Journal Home Page: https://sjes.univsul.edu.iq/

Research Article:

Safety Practice Implementation and Challenges in Construction Sites: A Case Study in Sulaimani City, Kurdistan Region , Iraq

Twana A.Tahir [1,a,*]
Ako R. Hama [2,a,b]
Shokh M. Ahmed[3,a]
Saya A. Abdalla[4,a]
Shanya S. Ghafoor [5,a]
Tabin N. Latif [6,a]
[a] College of engineering, Komar University of Science and Technology , Sulaimani , KR, Iraq.
[b] College of engineering, University of Sulaimani, Sulaimani , KR, Iraq.

Article Information

Article History:
Received: November 27, 2025
Accepted : April 16, 2026
Available Online: April , 2026

Keywords:
Safety training, Safety culture, Regulatory compliance, Risk management, Safety policy enforcement.

About the Authors:
Corresponding author:
Dr.Twana A. Tahir
E-mail: twana.abdulrazaq@komar.edu.iq
Researcher Involved:
Professor Dr. Ako Rashed Hama
E-mail: ako.rashed@komar.edu.iq
Dr. Shokh Mukhtar Ahmed
E-mail: shokh.mukhtar@komar.edu.iq

DOI https://doi.org/10.17656/sjes.10211

Abstract

This study evaluates the implementation and challenges of safety practices at construction sites in Sulaimani City, Kurdistan Region of Iraq, against the backdrop of rapid urbanization and rising workplace hazards. Despite adherence to local and international safety standards, high accident rates persist, revealing critical gaps between theoretical protocols and real-world applications. Using a mixed-methods approach, data from 217 participants (200 workers and 17 safety officers) were analyzed through statistical methods, including Kolmogorov-Smirnov and Spearman's rank correlation tests. Results highlighted non-normal distributions in key safety metrics and significant variability in knowledge, training, and availability of personal protective equipment (PPE). A moderate positive correlation ($r = 0.45$, $p < 0.01$) was found between training adequacy and worker empowerment, emphasizing the role of structured training programs. Financial constraints, insufficient enforcement, and a lack of cohesive safety culture emerged as primary barriers to compliance. The findings underscore the need for integrated strategies combining enhanced training, financial investment, and management-driven safety initiatives to bridge the gap between policy and practice, ultimately reducing accidents and improving worker well-being.

1 Introduction

The construction sector in Sulaimani City, located in the Kurdistan Region of Iraq, has seen rapid development over the past decade. This growth has been driven by urbanization and infrastructural demands, requiring more labor and resources. However, the increasing complexity of construction projects has also introduced heightened risks to worker safety. As more construction workers are employed in diverse roles, ensuring adherence to safety regulations becomes increasingly critical. Construction companies are required to comply with local and international safety standards, such as those provided by the Occupational Safety and Health Administration (OSHA) and other regulatory bodies. However, the high rate of workplace accidents—especially falls from heights, electrical injuries, and equipment-related hazards—indicates that these safety regulations are not being effectively implemented. Safety program implementation in the city remains inconsistent, which has prompted numerous calls for better training, enforcement of safety policies, and a stronger safety culture in construction environments. The primary objective of this research is to analyze the implementation of safety programs in Sulaimani City's construction sector by comparing theoretical safety measures with real-world applications. By integrating statistical and qualitative data, this study aims to provide actionable insights into how companies can improve safety outcomes. Specifically, the research focuses on how companies can bridge the gap between the safety standards they are required to uphold and the actual practices observed on-site. The research also seeks to identify the underlying causes of the persistent safety challenges, offering recommendations that address both the structural and behavioral barriers to effective safety management. Considering the alarming rates of accidents and fatalities in the local construction sector, the need for this research is urgent. By exploring the relationship between safety training, enforcement, and worker compliance, the study offers a comprehensive view of the state of safety in Sulaimani City's construction industry and paves the way for reforms that can safeguard worker health and improve overall productivity. The rapid development of construction industries globally has heightened attention toward occupational health and safety. Safety practices within construction projects are crucial for mitigating risks, especially in regions undergoing accelerated urbanization, such as Sulaimani City, Iraq. This literature review explores the challenges and best practices of safety management across diverse construction environments, highlighting the implementation gaps and opportunities for improvement. Numerous studies emphasize integrating technology and structured frameworks to enhance safety outcomes in construction projects. For instance, Haadir et al. (2011) advocated for systems integrating ZigBee-enabled wireless sensor networks and RFID technology to address workplace hazards proactively. Similarly, Sunindijo (2015) examined safety challenges in small construction organizations in New South Wales, highlighting economic pressures and knowledge gaps as significant barriers to compliance. Recommendations included client engagement and subsidized safety training to address these issues. Studies in developing countries like Pakistan and Malaysia reflect systemic weaknesses in worker training, personal protective equipment (PPE) usage, and hazard communication. Nawi et al. (2016) identified falls, electrocution, and object strikes as prevalent hazards in Malaysian construction sites, emphasizing regulatory gaps. In Pakistan, benchmarking frameworks were proposed to strengthen safety practices, balancing regulatory support and practical training (Choudhry & Zahoor, 2016).

In Iraq, construction safety research highlights barriers rooted in governance, resource constraints, and organizational culture. Othman et al. (2020) stressed the importance of management commitment, stakeholder collaboration, and clear safety policies as critical success factors. These findings align with Mohanad et al. (2020), who identified 12 safety barriers, including governance shortcomings and lack of awareness, recommending a centralized regulatory framework. Similarly, Mohammed et al. (2021) proposed four primary safety constructs—worker involvement, control systems, safety arrangements, and management commitment—to enhance implementation. Financial limitations were often cited as key obstacles, further exacerbating the discrepancy between theoretical frameworks and on-site practices.

Technological solutions have gained traction as pivotal tools in mitigating safety risks. Agent-based modeling (Lu et al., 2016) revealed that strategic safety investments, such as innovative tools, improve outcomes without compromising productivity. This is echoed in the Learning from Incidents (LFI) framework employed in China, which underscores the importance of robust reporting and information-sharing mechanisms (Chan et al., 2023). A recurring theme in global safety studies is the disparity between policy design and practical application. Alhelo et al. (2023) highlighted the fragmented regulations in the UAE, proposing unified frameworks for optimizing health and safety. In the Kurdistan region, gaps in training adequacy, PPE availability, and enforcement were underscored, necessitating multidimensional strategies to bridge policy and practice gaps. The literature consistently points to management-driven safety cultures, structured training, and regulatory collaboration as foundational for sustainable improvements. Collaborative efforts among stakeholders, including policymakers and industry leaders, are crucial for creating safer work environments.

2 Materials and Methods

This study employed a mixed-methods approach to examine safety practices and their challenges at construction sites in Sulaimani City, Iraq. Combining quantitative and qualitative methods allowed for a comprehensive analysis of safety program implementation, worker compliance, and areas for improvement. Data were gathered from 217 participants, comprising 200 construction workers and 17 safety officers. Structured questionnaires were used as the primary instrument, containing 30 questions rated on a five-point Likert scale as in the questionaries tables 4 and 5 . These questions assessed perceptions of safety training, PPE availability, and enforcement of safety protocols. To enhance clarity and inclusivity, the questionnaires were translated into Kurdish.

Study Area

2.1 Ethical Considerations

Ethical protocols were strictly followed, ensuring informed consent, confidentiality, and voluntary participation. Participants were briefed on the study's objectives, and anonymity was maintained throughout data handling and analysis.

2.2 Data Analysis

The Kolmogorov-Smirnov (KS) test assessed the normality of data distributions. Non-normal results necessitated the use of non-parametric statistical tools, including Spearman's rank correlation coefficient (SRCorr). This approach identified significant relationships among safety variables, such as the adequacy of training, availability of PPE, and worker compliance. Additionally, the Weighted Sum Method (WSM) was employed to compute an overall safety performance score. Qualitative data from open-ended responses were analyzed thematically, focusing on challenges like resource shortages and gaps in safety culture. These responses were coded, converted into numerical data using Excel, and triangulated with quantitative findings for robust insights.

2.3 Limitations

Potential self-reporting bias was mitigated through careful questionnaire design and triangulation with secondary data. However, the study's reliance on self-reported measures and its localized scope may limit the generalizability of findings to broader contexts.

3 Results and Discussion

Examining safety practices in construction workplaces in Sulaimani revealed several insights into implementation effectiveness and challenges. While workers and safety officers expressed positive perceptions of safety measures, significant gaps were identified in resource availability, training adequacy, and enforcement of safety protocols. For instance, the Kolmogorov-Smirnov (KS) test results for normality, as detailed in the Kolmogorov-Smirnov Test for Primary Data, indicated non-normal distributions across all safety-related variables such as safety knowledge (SK), safety training (ST), and protective equipment (PE), with p-values below 0.05. These results highlight variability in worker perceptions and underscore the need for tailored safety interventions (Table 1). The One-Sample Kolmogorov-Smirnov (KS) test applied to the collected data indicated non-normality across all variables, necessitating the use of non-parametric methods for further analysis. Spearman's Rank Correlation Coefficient (SRCorr) provided insights into the relationships between safety variables, such as training effectiveness, incident reporting, and compliance with safety policies. Significant correlations suggest that enhancing training programs and hazard identification mechanisms can lead to improved safety outcomes. Structural Equation Modeling (SEM) further demonstrated that effective safety policies positively influence compliance and performance, while work pressures negatively impact safety implementation (Table 2).

3.1 Spearman's Rank Correlation Coefficient Results

The Spearman's rank correlation coefficients were computed to explore the relationships between different safety-related variables. The results are displayed in the table below (Table 3).

Safety Policies (SP) show a significant positive correlation with Motivation (M) ($r = 0.356$, $p = 0.161$) and a significant negative correlation with Government Fines (GF) ($r = -0.312$, $p = 0.222$).

Work Pressures (WP) does not exhibit significant correlations with other variables, indicating no substantial linear relationship.

Motivation (M) has significant positive correlations with Fines Policy (FP) ($r = 0.655$, $p = 0.004$) and External Collaboration (EC) ($r = 0.499$, $p = 0.041$).
Cost Factors (CF) show a significant negative correlation with PPE ($r = -0.433$, $p = 0.082$).
Fines Policy (FP) has strong positive correlations with External Collaboration (EC) ($r = 0.744$, $p = 0.001$) and Maintenance (MNT) ($r = 0.601$, $p = 0.011$).
OSHA Awareness (OW) is positively correlated with PPE ($r = 0.475$, $p = 0.054$).
PPE shows a significant positive correlation with Maintenance (MNT) ($r = 0.441$, $p = 0.077$).
External Collaboration (EC) is positively correlated with Government Fines (GF) ($r = 0.428$, $p = 0.086$).
Government Fines (GF) do not show significant correlations with other variables except for Maintenance (MNT) ($r = -0.348$, $p = 0.171$).
Maintenance (MNT) has significant positive correlations with Safety Policies (SP) ($r = 0.457$, $p = 0.065$) and Fines Policy (FP) ($r = 0.601$, $p = 0.011$).

3.2 Structural Equation Modeling (SEM) Analysis for Safety Officers' Responses

This analysis examines the relationships between latent variables using the Smart PLS software. We assessed the following latent variables in our model:

- **Latent Variable 1:** This variable is central to the overall model and influences various outcomes and compliance measures.
- **Safety Implementation and Compliance:** This represents the degree to which safety measures are implemented and adhered to.
- **Safety Performance and Outcomes:** Reflects the effectiveness and results of safety practices.
- **Safety Policies and Culture:** Indicates the presence and impact of safety policies and organizational culture on safety.
- **Work Pressures and Motivations:** Addresses how pressures and motivational factors influence safety behavior and performance.

3.3 Structural Model Analysis

The structural model evaluates the direct relationships between these latent variables (Figure 1):

- **Latent Variable 1** has a positive effect on Safety Policies and Culture (0.314) and a negative effect on Safety Implementation and Compliance (-0.148). This suggests that as Latent Variable 1 increases, Safety Policies and Culture improve, while Safety Implementation and Compliance decrease.
- **Safety Implementation and Compliance** is positively influenced by Safety Policies and Culture (0.828), indicating that better policies and culture enhance compliance and implementation.
- **Work Pressures and Motivations** have a moderately positive effect on Safety Performance and Outcomes (0.484), showing that higher pressures and motivations lead to improved safety performance.
- **Safety Policies and Culture** and **Work Pressures and Motivations** are related, with the latter showing a strong influence on Safety Performance and Outcomes.

3.4 Measurement Model Analysis

The measurement model focuses on how well the indicators reflect their respective latent variables. The model's validity and reliability are assessed through the measurement of each latent variable (Figure 2). These analyses offer insights into how different factors interact to influence safety outcomes in the workplace. The relationships between variables highlight the importance of safety policies and organizational culture, as well as the impact of work pressures and motivations on safety performance. Despite the generally positive perception of safety measures, barriers such as financial constraints, inconsistent enforcement, and a lack of clear regulations hinder optimal safety program implementation. Addressing these challenges will require targeted interventions, such as increased investment in safety resources, mandatory safety training, and enhanced regulatory oversight. Moreover, fostering a culture of empowerment, where workers feel confident to report unsafe practices, can further promote workplace safety. These findings, supported by secondary data from local union reports, emphasize the need for a multifaceted approach to elevate safety standards and ensure worker well-being.

3.5 Structural Equation Modeling (SEM) with SmartPLS for Construction Sector Workers

To examine the impact of two independent variables, Safety Systems and Tools, and Safety Measures on Safety Outcomes and Worker Empowerment and Behavior, we implemented a Structural Equation Modeling (SEM) analysis using SmartPLS software (Figure 3). This analysis includes the mediating effects of Safety Awareness and Knowledge, Safety Practices, and Safety Enforcement. The sample consisted of 200 participants who responded to a 20-item questionnaire regarding workplace safety.

The structural model illustrates the direct effects of Safety Systems and Tools Safety Measures on Safety Outcomes and Worker Empowerment and Behavior, as well as the indirect effects mediated through Safety Awareness and Knowledge, Safety Practices, and Safety Enforcement (Figure 4).

The measurement model confirms the reliability and validity of the constructs used in the SEM analysis. It includes factor loadings for each observed variable, composite reliability, and average variance extracted (AVE) for each latent variable.

4 Conclusion

This study offers a detailed examination of safety practices within Sulaimani City's construction sector, identifying substantial gaps between theoretical safety frameworks and practical implementation. Despite the presence of safety protocols aligned with OSHA and other international standards, analysis of data from 217 participants, 200 construction workers, and 17 safety officers revealed critical deficiencies in training adequacy, personal protective equipment (PPE) availability, and enforcement of safety regulations.

The Kolmogorov-Smirnov (KS) test for normality indicated significant deviations across key safety metrics, such as safety knowledge, compliance, PPE usage, and emergency preparedness, highlighting pervasive inconsistencies in the application of safety measures. Spearman's rank correlation analysis identified moderate positive relationships among key variables, including a correlation of 0.45 ($p < 0.01$) between training adequacy and worker empowerment, suggesting that structured training improves workers' confidence and ability to manage unsafe conditions. However, insufficient training in critical areas, including fall prevention and emergency protocols, continues to exacerbate workplace hazards, such as falls, electrical injuries, and equipment-related incidents.

Financial constraints emerged as a significant barrier to compliance, particularly in the provision of adequate PPE. Safety officers emphasized the need for cultivating a robust safety culture, where management visibly prioritizes worker safety. Furthermore, positive reinforcement strategies were found to enhance worker engagement with safety protocols, illustrating the critical interplay between motivation and accountability.

To address these challenges, the study underscores the necessity of a multi-dimensional approach to safety management. This includes the implementation of comprehensive training programs, increased financial investment in protective resources, and the establishment of a management-driven culture of safety. Integrating these elements is imperative to bridge the gap between policy and practice, fostering a safer construction environment and mitigating accident rates within Sulaimani's rapidly expanding construction industry.

5 Acknowledgements

The authors gratefully acknowledge the valuable contributions of individuals and organizations who supported this work but do not meet the criteria for authorship. Their assistance, professional input, and provision of materials are sincerely appreciated.

References:

[1] Alhelo, A. A., Alzubaidi, R., & Rashid, H. (2023). A framework supporting health and safety practices in the United Arab Emirates' construction projects. Sustainability, 15(2), 1587.

[2] Amiri, M. (2014). Risk-based analysis of construction accidents in Iran during 2007–2011: Meta-analyze study. PubMed Central (PMC).

[3] Kumar, A. (2019). Multicriteria decision-making methodologies and their applications in sustainable energy systems/microgrids. Decision Making Applications in Modern Power Systems.

[4] Bautista-Bernal, I., Quintana-García, C., & Marchante-Lara, M. (2024). Safety culture, safety performance, and financial performance: A longitudinal study. Safety Science, 172, 106409.

[5] Buniya, M. K., Othman, I., Sunindijo, R. Y., Kashwani, G., Durdyev, S., Ismail, S., Antwi-Afari, M. F., & Li, H. (2021). Critical success factors of safety program implementation in construction projects in Iraq. International Journal of Environmental Research and Public Health, 18(16), 8469.

[6] Buniya, M. K., Othman, I., Sunindijo, R. Y., Kineber, A. F., Mussi, E., & Ahmad, H. (2021). Barriers to safety program implementation in the construction industry. Ain Shams Engineering Journal, 12(1), 65–72.

[7] Carolino, R. C. (2021). Implementation of safety management of selected construction companies in Manila. Current Integrative Engineering, 1(1), 37–77.

[8] Chan, A. P. C., Guan, J., Choi, T. N. Y., Yang, Y., Wu, G., & Lam, E. (2023). Improving safety performance of construction workers through learning from incidents. International Journal of Environmental Research and Public Health, 20(5), 4570.

[9] Chen, W. T., Tsai, I., Merrett, H. C., Lu, S., Lee, Y., You, J., & Mortis, L. (2020). Construction safety success factors: A Taiwanese case study. Sustainability, 12(16), 6326.

[10] Dai, F., Yoon, Y., & GangaRao, H. V. S. (2016). State of practice of construction site safety in the USA. Frontiers of Engineering Management, 3(3), 275.

[11] Haadir, S. A., & Panuwatwanich, K. (2011). Critical success factors for safety program implementation among construction companies in Saudi Arabia. Procedia Engineering, 14, 148–155.

[12] Othman AA, Gloaguen R, Andreani L, Rahnama M (2018) Improving landslide susceptibility mapping using morphometric features in the Mawat area, Kurdistan Region, NE Iraq: comparison of different statistical models. Geomorphology 319:147–160. https://doi.org/10.1016/j.geomorph.2018.07.018

[13] Machhi, N., & Patel, D. (2019). The health and safety management performance of construction SMEs in Gujarat: Barriers and solutions.

[14] Jazayeri, E., & Dadi, G. B. (2017). Construction safety management systems and methods of safety performance measurement: A review. International Journal of Occupational Safety and Ergonomics, 23(3), 386–398.

[15] Lu, M., Cheung, C. M., Li, H., & Hsu, S. (2016). Understanding the relationship between safety investment and safety performance of construction projects through agent-based modeling. Accident Analysis and Prevention, 94, 8–17.

[16] Mohammadi, A. H., Tavakolan, M., & Khosravi, Y. (2018). Factors influencing safety performance on construction projects: A review. Safety Science, 109, 382–397.

[17] Osei-Asibey, D., Ayarkwa, J., Acheampong, A., Adinyira, E., & Amoah, P. (2021). Impacts of accidents and hazards on the Ghanaian construction industry. International Journal of Construction Management, 23(4), 708–717.

[18] Othman, I., Kamil, M., Sunindijo, R. Y., Alnsour, M., & Kineber, A. F. (2020). Critical success factors influencing construction safety program implementation in developing countries. Journal of Physics: Conference Series, 1529(4), 042079.
[19] Sunindijo, R. Y. (2015). Improving safety among small organizations in the construction industry: Key barriers and improvement strategies. Procedia Engineering, 125, 109–116.
[20] Watson, R., & Preedy, V. (2010). 5-point Likert scale. In V. R. Preedy & R. R. Watson (Eds.), Handbook of Disease Burdens and Quality of Life Measures (p. 4288). Springer.
[21] Yang, H., Chew, D. A. S., Wu, W., Zhou, Z., & Qi-Ming, L. (2012). Design and implementation of an identification system in construction site safety for proactive accident prevention. Accident Analysis & Prevention, 48, 193–203.

تطبيق إجراءات السلامة العملية المهنية وتحدياتها في مواقع البناء : حالة دراسية في مدينة السليمانية، إقليم كردستان العراق

المستخلص

في هذه الدراسة تتم تقيم إجراءات السلامة العملية المهنية وتحدياتها في مواقع البناء بمدينة السليمانية، إقليم كردستان العراق، في ظلّ التوسع العمراني السريع وتزايد مخاطر أماكن العمل. على الرغم من الالتزام بمعايير السلامة المحلية والدولية، لا تزال معدلات الحوادث مرتفعة، مما يكشف عن فجوات متباينة بين البروتوكولات النظرية والتطبيقات العملية. تم تحليل بيانات ٢١٧ مشاركًا (٢٠٠ عامل و١٧ مسؤول سلامة) باستخدام نهج متعدد الأساليب، من خلال أساليب إحصائية، بما في ذلك اختبارات ارتباط الرتب لكولموغوروف - سميرنوف وسبيرمان. سلّطت النتائج الضوء على التوزيعات غير الطبيعية في مقاييس السلامة الرئيسية والتباين الكبير في المعرفة والتدريب وتوافر معدات الحماية الشخصية. وُجد ارتباط إيجابي معتدل ($r = 0.45$، $p < 0.01$) بين كفاية التدريب وتمكين العمال، مما يؤكد على دور برامج التدريب المنظمة. برزت القيود المالية، وعدم كفاية التنفيذ، ونقص ثقافة السلامة المتماسكة كعوائق رئيسية أمام الامتثال و التطبيق. وتؤكد النتائج على الحاجة إلى استراتيجيات متكاملة تجمع بين التدريب المكثف والاستثمار المالي ومبادرات السلامة التي يقودها الإدارة لسد الفجوة بين السياسة والممارسة، مما يؤدي في نهاية المطاف إلى تقليل الحوادث وتحسين رفاهية العمال.

الكلمات المفتاحية:

السلامة المهنية , التدريب على السلامة، ثقافة السلامة المهنية ، الامتثال التنظيمي، إدارة المخاطر، تنفيذ سياسة السلامة المهنية .

Table 1: Kolmogorov-Smirnov Test Results for Safety-Related Variables

Question (Abbreviation)	KS Statistic	p-value	Normality
Safety Knowledge (SK)	0.134	0.002	Non-normal
Safety Training (ST)	0.145	0.001	Non-normal
Protective Equipment (PE)	0.128	0.003	Non-normal
Incident Reporting (IR)	0.152	0.000	Non-normal
Safety Compliance (SC)	0.137	0.002	Non-normal
Emergency Preparedness (EP)	0.146	0.001	Non-normal
Safety Inspections (SI)	0.139	0.002	Non-normal
Risk Assessment (RA)	0.150	0.001	Non-normal
Safety Communication (SCM)	0.132	0.004	Non-normal
Worker Empowerment (WE)	0.141	0.002	Non-normal
Safety Awareness (SA)	0.149	0.001	Non-normal
Safety Practices (SP)	0.135	0.002	Non-normal
Safety Enforcement (SE)	0.144	0.001	Non-normal
Hazard Recognition (HR)	0.138	0.002	Non-normal
Safety Rules (SR)	0.133	0.003	Non-normal
Workplace Safety (WS)	0.148	0.001	Non-normal
Safety Procedures (SPR)	0.147	0.001	Non-normal
Job Safety (JS)	0.136	0.002	Non-normal
Safety Feedback (SF)	0.142	0.002	Non-normal
Accident Prevention (AP)	0.153	0.000	Non-normal

Table 2: Spearman's Rank Correlation Coefficients and Structural Equation Modeling (SEM) Results for Safety Variables

Question (Abbreviation)	KS Statistic	p_value	Normality
Safety Policies (SP)	0.339	0.000	Non-normal
Work Pressures (WP)	0.290	0.000	Non-normal
Motivation (M)	0.349	0.000	Non-normal
Cost Factors (CF)	0.214	0.037	Non-normal
Fines Policy (FP)	0.293	0.000	Non-normal
OSHA Awareness (OW)	0.259	0.004	Non-normal
PPE (PPE)	0.419	0.000	Non-normal
External Collaboration (EC)	0.372	0.000	Non-normal
Government Fines (GF)	0.297	0.000	Non-normal
Maintenance (MNT)	0.410	0.000	Non-normal

Table 3: Spearman's Rank Correlation Coefficients for Safety-Related Variables

Variable (Abbreviation)	SP	WP	M	CF	FP	OW	PPE	EC	GF	MNT
SP	1.000	0.133	0.356	-0.154	0.395	0.220	0.224	0.127	-0.312	0.457
WP	0.133	1.000	-0.240	0.175	-0.152	-0.325	0.212	-0.239	-0.108	0.040
M	0.356	-0.240	1.000	0.186	0.655**	0.278	0.260	0.499*	0.064	0.450
CF	-0.154	0.175	0.186	1.000	-0.177	-0.433	-0.053	0.158	0.424	-0.324
FP	0.395	-0.152	0.655**	-0.177	1.000	0.553*	0.443	0.744**	-0.022	0.601*
OW	0.220	-0.325	0.278	-0.433	0.553*	1.000	0.475	0.356	-0.266	0.316
PPE	0.224	0.212	0.260	-0.053	0.443	0.475	1.000	0.277	-0.055	0.441
EC	0.127	-0.239	0.499*	0.158	0.744**	0.356	0.277	1.000	0.428	0.226
GF	-0.312	-0.108	0.064	0.424	-0.022	-0.266	-0.055	0.428	1.000	-0.348
MNT	0.457	0.040	0.450	-0.324	0.601*	0.316	0.441	0.226	-0.348	1.000

Significant at the 0.01 level (2-tailed).
Significant at the 0.05 level (2-tailed).

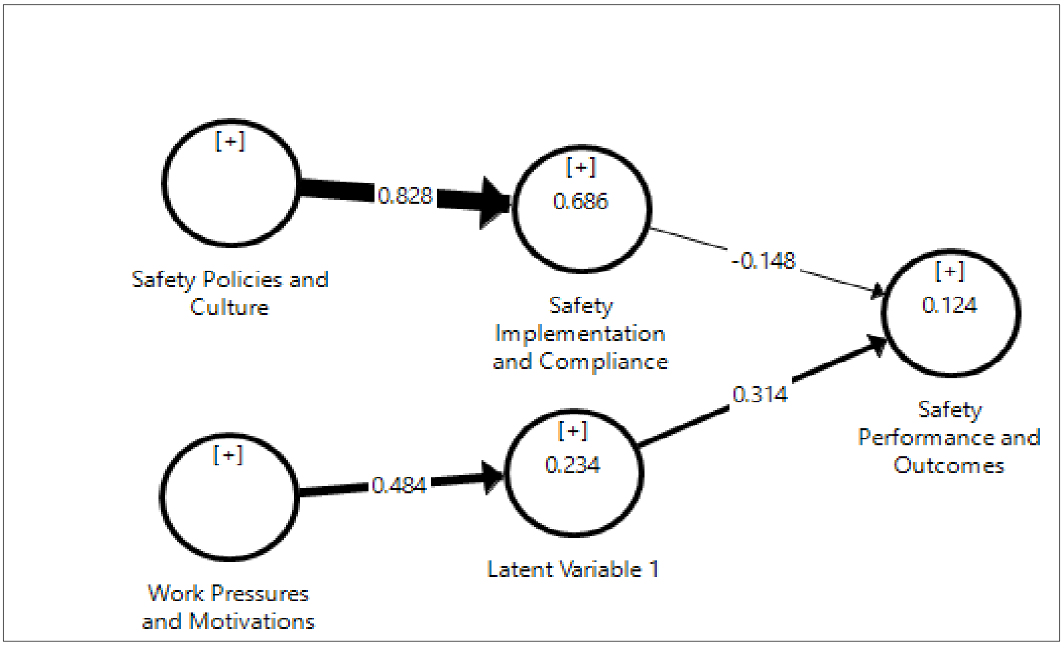

Figure 1: Structural Model Evaluating Direct Relationships Between Latent Variables

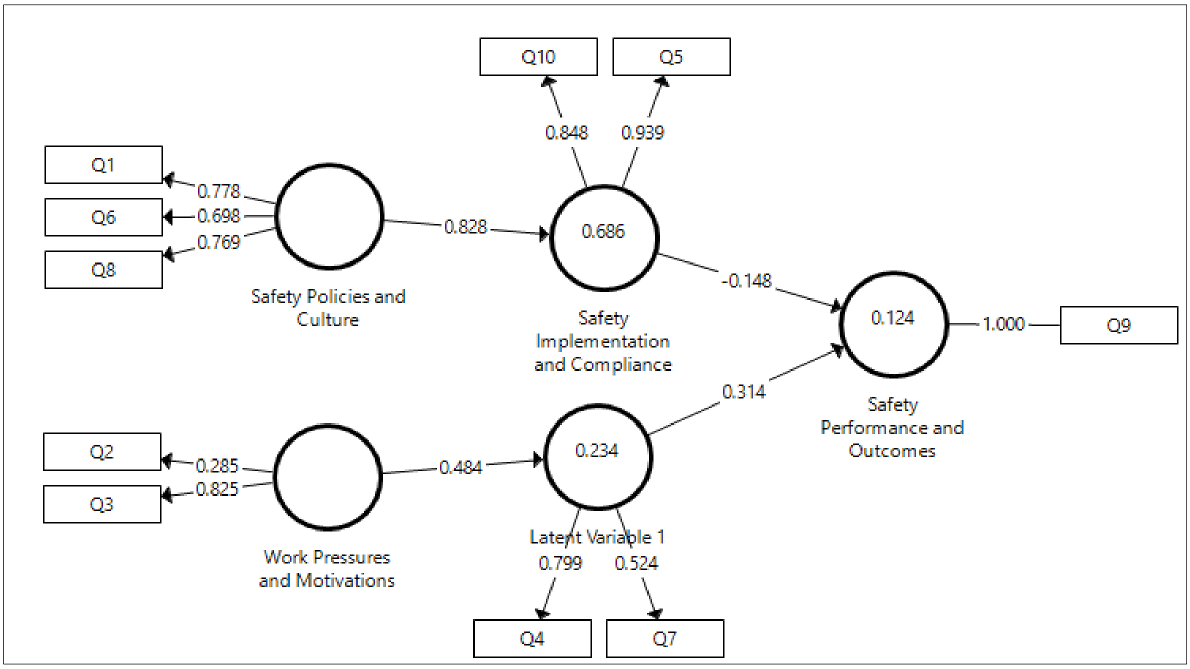

Figure 2: Measurement Model Assessing the Validity and Reliability of Latent Variables

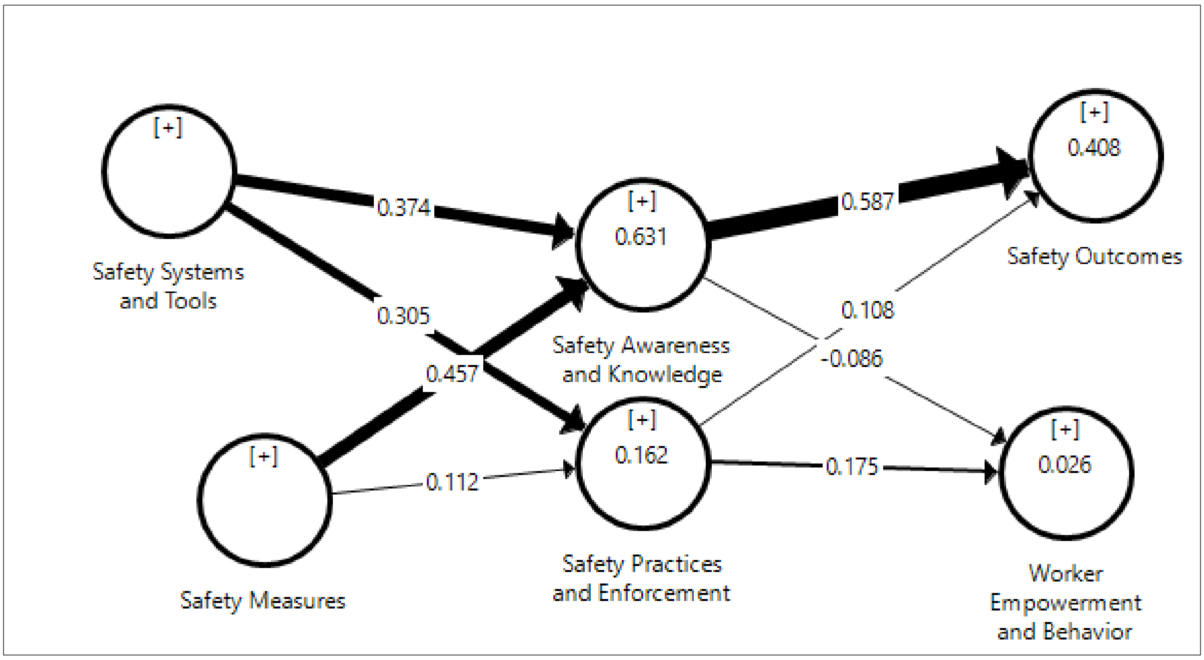

Figure 3: Structural Equation Modeling (SEM) Analysis of Safety Systems, Safety Measures, and Their Impact on Safety Outcomes and Worker Empowerment

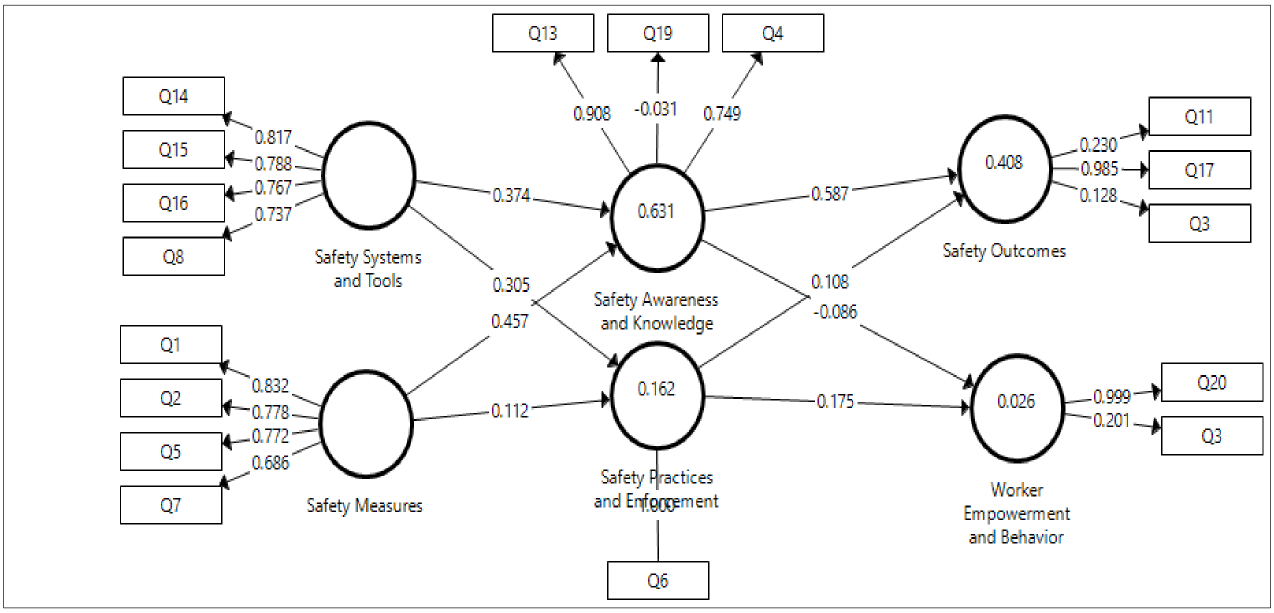

Figure 4: Structural Model Depicting Direct and Mediated Effects of Safety Systems and Measures on Safety Outcomes and Worker Empowerment.

Table 4: Workers questionaries form and list of the data collected questions

No.	Worker's Questionnaire
Q1	The company provides personal safety equipment (PPE) for workers at the construction sites, ensuring easy access and availability for all workers.
Q2	Safety signs are available, and they are in a language that all workers can understand.
Q3	A worker’s attitude or belief in safety is one of the main reasons for any accident at work.
Q4	There is sufficient awareness among the workers about emergency evacuation procedures.
Q5	I receive training on the safe use of ladders and fall protection measures at heights.
Q6	Safety measures are consistently enforced across all work shifts, including night shifts.
Q7	I receive adequate training on the safe use of machinery and personal protective equipment specific to my tasks.
Q8	There is a system in place for recognizing and addressing potential hazards related to electricity use on the construction site.
Q9	Hearing protection equipment is available at my workstation.
Q10	Poor design of workstations and processes creates traps that lead to unsafe behavior.
Q11	Reporting and investigating near-miss incidents significantly contribute to preventing future accidents.
Q12	The volatility of weather conditions significantly affects safety practices and incident rates on construction sites.
Q13	Safety meetings held shortly before work begins effectively ensure everyone is aware of the hazards and risks involved.
Q14	Technological tools, such as wearables or sensors, are utilized to enhance safety monitoring and prevent potential risks.
Q15	Fire extinguishers are easily accessible for emergencies at the construction site.
Q16	First aid kits are readily available for emergencies at the construction site.
Q17	Eye protection is available at my workstation to prevent injuries from flying debris or particles.
Q18	In my workplace, safety officers regularly use a checklist to monitor and assess the safety status.
Q19	Participating in additional safety training courses enhanced my understanding of workplace safety.
Q20	I feel empowered to stop work if I believe it is unsafe without facing negative consequences.

Table 5: Safety officer's questionaries form and list of the data collected questions

NO.	Safety Officer's Questionnaire
Q1	Safety policies, safety Officers, and clear safety laws are essential to minimizing accidents and instilling a culture of safety in the workplace to ensure worker compliance.
Q2	Push to finish projects quickly, and various work pressures lead to neglecting safety procedures.
Q3	Pay, job satisfaction, and rewards strongly motivate workers to follow safety procedures.
Q4	Cost is one of the factors in not applying safety procedures in my workplace.
Q5	The company will fine any worker who does not follow the safety policy.
Q6	The company is aware of OSHA and other international safety agencies and policies.
Q7	Inadequate personal protective equipment (PPE) at the workplace is one of the factors that affect safety performance.
Q8	The company has a safety checklist to check the safety status regularly.
Q9	The company has faced fines from the government for breaching safety regulations.
Q10	Safety equipment and machinery are regularly maintained to ensure their effectiveness and reliability.