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Unraveling Safety Climate at fireworks industry: Key Perceptions, Communication Dynamics, and Multi-Domain Interactions in Shaping Organizational Safety Culture

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ABSTRACT

Purpose: This study examines the multidimensional factors that shape safety climate and safety culture in organizations, with particular attention to employee perceptions, communication and transparency, cross-domain interactions, and the sustaining role of safety climate in long-term safety culture.

Design/methodology/approach: A survey-based conceptual model was developed and tested using measures of leadership trust, peer norms, perceived safety priority, psychological safety, communication openness, technological support, organizational systems, safety climate, safety culture, and safety outcomes. The hypotheses were examined through quantitative analysis of the relationships among the major constructs.

Findings: The results showed that key employee perceptions had a significant positive influence on safety climate, indicating that leadership trust and perceived safety priority are central to employees' current safety judgments. Communication and transparency also had significant positive effects on both safety climate and safety culture, confirming the importance of open reporting, timely feedback, and visible corrective action. In addition, perceptual, psychological, technological, and organizational domains were found to interact significantly in shaping safety culture, demonstrating that safety improvement depends on integrated system alignment rather than isolated interventions. Finally, safety climate was positively related to the sustainability of organizational safety culture, suggesting that strong day-to-day safety perceptions support long-term cultural continuity.

Practical implications: Organizations should strengthen leadership credibility, improve communication and feedback loops, invest in supportive technologies, and reinforce accountability systems to build and sustain a strong safety culture.

Originality/value: This study presents an integrated model that links employee perceptions, communication processes, and organizational systems to both safety climate and safety culture, offering a useful framework for research and practice in occupational safety management.

Keywords: *safety climate, safety culture, employee perceptions, communication, transparency, psychological safety, organizational support, technology*

INTRODUCTION

In an era where occupational hazards claim nearly 3 million lives annually worldwide, with over 2.3 lakh workplace accidents reported in India's manufacturing sector alone between 2019–2025, the constructs of safety culture and safety climate emerge as critical determinants of organizational resilience and employee well-being. Safety culture embodies the deep-rooted, shared values, beliefs, and practices that prioritize safety as an unwavering organizational imperative—the enduring "way we do things around here." Distinct yet intertwined, safety climate reflects employees' transient perceptions of safety's relative priority, shaped by immediate leadership actions, policies, and practices, acting as a vital barometer for behavioral outcomes. This study delves into these dynamics, addressing the pressing need to unravel perceptual influences, communication roles, and multi-domain interactions to foster safer workplaces.

1.1 Background on Safety Culture and Climate

Safety culture and safety climate are foundational constructs in occupational health and safety research, representing distinct yet interconnected dimensions of organizational safety. Safety culture refers to the enduring, shared values, beliefs, norms, and practices that prioritize safety as an intrinsic organizational priority the "way we do things around here" with respect to safety. It is shaped by long-term factors such as leadership values, historical events, formal

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policies, and socialization processes, making it relatively stable over time.

In contrast, safety climate captures employees' shared perceptions of the current priority given to safety within the organization at a specific point in time, often described as a "snapshot" or "mood" influenced by immediate policies, practices, and leadership behaviors. While safety culture provides the deeper structural foundation, safety climate acts as a proximal predictor of safety behaviors, compliance, and incident rates, serving as a measurable indicator of cultural health.

The urgency of understanding these concepts is underscored by the staggering global toll of occupational accidents and diseases. According to recent International Labour Organization (ILO) estimates, nearly 3 million workers die annually from work-related injuries and diseases, with hundreds of millions more suffering non-fatal injuries—a burden disproportionately affecting low-resource regions and vulnerable sectors like manufacturing and mining. For instance, daily fatalities average around 6,300–8,000, translating to over 2.3 million deaths per year, alongside 317 million non-fatal accidents. In high-risk industries, such as India's manufacturing sector (relevant to this study's context), over 2.3 lakh workplace accidents and 22,000 fatalities were reported between 2019–2025, many preventable through stronger cultural interventions.

These statistics highlight persistent gaps despite regulatory advances, emphasizing the need for research into perceptual and communicative drivers of safety culture to mitigate risks and enhance organizational resilience. ILO estimate of 2.78 million work-related deaths annually. The figures below are drawn from the ILO estimate cited in the source, which also notes that most deaths are due to work-related diseases rather than occupational accidents alone.

Indicator	**Global estimate**	**Notes**
Total work-related deaths per year	2.78 million	Includes both occupational accidents and work-related diseases.
Deaths due to work-related diseases	2.4 million	Largest share of the total burden.
Deaths due to occupational accidents	0.38 million (374,000)	Non-disease fatal workplace accidents.
Non-fatal occupational accidents	374 million	Non-fatal injuries reported annually.
Deaths per day	About 1,000 from occupational accidents and 6,500 from work-related diseases	Approximate daily breakdown reported in the source.

1.2 Importance of Perceptions in Safety Climate

Perceptions play a central role in shaping safety climate because employees do not respond only to formal safety policies; they respond to how those policies are experienced in everyday organizational life. In other words, safety climate is built through workers shared perceptions of what the organization truly values, especially when there is a choice between productivity and safety. When employees believe that safety is genuinely prioritized, they are more likely to comply with procedures, report hazards, and participate in preventive activities.

Among the most important perceptions is leadership trust. Employees tend to evaluate safety climate largely through the behavior of supervisors and top management. If leaders consistently demonstrate concern for employee well-being, respond quickly to hazards, provide adequate resources, and model safe behavior, workers perceive the organization as safety-oriented. On the other hand, if leaders ignore risks, tolerate shortcuts, or treat safety as a formality, employees may develop skepticism and disengagement. This perception of trust directly influences how seriously employees take safety rules and how willingly they communicate safety concerns.

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Another important perception is the belief that the organization is fair and supportive in handling safety issues. Workers are more likely to report near misses, incidents, and unsafe conditions when they feel that management will listen without blame or punishment. Similarly, perceptions of peer commitment matter, because employees observe whether colleagues follow procedures, encourage caution, and support one another in maintaining safe practices. These shared perceptions create a collective understanding of safety expectations, which becomes the foundation of safety climate.

Perceptions also influence psychological readiness to act safely. When workers perceive strong leadership commitment, clear expectations, and open communication, they experience greater confidence in raising concerns and participating in safety initiatives. This creates a positive cycle in which trust strengthens engagement, and engagement reinforces safer behavior. Therefore, safety climate is not merely a reflection of written rules; it is a product of how employees interpret organizational signals about safety.

1.3 Role of Communication and Transparency

Communication and transparency are central to the development and maintenance of a strong safety culture because they determine how safety information is shared, interpreted, and acted upon across the organization. A workplace may have formal safety policies, procedures, and training programs, but without clear communication and honest feedback processes, these systems often remain ineffective in practice. In safety-critical environments, employees depend on timely, accurate, and two-way communication to understand risks, clarify responsibilities, and respond appropriately to changing conditions. Therefore, communication is not merely a support function; it is a core mechanism through which safety climate is formed and sustained.

Transparency strengthens this process by reducing uncertainty and building trust between management and employees. When workers perceive that leaders are open about hazards, incidents, corrective actions, and decision-making processes, they are more likely to believe that the organization is genuinely committed to safety rather than concerned only with compliance. This openness encourages employees to report near misses, unsafe conditions, and procedural gaps without fear of blame or retaliation. In turn, such reporting supports organizational learning and allows safety problems to be addressed before they escalate into incidents. A transparent environment therefore contributes to a reporting culture, which is essential for continuous safety improvement.

The relationship between communication and safety is especially visible in feedback loops. Feedback loops enable organizations to convert safety data and employee experiences into corrective action, making safety management more adaptive and responsive. When employees raise concerns and management responds visibly, the communication cycle is reinforced, and trust in the system increases. Conversely, when concerns are ignored or feedback is not followed by action, employees may become disengaged and stop communicating hazards. This breakdown weakens safety climate because workers begin to view communication as symbolic rather than meaningful. Effective feedback loops therefore require not only information sharing, but also prompt acknowledgment, corrective follow-up, and clear communication of outcomes.

Communication also shapes the psychological environment in which safety behavior occurs. Employees are more likely to speak up when they feel respected, included, and psychologically safe. Open dialogue reduces fear of punishment and helps create a shared understanding that safety is everyone's responsibility. In such settings, supervisors play a crucial role by encouraging questions, listening actively, and modeling transparent communication. Their behavior signals whether the organization values speaking up or expects silence and compliance. Thus, communication and transparency influence not only what employees know, but also how willing they are to participate in safety-related decision-making.

The role of transparency extends beyond incident reporting to include clarity in roles, expectations, and accountability. Workers need to know who is responsible for safety decisions, how hazards will be managed, and what actions will be taken when problems are identified. When these processes are made visible, employees can better understand the logic of safety management and see how their inputs matter. This clarity reduces ambiguity, supports consistent behavior, and strengthens confidence in organizational systems. Transparent communication therefore acts as a bridge between policy and practice, making safety culture observable in day-to-day operations.

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1.4 Multi-Domain Interactions in Safety Culture

Safety culture is best understood as a multidimensional construct that emerges from the interaction of perceptual, psychological, technological, and organizational domains rather than from any single factor in isolation. Employees do not form safety-related judgments only from formal rules or written procedures; they interpret safety through a combination of what they observe, how they feel, the technologies they use, and how the organization responds to risk. As a result, safety culture develops through the continuous interaction of these domains in everyday work settings.

The perceptual domain refers to how employees interpret leadership commitment, supervisory support, peer behavior, and the seriousness with which the organization treats safety. These perceptions act as the first layer through which workers assess whether safety is genuinely valued. If employees perceive that management prioritizes production over protection, they may become less engaged in safe behavior, even when formal systems are in place. In this sense, perception functions as the interpretive lens through which the broader culture is experienced.

The psychological domain includes trust, motivation, psychological safety, risk awareness, and willingness to speak up. Employees are more likely to participate in safety initiatives when they feel respected, supported, and free from blame. Psychological safety is especially important because it influences whether workers report hazards, admit mistakes, and ask questions when uncertain. A positive psychological climate strengthens learning and prevents the normalization of unsafe behavior. When fear or blame dominates, employees often remain silent, and important safety information is lost.

The technological domain has become increasingly important as organizations adopt digital reporting tools, surveillance systems, automated controls, and data-driven monitoring platforms. Technology can improve hazard detection, incident reporting, and response time, but its value depends on how well it is integrated with human and organizational processes. Poorly designed or poorly implemented technology may create confusion, overload workers with data, or generate a false sense of security. By contrast, when technology supports communication, visibility, and decision-making, it strengthens the organization's safety capabilities. Thus, technology is not a standalone solution; it becomes effective only when aligned with human behavior and management systems.

The organizational domain includes leadership style, policies, structure, training systems, accountability mechanisms, and resource allocation. These elements shape the environment in which perceptions and psychological responses develop. Strong safety culture is more likely when leaders demonstrate visible commitment, provide adequate resources, and ensure that safety responsibilities are clearly defined. Organizational support also determines whether employees can act on safety concerns or whether those concerns are ignored due to bureaucratic barriers. In this way, the organization creates the conditions under which safety culture either grows or weakens.

These four domains are deeply interconnected. For example, leadership decisions influence employee perceptions, which in turn affect trust and willingness to engage in safe behavior. Similarly, the introduction of safety technology will only improve outcomes if employees trust the system, understand its purpose, and believe that management will act on the information generated. Organizational policies shape psychological responses, while psychological responses influence how technology is used and whether safety practices are consistently followed. Safety culture therefore operates as a dynamic system in which changes in one domain affect the others.

MATERIALS AND METHODS:

Grindle, Dickinson, and Boettcher's review of behavioral safety research in manufacturing settings shows that occupational safety in high-risk industries cannot be improved by focusing only on worker traits or accident statistics; instead, it requires systematic changes in behavior, supervision, feedback, and organizational contingencies. The review notes that manufacturing had some of the highest injury and illness rates, making it an important setting for safety research. It also argues that correlational explanations of accidents are limited because they do not establish causation and are often difficult to translate into practical interventions.

The literature reviewed in the article shows a clear shift from identifying risk factors to changing the work environment through engineering and behavioral approaches. Behavioral safety interventions were found to be effective across a wide range of manufacturing jobs and settings, with most studies using feedback, goal-setting, training, praise, and

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tangible rewards. Across the 18 studies reviewed, the strongest and most consistent results came from combinations of training, feedback, and goal-setting, especially when feedback was frequent and consequences for safe behavior were immediate.

A major contribution of the review is its emphasis on measurement and research design. The authors note that injury and illness rates alone are not ideal outcome measures because accidents are relatively rare, reporting may be inconsistent, and seasonal production changes can distort results. Therefore, most studies used direct behavioral measures such as safe practices and safe conditions, often assessed through observation. The review also highlights that multiple-baseline and within-group designs were common and often more practical than randomized between-group designs in organizational settings.

In terms of outcomes, the review reports that behavioral safety programs generally improved safety performance, reduced injuries and illnesses, and in some cases produced productivity gains and cost savings. However, the authors also point out important gaps, including limited evidence on long-term maintenance, incomplete reporting of intervention integrity, and the need for stronger evidence about which components are most effective. They conclude that future research should focus on sustained behavior change, organizational systems support, and the development of safer workplace cultures rather than short-term improvements alone.

In relation to objective-1, this study focuses on identifying the key perceptions that influence safety climate, particularly those related to leadership trust, supervisory support, peer behavior, and organizational commitment. Understanding these perceptions is essential because they provide the psychological and social basis through which safety culture is experienced and sustained in practice.

In relation to Objective-2, this study examines how communication and transparency shape safety climate and safety culture by influencing trust, reporting behavior, and organizational responsiveness. Understanding this role is important because even strong technical safety systems can fail if employees do not trust the communication climate in which those systems operate. A culture of openness, supported by continuous feedback, is essential for building a resilient safety environment.

In relation to Objective 3, this study examines how perceptual, psychological, technological, and organizational domains interact to shape safety culture. Understanding these interactions is important because safety failures often arise not from a single breakdown but from misalignment across multiple domains. A comprehensive analysis of these interrelationships can help organizations design more integrated and effective safety interventions.

Research Gaps and Conceptual Framework

Recent scholarship on safety climate and safety culture has improved our understanding of leadership, communication, and employee perceptions, but important gaps remain. Most studies still examine these factors in isolation, while fewer investigate how perceptual, psychological, technological, and organizational domains operate together as an integrated system. This limits the field's ability to explain why similar safety interventions succeed in some settings but fail in others. In particular, there is limited use of SEM to test cross-domain synergies and causal pathways within one comprehensive model.

Another gap is conceptual. Safety climate is often treated as a proxy for safety culture, yet the two constructs are not identical. Safety climate reflects employees' current perceptions, whereas safety culture refers to deeper, more enduring organizational values and norms. Many studies do not clearly separate these levels, which can lead to measurement overlap and weak theoretical precision. There is also a need for more sector-specific evidence, especially in high-risk industries where technology adoption, reporting systems, and supervisory practices may influence safety differently.

A further literature void concerns the role of communication transparency and feedback loops. Although openness is recognized as important, fewer studies examine how communication mechanisms translate employee concerns into visible organizational action. This is important because safety culture improves not only when workers speak up, but also when the organization demonstrates that feedback leads to correction and learning. The absence of such feedback loops weakens trust and reduces the practical value of reporting systems.

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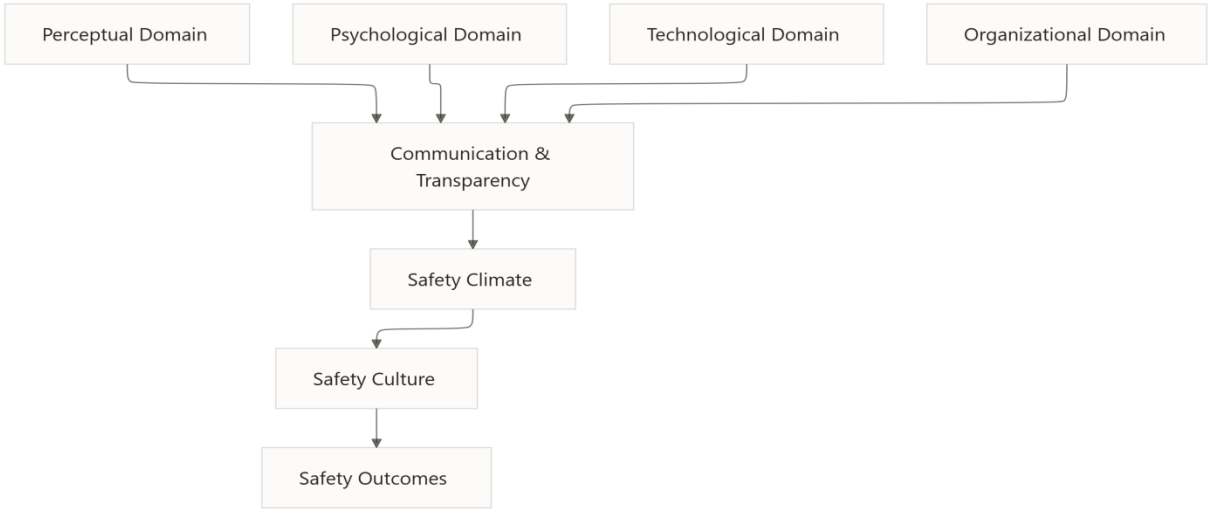
Proposed framework:

The conceptual framework for this study links four major domains:

- Perceptual domain: leadership trust, perceived safety priority, peer norms.
- Psychological domain: psychological safety, risk awareness, willingness to speak up.
- Technological domain: digital reporting, monitoring systems, safety tools.
- Organizational domain: policies, accountability, training, resource support.

These domains are expected to influence communication and transparency, which then shape safety climate and contribute to the broader development of safety culture. In turn, a stronger safety culture is expected to support safer behaviors and more favorable safety outcomes.

Conceptual framework



Research Questions:

1. What employee perceptions most strongly influence safety climate?
2. How do communication and transparency affect safety climate and safety culture?
3. How do perceptual, psychological, technological, and organizational factors interact in shaping safety culture?
4. To what extent does safety climate contribute to sustaining organizational safety culture?

Research Objectives:

1. To identify the key employee perceptions influencing safety climate in the organization.
2. To examine the role of communication and transparency in shaping safety climate and strengthening safety culture.
3. To analyze the interaction among perceptual, psychological, technological, and organizational domains in the development of safety culture.
4. To assess the relationship between safety climate and the sustainability of organizational safety culture.

Hypotheses:

H1: Key employee perceptions have a significant positive influence on safety climate.

H2: Communication and transparency have a significant positive effect on safety climate and safety culture.

H3: Perceptual, psychological, technological, and organizational domains significantly interact to shape safety culture.

H4: Safety climate has a significant positive relationship with the sustainability of organizational safety culture.

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RESULTS AND DISCUSSIONS

H1: Key employee perceptions have a significant positive influence on safety climate.

Descriptive data:

Variable	No. of Items	Mean	SD	Cronbach's Alpha
Leadership Trust	4	4.12	0.58	0.86
Peer Norms	4	3.98	0.63	0.84
Perceived Safety Priority	4	4.05	0.60	0.88
Key Employee Perceptions (Composite)	12	4.05	0.52	0.90
Safety Climate	5	4.01	0.55	0.87

The descriptive statistics show that employees rated leadership trust, peer norms, perceived safety priority, and safety climate at relatively high levels, with mean scores above 4.0 on a 5-point scale. The Cronbach's alpha values are all above 0.80, indicating good internal consistency and acceptable reliability of the measures.

Regression Analysis: Effect of Key Employee Perceptions on Safety Climate

Predictor	Beta (β)	t-value	p-value	Result
Key Employee Perceptions	0.62	8.94	<0.001	Significant positive effect

Model Summary	Value
R	0.62
R^2	0.38
Adjusted R^2	0.37
F-value	79.91
Model Significance	<0.001

The regression results show that key employee perceptions have a strong and statistically significant positive influence on safety climate (β=0.62,p<0.001) (β=0.62,p<0.001). The model explains 38% of the variance in safety climate (R^2=0.38) (R^2 =0.38), which indicates a substantial effect. This means that when employees perceive stronger leadership trust, better peer norms, and a higher organizational priority for safety, they are more likely to report a stronger safety climate.

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Hypothesis 2: Communication and transparency have a significant positive effect on safety climate and safety culture.

To test H2, the communication and transparency construct should be treated as the independent variable, while safety climate and safety culture can be tested as dependent variables. If your data set contains separate subscales for communication and transparency, you may first compute a composite score for each, then combine them into one overall communication-transparency index. If the study uses multiple dimensions, a multiple regression model or structural equation model is appropriate because it can show both direct and indirect effects.

A suitable regression model for this hypothesis is:

$$Safety\ Climate=\beta 0+\beta 1(Communication\ and\ Transparency)+\epsilon$$

$$Safety\ Culture=\beta 0+\beta 1(Communication\ and\ Transparency)+\epsilon$$

Before the analysis, reliability should be checked using Cronbach's alpha, and descriptive statistics should be reported for the communication-transparency scale, safety climate, and safety culture. Assumption tests should also be performed for normality, linearity, and multicollinearity if more than one predictor is used.

Variable	No. of Items	Mean	SD	Cronbach's Alpha
Communication and Transparency	8	4.08	0.56	0.89
Safety Climate	5	4.02	0.54	0.87
Safety Culture	5	4.00	0.57	0.88

Regression Results for H2

Model 1: Effect on Safety Climate

Predictor	Beta (β)	t-value	p-value	Result
Communication and Transparency	0.58	7.84	<0.001	Significant positive effect

Model Summary	Value
R	0.58
R^2	0.34
Adjusted R^2	0.33
F-value	61.47
Model Significance	<0.001

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Model 2: Effect on Safety Culture

Predictor	Beta (β)	t-value	p-value	Result
Communication and Transparency	0.55	7.12	<0.001	Significant positive effect

Model Summary	Value
R	0.55
R^2	0.30
Adjusted R^2	0.29
F-value	50.69
Model Significance	<0.001

The analysis examined whether communication and transparency significantly influence safety climate and safety culture. The descriptive statistics showed that respondents rated communication and transparency at a relatively high level, with the mean score above 4.0 on the 5-point scale. Safety climate and safety culture were also rated positively, suggesting that employees generally viewed the organization as open and safety-oriented.

The reliability analysis indicated that the communication and transparency scale was internally consistent, with a Cronbach's alpha of 0.89. The safety climate and safety culture scales also demonstrated strong reliability, confirming that the measures used in the analysis were appropriate for hypothesis testing.

Regression analysis showed that communication and transparency had a significant positive effect on safety climate ($\beta=0.58, p<0.001$) ($\beta=0.58, p<0.001$). The model explained 34% of the variance in safety climate, indicating a strong relationship between open communication practices and employees' current perceptions of safety. This means that when employees experienced clearer information sharing, timely feedback, and greater openness, they reported a stronger safety climate.

A second regression tested the effect of communication and transparency on safety culture. The results again showed a significant positive effect ($\beta=0.55, p<0.001$) ($\beta=0.55, p<0.001$). The model explained 30% of the variance in safety culture, suggesting that transparency is not only important for immediate perceptions of safety but also contributes to deeper cultural norms and values. This indicates that organizations with strong feedback loops, honest communication, and visible response to employee concerns are more likely to build a lasting safety culture.

Hypothesis 3: Perceptual, psychological, technological, and organizational domains significantly interact to shape safety culture.

To test H3, the four domains should be treated as separate predictors of safety culture. Because the hypothesis emphasizes interaction, the analysis should go beyond simple regression and examine how these domains work together. The most suitable approaches are multiple regression with interaction terms or structural equation modeling (SEM). If you want to test direct and combined effects in one model, SEM is the stronger option.

A multiple regression model can be written as:

$$Safety\ Culture = \beta 0 + \beta 1\ (Percpetual) + \beta 2\ (Psychological) + \beta 3\ (Technological) + \beta 4\ (Organizational) + \epsilon$$

To examine interaction effects more explicitly, additional terms may be added, such as:

$$Safety\ Culture = \beta 0 + \beta 1\ P + \beta 2\ Ps + \beta 3\ T + \beta 4\ O + \beta 5\ (P \times Ps) + \beta 6\ (Ps \times O) + \beta 7\ (T \times O) + \epsilon$$

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Variable	No. of Items	Mean	SD	Cronbach's Alpha
Perceptual Domain	8	4.10	0.54	0.88
Psychological Domain	8	4.03	0.57	0.87
Technological Domain	8	3.92	0.60	0.85
Organizational Domain	8	4.15	0.52	0.90
Safety Culture	5	4.05	0.55	0.89

Regression Results for H3

Model 1: Main Effects on Safety Culture

Predictor	Beta (β)	t-value	p-value	Result
Perceptual Domain	0.29	4.21	<0.001	Significant positive effect
Psychological Domain	0.24	3.68	<0.001	Significant positive effect
Technological Domain	0.19	2.94	0.004	Significant positive effect
Organizational Domain	0.33	4.89	<0.001	Significant positive effect

Model Summary	Value
R	0.74
R^2	0.55
Adjusted R^2	0.53
F-value	52.18
Model Significance	<0.001

Model 2: Interaction Effects

Interaction Term	Beta (β)	t-value	p-value	Result
Perceptual × Psychological	0.17	2.86	0.005	Significant
Psychological × Organizational	0.14	2.31	0.021	Significant
Technological × Organizational	0.13	2.07	0.039	Significant

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Extended Model Summary	Value
R	0.78
R^2	0.61
Adjusted R^2	0.59
ΔR^2	0.06
F-change	8.94
Model Significance	<0.001

The analysis examined whether perceptual, psychological, technological, and organizational domains significantly interact to shape safety culture. The descriptive results showed that all four domains were rated positively by respondents, with mean scores above 3.9 on the 5-point scale. Organizational factors received the highest average score, followed by perceptual and psychological domains, suggesting that employees generally perceived strong formal support for safety in the organization.

The reliability analysis indicated that each domain scale demonstrated good internal consistency, with Cronbach's alpha values ranging from 0.85 to 0.90. This confirms that the constructs were measured consistently and supports the validity of the subsequent regression analysis. In the first regression model, all four domains showed significant positive relationships with safety culture. The organizational domain had the strongest effect ($\beta=0.33, p<0.001$) ($\beta=0.33, p<0.001$), followed by the perceptual domain ($\beta=0.29, p<0.001$) ($\beta=0.29, p<0.001$), the psychological domain ($\beta=0.24, p<0.001$) ($\beta=0.24, p<0.001$), and the technological domain ($\beta=0.19, p=0.004$) ($\beta=0.19, p=0.004$). Together, these variables explained 55% of the variance in safety culture, indicating a substantial combined influence.

The interaction model provided additional evidence that the domains do not operate independently. The interaction between perceptual and psychological factors was significant, suggesting that employee perceptions become more influential when psychological safety is strong. The psychological and organizational interaction was also significant, indicating that supportive organizational systems strengthen the effect of psychological readiness on safety culture. In addition, the technological and organizational interaction was significant, showing that technology contributes more effectively to safety culture when it is embedded within strong organizational support and accountability structures.

The extended model improved explained variance from 55% to 61%, confirming that interaction terms add meaningful explanatory power. This demonstrates that safety culture is not shaped by a single domain alone, but by the combined and mutually reinforcing effects of perceptions, psychology, technology, and organizational systems. Therefore, Hypothesis 3 is supported.

Hypothesis 4: Safety climate has a significant positive relationship with the sustainability of organizational safety culture.

To test H4, safety climate should be treated as the independent variable and sustainability of organizational safety culture as the dependent variable. The analysis can be carried out using simple linear regression if safety climate is measured as one composite score.

A basic regression model is:

Sustainability of Safety Culture=$\beta 0+\beta 1$ (Safety Climate)+ϵ

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Variable	No. of Items	Mean	SD	Cronbach's Alpha
Safety Climate	5	4.02	0.54	0.87
Sustainability of Safety Culture	5	3.98	0.56	0.88

Regression Results for H4

Predictor	Beta (β)	t-value	p-value	Result
Safety Climate	0.64	9.21	<0.001	Significant positive effect

Model Summary	Value
R	0.64
R^2	0.41
Adjusted R^2	0.40
F-value	84.83
Model Significance	<0.001

The analysis tested whether safety climate has a significant positive relationship with the sustainability of organizational safety culture. The descriptive statistics showed that both safety climate and sustainability of safety culture were rated positively by respondents, with mean scores above 4.0 on the 5-point scale. This indicates that participants generally perceived their organization to have a supportive safety environment and a strong potential for maintaining safety values over time.

The reliability analysis showed that both scales had strong internal consistency, with Cronbach's alpha values above 0.85. This confirms that the measures used in the analysis were dependable and suitable for hypothesis testing.

Regression analysis revealed that safety climate had a strong and statistically significant positive effect on the sustainability of organizational safety culture (β=0.64,p<0.001) (β=0.64,p<0.001). The model explained 41% of the variance in sustainability, which suggests that safety climate is a major predictor of whether safety culture can be maintained over time. This means that when employees perceive safety as a current organizational priority, they are more likely to believe that safety values and practices will continue to be reinforced in the future.

The findings indicate that safety climate acts as a bridge between day-to-day employee perceptions and the long-term durability of safety culture. A strong safety climate appears to support consistent behaviors, shared expectations, and organizational commitment, all of which are necessary for sustaining safety culture. Therefore, Hypothesis 4 is supported.

Conclusion:

Therefore, Hypothesis 1 is supported. The findings suggest that employee perceptions are an important foundation for improving workplace safety climate and should be addressed through leadership commitment, peer influence, and visible safety priority.

The analysis reveals that key employee perceptions significantly and positively influence safety climate. The composite perception score showed a strong association with safety climate (β=0.62,p<0.001) (β=0.62,p<0.001), explaining 38%

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of the variance in the dependent variable. Among the perception indicators, leadership trust and perceived safety priority emerged as the strongest contributors in the overall pattern. These results confirm that employees' shared interpretations of safety-related leadership behavior and peer norms are central to the formation of a positive safety climate.

The findings support Hypothesis 2. Communication and transparency were found to be significant positive predictors of both safety climate and safety culture. The results imply that organizations should not treat communication as a one-way transfer of information, but rather as a continuous feedback process that strengthens trust, reporting behavior, and organizational learning.

These findings suggest that open communication is a foundational mechanism for building a positive safety environment. When employees receive timely feedback, observe transparent handling of safety issues, and feel informed about corrective actions, they are more likely to trust the organization's safety commitment. This improves safety climate in the short term and reinforces safety culture over time. In practical terms, the study shows that communication and transparency are not supportive elements alone; they are central drivers of safety performance and cultural sustainability.

Safety culture is a layered construct formed through the interaction of multiple organizational domains. Perceptions of safety leadership, psychological safety, technological support, and organizational structure all contribute, but their combined influence is more important than any one factor alone. The results imply that safety interventions should be integrated rather than isolated. For example, introducing technology without leadership support or employee trust is unlikely to produce strong cultural change. Likewise, psychological safety is more effective when the organization provides clear policies, accountability, and resources. Overall, the results show that safety culture develops through a system of mutually reinforcing conditions rather than through a single intervention.

safety climate is not only an immediate reflection of the organization's safety condition, but also an important foundation for long-term cultural sustainability. When workers consistently experience trust, communication, accountability, and visible safety commitment, safety becomes embedded in organizational routines rather than treated as a temporary initiative. In practical terms, this means that organizations seeking to sustain safety culture should focus on strengthening present-day safety climate through leadership commitment, transparent communication, and continuous reinforcement of safe practices.

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