

## IMPLEMENTATION SAFETY CONSTRUCTION CYCLE TO IMPROVE SAFETY AWARENESS, MOTIVATION, AND REDUCE UNSAFE ACTION AMONG SUBCONSTRUCTION WORKER

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### Abstract

Unsafe actions remain the leading cause of occupational accidents among subcontractor workers in manufacturing industries, despite widespread safety programs. Persistent gaps in safety awareness and motivation highlight the need for a theory-driven behaviour intervention. This study aimed to evaluate the effectiveness and mechanism of the Safety Construction Cycle, developed based on the Loss Causation Model, in improving safety awareness and motivation while reducing unsafe actions. A quasi-experimental study with a not equivalent control group design was conducted among 120 subcontractor workers at PT X, consisting of an intervention group (n=60) and a control group (n=60). The intervention group received the Safety Construction Cycle over two weeks through six iterative cycles integrating safety communication, behaviour observation, hazard prediction, management engagement, and reinforcement, while the control group continued routine practices. Safety awareness was analysed using the paired sample t-test, whereas safety motivation and unsafe actions were analysed using the Wilcoxon signed-rank test. Between-group differences were assessed using the Mann Whitney U test. The results showed significant improvements in safety awareness and motivation and a reduction in unsafe actions in the intervention group (all  $p < 0.001$ ), with no significant changes in the control group ( $p > 0.05$ ). Post-intervention comparisons confirmed significant differences between groups ( $p < 0.001$ ). That novelty of this program lies in its cyclical, integrated approach that operationalizes the Loss Causation Model by linking management control, basic causes (awareness and motivation), and unsafe actions. Practically, it offers a scalable intervention to enhance safety performance in high-risk industries.

Keywords: Construction; Cycle; Occupational Safety; Safety Awareness; Safety Motivation.

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### 1. INTRODUCTION

Despite substantial advances in occupational safety and health (OSH) management systems, occupational accidents continue to impose a considerable burden on industries worldwide. According to the

International Labour Organization (ILO), approximately 2.93 million workers die annually due to occupational accidents and work-related diseases, while nearly 395 million non-fatal occupational injuries occur each year (1). Importantly, investigations consistently indicate

that most occupational accidents are associated with unsafe actions, suggesting that improvements in technical controls and safety regulations alone are insufficient to eliminate workplace incidents (2). The construction sector remains one of the highest risk industries because many work processes involve hazardous machinery, heavy equipment, welding operations, confined spaces, and work at height (3).

Subcontractor workers construction represent one of the most vulnerable occupational groups within industries (4). Unlike permanent employees, contractor personnel frequently perform temporary, maintenance, and installation, requiring rapid adaptation to different work environments and organizational safety cultures (5). These conditions increase their exposure to workplace hazards while simultaneously creating challenges in maintaining consistent safety behavior. Consequently, contractor safety management has become an increasingly important concern for construction companies seeking to reduce occupational accidents and improve overall safety performance (6).

Relationship between unsafe action and occupational accidents has long been explained by the Loss Causation Model proposed by Bird and Germain. Rather than viewing accidents as isolated events, the model suggests that unsafe actions and unsafe conditions are immediate

causes that originate from deficiencies in management control, organizational systems, job related factors, and individual characteristics (7). This perspective emphasizes that accident prevention should not rely solely on engineering controls or regulatory compliance but should also address the behavioral factors influencing workers' daily safety decisions. Accordingly, interventions designed to improve safety behavior are expected to play an essential role in preventing occupational accidents (8).

Among the behavioral factors associated with workplace safety, safety awareness and safety motivation have consistently been identified as key predictors of safe work behavior (9). Workers with adequate safety awareness are more capable of recognizing hazards, assessing risks, and selecting safer work practices before accidents occur. Likewise, workers with stronger safety motivation demonstrate greater willingness to comply with safety procedures, actively participate in safety initiatives, and maintain safe behavior even under production pressure (10). Previous studies have consistently reported that improvements in these two behavioral attributes are associated with higher safety compliance, stronger safety participation, and lower unsafe action (11). However, evidence also suggests that safety awareness and safety motivation cannot be sustainably improved

through conventional knowledge-based training alone, as behavioral change requires continuous reinforcement within everyday work activities (12).

Prior research on safety culture in the construction industry has mostly focused on discrete factors like safety leadership or safety climate, which has led to fragmented and inconsistent results about behavioral safety outcomes. Furthermore, the majority of studies uses static, cross-sectional methods that fall short of capturing the dynamic process necessary to concurrently increase safety awareness, boost motivation, and decrease risky behavior. Integrative and intervention-based models that methodically connect the behavioral (unsafe action), affective (safety motivation), and cognitive (safety awareness) aspects of a continuous improvement framework are still lacking (13). In order to close this gap, this study presents the Safety Construction Cycle, an organized and iterative intervention paradigm designed to improve safety awareness, increase safety motivation, and decrease dangerous behavior in construction environments (14).

In practice, organizations commonly implement safety briefings, toolbox meetings, and periodic safety training as part of routine occupational safety programs. Although these interventions improve workers' understanding of safety procedures, their effectiveness in

producing long-term behavioral change remains inconsistent because they primarily focus on knowledge transfer rather than continuous behavioral reinforcement (15). Workers often understand safe work procedures yet continue performing unsafe actions due to production demands, workload pressures, fatigue, habitual behavior, or insufficient supervisory feedback (16). These limitations indicate that sustainable behavioral improvement requires an intervention integrating communication, workplace observation, immediate feedback, management commitment, and active worker participation within a continuous improvement process.

Behavior Based Safety (BBS) is the foundation of the Safety Construction Cycle, which has four domains: Define, Observe, Intervene, and Test. Subsequently, the goal of the Safety Construction Cycle is to assist organizations in mitigating the risks associated with construction work. Through the cycles of Safety Inspection, Communication Sharing, Management Sharing & Safety Reflection, Identification Hazard, Safety Briefing, and Safety Evaluation, the focus Safety Construction Cycle reduces risk (17). Safety Construction Cycle was developed to address these challenges through an integrated behavioral safety intervention. Unlike conventional safety programs that are implemented as separate activities, the combines safety communication,

behavioral observation, hazard prediction, management engagement, and reinforcement into a structured and continuous intervention cycle (18). The program encourages workers to actively identify hazards, discuss workplace risks, receive immediate feedback on unsafe behaviors, and continuously strengthen safe work practices through repeated observation, evaluation, and behavioral reinforcement. Such an approach is expected not only to improve workers' understanding of occupational safety but also to strengthen their intrinsic motivation to consistently perform safe work behaviors (19).

Although previous studies have demonstrated the effectiveness of individual interventions, including safety communication, behavioral observation, safety training, and feedback in improving workplace safety, limited evidence has evaluated an integrated intervention that systematically combines these behavioral components within a continuous improvement cycle, particularly among contractor workers in construction industries (20). Moreover, most existing studies have focused on a single behavioral outcome rather than simultaneously evaluating safety awareness, safety motivation, and unsafe action (21). Addressing these gaps, this study effect implementation of the Safety Construction Cycle to improve safety awareness and safety

motivation while reducing unsafe action among subcontractor construction workers at PT X.

## 2. METHOD

This study employed a quantitative quasi-experimental design with a nonequivalent control group to evaluate the effects of the Safety Construction Cycle on safety awareness, safety motivation, and unsafe actions among subcontractor construction workers at PT X, Indonesia (22). The study population comprised 352 contractor workers. Eligible participants were subcontractor workers involved in high-risk activities, including working at heights, hot work, and operating heavy or specialized equipment, at the field operator level. Based on the Slovin formula with a 5% margin of error, the minimum sample size was 116 respondents, which was increased to 120. Participants were divided into an intervention group and a control group, each consisting of 60 respondents, using a lottery-based randomization procedure (23).

The study variables included safety awareness, safety motivation, and unsafe actions, while age, educational level, and work experience were collected as demographic characteristics. The intervention group received the Safety Construction Cycle over two weeks through six interdependent cycles: safety communication, safety inspection, hazard identification, management engagement, safety briefings, and reinforcement through rewards and corrective actions. Each cycle lasted 1–2

hours and involved management representatives, two SHE officers from PT X as persons in charge, two subcontractor safety leaders, and all participating subcontractor workers. All cycles followed a standardized protocol under the research team's supervision, and incomplete cycles required the program to be repeated from the beginning. The control group continued routine company safety activities without the intervention.

Data were collected using structured self-administered questionnaires administered before and after the intervention. The final instruments comprised 11 safety awareness items, 12 safety motivation items, and 13 unsafe action items, measured using a five-point Likert scale. The questionnaires were adapted from previously validated instruments and reassessed for validity and reliability. Items that did not meet the validity criteria were excluded, resulting in four items removed from the safety awareness questionnaire, three from the safety motivation questionnaire, and three

from the unsafe action questionnaire. Cronbach's alpha coefficients were 0.896, 0.914, and 0.925, respectively, indicating good internal consistency.

Data were analyzed using IBM SPSS Statistics. Descriptive statistics summarized participants' characteristics, while Spearman's rank correlation assessed the relationships between age, education, work experience, and the study outcomes. Changes in normally distributed safety awareness scores were analyzed using the paired-samples t-test, whereas the Wilcoxon signed-rank test was used for non-normally distributed data. Post-intervention outcomes were compared between groups using the Mann–Whitney U test. Statistical significance was set at  $p < 0.05$  (24). This study has obtained ethical clearance approval from Dr. Moewardi Hospital in Surakarta, as evidenced by the issuance of ethical clearance letter number: Nomor: 1.161/VI/HREC/2026.

### 3. RESULTS AND DISCUSSION

#### Results

Table 1. Characteristics of the Participants

| Characteristic                            | Value            |
|-------------------------------------------|------------------|
| Age (years), mean $\pm$ SD                | 39.01 $\pm$ 8.71 |
| Working experience (years), mean $\pm$ SD | 14.48 $\pm$ 7.34 |
| <b>Education, n (%)</b>                   |                  |
| Junior high school                        | 19 (15.8)        |
| Vocational high school                    | 101 (84.2)       |

Sources: Primary Data, 2026

A total of 120 contractor workers participated in this study (Table 1). The

participants had a mean age of 39.01  $\pm$  8.71 years and an average work experience of 14.48

± 7.34 years. Most participants had completed vocational high school education (84.2%), while 15.8% had completed junior high school.

Table 2. Relationships between Participant Characteristics and Study Outcomes

| Characteristic     | Safety Awareness p<br>(P-value) | Safety Motivation p<br>(P-value) | Unsafe Action p<br>(P-value) |
|--------------------|---------------------------------|----------------------------------|------------------------------|
| Age                | -0.004 (0.978)                  | 0.109 (0.409)                    | -0.158 (0.228)               |
| Working experience | 0.057 (0.663)                   | 0.074 (0.574)                    | -0.206 (0.114)               |
| Educational level  | 0.032 (0.807)                   | -0.276 (0.033)                   | 0.192 (0.143)                |

Source : Primary Data, 2026

Table 2 shows the relationships between participants' demographic characteristics and the study outcomes. Educational level was significantly associated with safety motivation ( $p = -0.276$ ,  $p = 0.033$ ). However, no significant relationships were identified between age or working experience and safety awareness, safety motivation, or unsafe action ( $p > 0.05$ ). Likewise, educational level was not significantly associated with safety awareness or unsafe action.

Table 3. Normality Test

| No | Groups     | Safety Awareness<br>P-value | Safety Motivation<br>P-value | Unsafe Action<br>P-value |
|----|------------|-----------------------------|------------------------------|--------------------------|
| 1  | *Control   | 0,200                       | 0,200                        | 0,003                    |
| 2  | Experiment | 0,200                       | 0,033                        | 0,001                    |
| 3  | **Control  | 0,200                       | 0,017                        | 0,058                    |
| 4  | Experiment | 0,022                       | 0,003                        | 0,200                    |

Sources: Primary Data, 2026; \* Data Pretest, \*\*Data Posttest

Based on Table 3, the normality test for the variables of safety awareness, safety motivation, and unsafe actions was conducted using the Kolmogorov Smirnov test. Since the p-value was greater than 0.05, it can be concluded that the data are normally distributed.

Table 4. Within-Group Changes in Safety Awareness Following the Safety Construction Cycle

| Group        | Pre-test<br>(Mean ± SD) | Post-test<br>(Mean ± SD) | Statistical Test          | P-value |
|--------------|-------------------------|--------------------------|---------------------------|---------|
| Intervention | 36.05 ± 4.36            | 48.50 ± 3.42             | Paired Sample t-test      | <0.001  |
| Control      | 36.28 ± 4.36            | 36.90 ± 4.80             | Wilcoxon Signed Rank Test | 0.092   |

Sources: Primary Data, 2026

As presented in Table 4, safety awareness increased substantially in the intervention group following implementation of the Safety Construction Cycle, with the mean score increasing by 12.45 points. In contrast, the control group demonstrated only a slight increase of 0.62 points. Statistical analysis confirmed a significant improvement in safety awareness within the intervention group ( $p < 0.001$ ), whereas the change

observed in the control group was not statistically significant ( $p = 0.092$ ).

Table 5. Between-Group Comparison of Safety Awareness After the Intervention

| Outcome          | Intervention<br>(Mean $\pm$ SD) | Control<br>(Mean $\pm$ SD) | Statistical Test           | P-value |
|------------------|---------------------------------|----------------------------|----------------------------|---------|
| Safety Awareness | 48.50 $\pm$ 3.42                | 36.90 $\pm$ 4.80           | Mann–Whitney <i>U</i> test | <0.001  |

Sources: Primary Data, 2026

Following the intervention, the intervention group achieved significantly higher safety awareness scores than the control group ( $p < 0.001$ ), indicating that the Safety Construction Cycle was more effective than routine workplace safety practices in improving workers' safety awareness (Table 5).

Table 6. Within-Group Changes in Safety Motivation Following the Safety Construction Cycle

| Group        | Pre-test<br>(Mean $\pm$ SD) | Post-test<br>(Mean $\pm$ SD) | Statistical Test          | <i>p</i> -value |
|--------------|-----------------------------|------------------------------|---------------------------|-----------------|
| Intervention | 38.43 $\pm$ 5.48            | 52.73 $\pm$ 3.59             | Wilcoxon Signed Rank Test | <0.001          |
| Control      | 39.48 $\pm$ 4.37            | 40.27 $\pm$ 4.96             | Wilcoxon Signed Rank Test | 0.078           |

Sources: Primary Data, 2026

As shown in Table 6, safety motivation increased markedly in the intervention group after implementation of the Safety Construction Cycle, with the mean score increasing by 14.30 points. Conversely, only a minimal increase (0.79 points) was observed in the control group. The increase in safety motivation was statistically significant in the intervention group ( $p < 0.001$ ) but not in the control group ( $p = 0.078$ ).

Table 7. Between-Group Comparison of Safety Motivation After the Intervention

| Outcome           | Intervention<br>(Mean $\pm$ SD) | Control<br>(Mean $\pm$ SD) | Statistical Test           | <i>p</i> -value |
|-------------------|---------------------------------|----------------------------|----------------------------|-----------------|
| Safety Motivation | 52.73 $\pm$ 3.59                | 40.27 $\pm$ 4.96           | Mann–Whitney <i>U</i> test | <0.001          |

Sources: Primary Data, 2026

Post-intervention safety motivation scores differed significantly between the intervention and control groups ( $p < 0.001$ ) (Table 7), demonstrating that participants receiving Safety Construction Cycle achieved higher levels of safety motivation than those receiving routine safety practices.

Table 8. Within-Group Changes in Unsafe Action Following the Safety Construction Cycle

| Group        | Pre-test<br>(Mean $\pm$ SD) | Post-test<br>(Mean $\pm$ SD) | Statistical Test             | <i>p</i> -value |
|--------------|-----------------------------|------------------------------|------------------------------|-----------------|
| Intervention | 46.55 $\pm$ 3.84            | 32.00 $\pm$ 4.76             | Wilcoxon Signed Rank Test    | <0.001          |
| Control      | 48.57 $\pm$ 4.14            | 48.52 $\pm$ 5.63             | Paired Sample <i>t</i> -test | 0.935           |

Sources: Primary Data, 2026

Table 8 demonstrates a marked reduction in unsafe action following implementation of the SafeCon Cycle Program. The intervention group experienced a decrease of 14.55 points,

whereas the control group showed virtually no change (0.05 points). Statistical analysis confirmed a significant reduction in unsafe

action within the intervention group ( $p < 0.001$ ), while the control group showed no statistically significant change ( $p = 0.935$ ).

Table 9. Between-Group Comparison of Unsafe Action After the Intervention

| Outcome       | Intervention<br>(Mean $\pm$ SD) | Control<br>(Mean $\pm$ SD) | Statistical Test           | p-value |
|---------------|---------------------------------|----------------------------|----------------------------|---------|
| Unsafe Action | 32.00 $\pm$ 4.76                | 48.52 $\pm$ 5.63           | Mann–Whitney <i>U</i> test | <0.001  |

Sources: Primary Data, 2026

The post-intervention unsafe action score was significantly lower in the intervention group than in the control group ( $p < 0.001$ ) (Table 9), indicating that the Safety Construction Cycle was effective in reducing unsafe actions among contractor workers.

### Discussion

The results of this study show that by increasing safety awareness and safety motivation while decreasing unsafe acts, the Safety Construction Cycle considerably helps to behavioral change. However, this study contends that functions through a multi-layered socio-cognitive mechanism where cognitive (awareness), affective (motivation), and behavioral (action) domains interact dynamically, as opposed to perceiving these effects as direct linear consequences(25). Recent empirical data demonstrating that safety culture affects safety consciousness and behavior through mediating mechanisms including engagement and social exchange processes is consistent with this hypothesis. As a result, Safety Construction Cycle serves as a behavioral transformation system that initiates internal psychological processes that result in

persistent safety behavior rather than just a training intervention (26).

Crucially, the predominance of safety awareness and motivation in explaining behavioral change is consistent with recent research showing that risky behavior is more strongly motivated by inadequacies in awareness, knowledge, and risk perception than by procedural non compliance alone (27). This calls into question conventional compliance based safety management, which is predicated on the idea that merely implementing regulations will alter behavior. Rather, the current results support the claim that the main factor influencing safety performance in high-risk construction situations is behavioral internalization rather than external enforcement (28).

However, it would be conceptually insufficient to attribute behavioral change exclusively to the Safety Construction Cycle. This study specifically recognizes that contextual elements serve as both enablers and limitations for safety behavior, which is entrenched within a larger organizational structure(29). For example, it has been

demonstrated that the psychosocial safety atmosphere both directly affects safety behavior and modifies the efficacy of motivational pathways. Practically speaking, this means that organizational preparedness specifically, the degree to which the workplace promotes psychological safety, lowers stress levels, and upholds safe practices determines the efficacy of Safety Construction Cycle (30).

Additionally, organizational safety support particularly from coworkers and supervisors is essential for boosting safety motivation and converting it into real behavior (31). This implies that Safety Construction Cycle should be viewed as a catalytic process that necessitates alignment with social support networks and leadership approaches rather than as a stand-alone intervention. The noted increases in motivation and awareness might not fully result in long-term behavioral change in the absence of such alignment (32).

The association between safety climate and safety behavior has been demonstrated to be weakened by workload and safety related stress, which is another crucial border condition. Excessive workloads may compel employees to put production ahead of safety, negating the benefits of motivation and awareness (33). This draws attention to a significant theoretical implication: behavioral change initiatives are context dependent and not always successful, necessitating

concurrent control of operational pressures (34). From a systems perspective, risky behavior in construction is the result of interactions between group dynamics, environmental factors, and safety management procedures rather than just an isolated incident. Thus, systemic alignment where Safety Construction Cycle works in concert with current safety management systems, organizational rules, and team-level influences should be seen as the cause of the decrease in risk behavior seen in this study (35).

#### **Research Limitations**

This study focuses on construction subcontractor workers on a single company project, thus necessitating research on the same topic across various industrial sectors..

#### **4. CONCLUSIONS**

The Safety Construction Cycle serves as a behavioral safety intervention that improves safety awareness, enhances safety motivation, and decreases unsafe behaviors among subcontractor workers through the integration of safety communication, safety inspections, hazard identification, management engagement, and continuous reinforcement.

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#### **Conflict of Interest**

The authors declare no conflict of interest.

#### **Ethical Clearance**

This study has obtained ethical clearance approval from Dr. Moewardi Hospital in Surakarta, as evidenced by the issuance of ethical clearance letter number: Nomor: 1.161 / VI / HREC / 2026 dated: July 02, 2026.

#### **Author Contributions**

Conceptualization: BC; Methodology: BC; Supervision: BC; Investigation: S; Writing – original draft: S; Visualization: FSNS, MPW; Formal analysis: FSNS, YRA, RP, MPW; Validation: YRA, RP; Software: RP; Data curation: RW; Writing – review & editing: RW. All authors have read and approved the final version of the manuscript.

#### **Artificial Intelligence (AI) Use Disclosure / AI**

##### **Usage Statement**

The authors used artificial intelligence (AI) tools to assist with language editing and

improve the clarity of the manuscript. All authors take full responsibility for the accuracy, integrity, and final content of the manuscript.

#### **Data Availability**

The author cannot share the research data in order to protect the confidentiality of the respondents' data.

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