, through planning constraints, staffing limitations or implicit expectations, rather than through explicit directives. This is further evident in lift planning practices, where 52% of respondents described lift planning as last minute, inconsistent or absent, indicating that planning decisions are frequently shaped by schedule demands rather than structured risk management.

Site Management and Accountability

Supervision plays a critical role in reinforcing or mitigating the pressures identified above. Research identifies four distinct types of supervision that commonly contribute to crane and rigging incidents: negligent supervision (modeling unsafe shortcuts), inadequate supervision (assigning supervisory roles based on availability rather than competence), passive supervision (ignoring known hazards) and planned unsafe acts (intentionally designing unsafe work sequences to save time) (Garrett & Teizer, 2009). Focus group discussions echoed these findings, with participants describing supervisors who lacked sufficient technical knowledge to evaluate lift plans or enforce safety requirements effectively.

In such environments, accountability often shifts downstream. Operators and riggers may be expected to make final safety judgments without adequate authority, information or support. This dynamic reflects a breakdown in psychological safety at the jobsite level. When workers feel pressure to proceed despite unclear or unsafe conditions, they are less likely to stop work or challenge decisions. Focus group findings suggest this pressure disproportionately affects newer or less experienced workers, who may defer to senior personnel and adopt informal or improper practices despite formal training, as was evidenced by the disconnect between certification and nonstandard signaling practices.

Human Factors

Human factors are another common contributor to safety outcomes in crane operations, with research suggesting that human error contributes to as much as 80% – 90% of workplace accidents (Reason, 1997). However, modern safety research emphasizes that these errors are more accurately understood as symptoms of deeper systemic weaknesses rather than as root causes.

"Probably the biggest problem is workers are scared to ask for help, or how to do things. That, plus the fact they are working extremely hard, leads to even more mistakes."

–Tower Crane Operator, Construction



In crane operations, human performance is particularly sensitive to workload, planning quality and communication conditions. Studies consistently show that time pressure, incomplete site information, and unclear role definitions increase cognitive demand and degrade situation awareness, creating conditions where slips, lapses and misjudgments become more likely (Garrett & Teizer, 2009; Lingard et al., 2021). These risks are amplified during routine or highly repetitive tasks, where familiarity can lead to reduced vigilance and greater reliance on expectation rather than active monitoring, patterns frequently identified in crane incident and near miss analyses (Beavers et al., 2006; McCann et al., 2009).

Fatigue and sustained cognitive load further compound these risks. Fatigue, physical exertion, heat stress and prolonged attention demand have all been shown to reduce alertness, slow reaction time and impair decision making, particularly in safety critical environments (Piil et al., 2018; Morrissey et al., 2021). In crane operations, where safe execution depends on continuous coordination and shared awareness across roles, even brief lapses in attention can lead to misaligned actions and escalating hazards.

Across incident investigations and near-miss analyses, a consistent pattern emerges: human errors in crane operations rarely occur in isolation. Instead, they reflect systems in which planning, supervision, communication and workload management fail to adequately support safe human performance (Beavers et al., 2006; Garrett & Teizer, 2009; Gharaie et al., 2015). Interview participants often described jobsite cultures where the burden of safety judgment falls disproportionately on operators, even when they lack full visibility into the lift and stopping work is not always experienced as a supported option. Addressing these risks requires organizational and managerial controls that reduce cognitive burden, strengthen communication and empower workers to pause operations when conditions are unsafe.



Recommendations

Based on these findings, several opportunities exist to strengthen rigging and signaling practices and reduce variability in crane safety performance:

- **Establish certification requirements for riggers and signalpersons.** The current employer-driven qualification model results in inconsistent training and limited verification of competency. Extending third-party certification requirements to riggers and signalpersons would establish a consistent baseline of knowledge and skill and better align these roles with existing operator standards. A standardized credential would also provide a reliable mechanism for verifying preparedness across jobsites.
- **Reinforce the use of standard signals.** Certification and training programs should emphasize mastery and consistent application of standard signaling practices, reinforcing their role as the primary means of communication during crane operations. Training should also prepare workers to identify situations where nonstandard signals are being substituted for established standards and reinforce appropriate corrective actions, including clarification, signal alignment and stop-work authority. At the jobsite level, employers and supervisors should reinforce standardized signals as the default and limit deviations to rare circumstances where standard signals are genuinely infeasible.
- **Strengthen and enforce rigging and signaling lift planning requirements.** With 52% of respondents describing rigging planning as last-minute, inconsistent or absent, the gap between regulatory expectations and practice is significant. Although formal lift planning is typically required for high-risk lifts, greater emphasis should be placed on pre-lift rigging and signaling coordination, including assignment of responsibilities, communication methods, signal alignment and hazard identification. Regulators should continue clarifying minimum planning expectations, while project owners, general contractors and site supervisors should require documented lift plans as a condition of work.
- **Invest in site-level supervisory training specific to crane operations.** Supervisors play a critical role in enforcing safe practices, yet interview findings indicate that many lack the technical expertise necessary to evaluate lift plans or identify signaling and rigging issues. Targeted training for supervisors, focused on crane operations, signaling requirements, rigging fundamentals and lift planning would strengthen accountability and enable earlier identification of safety risks.
- **Address language barriers through standardized multilingual resources.** With Hispanic workers comprising 34% of the construction workforce and language barriers reported by 55% of respondents, communication challenges are both common and consequential. Expanding multilingual training materials, certification pathways and standardized communication protocols would support consistent communication across diverse crews and reduce reliance on informal or improvised workarounds.
- **Continue building the evidence base on rigging and signaling practices.** This study establishes a baseline understanding of current rigging and signaling conditions. Continued data collection, particularly related to qualification, communication practices and incident causation, is needed to evaluate the effectiveness of interventions and inform future regulatory and industry action.

Conclusion

This study set out to establish a baseline understanding of current crane safety practices as it relates to current rigging and signaling practices. The findings show an industry that is operating within significant variability in training, qualification, communication and organizational support, often without the standardized frameworks that exist for crane operators.

Across all data sources, a consistent pattern emerged: communication failures are not isolated events but routine occurrences during lifts, with respondents encountering a range of challenges including signal inconsistencies, training gaps and language barriers within a 90-day period. **In particular, the widespread use of nonstandard signals undermines the shared understanding that safe lifts depend on, forcing operators to interpret, question or halt movements in the moment.** Language barriers further compound this issue, limiting the ability to clarify instructions when standard signals or radio communication break down. Together, these factors create conditions where miscommunication is common and where workers must rely on experience, inference or workarounds to maintain control of the lift.

Rigging errors, while less frequent than communication breakdowns, often carry more safety risks comparatively. Survey and qualitative findings suggest these errors are rarely driven by technical knowledge alone. Instead, they emerge from a combination of inconsistent training, inadequate planning and jobsite pressures that constrain how work is performed. Respondents identified production pressure, poor supervision and inattention as more common contributors to unsafe rigging than issues like equipment selection or load calculation. This reflects a broader pattern in which rigging failures are shaped less by what workers know and more by the conditions under which they are expected to apply that knowledge. When time is limited, oversight is weak or roles are unclear, even routine rigging decisions become points of risk.

Ultimately, these findings suggest that rigging and signaling safety is influenced by a combination of human, organizational and competency-related factors. Communication challenges, inconsistent signaling practices, variable levels of training and qualification, language barriers, and weaknesses in planning or supervision can all contribute to increased risk during crane operations. While organizational conditions such as production pressure and role clarity play an important role, the findings also highlight the value of standardized training, certification and consistent communication practices in establishing a common baseline of knowledge and performance across the workforce. Taken together, these results indicate that improving crane safety requires both stronger safety management practices and greater consistency in how riggers and signalpersons are trained, qualified and supported on the job.



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