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RESEARCH ARTICLE

FORMULATION OF SAFETY PREDICTORS IN CONSTRUCTION SITES THROUGH THE LENS OF THEORY OF PLANNED BEHAVIOUR: A DEMATEL BASED MODEL

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ABSTRACT - The construction sector drives our country's economic growth and fosters the development of human resources. Yet, the industry faces a significant challenge with a heightened rate of workplace fatalities, making safety a pressing concern. Unsafe working environments and employee conduct contribute to the escalation of construction accidents. Addressing safety compliance and safety participation is critical for improving safety performance. Past studies have concentrated around technological approaches, leaving a notable gap in exploring behavioural interventions within the workplace. The critical factors that influence safety compliance intention and safety participation would be best explained by using Theory of Planned Behaviour (TPB). TPB posits that actual behaviour can be predicted by intention, while the formation of intention is mainly determined by attitude, subjective norms and perceived behavioural control. Although the TPB framework is considered, there remains a lack of evidence substantiating the correlation between the safety predictors, safety compliance intention, and safety participation. This study investigates the impact of safety predictors on both safety compliance intention and safety participation through the application of the Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique. Through DEMATEL technique, 25 experts were enlisted to offer pairwise rankings regarding the predictors influencing both safety compliance intention and safety participation. The predictors examined in the study include Attitude, Subjective Norm and Perceived Behavioural Control. The research findings highlighted substantial interconnections among all safety predictors, with "Attitude" identified as the most influential predictor among them. Organizations should prioritize this to enhance safety performance. Enhancing safety performance in construction projects becomes feasible through comprehensive understanding and intervention in the interconnections among safety predictors, safety compliance intention, and safety participation.

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INTRODUCTION

The construction industry continues to be one of the most perilous sectors (Khahro, Memon & Memon, 2020; Lee et al., 2019), contributing to 30% to 40% of all work-related injuries and fatalities, despite employing only approximately 7% of the total labour force. The intricate interplay between the dynamic environment and various safety-influencing factors poses numerous challenges in managing construction projects. These challenges introduce uncertainties that demand effective and targeted resolutions in construction project management (Mohammadi & Khosravi, 2018).

Construction projects are dynamic and undergo frequent changes, characterized by inherent risks (Newaz, Davis, Jefferies, & Pillay, 2016). Ensuring workplace safety has been a persistent concern for researchers and practitioners alike. The repercussions of inadequate workplace safety behaviour can be severe. The prevalence of poor safety compliance and participation on construction sites leads to substantial losses for various stakeholders, as mishaps contribute to significant financial and social burdens. Incidents resulting in workplace injuries and fatalities cause considerable losses for both individuals and communities (Xu et al., 2021). Therefore, addressing workers' safety is a pressing matter that demands swift resolution to prevent adverse effects on organizational costs and subsequent declines in productivity (Singh & Misra, 2020).

Enhancing site safety necessitates a comprehensive understanding of compliance behaviours on construction sites. The fundamental key to achieving successful safety performance lies in grasping the intricacies of safety compliance behaviour (Hu, Yeo, & Griffin, 2020). The examination of crucial factors influencing safety behaviour and compliance will be conducted utilizing the Theory of Planned Behaviour (TPB). TPB asserts that the prediction of actual behaviour is contingent upon intention, and the formation of intention is predominantly influenced by attitude, subjective norms,

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and perceived behavioural control. Even though the suggested framework takes the Theory of Planned Behaviour (TPB) into account, there is little literature currently available that examines cognitive domains (particularly subjective norms, attitude, and perceived behavioural control) and safety behaviour elements (safety compliance and safety participation). Empirical data also does not support the relationship between the intention to comply with safety and the interaction of safety predictors within construction project sites.

Moreover, safety participation has gained prominence as a crucial aspect of safety behaviours among construction workers (Choi & Lee, 2022). Despite previous attempts to identify variables influencing safety participation among workers, there is a lack of clarity regarding how these factors impact the mechanisms of individual behaviour (Asilian-Mahabadi, Khosravi, Hassanzadeh-Rangi, Hajizadeh, & Behzadan, 2020). Furthermore, these studies have yet to pay attention to the interdependencies among the micro-level safety predictors, safety compliance intention, and safety participation in construction project sites.

Major construction projects in Malaysia are susceptible to hazardous conditions that can result in accidents, jeopardizing the overall safety outcomes of the project. However, there is a notable scarcity of research on the safety predictors influencing the safety performance of the construction field in Malaysia (Albarkani & Shafii, 2021). The impact of safety compliance and safety participation on safety performance is significant and requires attention. While prior studies concentrated on technological methods to improve safety, behavioural interventions on the job were largely overlooked.

Limited research has investigated the application of planned behaviour in addressing safety compliance and safety participation on construction sites. Furthermore, there is a notable absence of studies that have mapped the interrelationships between safety predictors, safety compliance intention, and safety participation in construction project sites using the DEMATEL technique. Considering these identified gaps, this study endeavours to formulate a model for safety predictors that can predict both safety compliance and safety participation among construction workers. A unique model utilizing DEMATEL will be formulated to explore the interrelationships among safety predictors, safety compliance and safety participation on construction project sites.

LITERATURE REVIEW

Safety Behaviour

Safety behaviour refers to job performance focused on safety, and it is also one of the most important variables in preventing accidents (Sampson, Armond, & Chen, 2014). According to Seo, Lee, Kim, and Jee (2015), safety behaviours are personal measures undertaken for self-defence, including adhering to regulations for safety to avoid harm to themselves and others, as well as wearing protective gear. Safety behaviour has been determined to be a vital safety performance indicator (Hinze, Thurman, & Wehle, 2013) since it has been demonstrated to reduce the likelihood of injuries, dangerous events, and mishaps along with other critical safety results (Aryee & Hsiung, 2016). As a result, safety behaviour is a critical factor in regulating and enhancing safety in construction sites (Fang, Wu, & Wu, 2015). According to work performance theory, two elements of safety behaviour (performance) are established; the first is safety compliance, while the other is safety participation (Borman & Motowidlo, 1993).

Safety Compliance

This article is a preliminary investigation to establish safety predictors for behavioural safety compliance in the construction sector. Safety compliance refers to the first element of the expression “safety behaviour” and is more frequently applied to study safety performance systems, with safety participation being the other component. The term “safety compliance” describes “the main actions that an individual must exhibit to maintain the workplace’s safety” (Griffin & Neal, 2000). “I apply all required protective gear to conduct my work” is a sample predictor for determining safety compliance. Safety compliance was explained as workplace behaviours aimed at adhering to the minimum safety standards (Inness et al., 2010).

Safety Participation

Safety participation refers to workers’ additional contribution to safety practices, including involving actively in safety meetings, passionately assisting co-workers in accomplishing safety work activities and constructively providing safety suggestions (Liu, Ye, & Guo, 2019). Safety participation is becoming more widely recognised as a key aspect of construction workers’ safety behaviours (Choi & Lee, 2022). Safety participation correlates directly to situational performance and corresponds to “behaviours which do not immediately impact personal safety, however, support the development of an environment that promotes safety”. It refers to the voluntary actions employees take to improve safety, including aiding colleagues, voicing safety concerns, and providing suggestions to improve safety (Griffin & Neal, 2000). “I make every effort to enhance workplace safety” is a sample indicator for measuring safety participation.

Theory of Planned Behaviour as Safety Predictor

Ajzen (1991) first proposed the theory of planned behaviour to indicate general individual behaviours. Three fundamental elements, which involve attitude on a behaviour, subjective norm, and perceived behavioural control, motivate a behavioural intention and then influence the individual’s actual behaviour. The theory of planned behaviour was indeed a generic design; the constructs in this research were adjusted to suit the construction industry better. Behavioural intention (BI) is an assembly of three factors, which include Attitude (A), Subjective Norm (SN), and Perceived Behavioural Control (PBC). The individuals' attitudes, subjective norms, and perceived behaviour control were connected to their behavioural intention and actual behaviour under the TPB framework (Swarna, Tezeswi, & Siva, 2022). It has long been used to anticipate and explain individual behaviour.

The favourable or unfavourable judgement of safety compliance by construction workers is referred to as attitude toward safety compliance. Construction workers seem more inclined to comply with safety requirements when they have a positive attitude toward it. Construction workers' subjective norm is that persons who are important to them believe they should comply with safety requirements. Construction workers are more inclined to follow safety requirements if they perceive those important to them agree. Construction workers' perceptions of how simple or challenging it is to comply with safety requirements are known as perceived behavioural control. Construction workers with a stronger perceived level of behavioural control over safety compliance are more likely to do so.

Intention Towards Safety Behaviour

Intention is the most immediate behaviour predictor. Individual's intentions indicate how difficult they are prepared to attempt or the amount of effort they are ready to put into accomplishing a behaviour (Lee, Yiu, & Cheung, 2018b). The intention to act is analogous to an individual's action choice. As per the research and theories proposed by Fishbein and Ajzen (2011), determining the behavioural intention construct is the same as assessing the real behavioural framework of many behaviours, including any construction workers who do not wear safety shoes, helmets and protective gloves. Safety behaviour can be forecasted from an individual's intentions, and the effects of intentions can be mitigated through practical controls such as abilities, skills and environmental factors. Intention towards safety compliance can be determined by attitudes towards safety compliance, subjective norms towards safety compliance and control of perceived behaviour towards safety compliance (Goh, Ubeynarayana, Wong, & Guo, 2018).

Attitude Towards Safety Behaviour

Attitude can be defined as one's positive or negative feelings toward a specific behaviour (Lee, Yiu, & Cheung, 2018a; Lee et al., 2018b). An individual's attitude toward the attributes of a behaviour is formed by his belief about that behaviour. The total of one's beliefs about the outcomes of executing a particular action, including the outcome of compliance with requirements for safety, in the context of investigations like "Compliance with safety requirements will ensure my safety", is multiplied by the assessment of the repercussions (e.g., desirability of compliance in the form of questions like "Compliance with safety requirements and ensure my safety is Good/Bad"). People's attitudes are said to be driven by their attitudinal beliefs. They are influenced by the perceived repercussions of behaviour as well as people's assessments of these repercussions (Fishbein & Ajzen, 1980).

Subjective Norm Towards Safety Behaviour

Subjective norm is identified as the person's social constraint to perform or refrain from performing that specific intended act (Lee et al., 2018b). It is determined by adding the outcome of normative beliefs, representing the site personnel's perception of the importance of other people/groups (for example, the probability that the site personnel's peers, important friends, and families will support, agree, or assert pressure on his decision to complete and comply with the safety requirements), by the intention to comply, that also refers to the motivation to conform to people's or group's perceived expectations. For instance, a site employee may feel intense pressure from essential family or friends to comply with safety rules, and the site personnel has a strong and essential feeling to comply. The function of this normative belief is to convey to site personnel the perceptions of other significant persons.

Perceived Behavioural Control Towards Safety Behaviour

Perceived behavioural control (PBC) refers to one's belief and confidence in one's capacity to execute an action. It is consistent with the concept of self-efficacy. It speaks of the apparent simplicity or complexity of carrying out a behaviour. PBC relates to beliefs according to the previous behaviour, prior knowledge, secondary data, the opportunities, and resources accessible, in addition to four self-efficacy theory sources such as performance successes, persuasive speech, activation of emotions, and simulated experiences. Fewer resources and a lack of opportunity will reduce the perceived control over behaviour. PBC can be illustrated with the following. For example, site personnel might feel a lack of availability, time, and control in complying with the safety requirement, and the site personnel might think that being in control of availability and time is very important in compliance with the project. The more control one feels they have over an action, the more serious the intention that the particular site personnel would act on it (Lee et al., 2018a).

Conceptual Safety Behaviour Model

The conceptualized safety behaviour model is displayed in Figure 1 below.

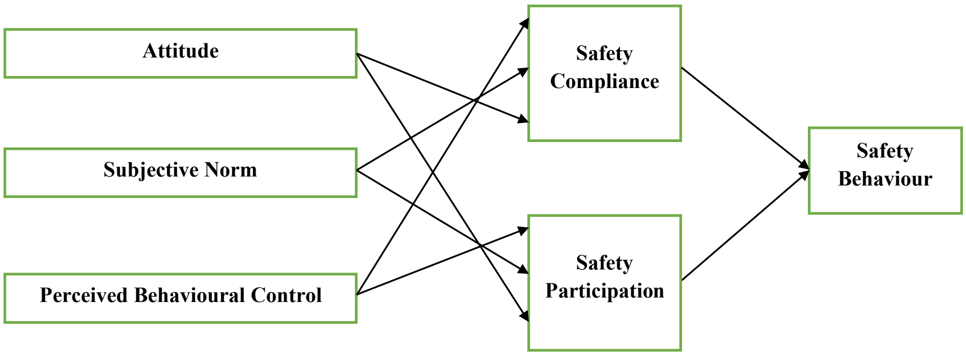

Figure 1. Conceptual Safety Behaviour Model

METHODOLOGY

In this study, the DEMATEL technique was used. The Science and Human Affairs Program at the Battelle Memorial Institute in Geneva pioneered the DEMATEL method in 1972. Its goal is to investigate problematic groups that are intertwined and complex. It has been used to help solve many complex global issues in science, economics, and politics by considering the attitudes of relevant experts. It is now widely regarded as one of the most effective tools for determining causality between assessment criteria (Lin, 2009). The DEMATEL method can be used to investigate and establish the causal relationship between evaluation criteria or to assist in determining the interdependence of factors at the same level in the decision network structure (Gholamnia et al., 2019; Shieh et al., 2010). DEMATEL can be used to effectively generate the Influential Relation Map (IMR).

The DEMATEL technique employs structural modelling to generate digraphs that depict the causal connections and magnitudes of the effects among various elements. As a result, this technique is capable of helping to determine whether or not specific system components are interdependent (Mohandes et al., 2022). In total, six steps were used in this study. The research results will be mapped or linked to each other, and a digraph based on DEMATEL will be obtained. These findings will be useful in identifying the most critical factors (safety predictors) that affect workers, such as safety behaviour on construction project sites, which involves ensuring their compliance with safety regulations and active participation in safety-related activities.

Step 1: Gather expert opinions and compute the average matrix *Z*

When using the DEMATEL technique, there is no upper or lower bound to the number of experts involved during the decision-making process. In reality, the number of experts involved in the DEMATEL method is determined by their accessibility (Gholamnia et al., 2019). 25 experts in construction safety with a minimum of ten years of experience were contacted and interviewed. Each expert was consulted to provide feedback on the degree to which two criteria directly interact using integer scores by pair-wise comparison. The value x_{ij} indicates how much the professional believes that criterion *i* has an impact on the criterion *j*. The four discrete categories of the numerical rating scale are 0 (No impact), 1 (Low impact), 2 (Moderate impact), 3 (High impact), and 4 (Very high impact). The value of the integer rating has been set to zero (0) automatically when $i = j$. As $X^k = [x_{ij}^k]$, a non-negative *n* x *n* matrix was created, in which *k* is the number of specialists engaging in this assessment progress with $1 \leq k \leq m$. *m* specialists in a group and *n* causes are employed here. As a result, the matrices from *m* specialists are $X^1, X^2, X^3, \ldots, X^m$. The average matrix Z = $[z_{ij}]$ was obtained as follows to represent all specialist opinions from *m* specialists as a whole:

$$z_{ij} = \frac{1}{m} \sum_{i=1}^{m} x_{ij}^k \tag{1}$$

A criterion with a greater numerical rating suggests that a greater enhancement in *i* is essential to enhance *j*. The average matrix, often referred to as the initial direct-relation matrix Z, is used to show the initial direct influence each criterion has on and receives from another criterion.

Step 2: Calculate the normalized initial direct-relation matrix *D*

The resulting matrix *D* has all its values falling between [0,1] and is known as the normalized initial direct-relation matrix *D* = $[d_{ij}]$. Following is the formula:

$$D = \lambda * Z, \tag{2}$$

or

$$[d_{ij}]_{n \times n} = \lambda \, [z_{ij}]_{n \times n} \tag{3}$$

where

$$\lambda = Min \left[\frac{1}{max\ 1 \leq i \leq n \sum_{j=1}^{n} |z_{ij}|}, \frac{1}{max\ 1 \leq i \leq n \sum_{i=1}^{n} |z_{ij}|} \right] \tag{4}$$

The entries in this normalized initial direct-relation matrix D will only have values among zero (0) and one (1).

Step 3: Develop the total relation matrix T

The total-influence matrix T was derived using the equation $T = D\,(I - D)^{-1}$ in which I is $n \times n$ identity matrices. The matrix T shows the overall relationship between each pair of criteria, while the element T_{ij} shows how criterion *i* indirectly influences criterion *j*.

$$T = D\,(I - D)^{-1} \tag{5}$$

Step 4: Determine the sums of columns & rows of matrix T

The row and column sums in the total-influence matrix T are computed using the subsequent formulas, each represented by a separate vector (r or c).

$$= [r_i]_{n\times 1} = \left(\sum_{j=1}^{n} t_{ij}\right)_{n\times 1}, \tag{6}$$

$$= [c_j]'_{1\times n} = \left(\sum_{j=1}^{n} t_{ij}\right)'_{1\times n}, \tag{7}$$

where $[c_j]'$ is a transposition matrix expression.

Let the sum of i^{th} row in matrix T be r_i. The sum of the direct and indirect effects that criterion *i* has on the other criteria is represented by the value of r_i

Let c_j be the total value of the j^{th} column in matrix *T*. The value of c_j is the total influence that all other criteria received, both directly and indirectly, have on criterion *j*. If *j=i,* then the value of (r_i+ c_j) represents the overall impacts both provided and obtained by criterion *i*. The distinction is that the value of (r_i− c_j) displays the criterion *i* net contribution to the system. Furthermore, when ($r_i - c_j$) is positive, criterion *i* will be the net cause, whereas when ($r_i - c_j$) is negative, criterion *i* will be the net receiver (Lin & Tzeng, 2009; Liou, Tzeng, & Chang, 2007; Shieh, Wu, & Huang, 2010; Sumrit, 2013).

Step 5: Determine the threshold value

The directed graph was created by setting a threshold value. Impacts that are bigger than the threshold value are shown in Matrix *T* (Lin, 2009). The calculation's formula is displayed below:

$$\alpha \; \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}[t_{ij}]}{N} \tag{8}$$

In which N is the number of criteria in matrix *T* as a whole.

Step 6: Create a causal relationship diagram

To depict the complicated interrelationship, the causal diagram will be created by mapping all sets of coordinates (r_i + c_j, $r_i - c_j$), which ($r_i - c_j$) represents the vertical axis (*y*-axis) and (r_i + c_j) represents the horizontal axis (*x*-axis) (Shieh et al., 2010). It may additionally be employed to provide information so that decisions about the most important causes and how to influence impacted causes can be made. The causal diagram shows that the elements t_{ij} are higher than α. The plot graph displaying the outcome will demonstrate how the predictors are interrelated (Lin & Tzeng, 2009).

RESULTS AND DISCUSSION

Respondent Profile

Data was collected from 25 professionals, including engineers, project managers, site managers, risk managers, and construction managers, all regarded as safety experts in the construction sector with at least ten years of experience and focus on high-rise building construction projects in Selangor, Malaysia. They had a certain level of understanding and knowledge regarding safety predictors in the construction industry. According to previous research, there are no minimum participant requirements for the DEMATEL method analysis. Previous studies have typically had between 3 and 30 respondents. Typically, the purposive sample size is determined by theoretical data saturation (when new data no longer brings more insights to the research question, information seems redundant for data collection).

The opinions of experts were gathered through virtual interviews. A series of questions that complied with the standards of the DEMATEL method was developed to gather the required data. They were asked to use a 0-4 scale to assess the accuracy of the safety predictors and safety behaviours that influence each other. The respondents' backgrounds are displayed in Table 1 below.

Table 1. Respondents' Demographic Profile

	Frequency	Percentage (%)
Experiences		
10-15	11	44
16-20	7	28
> 20	7	28
Position		
Safety and Health Manager	3	12
Project Managers	7	28
Site Managers	5	20
Risk Managers	8	32
Construction Managers	2	8
Type of Company		
Main Contractor	17	68
Sub-Contractor	8	32
Project Funding		
Government funded	2	8
Private funded	21	84
Both	2	8
Project Contract Sum (RM)		
< 1 Million	6	24
1 Million ≤ Contract sum < 10 Million	1	4
10 Million ≤ Contract sum < 50 Million	6	24
50 Million ≤ Contract sum < 100 Million	7	28
> 100 Million	5	20
Total	25	

Interrelationship between Predictors, Safety Compliance Intention and Safety Participation

Table 2 below displays the list of safety predictors, safety compliance and safety participation in construction project sites.

Table 2. List of Safety Predictors and Safety Behaviour

Label	Safety Predictors	Label	Safety Behaviour
A	Attitude	D	Safety Compliance
B	Subjective Norm	E	Safety Participation
C	Perceived Behavioural Control		

Step 1: Gather expert opinions and compute the average matrix Z

The experts evaluated the predictors on a 0-4 scale. This level indicates the impact of a particular factor on another. Equation 1 can be employed to determine the average matrix Z according to these ratings, which is then stated in Table 3 below.

Table 3. Average Matrix Z

Predictors	A	B	C	D	E	Sum
A	0	2.7222	3.3333	3.8889	3.9444	13.889
B	3.7222	0	3.6111	3.6667	3.6667	14.667
C	3.7222	2.2778	0	3.3889	3.4444	12.833
D	0	0	0	0	0	0
E	0	0	0	0	0	0
Sum	7.4444	5	6.9444	10.944	11.056	

Step 2: Generate and calculate the normalized initial Direct-relation Matrix D

Equations 2, 3, and 4 were used to normalize the direct-relation matrix D, and the results are presented in Table 4.

Table 4. Normalized Direct-Relation Matrix D

Predictors	A	B	C	D	E
A	0	0.1856	0.2273	0.2652	0.2689
B	0.2538	0	0.2462	0.25	0.25
C	0.2538	0.1553	0	0.2311	0.2348
D	0	0	0	0	0
E	0	0	0	0	0

Step 3: Attain total relation Matrix T

Equation 5 was employed to compute the total relation matrix T from the normalized matrix; the resulting matrix is displayed in Table 5 below.

Table 5. Total Relation Matrix T

Predictors	A	B	C	D	E
A	0.1499	0.2641	0.3264	0.4463	0.4519
B	0.3781	0.1266	0.3633	0.4659	0.4687
C	0.3505	0.242	0.1393	0.4167	0.4223
D	0	0	0	0	0
E	0	0	0	0	0

Step 4: Calculate the sums of rows and columns of matrix T

Equations 6 and 7 were used to compute the total influences acquired and given by every predictor, with the results displayed in Table 6.

Table 6. The sum of Influence Received from Predictors

Predictors	SUM R	SUM C	R + C	R - C
Attitude	1.6385	0.8785	2.5171	0.76
Subjective Norm	1.8026	0.6327	2.4353	1.1699
Perceived Behavioural Control	1.5708	0.8289	2.3997	0.7419
Safety Compliance	0	1.3289	1.3289	-1.329
Safety Participation	0	1.3429	1.3429	-1.343

Step 5: Set a threshold value ($\boldsymbol{\alpha}$)

The threshold value was chosen to screen out a few inconsequential effects. Equation 8 was used to derive the threshold value, which α = 0.2005.

Step 6: Create a cause-and-effect relationship diagram

Based on the influence of each predictor on the others, an influence diagram was created. It defined each predictor's role in the others. Figure 2 depicts the diagram. The X-axis shows how much influence a predictor has, and the Y-axis shows how much influence one predictor has on other predictors. The direction of the arrows signifies the interaction of various predictors.

According to the $r_i + c_j$ values in Table 6, show that the most significant predictor to improve safety performance on construction project sites is Attitude (A), with its highest $r_i + c_j$ value of 2.5171, while the lowest $r_i + c_j$ value of 2.3997 belongs to the least important predictor, which is Perceived Behavioural Control (C), and it is located in the farthest left corner of the diagram. Based on the ascending order of the displayed $r_i + c_j$ values displayed in Table 6, the arrangement of predictor importance is as follows: Attitude (A) > Subjective Norm (B) > Perceived Behavioural Control (C). Based on their positive $r_i - c_j$ values, all safety predictors in this study are categorized within the causal category. It was discovered that Subjective Norm (B), which has the largest $r_i - c_j$ value of 1.1699 when compared to the other predictors, has the most significant direct impact on the effect group and exhibits the strongest correlation.

Table 6 further demonstrates that, depending on their values exceeding the threshold value, α = 0.2005, every predictor in the causal group interacts with every predictor in the impact group. The effect group consists of all the Safety Compliance (D) and Safety Participation (E) as they both have negative $r_i - c_j$ values of -1.329 and -1.343, respectively. Based on its lowest $r_i - c_j$ value of -1.343, Safety Participation (E) is the predictor most affected by the other predictors. It can be inferred that all-cause group predictors influence all effect group predictors. The interactions are further depicted in Table 5 and Figure 2.

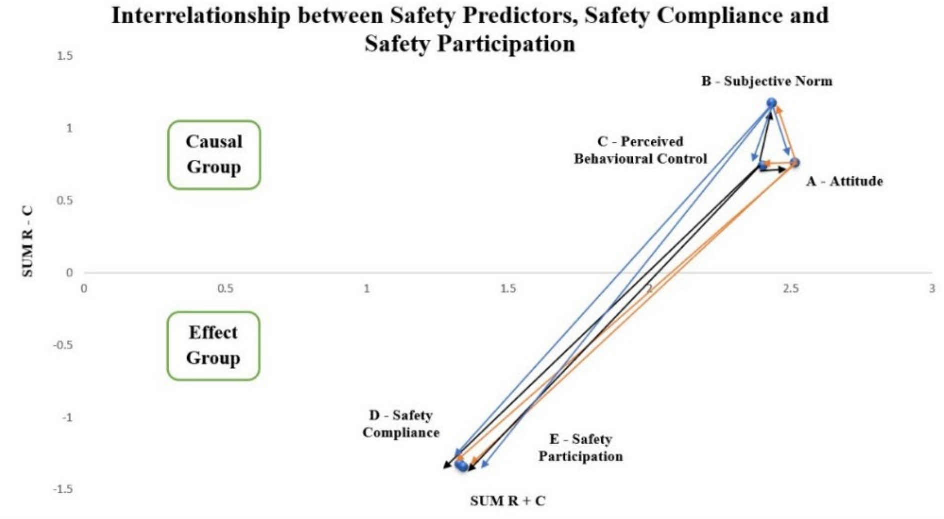

Figure 2. Impact-direction Diagram Among Safety Predictors, Safety Compliance and Safety Participation

"Attitude" emerges as the most influential predictor, surpassing subjective norm and perceived behavioural control, due to its profound impact on shaping individual behaviour in construction settings. The significance of attitudes lies in their ability to reflect individuals' beliefs, values, and perceptions regarding safety practices. Unlike subjective norms, which represent perceived social pressure to conform to safety behaviours, and perceived behavioural control, which pertains to individuals' perceived ability to enact those behaviours, attitudes encapsulate a broader spectrum of cognitive and affective evaluations towards safety measures.

In construction contexts, attitudes towards safety serve as powerful determinants of behaviour. Workers with positive attitudes towards safety are more likely to engage in safe practices voluntarily, adhere to safety guidelines, and proactively identify and mitigate hazards. Conversely, workers with negative attitudes may exhibit non-compliant behaviour, take unnecessary risks, or resist safety protocols, increasing the likelihood of accidents or incidents on construction sites.

Several factors contribute to the superiority of attitudes as a predictor of safety behaviour. Past experiences, organizational culture, peer influences, and personal beliefs all shape individuals' attitudes towards safety. Moreover, attitudes are inherently subjective and deeply ingrained, making them resistant to external influences and interventions. As such, addressing and modifying attitudes towards safety requires targeted strategies that go beyond mere provision of information or enforcement of rules.

Understanding why attitudes surpass subjective norms and perceived behavioural control in impact provides valuable insights for designing effective interventions. By focusing on attitudinal change and fostering a positive safety culture within construction teams, organizations can promote long-term behavioural shifts and improve safety outcomes. Tailored training programs, leadership initiatives, and communication strategies can be developed to target specific attitudes and beliefs that drive safety behaviour, ultimately creating safer work environments and reducing the risk of accidents in construction settings.

CONCLUSION

Despite significant advances in construction technology and management practices, work-related injury statistics show that construction workers remain at a greater risk than workers in other occupations. It has been demonstrated that the number of accident cases is steadily increasing year after year; consequently, to prevent accidents, a proper approach to safety regulation should be followed (Choi & Lee, 2022).

A particularly influential safety predictor for safety performance on construction sites is Attitude (A), as indicated by its highest $r_i + c_j$ value. Consequently, organizations should prioritize and place greater emphasis on addressing and enhancing Attitude to enhance overall safety performance and reduce the likelihood of mishaps or incidents at construction sites. A worker's attitude towards safety not only influences their adherence to safety practices on the worksite but also dictates their compliance with formal worksite guidelines. Additionally, it plays a crucial role in motivating them to take initiative, especially when informal practices are needed to achieve the same safety objectives.

When r_i - c_j values are positive, it indicates that the degree of influenced impact (C) is less than the degree of influencing impact (R), and it is important to pay attention. This indicates that they are drivers since they have a more significant impact on other predictors than other predictors have on themselves. With the highest r_i - c_j value, Subjective Norm (B) is the most influential predictor driving safety performance.

As depicted in Figure 2, Subjective Norm (B) can influence construction workers' Attitude (A) and Perceived Behavioural Control (C). The determination is derived by summing the outcome of normative beliefs, which signifies the construction worker's perception of the significance attributed by other people or groups (such as the likelihood that peers, close friends, and family members of the construction workers will offer support, agreement, or exert pressure on their decision to fulfil and adhere to safety requirements). This is then coupled with compliance, representing the motivation to align with the perceived expectations of individuals or groups.

Social groups, including managers, foremen, and co-workers, wield a significant impact on safety behaviour within the construction workforce. Co-workers exert a dual influence on construction workers. Co-workers can serve as cautionary figures, advising their colleagues against unsafe behaviour, thereby promoting safety. On the other hand, instances of co-workers violating safety regulations or requirements may be imitated by their peers, leading to a notably adverse effect on individual safety behaviour. Safety compliance and safety participation can be increased by positively influencing workers' attitudes, leading to accident prevention and reduction. This highlights the significance of Subjective Norms in cultivating a solid safety culture.

The causal relationship between safety predictors and safety performance offers valuable insights for the development and implementation of effective safety interventions. However, the use of purposive sampling may introduce sample biases, limiting the generalizability of the findings. Additionally, while the integration of TPB and DEMATEL provides a comprehensive framework for analysing safety behaviour, methodological constraints may impact the accuracy of the results. Future research should consider employing larger, more diverse samples and utilizing mixed-method approaches to mitigate these limitations.

Furthermore, this study focused primarily on individual-level predictors, overlooking potential organizational and environmental factors influencing safety behaviour. Exploring the interaction between these factors and individual attitudes could provide a more holistic understanding of safety compliance in construction settings. Future research can also broaden the scope by exploring additional safety predictors, investigating the connections between macro and micro safety predictors, and examining the impact on construction site safety performance. Identifying potential interventions and enhancing the efficacy of safety practices can be crucial outcomes of such extended research efforts.

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CONFLICT OF INTEREST

The author(s), as noted, certify that they have NO affiliations with or involvement in any organisation or agency with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, jobs, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, expertise or beliefs) in the subject matter or materials addressed in this manuscript.

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