

From Knowledge to Practice: Uncovering the Safety Behavior Gap among Construction Workers Using Structural Equation Modeling (Empirical Evidence from Ongoing Construction Projects in South Sulawesi, Indonesia)

Andi Arifah Pasri¹, Nurlita Pertiwi², Gufran D. Dirawan³

¹Doctoral Student, Doctoral Study Program in Population and Environmental Education, Universitas Negeri Makassar, Indonesia

^{2,3}Lecturer, Department of Building Engineering Education, Faculty of Engineering, Universitas Negeri Makassar, Indonesia

Abstract

Construction safety programs often assume that better knowledge, positive attitudes, supportive leadership, and formal safety systems will lead to safer behavior. However, this transformation does not always occur automatically. This study analyzes the gap between workers' cognitive and organizational safety conditions and their actual behavior, conceptualized as the safety behavior gap. A cross-sectional survey of 250 workers from active construction projects in South Sulawesi, Indonesia, was analyzed using structural equation modeling. The model integrated Occupational Safety Knowledge, Attitudes toward Occupational Safety, Risk Perception, Safety Leadership, Safety Culture, Safety Climate, Safety Motivation, and Safety Behavior, represented by Safety Compliance and Safety Participation. The measurement model demonstrated adequate convergent validity and composite reliability. The structural model explained 70.3% of the variance in Safety Behavior. Occupational Safety Knowledge ($\beta = 0.172$; $p = 0.003$), Safety Climate ($\beta = 0.369$; $p = 0.001$), and Safety Motivation ($\beta = 0.365$; $p < 0.001$) had significant direct effects on Safety Behavior, whereas Attitudes, Risk Perception, Safety Leadership, and Safety Culture did not have significant direct effects. Risk Perception indirectly affected behavior through Safety Motivation ($\beta = 0.082$; $p = 0.006$). Safety Culture influenced behavior through Safety Climate ($\beta = 0.208$; $p = 0.002$), while the sequential pathway from Safety Leadership through Safety Culture, Safety Climate, and Safety Motivation to Safety Behavior was also significant ($\beta = 0.033$; $p = 0.003$). Descriptively, 69% of respondents exhibited low or very low Safety Behavior despite relatively positive levels of several antecedent factors. These findings indicate that construction safety is not merely a matter of knowing how to work safely, but also of transforming knowledge, awareness, organizational signals, and motivation into consistent action. The safety behavior gap is therefore positioned as an empirical-conceptual lens for understanding the knowing-doing discontinuity in construction safety.

Keywords: Construction safety; safety behavior gap; safety compliance; safety participation; safety climate; safety motivation; structural equation modeling.

1. Introduction

Construction work is characterized by a dynamic environment involving changes in work areas, the use of heavy equipment, work at height, excavation, material handling, subcontracting, and time pressure. These characteristics make workers' behavior a critical element in accident prevention. Safety management systems can provide procedures and controls, but their effectiveness ultimately depends on workers' consistent application of safe behaviors.

Safety behavior is generally differentiated into Safety Compliance and Safety Participation. Safety Compliance refers to core activities required to maintain safety, such as following procedures and using personal protective equipment (PPE), whereas Safety Participation describes voluntary activities that contribute to the broader safety environment [1]. This distinction is important because workers may meet minimum safety requirements without actively participating in hazard reporting, reminding coworkers, or contributing to safety improvements.

The safety performance literature distinguishes distal antecedents from more proximal determinants. Safety Climate provides signals regarding the organization's safety priorities, whereas safety knowledge and motivation are more closely associated with the formation of behavior [2], [3]. Meta-analytic evidence also indicates that both individual and situational factors contribute to safety performance [4]. In the construction sector, leadership and safety climate may influence behavior through sequential organizational and psychological mechanisms [5].

However, an important issue remains: workers may understand hazards and procedures, perceive safety as important, and work within a formally established safety system, yet still fail to consistently demonstrate safe behavior. Research on deep compliance and surface compliance further indicates that observable compliance does not necessarily reflect the internalization of safety behavior [6]. Therefore, safety research needs to assess not only the presence of antecedent factors but also the processes through which they are transformed into actual actions.

This study refers to this discontinuity as the safety behavior gap, defined as the misalignment between the potential for safe behavior, represented by knowing, awareness, organizational safety conditions, and motivation, and actual behavior, represented by doing, compliance, and participation. The term is used as an empirical-conceptual synthesis rather than as a separately measured latent construct.

This study aims to explain how individual and organizational factors jointly shape construction workers' Safety Behavior and the mediating mechanisms that bridge the process from knowing to doing. The contribution of this study lies in integrating Safety Knowledge, Attitudes, Risk Perception, Safety Leadership, Safety Culture, Safety Climate, and Safety Motivation within a single structural equation modeling framework, while examining direct and indirect effects to explain the safety behavior gap.

2. Theoretical Framework and Hypothesis Development

A. Safety Behavior: Safety Compliance and Safety Participation

Following [1], Safety Behavior is conceptualized as a two-dimensional construct consisting of Safety Compliance and Safety Participation. Safety Compliance refers to required safety-related actions, whereas Safety Participation represents voluntary behaviors that strengthen the broader safety

environment. This framework allows the analysis to move beyond formal compliance and also assess workers' active involvement in safety.

B. Individual Antecedents: Knowledge, Attitudes, and Risk Perception

Occupational Safety Knowledge provides the cognitive foundation for workers to identify hazards, understand procedures, and select safe responses. The Theory of Planned Behavior positions attitudes and perceived behavioral control as key determinants of intention and behavior [7] whereas Social Cognitive Theory emphasizes the reciprocal interaction among cognition, environment, and behavior [8]. Risk Perception can increase awareness of vulnerability and potential consequences; however, such awareness requires motivation to be translated into actual behavior.

C. Organizational Antecedents: Leadership, Culture, and Climate

Safety Leadership provides coaching, caring, monitoring, and corrective actions. Safety Culture represents deeper organizational values, norms, and practices, whereas Safety Climate reflects workers' perceptions of management commitment, safety systems, and communication experienced in their day-to-day work. Accordingly, Safety Climate can function as a mechanism through which organizational values are translated into behaviorally relevant signals [9], [10].

D. Safety Motivation as a Proximal Mechanism

Safety Motivation refers to workers' willingness to exert effort to work safely. Longitudinal evidence indicates that Safety Climate predicts changes in Safety Motivation, which subsequently predict changes in safety behavior [3]. Therefore, motivation is positioned as an important mechanism through which individual awareness and organizational safety signals are translated into action.

E. Integrative Proposition: Safety Behavior Gap

The integrated model assumes that safe behavior is shaped by the interaction between individual knowledge and awareness and organizational factors, including leadership, culture, and safety climate, while motivation functions as a proximal mechanism driving actual behavior. The safety behavior gap emerges when antecedent conditions are relatively positive, but Safety Compliance and Safety Participation remain weak. The empirical analysis examines 21 direct relationships and seven specific indirect pathways, including the sequential mechanism involving Safety Leadership, Safety Culture, Safety Climate, Safety Motivation, and Safety Behavior.

3. Methods

A. Research Design and Study Location

This study employed a quantitative approach with an explanatory cross-sectional design. Data were collected from workers employed on active construction projects in South Sulawesi, Indonesia, including large-scale building projects in Makassar and road/infrastructure projects in Bone. The worker population at the time of the study was approximately 1,200 individuals. A proportional sample of 250 workers was included in the SEM analysis.

B. Respondent Characteristics

The respondents were predominantly male (96%), and 80% had completed senior high school education. Regarding work experience, 34.8% had 1–5 years of experience, while 36.8% had 6–10 years of experience. Daily workers accounted for 74.4% of the sample. By project type, 85.2% of respondents worked on building projects, while the remainder were employed on road, bridge, and drainage projects.

C. Variable Measurement

All constructs were measured using a five-point Likert scale adapted to the construction context. Occupational Safety Knowledge covered cognitive, affective, and psychomotor aspects; Attitudes toward Occupational Safety included cognitive, affective, and conative dimensions; and Risk Perception comprised cognitive, affective, and conative dimensions. Safety Leadership consisted of coaching, caring, and controlling; Safety Culture comprised safety values, norms, and practices; Safety Climate included management commitment, safety systems, and safety communication; and Safety Motivation consisted of intrinsic and extrinsic motivation. Safety Behavior was represented by Safety Compliance and Safety Participation.

D. Data Analysis

Structural equation modeling (SEM) was employed to evaluate both the measurement and structural models. Measurement quality was assessed using outer loadings, Cronbach's alpha, composite reliability, and average variance extracted (AVE). Structural model evaluation included path coefficients, t-statistics and p-values obtained through bootstrapping, R^2 , predictive relevance (Q^2), effect sizes, and specific indirect effects. Statistical significance was established at $\alpha = 0.05$.

4. Results

A. Descriptive Evidence of the Knowing–Doing Discontinuity

Occupational Safety Knowledge was relatively favorable, with 62% of respondents classified in the high or very high categories. Safety Leadership was also relatively strong, with 78% of respondents falling within the high or very high categories. In contrast, Safety Behavior was substantially weaker: 59% of workers were classified in the low category and 10% in the very low category, while only 4% were classified as high, with no respondents in the very high category. The mean scores for Safety Compliance (2.452) and Safety Participation (2.409) were both within the low category. This descriptive misalignment provides an initial indication of the safety behavior gap.

B. Measurement Model

Table 1: Measurement Model Assessment

Construct	Loading Range	α	CR	AVE
Safety knowledge (X1)	0.778–0.892	0.802	0.884	0.718
Safety attitude (X2)	0.752–0.890	0.768	0.867	0.685
Risk perception (X3)	0.828–0.890	0.831	0.898	0.746
Safety leadership (X4)	0.853–0.871	0.829	0.897	0.745
Safety culture (Z1)	0.843–0.869	0.820	0.893	0.735
Safety climate (Z2)	0.842–0.886	0.820	0.893	0.735
Safety motivation (Z3)	0.866–0.918	0.748	0.887	0.797
Safety behavior (Y)	0.850–0.877	0.659	0.854	0.745

All AVE values exceeded 0.50, while composite reliability values exceeded 0.85. Cronbach's alpha values were generally adequate. The Safety Behavior construct showed a lower alpha value (0.659); however, its composite reliability (0.854), AVE (0.745), and strong outer loadings supported the retention of the construct, although its interpretation should remain cautious.

C. Structural Model

Table 2: Structural Model Assessment

Endogenous construct	R ²	Adjusted R ²	Q ²
Safety behavior (Y)	0.703	0.694	0.507
Safety climate (Z2)	0.709	0.703	0.513
Safety culture (Z1)	0.531	0.524	0.381
Safety motivation (Z3)	0.531	0.522	0.405

The model explained 70.3% of the variance in Safety Behavior and 70.9% of the variance in Safety Climate. All endogenous constructs demonstrated positive predictive relevance ($Q^2 > 0$).

Table 3: Direct Effects and Hypothesis Testing Results

Path	β	t	p	Decision
X1 → Y	0.172	3.000	0.003	Significant
X1 → Z2	-0.031	0.635	0.526	Not Significant
X1 → Z1	0.086	1.266	0.206	Not Significant
X1 → Z3	0.075	1.157	0.248	Not Significant
X3 → Y	0.027	0.424	0.672	Not Significant
X3 → Z2	-0.098	1.826	0.068	Not Significant
X3 → Z1	0.036	0.462	0.644	Not Significant
X3 → Z3	0.224	3.136	0.002	Significant
Z2 → Y	0.369	3.244	0.001	Significant
Z2 → Z3	0.290	3.895	<0.001	Significant
Z1 → Y	0.096	1.026	0.305	Not Significant
Z1 → Z2	0.563	9.457	<0.001	Significant
X4 → Y	0.008	0.094	0.925	Not Significant
X4 → Z2	0.384	5.861	<0.001	Significant
X4 → Z1	0.548	7.395	<0.001	Significant
X4 → Z3	0.201	2.526	0.012	Significant
Z3 → Y	0.365	6.740	<0.001	Significant
X2 → Y	-0.032	0.430	0.668	Not Significant
X2 → Z2	0.047	0.733	0.464	Not Significant
X2 → Z1	0.147	1.228	0.220	Not Significant
X2 → Z3	0.102	1.235	0.218	Not Significant

Nine of the 21 direct paths were statistically significant. Occupational Safety Knowledge, Safety Climate, and Safety Motivation directly predicted Safety Behavior. Risk Perception did not have a direct effect on Safety Behavior but had a significant effect on Safety Motivation. Safety Leadership had strong effects on Safety Culture and Safety Climate and also influenced Safety Motivation, but it did not have a direct effect on Safety Behavior. Safety Culture had a strong effect on Safety Climate but did not directly influence Safety Behavior.

D. Specific Indirect Effects

Table 4: Specific Indirect Effects

Indirect Path	β	t	p
Z1 $\rightarrow$ Z2 $\rightarrow$ Y	0.208	3.064	0.002
X4 $\rightarrow$ Z2 $\rightarrow$ Y	0.142	2.516	0.012
X3 $\rightarrow$ Z3 $\rightarrow$ Y	0.082	2.755	0.006
Z1 $\rightarrow$ Z2 $\rightarrow$ Z3 $\rightarrow$ Y	0.060	2.923	0.004
X4 $\rightarrow$ Z1 $\rightarrow$ Z2 $\rightarrow$ Y	0.114	3.007	0.003
X4 $\rightarrow$ Z2 $\rightarrow$ Z3 $\rightarrow$ Y	0.041	2.741	0.006
X4 $\rightarrow$ Z1 $\rightarrow$ Z2 $\rightarrow$ Z3 $\rightarrow$ Y	0.033	2.989	0.003

All seven specific indirect effects tested were statistically significant. The largest specific mediation coefficient was observed for the pathway from Safety Culture through Safety Climate to Safety Behavior ($\beta = 0.208$; $p = 0.002$). The longest sequential pathway, from Safety Leadership through Safety Culture, Safety Climate, and Safety Motivation to Safety Behavior, was also significant ($\beta = 0.033$; $p = 0.003$), indicating a stepwise mechanism through which organizational factors are translated into worker behavior.

E. Key Findings

Overall, the study demonstrates a gap between safety antecedent conditions and workers' actual safety behavior. As many as 69% of workers were classified as having low to very low Safety Behavior, despite relatively positive levels of several safety antecedents. The structural model indicates that Safety Climate and Safety Motivation are important direct predictors of Safety Behavior, while Occupational Safety Knowledge also has a significant direct effect. In contrast, Risk Perception does not directly influence behavior but operates through Safety Motivation. Safety Leadership likewise has no direct effect on behavior but operates through Safety Culture, Safety Climate, and Safety Motivation. This pattern indicates that the safety behavior gap is not solely a matter of limited knowledge, but particularly concerns the process of transforming knowledge, awareness, organizational conditions, and motivation into consistent safety actions.

5. Discussion

A. From Knowing to Doing: The Safety Behavior Gap

The main finding of this study is not that workers completely lack safety resources, but rather that there are challenges in the process of transforming these resources into actual behavior. Safety Knowledge was relatively favorable and Safety Leadership was positively perceived, whereas Safety Compliance and Safety Participation remained low. This pattern supports the use of the safety behavior gap as a lens for understanding that the presence of knowledge, awareness, organizational systems, or motivation cannot be directly equated with consistent safe action.

The significant direct effect of Occupational Safety Knowledge on Safety Behavior confirms that knowing remains important. However, Safety Knowledge did not have significant effects on Safety Culture, Safety Climate, or Safety Motivation. Thus, knowledge can serve as a foundation for behavior without automatically developing into organizational or motivational processes. This finding is

consistent with the safety performance literature, which positions knowledge as an important condition, but not the sole requirement, for safe behavior.

B. Why Risk Awareness Requires Motivation

Risk Perception did not have a direct effect on Safety Behavior but had a significant effect on Safety Motivation, and the indirect pathway from Risk Perception through Safety Motivation to Safety Behavior was also significant. This indicates that risk awareness becomes behaviorally relevant when it generates the willingness to act. The implication is that risk communication that merely increases awareness of hazards may have limited effects if it does not simultaneously establish personal reasons and motivation for working safely.

C. Safety Climate and Safety Motivation as Translational Mechanisms

Safety Climate and Safety Motivation demonstrated relatively similar direct effects on Safety Behavior. This finding reinforces the view that workers respond not only to the existence of rules but also to the meaning they derive from management commitment, safety systems, communication, and the motivational value attached to safety. This pattern is consistent with the climate–motivation–behavior sequence described by Neal and Griffin [3] and the findings of Neal et al. [2].

D. Leadership Works Through the System, Not Merely Through Direct Control

Safety Leadership did not have a direct effect on Safety Behavior but significantly influenced Safety Culture, Safety Climate, and Safety Motivation. The sequential mediation pathway suggests that leadership becomes behaviorally meaningful when it is institutionalized through organizational values and practices, perceived as a credible safety climate, and subsequently internalized as motivation. This finding complements evidence from the construction sector regarding the cascading influence of leadership through Safety Climate and workers' psychological resources [5].

E. Surface Compliance as an Interpretive Caution

The low level of actual safety behavior despite relatively positive organizational antecedents raises the question of whether some observable compliance may be situational and not yet fully internalized. Hu et al. [6] distinguish between deep compliance and surface compliance and show that observable compliance is not necessarily equivalent to better safety outcomes. This study did not measure surface compliance as a latent construct and therefore does not claim that superficial compliance has been empirically demonstrated. Instead, this literature is used as a cautionary lens for interpreting the knowing–doing gap.

F. Theoretical Contributions

This study provides three contributions. First, individual and organizational factors are integrated into a single structural model and demonstrate different levels of proximity to Safety Behavior. Second, Safety Climate and Safety Motivation are identified as important translational mechanisms linking organizational context and individual awareness to action. Third, the safety behavior gap is developed as an empirical-conceptual synthesis of the misalignment between knowing–awareness–motivation and doing–compliance–participation. The concept is not proposed as a new latent construct but as a theoretical interpretation supported by descriptive and structural patterns.

G. Practical Implications

Construction safety programs need to move beyond repeated information delivery and rule enforcement. Management should identify specific behaviors that need to change, connect risk awareness with personal reasons for working safely, provide practice- and behavior-based training, monitor behavioral

changes, provide corrective feedback, and strengthen active participation. Leadership should also ensure that safety values are translated into credible daily systems and communication because Safety Climate and Safety Motivation represent mechanisms that are relatively close to actual behavior.

6. Limitations and Future Research Agenda

The cross-sectional design limits causal inference. Most measures were based on self-reports and may therefore be subject to common-method and social-desirability bias. The sample was drawn from construction projects within a single province, requiring replication across regions, project types, and countries. The safety behavior gap represents an empirical-conceptual synthesis and has not been measured as a separate construct. Future research should combine surveys with repeated behavioral observations, incident data, longitudinal designs, measures of deep and surface compliance, and intervention studies assessing behavioral change before and after implementation.

7. Conclusion

Construction safety is not merely a matter of ensuring that workers know how to work safely. In this study, relatively favorable Safety Knowledge and several organizational antecedents coexisted with low levels of Safety Compliance and Safety Participation. The SEM results indicate that Safety Climate and Safety Motivation are important mechanisms for translating organizational conditions and risk awareness into action, while the influence of Safety Leadership primarily operates through Safety Culture, Safety Climate, and Safety Motivation. The safety behavior gap represents a critical discontinuity between the potential for safe behavior and its consistent application. Closing this gap requires behavioral transformation: turning what workers know and recognize into what they actually do, routinely practice, and actively support.

References

1. M. A. Griffin and A. Neal, "Perceptions of safety at work: a framework for linking safety climate to safety performance, knowledge, and motivation.," *J. Occup. Health Psychol.*, vol. 5, no. 3, p. 347, 2000, doi: doi.org/10.1037/1076-8998.5.3.347.
2. A. Neal, M. A. Griffin, and P. M. Hart, "The impact of organizational climate on safety climate and individual behavior," *Saf. Sci.*, vol. 34, no. 1–3, pp. 99–109, 2000, doi: [doi.org/10.1016/S0925-7535\(00\)00008-4](https://doi.org/10.1016/S0925-7535(00)00008-4).
3. A. Neal and M. A. Griffin, "A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels.," *J. Appl. Psychol.*, vol. 91, no. 4, p. 946, 2006, doi: doi.org/10.1037/0021-9010.91.4.946.
4. M. S. Christian, J. C. Bradley, J. C. Wallace, and M. J. Burke, "Workplace safety: a meta-analysis of the roles of person and situation factors.," *J. Appl. Psychol.*, vol. 94, no. 5, p. 1103, 2009, doi: doi.org/10.1037/a0016172.
5. C. He, B. McCabe, and G. Jia, "Effect of leader-member exchange on construction worker safety behavior: Safety climate and psychological capital as the mediators," *Saf. Sci.*, vol. 142, p. 105401, 2021, doi: doi.org/10.1016/j.ssci.2021.105401.
6. X. Hu, G. Yeo, and M. Griffin, "More to safety compliance than meets the eye: Differentiating deep compliance from surface compliance," *Saf. Sci.*, vol. 130, p. 104852, 2020, doi: doi.org/10.1016/j.ssci.2020.104852.

doi.org/10.1016/j.ssci.2020.104852.

7. I. Ajzen, "The theory of planned behavior," *Organ. Behav. Hum. Decis. Process.*, vol. 50, no. 2, pp. 179–211, 1991.
8. A. Bandura, "Social foundations of thought and action," *Englewood Cliffs, NJ*, vol. 1986, no. 23–28, p. 2, 1986.
9. D. Zohar, "Safety climate in industrial organizations: theoretical and applied implications.," *J. Appl. Psychol.*, vol. 65, no. 1, p. 96, 1980, doi: doi.org/10.1037/0021-9010.65.1.96.
10. F. W. Guldenmund, "The nature of safety culture: a review of theory and research," *Saf. Sci.*, vol. 34, no. 1–3, pp. 215–257, 2000, doi: [doi.org/10.1016/S0925-7535\(00\)00014-X](https://doi.org/10.1016/S0925-7535(00)00014-X).