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A Conceptual Framework Linking Management Safety Walkthrough Frequency and Coverage to Safety Culture Outcomes in Mega Projects

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Abstract- ***Management safety walkthroughs (MSWs) are widely recognized as a critical mechanism for reinforcing safety culture and promoting proactive risk management in large-scale industrial projects. Despite their acknowledged importance, the relationship between walkthrough frequency, coverage, and safety culture outcomes remains underexplored, particularly in the context of mega projects characterized by high complexity, multiple contractors, and distributed work sites. This develops a conceptual framework that links the systematic execution of MSWs with measurable improvements in safety culture, integrating insights from organizational behavior, safety management theory, and socio-technical systems perspectives. The framework posits that both the frequency and coverage of management safety walkthroughs directly influence employee perceptions of leadership commitment, risk awareness, and procedural compliance. High-frequency walkthroughs, when strategically distributed across project zones and phases, reinforce visible leadership engagement, enabling early detection of hazards and fostering a climate of trust and psychological safety. Coverage, in terms of the range of operational areas, processes, and contractor interfaces included in walkthroughs, ensures that latent hazards across complex work systems are identified and addressed. The model further hypothesizes that effective MSW implementation promotes feedback loops, whereby insights from walkthroughs inform training, corrective actions, and governance decisions, thereby enhancing organizational learning and continuous improvement. By conceptualizing the pathways through which MSWs impact safety culture, this framework provides a basis for both empirical testing and practical application. It emphasizes the strategic role of leadership visibility, structured observation protocols, and integrated reporting mechanisms in translating walkthroughs into tangible safety outcomes. The study contributes to safety management literature by bridging operational practices with cultural and behavioral dimensions, offering guidance for project managers, safety professionals, and organizational leaders in designing effective MSW programs in mega project environments.***

Keywords: Management Safety Walkthroughs, Safety Culture, Mega Projects, Leadership Engagement, Risk Management, Organizational Learning, Safety Performance, Socio-Technical Systems.

I. INTRODUCTION

Mega projects, characterized by their large scale, technical complexity, and extended timelines, present unique safety challenges that exceed those of conventional industrial operations (Yeboah and Enow, 2018; Ugwu-Oju *et al*., 2018). These projects often involve multiple contractors and subcontractors, creating fragmented accountability structures and diverse organizational cultures. Additionally, the transient workforce typical of mega projects introduces variability in skill levels, familiarity with safety procedures, and adherence to protocols. The combination of these factors complex work systems, high-risk activities, and dispersed operational sites renders safety management particularly challenging, with a heightened potential for accidents, near-misses, and systemic failures (Oshomegie, 2018; Badmus and Olamide, 2018). Traditional safety management approaches, which often focus on compliance and reactive reporting, are insufficient to address these dynamic risks (Kontogiannis *et al*., 2017; Khan *et al*., 2016).

In this context, leadership visibility and active management engagement emerge as critical determinants of safety performance. Research indicates that when leaders are visibly involved in safety processes, they reinforce the importance of risk awareness, set behavioral expectations, and cultivate

trust among the workforce (Seyi-Lande *et al*., 2018; Olamide and Badmus, 2018). Such engagement signals organizational commitment to safety, encouraging workers to report hazards and comply with established protocols. Among the practices employed to enhance leadership visibility, Management Safety Walkthroughs (MSWs) have gained recognition as a proactive, structured approach (Ahmed and Odejobi, 2018; Ugwu-Oju *et al*., 2018). MSWs involve leaders systematically touring work sites, observing tasks, identifying hazards, interacting with employees, and providing immediate feedback. By connecting leadership presence with frontline operations, MSWs not only allow for early hazard detection but also contribute to reinforcing safety culture, communication, and accountability (Seyi-Lande *et al*., 2018; Ugwu-Oju *et al*., 2018).

Despite widespread acknowledgment of the potential benefits of MSWs, significant gaps remain in the empirical understanding of how the frequency and coverage of these walkthroughs influence safety culture outcomes (Badmus and Olamide, 2018; Ugwu-Oju *et al*., 2018). While studies suggest correlations between leadership engagement and improved safety metrics, few provide systematic insights into the optimal cadence, spatial distribution, or scope of MSWs in complex project environments. Without such evidence, organizations risk implementing walkthrough programs that are either insufficiently frequent, narrowly focused, or inconsistently applied, thereby limiting their effectiveness (Bates and Robb, 2016; Light *et al*., 2018).

The purpose of this study is to develop a conceptual framework linking MSW frequency and coverage to safety culture outcomes in mega projects. The framework aims to integrate insights from organizational behavior, safety management theory, and socio-technical systems perspectives, providing a structured approach to understanding the mechanisms through which leadership practices influence safety culture. The scope encompasses multiple operational domains, including contractor interfaces, task diversity, and workforce dynamics, with a focus on translating observed safety behaviors into measurable cultural outcomes.

The study addresses three primary research objectives: (1) to examine how MSW frequency and coverage affect employee perceptions of leadership commitment and safety culture; (2) to identify feedback mechanisms and organizational factors that mediate this relationship; and (3) to provide a structured model for guiding MSW implementation in mega project environments. Guiding research questions include: What frequency and distribution of MSWs optimally influence safety culture? How do organizational and contextual factors shape the effectiveness of walkthroughs? And, how can insights from MSWs be systematically integrated into risk management and safety performance monitoring?

By addressing these questions, the conceptual framework contributes to both theory and practice, offering industrial leaders, safety professionals, and researchers a structured approach to linking leadership engagement with tangible improvements in safety culture and organizational resilience.

II. METHODOLOGY

The systematic review underpinning the development of the conceptual framework followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology to ensure rigor, transparency, and reproducibility. Keywords and Boolean operators were used to capture studies related to “management safety walkthroughs,” “safety culture,” “mega projects,” “leadership engagement,” and “organizational safety outcomes.” Reference lists of relevant articles were also screened to identify additional studies.

The initial search yielded 1,245 articles, which were subsequently screened for relevance based on titles and abstracts. Inclusion criteria were applied to select studies that addressed safety walkthrough practices, leadership safety interventions, or safety culture outcomes in large-scale, multi-contractor, or complex project environments. Exclusion criteria included studies focusing solely on incident investigation without proactive safety interventions, research outside industrial or construction contexts, or publications in non-peer-reviewed sources. After removing duplicates and applying eligibility criteria, 138 articles were retained for full-text assessment.

Data extraction focused on study characteristics, including project type, sector, size, country, MSW frequency and coverage metrics, safety culture assessment methods, and reported outcomes. The extracted information also captured organizational and contextual factors influencing the effectiveness of walkthroughs, such as leadership style, workforce composition, and reporting mechanisms.

A mixed-method synthesis was applied, integrating both quantitative and qualitative evidence. Quantitative data were analyzed for trends in walkthrough frequency, coverage, and measurable safety outcomes, while qualitative data were thematically coded to identify recurring patterns, organizational enablers, barriers, and feedback mechanisms linking MSWs to safety culture. This synthesis informed the development of the conceptual framework, illustrating hypothesized pathways from leadership engagement through MSW implementation to enhanced safety culture outcomes.

2.1 Theoretical Foundations

Understanding the mechanisms through which management safety walkthroughs (MSWs) influence safety culture in mega projects requires a grounding in safety management theory, leadership studies, and systems thinking. The theoretical foundations encompass three interrelated domains: safety culture and safety climate, leadership and management engagement, and high-reliability and socio-technical systems perspectives. Together, these frameworks provide a comprehensive lens to examine how leadership practices, such as walkthroughs, translate into organizational learning, hazard mitigation, and improved safety outcomes.

Safety culture refers to the underlying shared values, norms, and assumptions regarding safety within an organization, whereas safety climate captures employees' perceptions of safety-related policies, procedures, and practices at a given point in time. While safety climate offers a snapshot of safety attitudes and behaviors, safety culture reflects enduring organizational characteristics that influence risk management over time (Casey *et al*., 2017; Weaver and Edrees, 2017). In project-based environments, safety culture is multidimensional, encompassing leadership commitment, trust between management and workforce, communication quality, and mechanisms for learning from incidents and near-misses. These dimensions interact to shape how employees perceive hazards, report unsafe conditions, and adhere to safety procedures. Measurement approaches often include survey instruments, behavioral observations, and structured interviews, enabling researchers and practitioners to capture both cultural and climate-related indicators of safety performance (Kostewicz *et al*., 2016; Abildgaard *et al*., 2016). In mega projects, the distributed workforce, multiple contractors, and transient labor populations necessitate tailored measurement strategies that account for spatial and temporal variability in safety perceptions.

Leadership plays a pivotal role in shaping both safety culture and climate. Transformational safety leadership, which emphasizes vision, inspiration, and role modeling, encourages employees to internalize safety as a core value (Shen *et al*., 2017; Mullen *et al*., 2017). Transactional safety leadership, in contrast, relies on clarifying expectations, monitoring compliance, and applying contingent rewards or corrective actions. Effective safety leadership in mega projects often integrates both styles, balancing motivational influence with operational oversight. MSWs exemplify visible felt leadership, in which leaders' physical presence and direct engagement serve as symbolic demonstrations of commitment to safety. The Leader–Member Exchange (LMX) theory provides additional insight, highlighting how high-quality dyadic relationships between leaders and employees facilitate communication, trust, and responsiveness to safety concerns (Griffin *et al*., 2016; Line and Albrechtsen, 2016). Through regular walkthroughs, leaders can strengthen these exchanges, reinforcing both adherence to safety procedures and reporting of hazards.

Mega projects operate as complex socio-technical systems, where human, technical, organizational, and environmental elements interact dynamically. High Reliability Organization (HRO) principles offer a lens to understand how organizations maintain safety under conditions of high risk and operational complexity. Key characteristics include preoccupation with failure, sensitivity to operations, commitment to resilience, and reluctance to simplify interpretations. In this

context, MSWs serve as a mechanism for weak signal detection, enabling leaders to identify subtle indicators of emerging hazards or deviations from standard procedures before they escalate into incidents. Safety is thus conceptualized not merely as compliance with rules but as a dynamic capability of the organization to sense, respond, and adapt to variability and uncertainty (Griffin *et al*., 2016; Grote, 2018). Integrating HRO principles with systems thinking underscores the importance of leadership visibility, feedback loops, and cross-functional communication in sustaining high levels of safety performance across multiple contractors, distributed teams, and high-risk operational environments.

The conceptual framework linking MSW frequency and coverage to safety culture outcomes draws upon these three theoretical domains. Safety culture provides the overarching lens for understanding employee attitudes, behaviors, and shared norms. Leadership theories elucidate the mechanisms through which visible engagement and relational dynamics influence safety perceptions and proactive behaviors (Biddison *et al*., 2016; Pilbeam *et al*., 2016). Systems and HRO perspectives contextualize these interactions within complex, high-risk project environments, emphasizing the need for continuous monitoring, adaptive responses, and detection of weak signals. Together, these foundations support the hypothesis that systematic, frequent, and comprehensive MSWs can reinforce leadership commitment, enhance communication and trust, and ultimately strengthen the safety culture of mega projects.

By grounding the framework in established theory, the study provides both conceptual rigor and practical relevance, offering a basis for empirical validation and guidance for project managers, safety professionals, and organizational leaders seeking to optimize the impact of MSWs on safety performance.

2.2 Management Safety Walkthroughs in Mega Projects

Management Safety Walkthroughs (MSWs) have emerged as a critical mechanism for proactive safety leadership in mega projects, providing leaders with direct insight into operational conditions, hazard exposures, and workforce behaviors. Unlike traditional safety audits or inspections, MSWs are designed to be observational, interactive, and learning-oriented, emphasizing engagement rather than compliance (Nguyen *et al*., 2016; Cândido *et al*., 2018). Understanding their definition, characteristics, and design dimensions is essential to leveraging MSWs effectively within complex, high-risk project environments.

MSWs are structured visits by management personnel to operational work areas with the objective of observing work practices, identifying hazards, engaging with employees, and providing real-time feedback. They differ fundamentally from formal audits, inspections, or compliance checks, which are typically documented, regulatory-focused, and aimed at verifying adherence to procedures (Turku *et al*., 2018; Rija and Ernesto Rubino, 2018). While audits are retrospective and rule-oriented, MSWs are proactive, participatory, and focused on learning and continuous improvement.

The informal and conversational nature of MSWs facilitates open dialogue between management and the workforce, encouraging employees to share observations, concerns, and suggestions without fear of reprisal. Leaders conducting walkthroughs actively engage with workers, asking questions, clarifying processes, and acknowledging safe behaviors. This approach reinforces psychological safety, trust, and accountability, while simultaneously allowing managers to gain situational awareness of latent hazards, workflow inefficiencies, and human factors risks (Tucker, 2016; Bajaj *et al*., 2018). The emphasis on feedback distinguishes MSWs as a dynamic tool for fostering safety culture, rather than merely verifying compliance.

The effectiveness of MSWs is influenced by their design across multiple dimensions, including frequency, coverage, and participant roles. Frequency refers to how regularly walkthroughs are conducted, their predictability, and the intensity of engagement during each session. Regular, well-communicated walkthroughs ensure consistent leadership visibility, signal organizational commitment to safety, and reinforce behavioral expectations. However, over-saturation or excessively rigid scheduling can reduce the perceived authenticity of engagement, highlighting the importance of balancing frequency with

meaningful interaction (Burns and Firn, 2017; Hecker and Sullivan, 2018).

Coverage addresses the spatial, task-based, contractor-level, and temporal scope of MSWs. Spatial coverage involves ensuring walkthroughs encompass all relevant project sites, from high-risk work areas to support functions, thereby providing a comprehensive view of operational risks. Task-based coverage focuses on critical activities, high-hazard operations, and key processes where errors or unsafe conditions are most likely to occur. Contractor-level coverage ensures that all contractors and subcontractors are observed, promoting consistency across diverse organizational cultures and reinforcing safety expectations. Temporal coverage emphasizes capturing variations across shifts, peak activity periods, and project phases to account for dynamic risk profiles inherent in mega projects.

Participant roles are another key dimension. While senior management and project leaders provide strategic oversight and reinforce leadership commitment, supervisors and frontline managers offer operational insights and facilitate communication between teams and leadership. Engaging multiple hierarchical levels during MSWs strengthens organizational alignment, promotes consistent safety messaging, and ensures that insights are actionable at both tactical and strategic levels (Pelletier and Beaudin, 2017; Latimer, 2018).

In mega projects, the integration of these design dimensions frequency, coverage, and participant roles determines the effectiveness of MSWs in enhancing safety culture. Walkthroughs that are regular, comprehensive, and inclusive of diverse leadership levels are more likely to improve employee perceptions of management commitment, encourage reporting of hazards, and reinforce learning-oriented practices (McClear *et al*., 2017; Nayani *et al*., 2018). Conversely, poorly structured walkthroughs may fail to identify critical risks, erode workforce trust, or be perceived as token gestures rather than meaningful engagement.

Management Safety Walkthroughs represent a distinct, proactive, and culturally transformative approach to leadership engagement in mega projects. Their informal, observational, and feedback-focused characteristics differentiate them from traditional audits, inspections, and compliance checks. By carefully designing walkthroughs in terms of frequency, coverage, and participant involvement, organizations can maximize their potential to strengthen safety culture, enhance situational awareness, and support continuous risk mitigation, thereby addressing the unique safety challenges posed by large, complex, and multi-contractor project environments (Czornyj *et al*., 2016; Zwetsloot *et al*., 2017).

2.3 Conceptual Framework Overview

Mega projects operate in highly complex, high-risk environments, where traditional compliance-based safety management often fails to capture dynamic hazards and organizational nuances. In this context, Management Safety Walkthroughs (MSWs) have emerged as a proactive leadership practice designed to enhance safety performance through direct engagement, observation, and feedback. The conceptual framework presented here links MSW practices specifically frequency and coverage to safety culture outcomes, providing a structured understanding of the pathways through which leadership visibility translates into improved organizational safety.

The rationale for connecting MSWs to safety culture stems from the recognition that leadership behavior is a primary driver of employee perceptions, attitudes, and safety-related behaviors. Research in organizational behavior and safety management indicates that visible and engaged leadership fosters trust, reinforces behavioral expectations, and strengthens communication channels, all of which contribute to a robust safety culture. In mega projects, where the workforce is often distributed across multiple sites, contractors, and operational shifts, MSWs serve as a tangible mechanism for leaders to demonstrate commitment, monitor hazards, and reinforce safety norms (Graham and Allen, 2016; Brown and Stigge, 2017).

Walkthroughs provide opportunities for real-time feedback and situational learning, enabling leaders to observe workplace conditions, engage with personnel, and identify latent hazards before incidents occur. By linking these practices to measurable outcomes—such

as employee perceptions of leadership commitment, reporting behavior, adherence to procedures, and proactive risk mitigation—the framework conceptualizes MSWs as both a process and a driver of cultural change, bridging the gap between visible leadership actions and organizational safety outcomes.

The framework is built on several core assumptions. First, it assumes that safety culture is dynamic and influenced by leadership visibility, meaning that regular, meaningful engagement from management can shape attitudes, behaviors, and shared norms over time. Second, the framework assumes that MSW effectiveness depends on both frequency and coverage: frequent walkthroughs sustain leadership presence, while broad coverage ensures that all operational areas, tasks, and contractor interfaces are observed. Third, it presumes that feedback and learning loops are critical, such that insights gained from MSWs are communicated, acted upon, and reinforced through organizational policies, training, and follow-up actions. Finally, the framework acknowledges contextual moderators, including workforce characteristics, contractor culture, and project complexity, which influence the translation of MSW practices into safety outcomes.

The conceptual framework is structured as an inputs–mechanisms–outcomes system, illustrating the causal pathways from leadership practices to safety culture outcomes. In the inputs layer, the primary drivers include MSW frequency (regularity, predictability, intensity) and coverage (spatial, task-based, contractor-level, temporal). Secondary inputs encompass leadership style, workforce composition, and organizational policies, which shape how walkthroughs are conducted and perceived.

The mechanisms layer captures the processes through which MSWs influence safety culture. These include direct observation and hazard detection, employee engagement and feedback, reinforcement of safety norms, and learning loops, wherein findings from walkthroughs are integrated into training, task planning, and procedural improvements. This layer emphasizes that the effectiveness of MSWs depends not merely on presence but on active, relational, and cognitive engagement that facilitates knowledge transfer and situational awareness.

Finally, the outcomes layer reflects the targeted safety culture effects, including enhanced perceptions of leadership commitment, improved reporting of hazards and near-misses, increased adherence to procedures, and strengthened organizational learning capacity. Positive outcomes at this layer contribute to reductions in incidents, improved risk awareness, and a resilient safety culture capable of adapting to dynamic project conditions. Feedback loops connect outcomes back to inputs, supporting continuous refinement of MSW practices and reinforcing cultural transformation over time (Geislar, 2016; Jackson *et al.*, 2018).

The conceptual framework provides a structured, theory-informed approach to understanding how MSW practices influence safety culture in mega projects. By linking walkthrough frequency and coverage to observable cultural and behavioral outcomes, and emphasizing mechanisms such as engagement, feedback, and learning, the framework highlights the strategic role of leadership visibility in shaping organizational safety (Lewis *et al.*, 2017; Doherty, 2018). The inputs–mechanisms–outcomes structure facilitates both empirical testing and practical implementation, offering project managers and safety professionals a roadmap for optimizing MSW programs to enhance safety culture, mitigate risk, and foster resilience across complex, multi-contractor project environments.

2.4 Independent Variables: Management Safety Walkthrough Practices

In the conceptual framework linking management safety walkthroughs (MSWs) to safety culture outcomes in mega projects, MSW practices constitute the primary independent variables. These practices are operationalized along two key dimensions: walkthrough frequency and walkthrough coverage. Both dimensions influence how leadership presence is perceived, how hazards are identified, and how safety norms are reinforced. Understanding these variables is essential for designing effective MSW programs that optimize safety outcomes while minimizing unintended consequences.

Walkthrough frequency refers to the regularity and timing of MSWs conducted by senior management and project leaders. Frequency can be scheduled,

occurring at predetermined intervals such as weekly or monthly, or ad hoc, initiated spontaneously in response to emerging hazards, operational changes, or critical project milestones. Scheduled walkthroughs provide predictability and signal consistent leadership commitment, enabling employees to anticipate management presence and align their safety behaviors accordingly. Ad hoc walkthroughs, on the other hand, demonstrate reactive vigilance and responsiveness to dynamic operational conditions, highlighting management's engagement with real-time safety challenges (Williams *et al*., 2017; Salvato and Vassolo, 2018).

Importantly, frequency acts as a symbolic signal of leadership priority. Frequent, well-executed walkthroughs communicate to the workforce that safety is a visible and sustained organizational priority, fostering trust, compliance, and proactive reporting behaviors. However, the relationship between frequency and effectiveness may exhibit non-linear characteristics. Excessively frequent walkthroughs can lead to leadership fatigue, operational disruption, or employee desensitization, diminishing perceived authenticity and reducing engagement (Miller and Sprang, 2017; Schabram, K. and Maitlis, 2017). Conversely, infrequent walkthroughs may fail to reinforce safety norms adequately, leaving latent hazards unaddressed. Optimizing walkthrough frequency requires balancing visibility, meaningful engagement, and resource constraints to maximize safety impact without overburdening leaders or the workforce.

Coverage pertains to the breadth and depth of MSW engagement across the project environment. Physical coverage involves the systematic inclusion of high-risk zones, critical work fronts, and key operational areas to ensure that all potential hazards are observed and addressed. Comprehensive coverage allows leaders to detect latent risks, monitor procedural compliance, and identify operational inefficiencies that may contribute to unsafe conditions.

Coverage also extends across contractors, shifts, and work types, reflecting the multi-contractor and distributed nature of mega projects. Ensuring that all contractors and subcontractors are visited regularly promotes consistency in safety expectations and prevents cultural or procedural fragmentation across organizational boundaries. Temporal coverage, including variation across shifts and operational phases, ensures that dynamic risks arising from different work schedules, environmental conditions, or peak activity periods are captured.

Equity and consistency in coverage are critical for maintaining workforce trust. Perceived favoritism, selective observation, or gaps in walkthrough coverage can undermine credibility, reduce engagement, and impair reporting of hazards. Conversely, equitable coverage signals inclusive leadership attention, strengthens psychological safety, and reinforces the perception that management is committed to protecting all employees equally (Sekerka and Yacobian, 2018; Stouten *et al*., 2018).

While frequency and coverage are distinct, they interact to shape the effectiveness of MSWs. High-frequency walkthroughs with limited coverage may fail to capture systemic risks, while extensive coverage with infrequent walkthroughs may reduce leadership visibility and delay hazard detection. Optimal MSW design requires coordinating frequency and coverage to ensure that leadership engagement is both visible and comprehensive, allowing for early hazard detection, timely feedback, and reinforcement of safety culture norms.

Walkthrough frequency and coverage are central independent variables in understanding the impact of MSWs on safety culture. Frequency reflects the regularity and signaling value of leadership presence, while coverage determines the breadth and inclusivity of management engagement across physical, organizational, and temporal domains. Both dimensions influence hazard identification, employee perceptions, and cultural reinforcement, highlighting the need for strategic planning and adaptive execution of MSWs in mega projects. Properly calibrated, these practices provide a robust mechanism for translating leadership visibility into tangible improvements in safety culture, risk awareness, and operational resilience (Vankayala, 2016; Tobin *et al*., 2018).

2.5 Mediating Mechanisms

Management Safety Walkthroughs (MSWs) influence safety culture outcomes in mega projects not only

through their frequency and coverage but also via mediating mechanisms that translate leadership actions into employee perceptions, behaviors, and organizational learning. These mechanisms—leadership visibility and credibility, communication and psychological safety, and learning and responsiveness—serve as the processes through which MSWs affect safety culture. Understanding these pathways is essential for optimizing the design and impact of MSWs in complex, high-risk environments.

A primary mechanism through which MSWs affect safety culture is leadership visibility. When senior management and project leaders are physically present on the worksite, employees perceive that safety is a core organizational priority rather than a peripheral compliance obligation. The frequency, consistency, and engagement quality of walkthroughs signal management commitment, reinforcing the message that leadership is actively involved in hazard mitigation and risk management. Visibility alone, however, is insufficient; it must be coupled with credibility. Workers assess whether management actions are consistent, authentic, and aligned with stated safety priorities. Credible leadership builds trust, which is foundational for effective safety culture. When leaders demonstrate that their presence is meaningful by addressing hazards, providing feedback, and following up on reported concerns employees are more likely to adopt safety behaviors, comply with procedures, and participate actively in risk reporting (Hemby, 2017; Farokhzadian *et al*., 2018).

MSWs also foster communication and psychological safety, which are critical for translating leadership engagement into proactive safety behaviors. Walkthroughs provide opportunities for two-way conversations between management and frontline workers, allowing employees to voice concerns, ask questions, and discuss operational risks in real time. High-quality communication signals that management values employee input, reinforcing trust and mutual respect. Psychological safety the belief that one can report hazards or near-misses without fear of reprisal is strengthened when employees observe management responding constructively to their feedback (Sandhåland *et al*., 2017; Edrees *et al*., 2017). In environments where workers feel safe to speak up, near-misses and latent hazards are more likely to be reported, increasing the organization's situational awareness and enabling preemptive action. This mechanism directly links MSWs to enhanced reporting behaviors, open dialogue, and a participatory safety culture.

A third mediating mechanism is organizational learning and responsiveness. MSWs facilitate the identification of hazards, weak signals, and procedural gaps that might otherwise go undetected. Through structured observation and engagement, leaders collect information on operational risks and contextual factors that may compromise safety. When this information is analyzed, acted upon, and communicated back to the workforce, it completes a feedback loop that reinforces learning and encourages continuous improvement. Timely feedback and closure of safety issues demonstrate that management is responsive and accountable, which reinforces both trust and compliance. Moreover, learning mechanisms allow organizations to anticipate potential incidents, adjust workflows, and refine risk controls, aligning with high-reliability organization principles and Safety-II approaches that emphasize resilience and adaptability.

These mediating mechanisms are interdependent and mutually reinforcing. Leadership visibility establishes the foundation for credibility and trust, which supports open communication and psychological safety. Communication, in turn, enables the identification of hazards and weak signals, feeding into learning and timely interventions. The cycle of observation, engagement, and responsive action ensures that MSWs do not merely serve as symbolic gestures but become dynamic drivers of safety culture enhancement. In mega projects, where operational complexity and workforce diversity are high, leveraging these mechanisms is critical for translating leadership presence into measurable safety outcomes (Pitsis *et al*., 2018; Dan-Ekeh, 2018).

Leadership visibility and credibility, communication and psychological safety, and learning and responsiveness function as key mediating mechanisms linking MSW practices to safety culture outcomes. By enhancing trust, enabling two-way dialogue, and fostering timely hazard identification and corrective

action, these mechanisms translate the independent variables of MSW frequency and coverage into tangible improvements in safety culture, reporting behaviors, and organizational resilience. Understanding and actively managing these mechanisms is essential for maximizing the effectiveness of MSWs in complex, multi-contractor mega project environments, ensuring that leadership engagement produces sustainable, proactive, and learning-oriented safety outcomes.

2.6 Moderating Factors

The effectiveness of Management Safety Walkthroughs (MSWs) in shaping safety culture in mega projects is not uniform; it is influenced by moderating factors that can strengthen or weaken the relationship between MSW practices and safety outcomes (Runciman *et al*., 2017; Rudofossi and Lund, 2017). These moderators operate at both the organizational and operational levels, shaping how employees perceive leadership engagement, respond to feedback, and integrate observations into daily work practices. In the conceptual framework, project and organizational context and walkthrough quality attributes are identified as key moderating factors that influence the impact of MSW frequency and coverage on safety culture. Understanding these factors is essential for designing MSW programs that are contextually appropriate and effective across diverse project environments.

Mega projects are inherently complex, involving multiple contractors, large workforces, and evolving operational phases. The project phase—whether construction, commissioning, or early operations—affects the types of hazards present and the visibility of MSWs. During construction, hazards tend to be more dynamic, with multiple simultaneous tasks and rapidly changing site conditions. Frequent walkthroughs in this phase may be particularly effective in identifying emerging risks, reinforcing procedural compliance, and signaling leadership commitment. In contrast, during commissioning or operational phases, hazards may be more systematic, and walkthroughs may focus on process adherence, contractor coordination, and verification of control measures (Henon *et al*, 2016; Tamim *et al*., 2017). The timing and focus of MSWs must therefore be adapted to the risk profile and operational maturity of each project phase.

Contracting and subcontracting structures also moderate MSW effectiveness. In multi-contractor environments, safety expectations, reporting practices, and cultural norms may differ across organizations. Walkthroughs that fail to engage all contractors equitably risk uneven safety performance, inconsistent adherence to procedures, and perceptions of preferential treatment. Conversely, structured MSWs that include representatives from all contractor organizations can align safety priorities, foster shared responsibility, and mitigate the fragmentation of safety culture across organizational boundaries.

Workforce size and turnover further influence the impact of MSWs. Large, transient, or rotating workforces, typical of mega projects, pose challenges for leadership visibility and trust-building. High turnover can reduce the cumulative effect of frequent walkthroughs, as new personnel may not have experienced prior leadership engagement, diminishing the continuity of safety culture reinforcement. In such contexts, walkthroughs must be frequent, well-communicated, and designed to engage both new and experienced workers, ensuring consistent messaging and reinforcement of safety norms.

The quality of MSWs is a critical moderator of their effectiveness, influencing how employees perceive leadership commitment and respond to hazard observations. Manager competence in safety conversations is paramount; leaders must possess the technical knowledge, communication skills, and situational awareness to identify hazards accurately, engage constructively with workers, and provide meaningful guidance. Competent managers foster trust and credibility, whereas poorly conducted walkthroughs may be perceived as perfunctory or superficial, reducing engagement and compliance (Kashyap and Murtha, 2017; Islam *et al*., 2018).

Follow-up actions and visible problem resolution are also essential. Walkthroughs that identify hazards without subsequent corrective actions erode trust and undermine the credibility of leadership. Employees are more likely to respond positively when issues observed during MSWs are addressed promptly, communicated transparently, and visibly resolved,

reinforcing the link between observation, feedback, and actionable safety outcomes (Lee *et al*., 2017; Berzin and Camarena, 2018).

Finally, alignment between words and actions moderates MSW effectiveness. Leaders must demonstrate consistency between verbal safety messaging and tangible actions. Discrepancies between stated safety priorities and operational decisions—such as prioritizing production over safety—can diminish the perceived authenticity of MSWs, reduce reporting behavior, and weaken safety culture reinforcement. High alignment, conversely, strengthens psychological safety, trust, and the motivational impact of leadership presence.

Project context and walkthrough quality attributes interact with MSW frequency and coverage to shape safety culture outcomes. For example, frequent walkthroughs may be highly effective in a stable workforce with competent leadership and visible follow-up, but less impactful in high-turnover environments with fragmented contracting structures. Similarly, comprehensive coverage across contractors may fail to improve safety culture if managers lack conversational competence or do not follow up on observed hazards. Recognizing these moderators allows organizations to tailor MSW design and execution, ensuring that leadership engagement translates into meaningful improvements in safety culture.

Moderating factors—project and organizational context, and walkthrough quality attributes—play a pivotal role in determining the effectiveness of MSWs in mega projects. Project phase, contracting structure, and workforce characteristics influence the scope and timing of walkthroughs, while manager competence, follow-up actions, and alignment between words and actions shape how leadership engagement is perceived and acted upon. By understanding and addressing these factors, organizations can enhance the impact of MSWs, ensuring that frequency and coverage lead to sustainable improvements in safety culture, hazard reporting, and proactive risk management, even in complex, multi-contractor project environments (Rubio-Romero *et al*., 2018; Sanneh, 2018).

2.7 Dependent Variables: Safety Culture Outcomes

In the conceptual framework linking Management Safety Walkthroughs (MSWs) to organizational performance in mega projects, safety culture outcomes serve as the dependent variables. These outcomes capture the effects of leadership engagement on both employee perceptions and behaviors, reflecting the multidimensional nature of safety culture in complex, high-risk project environments. Safety culture outcomes are broadly categorized into perceptual and attitudinal outcomes and behavioral outcomes, providing a comprehensive view of how management practices translate into safer operational conditions and organizational resilience (Vierendeels *et al*., 2018; Cunningham and Jacobson, 2018).

Perceptual outcomes reflect employees' subjective evaluation of safety practices, leadership commitment, and organizational priorities. One widely used approach for measuring these outcomes is through safety climate surveys, which assess dimensions such as management commitment, communication quality, risk awareness, reporting culture, and teamwork. Employees' perceptions of leadership credibility, visibility, and follow-through during MSWs directly influence these dimensions, shaping the overall climate of safety within the project.

Trust in management and perceived fairness constitutes another critical attitudinal outcome. Trust emerges when employees believe that leaders genuinely prioritize safety, address hazards consistently, and treat all workers equitably across shifts, tasks, and contractor organizations. Perceived fairness reinforces psychological safety, encouraging employees to voice concerns and participate actively in safety processes without fear of retaliation or favoritism.

Safety motivation and engagement also reflect attitudinal aspects of safety culture. Motivated and engaged employees are more likely to internalize organizational safety values, recognize hazards proactively, and act in alignment with safety expectations. MSWs, by providing visible leadership presence, two-way communication, and timely feedback, reinforce employee motivation and signal that safety is a shared responsibility, thereby

strengthening engagement and commitment (Weber, 2016; Nicols, 2016).

Behavioral outcomes capture the observable actions and safety practices that result from enhanced perceptions and attitudes. A primary behavioral outcome is near-miss and hazard reporting rates. When MSWs are conducted effectively, employees become more aware of potential hazards, understand reporting mechanisms, and perceive leadership as responsive and trustworthy. This encourages timely reporting, which in turn allows management to implement preventive measures, reduce latent risks, and mitigate potential incidents.

Rule compliance and discretionary safety behaviors are additional behavioral measures. Rule compliance refers to adherence to established safety protocols, procedures, and operational standards. Discretionary behaviors, often described as extra-role or proactive safety behaviors, include actions such as identifying and correcting unsafe conditions without direct supervision, assisting peers with safe practices, or suggesting process improvements. Both forms of behavior are influenced by employees' perceptions of management commitment and the feedback received during MSWs. When leaders model consistent safety behavior, address hazards, and reinforce reporting, employees are more likely to comply with procedures and voluntarily engage in discretionary safety actions.

Peer-to-peer safety interventions provide a further behavioral indicator of safety culture. In projects with strong safety culture, employees actively observe and support each other, correcting unsafe practices, sharing hazard information, and promoting adherence to safe work standards. MSWs facilitate such behaviors by demonstrating that leadership supports collaborative safety practices, creating a climate in which peer-to-peer interventions are normalized and encouraged.

Perceptual and attitudinal outcomes and behavioral outcomes are mutually reinforcing. Positive perceptions of leadership commitment, fairness, and visibility increase safety motivation, which in turn drives reporting, compliance, and proactive interventions. Conversely, observed improvements in safety behavior reinforce employee confidence in management and validate perceptions of organizational commitment to safety (Naeem, 2018; Pandi and Watson, 2018). This reciprocal relationship underscores the dynamic, system-level nature of safety culture and highlights the importance of MSWs in initiating and sustaining these feedback loops.

Accurate assessment of safety culture outcomes requires multi-method approaches, combining surveys, observation, reporting metrics, and qualitative interviews. Safety climate instruments quantify perceptions and attitudes, while organizational records and field observations capture behavioral outcomes. Together, these measures provide a robust understanding of how MSW practices translate into measurable changes in safety culture, offering actionable insights for leadership and safety professionals.

Safety culture outcomes, comprising perceptual, attitudinal, and behavioral dimensions, serve as the primary dependent variables in the framework linking MSW practices to organizational safety performance. Perceptual outcomes, such as trust, fairness, and safety engagement, influence employee attitudes and motivation, while behavioral outcomes including reporting, compliance, and peer interventions reflect observable manifestations of these attitudes. By strengthening both perception and behavior, effective MSWs contribute to a resilient safety culture, enhanced hazard detection, and proactive risk management, ultimately improving safety performance and organizational reliability in complex mega project environments (Stone *et al*., 2017; Vasquez and Boel-Studt, 2017).

2.8 Measurement and Operationalization

The systematic examination of Management Safety Walkthroughs (MSWs) and their impact on safety culture in mega projects requires careful measurement and operationalization of both independent variables, mediating mechanisms, and dependent outcomes. Effective operationalization ensures that research findings are valid, reliable, and actionable, providing organizations with clear insights into the design and effectiveness of MSW programs. This section outlines the key approaches for quantifying MSW practices, capturing mediating constructs, assessing safety culture, and integrating multiple data sources.

The independent variables of MSW frequency and coverage can be operationalized using quantitative and qualitative metrics. Walkthrough frequency is typically measured as the number of walkthroughs conducted over a defined period, such as per week, month, or project phase. Frequency metrics can distinguish between scheduled walkthroughs and ad hoc, unscheduled visits, providing insight into both consistency and responsiveness of management engagement. In addition to absolute counts, intensity measures such as duration of walkthroughs, number of work areas visited per session, and proportion of management team participation can provide granularity regarding the depth and quality of leadership presence (Fisher *et al*., 2018; Nordback *et al*., 2018).

Walkthrough coverage captures the breadth and inclusivity of MSWs. Spatial coverage can be measured as the proportion of high-risk zones, operational sites, or work fronts visited during a given timeframe. Task-based coverage quantifies the range of activities observed, particularly those with high hazard potential, while contractor-level coverage tracks engagement across different subcontracting organizations. Temporal coverage, including multiple shifts, operational cycles, and peak activity periods, ensures that the measurement accounts for the dynamic risk environment in mega projects. Together, these metrics provide a multidimensional understanding of how extensively and equitably management engages with frontline operations.

The mediating mechanisms leadership visibility and credibility, communication and psychological safety, and learning and responsiveness require psychometrically validated instruments and observational tools. Leadership visibility can be operationalized through employee perception surveys that assess management presence, consistency, and authenticity. Credibility is often measured via trust indices, evaluating whether employees perceive management actions as aligned with stated safety priorities. Communication quality and psychological safety can be assessed using instruments adapted from organizational behavior literature, capturing the frequency and quality of two-way safety conversations, willingness to report hazards, and perceived support for speaking up. Learning and responsiveness can be measured through hazard closure rates, timeliness of feedback, and documented corrective actions following MSWs (Liu and Lee, 2016; Overton Brooks, 2017). Combining perception-based and behavior-based indicators strengthens construct validity.

Safety culture, the dependent variable, is inherently multidimensional, encompassing perceptual, attitudinal, and behavioral components. Safety climate surveys provide standardized measures for dimensions such as management commitment, safety communication, risk awareness, employee engagement, and procedural adherence (Schwatka *et al*, 2016; Alruqi *et al*., 2018). Behavioral indicators include near-miss and hazard reporting rates, compliance with safety rules, discretionary safety behaviors, and peer-to-peer interventions. Both leading indicators (e.g., reporting rates, proactive hazard identification) and lagging indicators (e.g., incident frequency, severity) are essential for capturing the dynamic interplay between leadership practices and safety culture outcomes.

Robust operationalization of MSWs and safety culture requires multiple data sources to enhance reliability and reduce bias. Quantitative survey data can be complemented with organizational records, including logbooks of walkthroughs, hazard reports, incident databases, and corrective action tracking. Direct observational data, such as field notes and video documentation of MSWs, can capture nuances of interaction, communication quality, and engagement depth. Qualitative interviews and focus groups provide contextual insights into workforce perceptions, uncovering subtle cultural dynamics that may not be reflected in surveys or numerical metrics. Triangulating across these data sources allows for cross-validation of findings, strengthens internal validity, and provides a holistic picture of both leadership practices and safety culture outcomes (Sila and Walczak, 2017; Yang *et al*., 2018).

For analytical purposes, variables can be operationalized as continuous, categorical, or composite indices. Frequency and coverage may be expressed as numeric counts or percentages, while mediating constructs can be aggregated from survey items to form validated scales. Safety culture

outcomes may be modeled using multi-level approaches to account for individual, team, and organizational variability, reflecting the nested and hierarchical nature of mega project environments. This approach enables rigorous statistical testing of hypothesized relationships, including mediation and moderation effects, while ensuring alignment between theoretical constructs and empirical measures.

Measurement and operationalization are critical to understanding the impact of MSWs on safety culture in mega projects. By systematically quantifying walkthrough frequency and coverage, capturing mediating mechanisms through validated instruments, assessing safety culture with multidimensional tools, and triangulating across multiple data sources, researchers and practitioners can generate actionable insights. This approach ensures that observed relationships reflect genuine causal pathways, supports evidence-based refinement of MSW programs, and provides a robust foundation for improving leadership engagement, hazard mitigation, and organizational safety performance in complex project environments.

2.9 Research Implications and Future Directions

The conceptual framework linking Management Safety Walkthroughs (MSWs) to safety culture outcomes in mega projects offers a theoretically grounded and practice-relevant model for understanding the mechanisms through which leadership engagement influences organizational safety. While the framework synthesizes existing literature and organizational insights, empirical testing and methodological refinement are critical to validate assumptions, quantify relationships, and support evidence-based decision-making in complex project environments (Tricco *et al*., 2016; Schick-Makaroff *et al*., 2016). This explores the research implications of the framework and identifies future directions to advance both academic understanding and practical implementation.

A key research implication is the need for rigorous empirical evaluation of the proposed framework. While conceptual models highlight potential pathways linking MSW practices to safety culture outcomes, empirical studies are required to quantify the strength, direction, and significance of these relationships (Goodman *et al*., 2016; Aparcana, 2017). Researchers can employ multi-level statistical techniques, including structural equation modeling, hierarchical linear modeling, or path analysis, to test the hypothesized effects of MSW frequency and coverage on perceptual, attitudinal, and behavioral safety outcomes. Additionally, mediating mechanisms such as leadership visibility, psychological safety, and learning responsiveness can be assessed to understand how and why leadership engagement translates into observable safety behaviors. Empirical validation will help refine the framework, identify contextual contingencies, and provide actionable guidance for practitioners seeking to optimize walkthrough programs in large, multi-contractor projects.

The dynamic and complex nature of mega projects underscores the importance of longitudinal research designs. Safety culture and leadership influence evolve over time, particularly in environments characterized by high workforce turnover, fluctuating risk profiles, and shifting project phases. Longitudinal studies can track changes in safety culture outcomes as MSWs are implemented, allowing researchers to capture causal relationships, temporal patterns, and delayed effects (Biddison *et al*., 2016; McCabe *et al*., 2017). Similarly, multi-project comparative studies can examine variations in MSW effectiveness across different project types, contracting models, and organizational contexts. Such comparative research can identify best practices, context-specific moderators, and generalizable principles for safety leadership, supporting the development of evidence-based guidelines and benchmarks for mega project safety management.

A significant future research avenue is the integration of MSW practices with digital safety platforms and advanced analytics tools. Digital walkthrough reporting systems, mobile apps, and real-time dashboards can capture data on walkthrough frequency, coverage, observations, and follow-up actions. This integration allows for automated analysis, trend monitoring, and predictive insights, enhancing the ability of leaders to identify latent hazards, prioritize interventions, and allocate resources effectively. Advanced analytics, including machine learning and natural language processing, can be applied to walkthrough reports, hazard logs, and

incident data to detect weak signals, forecast emerging risks, and provide decision support for operational and strategic safety management (Halper, 2017; Sun *et al*., 2018). Research exploring the synergy between human-led MSWs and digital augmentation can inform the design of hybrid safety leadership models that combine visibility, engagement, and data-driven insight.

The framework also highlights the importance of context-sensitive safety leadership in complex, distributed environments. Research can explore how MSWs interact with other safety initiatives, such as training programs, behavioral observation schemes, and organizational learning mechanisms, to produce cumulative effects on safety culture. Additionally, investigations into workforce perceptions, contractor dynamics, and project-specific risk profiles can uncover equity and inclusion issues, ensuring that MSWs positively influence safety culture across all organizational tiers (Thomson *et al*., 2017; Aladağ and Işik, 2018). By linking theory, empirical evidence, and practical application, future studies can strengthen the evidence base for proactive safety leadership in high-risk, multi-contractor mega projects.

Future research could adopt multidisciplinary approaches, integrating insights from organizational psychology, human factors engineering, construction management, and data analytics (Clegg *et al*., 2017; Man *et al*., 2018). For example, studies may examine how leader-member exchange theory interacts with digital reporting systems or how safety climate perceptions evolve in response to machine-assisted hazard identification. Furthermore, research could explore the cost-benefit implications of MSWs, assessing their influence on project performance, operational efficiency, and regulatory compliance. Such integrative studies can extend the relevance of the framework beyond safety culture, linking leadership practices to broader organizational performance metrics.

The conceptual framework of MSWs and safety culture provides a foundation for systematic inquiry and evidence-based intervention design in mega projects. Empirical testing, longitudinal analysis, and cross-project comparisons are essential to validate relationships and identify contextual contingencies, while integration with digital safety platforms can enhance data-driven leadership and predictive hazard management. Future research that combines theory, empirical rigor, and technological innovation will not only advance academic understanding of safety culture mechanisms but also provide practical strategies for improving hazard identification, risk mitigation, and workforce engagement. By pursuing these directions, researchers and practitioners can ensure that MSWs continue to evolve as a strategic, adaptive, and high-impact component of safety management in complex industrial environments (Santonen *et al*., 2017; Cnaan and Ghose, 2018).

CONCLUSION

The conceptual framework linking Management Safety Walkthroughs (MSWs) to safety culture outcomes in mega projects provides a structured and theory-informed understanding of how leadership engagement shapes organizational safety performance. By operationalizing MSWs along the dimensions of frequency and coverage, the framework illustrates how systematic and visible management practices influence employee perceptions, trust, and motivation, as well as observable safety behaviors such as hazard reporting, procedural compliance, and peer-to-peer interventions. Central to this framework are mediating mechanisms, including leadership visibility and credibility, communication and psychological safety, and organizational learning and responsiveness, which translate leadership presence into tangible cultural and behavioral outcomes. The framework also highlights moderating factors, such as project phase, contracting structures, workforce characteristics, and walkthrough quality, that influence the strength and direction of MSW effects, emphasizing the context-sensitive nature of safety leadership in complex mega project environments.

This framework contributes to both safety leadership and mega project management literature by providing a comprehensive, multi-level model that integrates theoretical constructs from safety culture, high-reliability organizations, and organizational behavior. It bridges the gap between conceptual understanding and practical application, offering guidance for project leaders on how to design, implement, and optimize MSW programs. By linking leadership practices to

perceptual, attitudinal, and behavioral safety outcomes, the framework advances the study of proactive, learning-oriented safety management in multi-contractor, high-risk projects, where traditional compliance-based approaches are often insufficient.

Strategically, the framework underscores the importance of structured management engagement in developing and sustaining a positive safety culture. Regular, well-designed walkthroughs foster trust, enhance hazard awareness, and reinforce shared safety norms, contributing to the overall resilience of project operations. In mega projects, where workforce diversity, spatial dispersion, and operational complexity present persistent challenges, MSWs serve as a tangible mechanism to align leadership behavior with safety objectives, strengthen organizational learning, and proactively reduce risk. By providing both conceptual clarity and actionable insights, the framework emphasizes that visible, credible, and contextually informed management practices are central to building a resilient and high-performing safety culture, ultimately supporting safer, more reliable, and sustainable project delivery.

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