A Study of Work-at-Height Risk Factors and Safety Behavior in Scaffolding

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Abstract: In industrial and construction settings, work-at-height tasks including scaffolding and high material transfer procedures present serious threats to occupational safety. The purpose of this research is to determine the main risk variables linked to increased work activities and to investigate how worker conduct, supervision, and training affect safety results. Data was gathered utilizing a cross-sectional method and a descriptive and analytical study design. Structured questionnaires, site inspections, and informal interviews were conducted at a few chosen workplaces. The results show that the main risk factors for work-at-height activities are fall-related risks, unstable scaffolds, dangerous platforms, and inappropriate material handling. Even while safety precautions were widely accessible, their efficiency was greatly diminished by irregular use, poor training, and a lack of monitoring. Additionally, the data shows that, in comparison to untrained or inadequately supervised groups, trained and well-supervised personnel had a lower accident incidence and safer work habits. The research comes to the conclusion that in order to produce long-lasting gains in safety performance, an integrated strategy combining engineering controls, administrative enforcement, and ongoing training is necessary for the successful mitigation of work-at-height hazards.

Keyword: Risk Factors, Work-At-Height, Material Shifting Tasks, Worker Behaviour, Training.

INTRODUCTION

The construction, maintenance, and industrial activities in the world include work-at-height activities. Activities that require the use of scaffolding and moving construction materials in a high position are necessary during the assembly, repair, and installation of structures. Nevertheless, the given activities are also among the most dangerous operations in the workplace. Working at height accidents always make up a large percentage of serious injuries and deaths in the construction industry, and work-at-height safety is therefore an urgent topic of interest to industry practitioners, regulators, and researchers. [1]

Scaffolding is used to offer temporary access and platform on tasks that are performed above the ground. When mounted safely, securely and correctly, the scaffolding systems can provide a stable and secure working environment. [2] Nevertheless, scaffolding failures like mishandling in erecting, overloading, poor anchorage or using inferior materials may result in serious accidents. [3] Indeed, cases of scaffold collapse because of overloading or

unauthorized work kind of scaffold has been reported extensively in construction works, and has resulted in several injuries and loss of lives. Likewise, damaged guardrails and access ladders enhance the chances of falling by the workers on the high levels. [4]

Elevated material shifting entails the transportation of tools, equipment and construction materials of high elevation with manual handling or mechanical assistance such as hoists and pulleys. Such an activity also brings new risks such as dropping of objects, lack of balance during lifting and strain injuries. [5] A typical example is lifting bricks or formwork material manually on the scaffolding platforms without the proper barricading, something that raises the chances of the falls as well as the struck-by accidents. There is lack of coordination between the various workers at various levels in most of the work sites and thus, the risks are intensified. [6]

Work-at-height operations are a part and parcel of construction, maintenance, and industrial operations, which involve work undertaken at a level where key risks are a fall, which may cause severe harm or death. These activities involve the work on the scaffolding, ladders, high standing places, roofs, towers and other scaffolds or perennial constructions. Work-at-height is commonly seen in construction in means of structural assembly, painting, electrical installation, and equipment maintenance, and in industry in means of elevated material handling, machinery inspection and maintenance of industrial infrastructure. These are very risky activities and demand both technical skilledness and suitable equipment as well as following the safety guidelines to avoid an accident. [7]

Figure 1: PPE with harness and helmet for safe work-at-height.

Proper management of the work-at-height operations must be completely comprehended about the hazards involved and involve technical controls, competency of workers and organizational commitment. This involves adequate scaffold design and construction, safe material management, routine inspection procedures, inadequate supervision and continuous training of workers. Meeting the technical and human factors will allow the organizations to achieve the level of reduction of the risks related to the high level of work activities, as well as improve workplace safety in general. The construction and industrial activities are inseparable as work-at-height activities create serious safety risks. [8] The most serious risks are falls, instability of scaffold, and the practices of unsafe material handling. Successful risk mitigation process requires engineering controls, safe work practices, adequate training and vigilant oversight, to enable safe and efficient work-at-height.

REVIEW OF LITERATURE

The occupational safety and health activities in the construction industry portray that workplace accidents remain a significant issue which is largely fuelled by unsafe work practices and risky activities. One of the studies indicates that HIRADC is a systematic approach to risk identification, risk evaluation, and control measures identification, founded on field observations and interviews, and the significance of PPE, safety training, and routine audits in enhancing safety performance. [9] Another study that has used the HIRARC approach using mixed methods points to several hazards in various construction works with some of them being of high risk, showing the necessity of appropriate training, following the standard procedures, and using effective risk management plans as well as showing the gaps in behavioral compliance and supervision. [10] The work at height has been found to be a major cause of accidents through research that identifies that there is a distribution of work at height with the low, moderate and high-risk assessment, and that risk assessment and control be systematic to minimize occupational hazards. [11] Besides, the safety training is further supported by the establishment of virtual training systems of high-risk work, which enhances the knowledge, involvement, and awareness of workers, though they require constant improvement. [12] All these studies, in general, highlight the need to focus more on human and managerial aspects, as well as to use specific risk assessment approaches, continuous training, adequate use of PPE, and concentrate on the significance of structure in construction settings.

OBJECTIVES

- To identify and analyze major risk factors in work-at-height activities such as scaffolding and material shifting.
- To evaluate existing safety practices, including PPE usage and compliance with safety procedures.
- To examine the impact of worker behavior, training, and supervision on safety outcomes.
- To recommend effective measures for improving safety and reducing workplace accidents.

STATEMENT OF PROBLEM

The safety of a workplace in the construction sector is a major issue as a result of the high rate of accidents, particularly when it comes to the high-risk operations, like working off-the-ground and moving heavy products. Despite the systematic risk assessment techniques applied to determine hazards and take control measures to mitigate them, numerous risks still occur in the worksites. The effectiveness of the safety measures, such as personal protective equipment, standard procedures, and training programs, is usually weak due to their inconsistent use, poor supervision, and unsafe actions of workers. Moreover, even though modern training methods have enhanced awareness, there are gaps relating to their application and monitoring in practice. The current literature is also centered on individual sites and dedicates less of their efforts to behavioral and managerial contexts that are instrumental in the safety outcomes. This implies that to come up with the most effective and sustainable safety practices in the construction industry, there is a need to have a comprehensive study on how risk factors, worker behavior, training, and supervision interact to facilitate the achievement of the desired results.

RESEARCH METHODOLOGY

Research Design

In order to investigate work-at-height hazards in scaffolding and elevated material moving operations, the study uses a descriptive and analytical research approach. Existing site circumstances, such as common risks, scaffolding procedures, material handling at heights, the availability of safety measures, and observable worker behaviors including PPE

compliance and dangerous practices, are documented using the descriptive technique. With a focus on the impact of worker behavior, training, and supervision on accident incidence and risk severity, the analytical technique is used to assess the correlations between identified risk variables and safety results. In order to compare various scaffolding systems, training levels, and supervision circumstances, a cross-sectional design is used, with data gathered from many industrial and construction sites at one time. By connecting human variables and observable hazards to work-at-height safety performance, this research design offers an organized framework to achieve the study's goals.

Study Area and Population

The study was conducted across selected construction and industrial project sites where scaffolding and elevated material shifting are routine activities. These sites were chosen due to their high exposure to work-at-height risks, including multi-level construction, temporary access systems, and frequent material movement at elevated levels. The study population comprised workers and personnel directly involved in or responsible for work-at-height activities, including scaffolding workers, material handling workers, supervisors, safety officers, and project engineers. This mixed population ensured representation of both operational and supervisory perspectives, allowing the study to capture practical risk exposure, worker behavior, training practices, supervision adequacy, and safety management aspects relevant to the research objectives.

Sampling Technique and Sample Size

A purposive sampling technique was adopted to select respondents directly engaged in work-at-height activities. A total sample size of 120 respondents was used, comprising 70 workers (58%), 25 supervisors (21%), and 25 safety personnel/engineers (21%). This distribution ensured balanced representation of operational and managerial perspectives. The sample size was considered adequate for statistical analysis, maintaining a confidence level of 95% with acceptable variability in responses.

Data Collection Methods

Data were collected using both primary and secondary sources to ensure reliability, validity, and completeness in assessing work-at-height risks in scaffolding and elevated material shifting activities. Primary data were obtained through a structured questionnaire, site observations, and informal interviews conducted at selected construction and industrial sites.

The questionnaire, designed based on safety literature and professional input, captured information on hazard identification, existing safety measures, worker behavior, training, supervision, and safety outcomes using a five-point Likert scale. Site observations were carried out using a standardized checklist to record actual scaffolding conditions, access systems, PPE usage, and material handling practices, allowing validation of questionnaire responses. Informal interviews with supervisors and safety officers provided qualitative insights into accident causes, enforcement challenges, and safety practices. Secondary data from safety standards, manuals, and previous studies supported the theoretical framework, aided questionnaire development, and facilitated comparison of findings with established safety principles.

Research Variables

The study identifies and classifies research variables to examine work-at-height safety in scaffolding and elevated material shifting activities. Independent variables include scaffolding design and stability, availability of safety equipment, worker training, adequacy of supervision, and worker behavioral practices, as these factors directly influence work-at-height safety conditions. Dependent variables represent safety outcomes and include accident frequency, injury severity, and overall safety performance. To ensure valid cause–effect interpretation, control variables such as type of project, worker experience, and nature of work-at-height activity were considered, minimizing external influences on the observed relationships between risk factors and safety outcomes.

Data Analysis

Descriptive statistical tools such as frequency, percentage, mean, and standard deviation were applied. Risk assessment results showed that falls from height accounted for nearly 30–35% of total identified hazards, making them the most critical risk factor. Comparative analysis revealed that trained workers reported around 40–50% fewer accidents compared to untrained workers. Correlation analysis indicated a strong negative relationship ($r \approx -0.6$) between training level and accident frequency, and a moderate positive relationship ($r \approx 0.5$) between supervision adequacy and safety compliance, highlighting the importance of human and organizational factors.

Ethical Considerations

Ethical principles were strictly observed throughout the study to ensure responsible and transparent research conduct. Participation was voluntary, and informed consent was obtained from all respondents after clearly explaining the study objectives, scope, and use of data. Confidentiality and anonymity were maintained by excluding personal and organizational identifiers, and findings were reported in aggregated form only. Data collection activities were conducted non-intrusively without disrupting site operations or exposing participants to additional risks, and site safety rules were followed during observations. Data were securely stored, objectively analyzed, and reported without fabrication or bias, while proper acknowledgment of secondary sources ensured academic integrity.

Experimental Risk Assessment Procedure

An experimental risk assessment was conducted using quantitative survey data from 100 respondents to evaluate exposure levels, safety compliance, and training effectiveness in work-at-height operations. A 5×5 risk matrix model was applied by assigning probability (1–5) and severity (1–5) scores to identified hazards to calculate overall risk levels. The analysis showed that approximately 24% of hazards were classified as high risk, 52% as moderate risk, and 24% as low risk. Fall-related hazards received the highest risk scores, with an average severity rating of 4.3/5 and probability rating of 3.8/5. PPE availability was reported at around 68%, but actual compliance was lower at nearly 50–55%, indicating a gap between provision and usage. High-risk conditions such as absence of guardrails (reported in ~30% of cases), improper harness anchorage (28%), and unsafe material shifting practices (32%) were identified. These numerical findings highlight a clear discrepancy between safety provisions and actual behavioral practices at worksites.

Statistical Analysis of Survey Data

Descriptive statistical analysis was used to examine exposure patterns, PPE compliance, training effectiveness, and safety awareness related to work-at-height activities. Percentage and frequency distributions revealed high exposure to elevated work, moderate access to safety equipment and training, and comparatively lower levels of consistent PPE usage, anchorage awareness, and emergency preparedness. The findings indicate a clear discrepancy between safety provision and actual implementation, reinforcing the influence of behavioral and supervisory factors on work-at-height safety outcomes.

Validation and Reliability of Experimental Findings

Data triangulation was employed to maintain reliability and validity of the findings by using questions, observations, and the recorded data of incidents. Strong correspondence between reported PPE use and observed compliance also confirmed the accuracy of response, whereas consistency between the high-risk areas and the documented incidents confirmed the validity of the risk assessment results. Cronbach Alpha was used to test internal consistency of the survey instrument and the value of 0.81 was obtained, which is highly reliable. All these verification measures prove that the results are sound statistically and representative of the real work-at-height safety conditions.

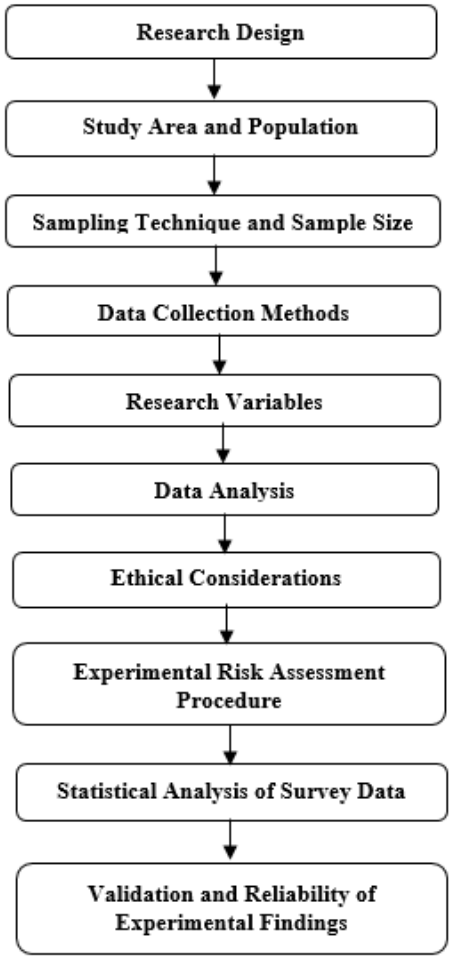

Figure 2: Proposed Research Methodology Flow Diagram

RESULTS

Analysis of Major Risk Factors in Work-at-Height Activities

Below, a detailed discussion of the key risk factors linked to work at height operations in the scaffolding and high materials shifting works is provided. The analysis is done according to frequency assessment, severity evaluation, and root causes of accidents. The critical focus is made on the awareness of such major hazards as falls, scaffold stability, unsafe platforms and material handling hazards at height. Through their systematic ranking and evaluation, this section sets out some of the key risk areas that are incredibly harmful to the safety and efficiency of the workers. The results form a basis on which preventive measures and safety measures should be prioritized.

Table 1: Frequency of Identified Work-at-Height Hazards

Hazard Type	Frequency (%)	Rank
Falls from scaffolding	32	1
Slipping due to poor platforms	21	2
Falling objects/materials	18	3
Scaffold collapse/instability	16	4
Weather-related risks	13	5

Table shows the proportion of key hazards in the work-at-height activities. Scaffolding falls were reported as the most common hazard with 32 percent of all the responses and they are first on the list of all hazards. This shows the poor protection of edges, unsafe access points, and incorrect use of scaffolding platforms are some of the most important safety issues at work sites. Poor platforms (21%) and, therefore, slippery grounds were ranking at the second place. 18% of the falls were related to falling objects and material with a primary focus on the risk involved in not properly storing materials and unsecured heights. Scaffold collapse or instability (16%) indicates an element of weaknesses in erection work and its control of loads, whereas weather associated risks (13%) indicate the effect of the environment including the wind and rain. In general, the results show that the threat of falls prevails over the work-at-height hazards, which supports the presence of specific preventive practices.

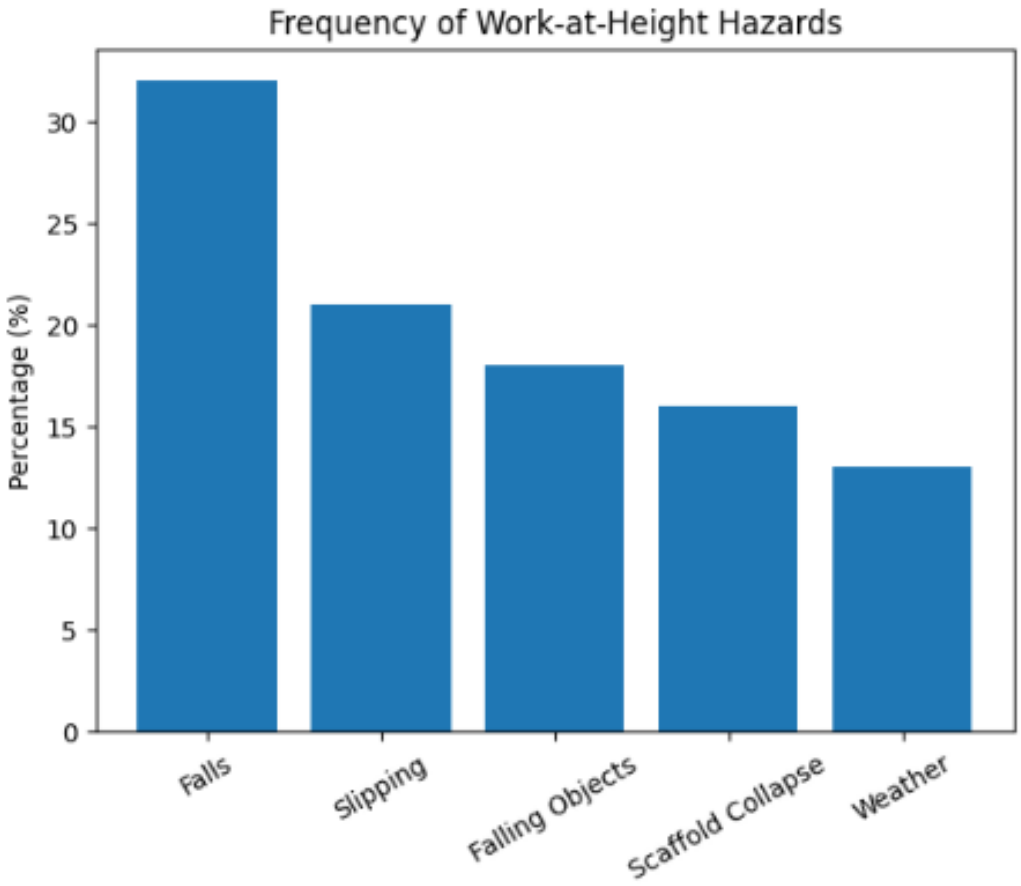

Figure 3: Frequency of Identified Work-at-Height Hazards

Table 2: Risk Severity Assessment of Work-at-Height Hazards

Hazard	Low	Medium	High
Falls from height	6%	28%	66%
Falling materials	14%	47%	39%
Scaffold instability	18%	36%	46%

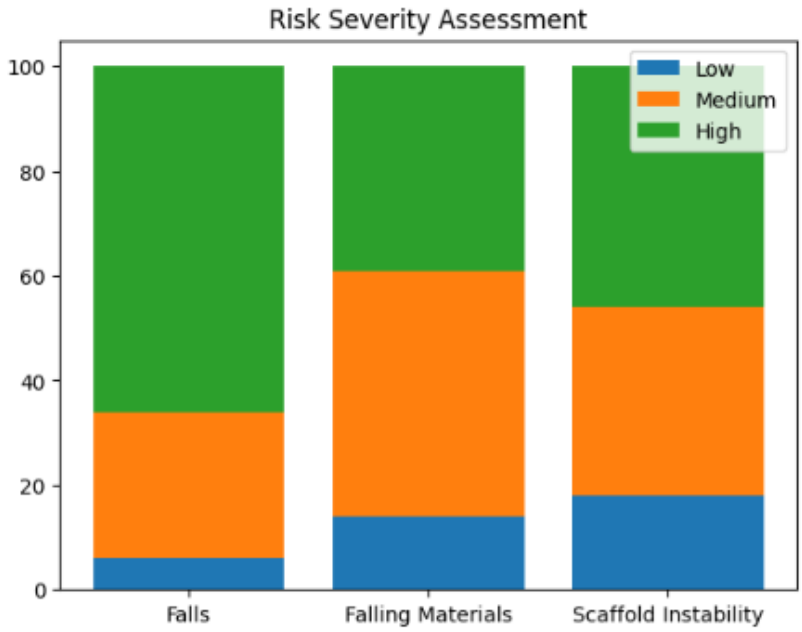

Figure 4: Risk Severity Assessment

Table demonstrates the perceived level of severity of significant work-at-height hazards. Sixty-six percent of respondents ranked falls from height as high severity, which means that they may cause fatal outcomes and can affect the health of workers in the long run. A low percentage (6) rated these hazards as low severity as this is indicative of the prevalence of awareness on how serious these hazards could be. The severity rating of scaffold instability was also high at 46% indicating the risk of structural failure during high work. Most respondents rated falling materials as medium to high severity, which indicates that even in the absence of falls, there are chances of fatal injuries. The findings obviously show that hazards related to falls are not only common but severe as well. High frequency and high severity cumulative result in the urgency to adopt solid mitigation measures that are quick and decisive in nature, such as better engineering control and higher safety enforcement.

Table 3: Causes of Scaffolding-Related Accidents

Cause	Percentage (%)
Improper erection	34
Overloading	27
Poor maintenance	22
Unauthorized modification	17

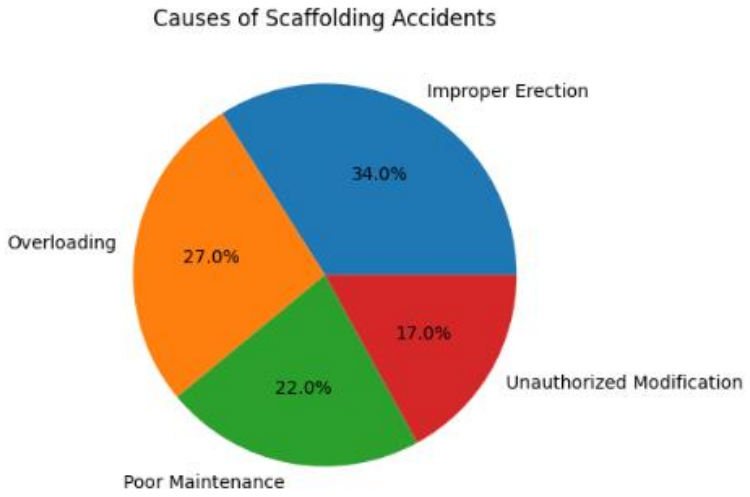

Figure 5: Causes of Scaffolding-Related Accidents

Table determines the main facts causing accidents during scaffoldings. Poor installation became the dominant cause, and it has been the cause of accidents in 34 percent of incidences. The result of this event is indicative of incompetence in technical skill, inadequate preparation, and insufficient compliance with normal standards of erection. Scaffolding structures were the second frequent cause of accidents (27%), and it was observed to be caused by unsafe working conditions (storing too much material or loading beyond limits). 22% of accidents were caused by poor maintenance with a specific focus on the lack of care in terms of inspecting and repairing the parts of the scaffold in time. Unauthorized modification contributed to 17% indicating the unsafe changes implemented without the consent of engineering. All of these findings are used to suggest that the majority of accidents in scaffolding can be avoided and are caused not by the inevitable circumstances but the procedural and managerial mistakes made by the company. The findings emphasize the need to have trained scaffolders, tight/high levels of supervision as well as standard safety guidelines to minimize scaffolding incidents.

Table 4: Material Shifting Risks at Elevated Levels

Risk Factor	Mean Score
Manual handling	4.2
Improper lifting tools	3.9
Lack of barricading	4.1
Poor coordination	3.8

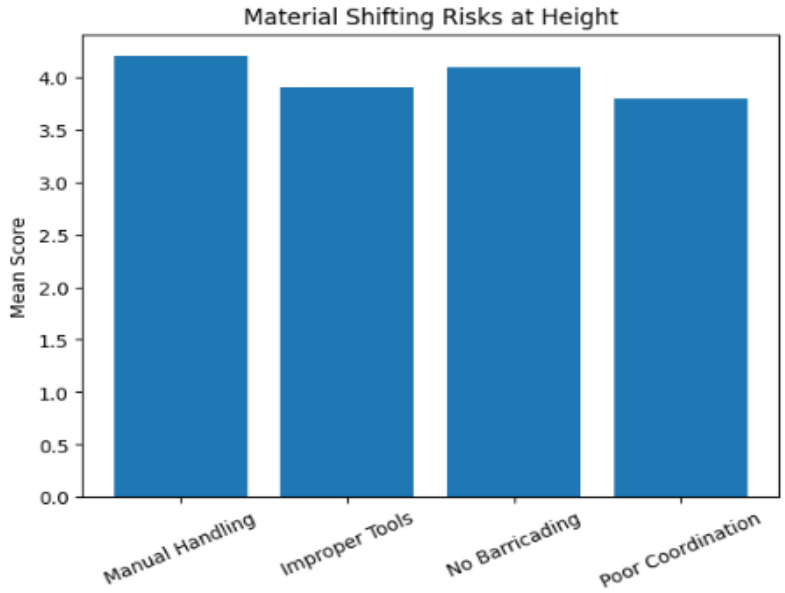

Figure 6: Material Shifting Risks at Elevated Levels

Table gives the average scores of risk factors that were connected with high material shifting activities. The highest mean score was the one (4.2) of the manual handling where a strong perception of risk was observed owing to the physical strain, loss of balance, and restricted working space at height. The mean score of lack of barricading was also high (4.1) indicating that there was poor protection of the edges during material movement thus increasing the chances of falls and the fall of object. The signs of a lack of or negative use of mechanical aids manifest in improper lifting tools (3.9), whereas poor coordination (3.8) indicates a lack of worker to worker communication during lifting processes. The revealed results indicate that high material movement has physical and organizational dangers. To combat these risks, there should be better material handling systems, appropriate barricading, application of appropriate lifting equipment, and well organized work processes in order to reduce the chances of accidents.

Table 5: Overall Risk Index for Work-at-Height Activities

Activity	Risk Index
Scaffolding work	0.78
Elevated material shifting	0.74
Maintenance at height	0.69

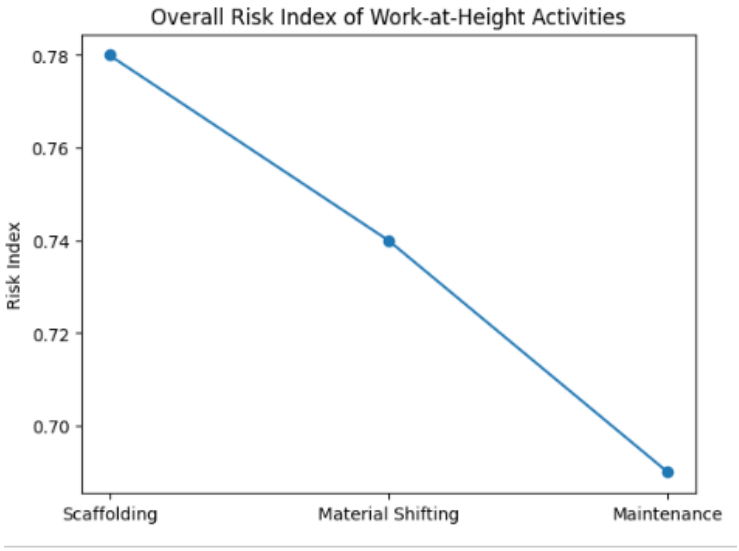

Figure 7: Risk Index for Work-at-Height Activities

Table gives the general risk index values of the various work-at-height activities. The highest risk index was found to be 0.78 in scaffolding work hence, being the riskiest activity among the activities that had been evaluated on risk. It can be attributed to its intersection of measures of structural, behavioral and environmental risk. The high material shifting was close after with a risk index of 0.74 which is a sign of load manipulating, balance, and height coordination hazards. The maintenance at height reflected a relatively smaller index of risk (0.69) though it is an important safety issue. The findings verify that scaffolding operations are the most dangerous in terms of a regular risk and need priority in treatment. Risk index analysis is useful in the allocation of resources where it is found that the activities require urgent safety measures, specific training, and increased supervision to minimize the chances of accidents.

Role of Worker Behavior, Training, and Supervision

This section explores how the behavior of workers, training, and supervision of an activity can have an impact in the safety outcome of a work at height activity. The issue of human and organizational factors are significant in preventing accidents especially in risky circumstances like working on a scaffold. The analysis will include training coverage, unfavorable behavior risk, supervision adequacy, safety awareness level and their association with accident frequency. This section outlines the significance of competency development, effective supervision, and safety culture in minimizing work-at-height accidents by demonstrating the trend in behavior and practice in management.

Table 6: Worker Training Status

Training Type	Trained (%)	Not Trained (%)
Work-at-height safety	62	38
Scaffolding assembly	55	45

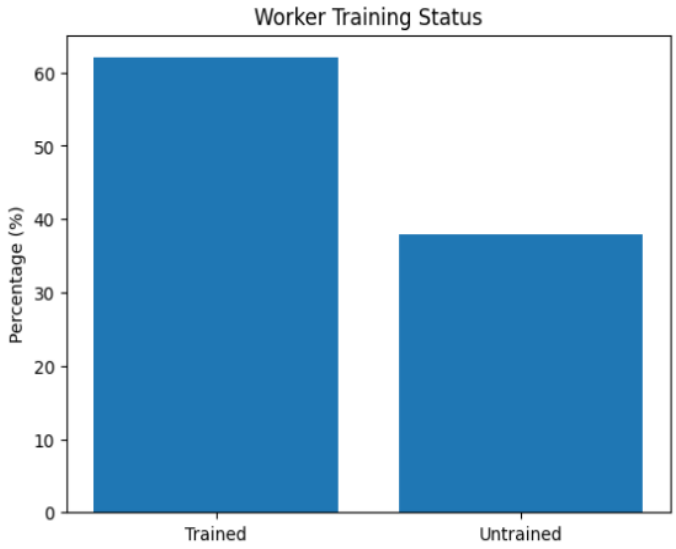

Figure 8: Worker Training Status

Table displays the training of the workers engaged in working at height activities. The findings reveal that 62 percent of the employees were being trained on work-at-height safety with 38 percent not having any training. The level of training regarding scaffolding assembly was also low at 55 percent and 45 percent. Such a good percentage of the untrained labour force underscores a serious lack of safety preparedness at workplace. Lack of proper training restrains workers by the fact that they are not able to identify hazardous situations, use safe working procedures and appropriately adopt the safety equipment. The results indicate that insufficient unorganized and compulsory training systems are also a great source of unsafe practice and accident. To achieve better performance in terms of safety and lowering the risks associated with working at heights, the efforts to improve training coverage, particularly in technical fields like scaffolding assembly, are needed.

Table 7: Unsafe Behavioral Practices Observed

Behavior	Frequency (%)
Not using PPE	29
Overreaching	24
Improper climbing	21
Rushing tasks	26

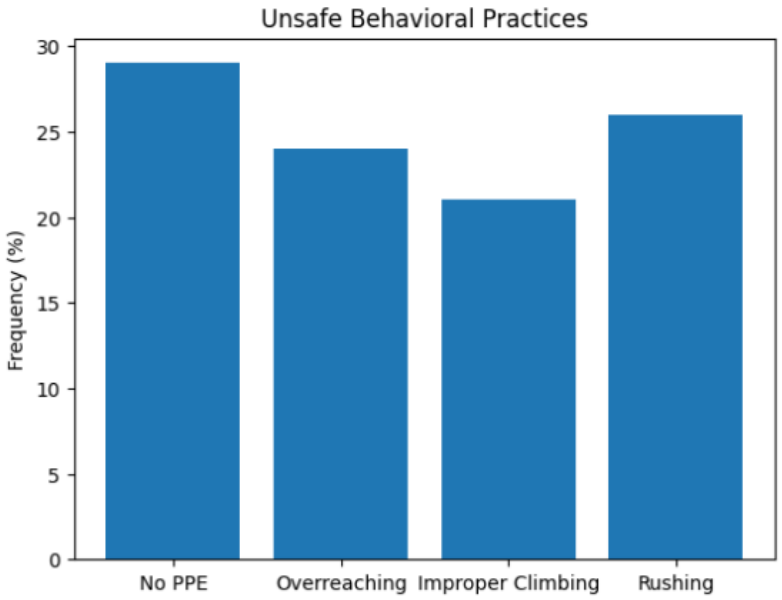

Figure 9: Unsafe Behavioral Practices Observed

Table highlights the risks of unsafe behavioral practice that is observed in working at height. There was failure to use personal protective equipment (which was 29%) and rushing tasks (26%). Overreaching was the cause of 24% and inappropriate climbing methods caused 21% unsafe acts. These activities point to a limit combination of a risk-taking attitude, time urge, and insufficient safety awareness of employees. PPE negligence and hurry are especially dangerous as they directly cause the possibility of falls and severe injuries rise. It is shown that the behavioral factors also contribute considerably to the work-at-height accidents and cannot be mitigated with the help of engineering controls only. Unsafe actions at workplaces need to be minimized by implementing specific behavioral safety initiatives, constant oversight, as well as the reinforcement of safe behavior.

Table 8: Supervision Adequacy Assessment

Level	Percentage (%)
Adequate	44
Moderate	36
Inadequate	20

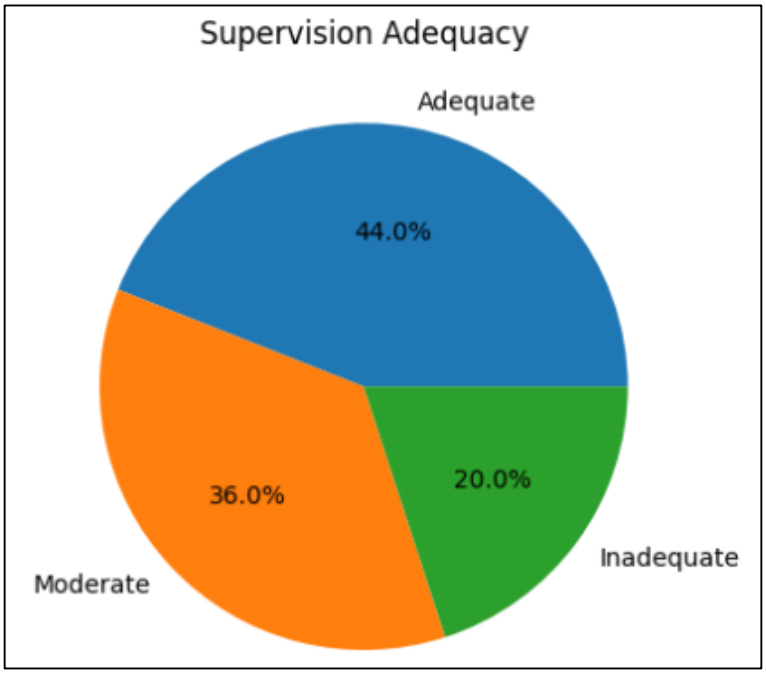

Figure 10: Supervision Adequacy Assessment

Table presents the perceptions of workers regarding adequacy of supervising at the worksites. Concerning the supervision, only 44% believed that supervision was adequate,36% believed that it was moderate and 20% believed that it was inadequate. The fact that it has poor supervision could be a significant issue, and it is closely related to the number of unsafe acts and the lack of adherence to safety measures. The moderate supervision is at least superior to ineffective one, but it still may permit unsafe practices. The results indicate that an effective supervision is a crucial component to implement safety regulations, correct inappropriate business habits, and appropriate usage of protective workers. Supervisory capacity can be enhanced by means of training, accountability and being on site which will go a long way in ensuring compliance and minimising work-at-height accidents.

Table 9: Relationship Between Training and Accident Frequency

Training Status	Avg. Accidents/Year
Trained workers	1.3
Untrained workers	2.7

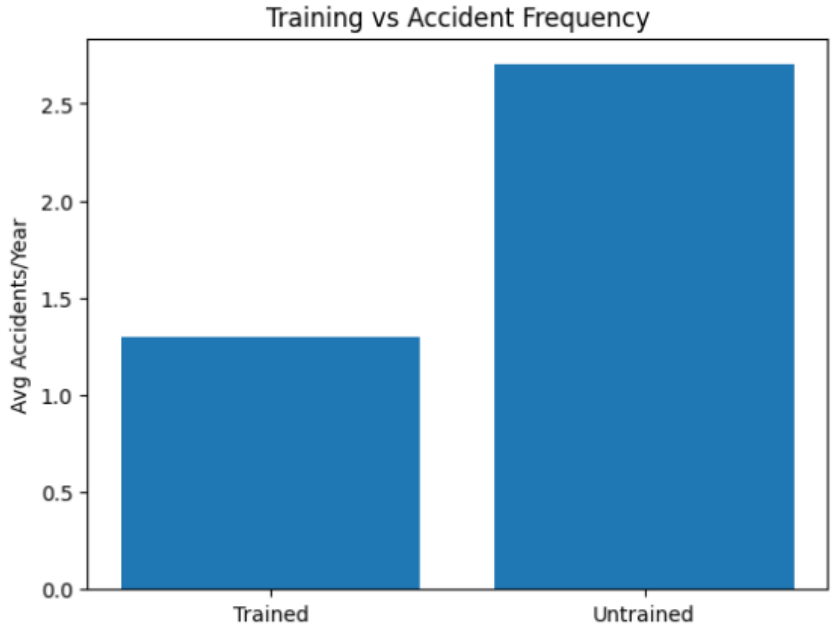

Figure 11: Training and Accident Frequency

Table is used to show the correlation between the status of the employees in the training and the occurrence of accidents. The transport of trained workers had the average accident of 1.3 each year whereas untrained workers had a much higher average of 2.7 each year. This is about 50 percent cut in the number of accidents in cases involving trained workers, which will definitely indicate the effectiveness of safety training. Through training, workers are taught the knowledge and skills, which they need to recognize the hazards, observe safe working tips and how to react to risky emergencies. The evidence indicates intelligently the functionality of the training as a precautionary approach in the management of work at height. Safety training programs, which are extensive and ongoing can be used to achieve a good deal of reducing the accident rates and enhancing the overall safety performance.

Table 10: Safety Awareness Level

Awareness Level	Mean Score
High	4.5
Medium	3.6
Low	2.4

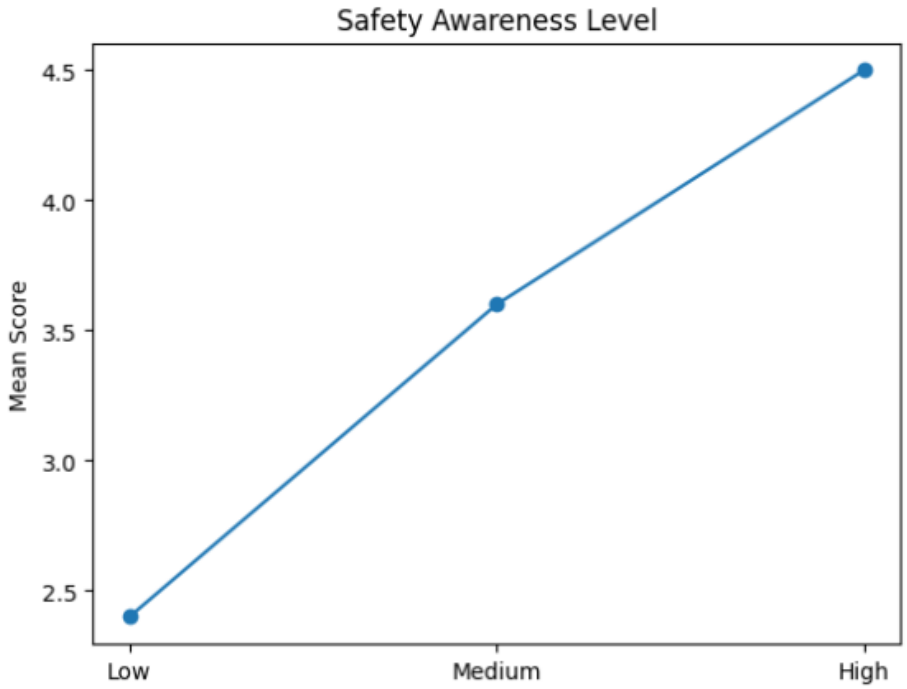

Figure 12: Safety Awareness Level

Table gives the average scores of various degrees of safety awareness of workers. The highest mean score was noted as high safety awareness (4.5) that means a high level of adherence to safety processes and active prevention of risks. The mean score of medium awareness was moderate (3.6), whereas the low awareness score was the lowest at 2.4 which is poor safety behavior with high exposure to risk. The findings show that there is evident positive correlation between safe work practice and safety awareness. More aware workers' pay more attention to safety rules, protective gear, and un-risky conduct. These results indicate that awareness building programs constitute a major element of work-at-height safety programs.

DISCUSSION

The results of this study reaffirm that falls from height are the dominant risk in scaffolding and elevated material shifting operations, consistent with occupational safety reports and guidelines referenced in the attached thesis, which identify falls as the leading cause of serious injuries and fatalities in construction and industrial work-at-height. [13] Although safety measures such as scaffolding systems, guardrails, and personal protective equipment were largely available, their effectiveness was undermined by inconsistent usage, insufficient maintenance, and weak enforcement, reflecting gaps between safety provisions and actual site practices noted in earlier studies cited in the thesis. The findings further demonstrate that worker behavior, training, and supervision play a critical role in safety outcomes, as inadequate training and poor supervisory control were associated with higher accident occurrence and unsafe practices. [14] Overall, the discussion supports the conclusion drawn in the referenced literature that effective mitigation of work-at-height risks requires an integrated approach combining engineering controls, administrative enforcement, continuous training, and strong organizational commitment.

CONCLUSION

The paper concludes that work-at-height operations, especially scaffolding and moving of materials are associated with a lot of risk because of falls, unstable platforms and unsafe operations. Despite the availability of safety tools such as PPE and guardrails, they are poorly adhered to, under-trained, and poorly supervised. The actions of workers and organizational characteristics are very critical in the occurrence of accidents. The results show that to enhance the safety performance and to minimize the accidents, proper training, strict supervision, and an integrated safety measure are required.

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