

Assessing Severity Level of Factors in Construction Accidents Using Risk Matrix Assessment: A Case Study of Sindh Province, Pakistan

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Abstract

Construction-related accidents remain a significant challenge in the Sindh province of Pakistan, contributing to safety concerns and economic losses. This systematic review aims to assess the severity of factors contributing to construction accidents using the Risk Matrix Assessment (RMA) method. The study analyzed peer-reviewed articles, government reports, and relevant literature published between 2017 and 2025, focusing on accident data specific to Sindh. The variables of study included Human Factors, Workplace Conditions, Regulatory and Operational Challenges. The findings highlight that inadequate safety training, lack of personal protective equipment, and poor site management are the primary risk factors leading to high accident severity. The RMA method proved effective in categorizing accident risks, offering a structured approach to prioritize safety interventions. The study also benchmarks Sindh's construction safety challenges against global best practices, providing actionable recommendations to enhance safety protocols and reduce accident rates. These insights to guide policymakers and industry stakeholders in implementing targeted safety measures, ultimately promoting a safer construction environment in Sindh.

Keywords: Construction accidents, Risk Matrix Assessment, Safety management, Sindh, Pakistan, Construction safety, Human Factors, Workplace Conditions, Regulatory Challenges

Introduction

The construction industry is recognized as one of the most hazardous sectors worldwide, contributing to a significant number of occupational injuries and fatalities each year. Due to the nature of construction work, employees are exposed to a variety of risks, including falls from heights, electrocution, heavy machinery malfunctions, hazardous material exposure, and structural collapses (Almaskati et al., 2024). These accidents not only lead to injuries and loss of life but also result in substantial financial burdens, project delays, and reputational damage for construction firms. According to global reports, construction-related accidents account for a large percentage of workplace fatalities, underscoring the need for effective risk management strategies (Costa et al., 2021). Workplace safety in construction is influenced by several factors, including worker training, regulatory enforcement, site conditions, equipment safety, and overall safety culture (Xia et al., 2023). Despite technological advancements and improved safety standards in developed countries, many developing regions continue to experience frequent and severe construction accidents due to inadequate safety regulations, lack of awareness, and poor risk assessment practices (Yap et al., 2022). Therefore, it is crucial to develop systematic methods to assess and mitigate these risks effectively. In an increasingly industrialized world, the construction sector plays a pivotal role in economic development, particularly in developing regions such as Sindh, Pakistan. However, construction workers in Sindh are frequently exposed to risks such as falls from heights, electrocution, equipment malfunctions, and structural failures (Khokhar et al., 2019). The severity of construction accidents in Sindh stems from multiple factors, including poor regulatory enforcement, lack of formal safety training, and the absence of effective risk assessment methodologies (Memon et al., 2023). In many instances, safety measures are only implemented after accidents occur, rather than through proactive hazard mitigation. This reactive approach to safety necessitates the adoption of structured risk assessment tools, such as the Risk Matrix Assessment (RMA), which classifies risks based on their likelihood and severity. The application of RMA in the construction sector can help prioritize risks and implement strategic safety measures to mitigate workplace hazards effectively (Baig et al., 2024). This study is grounded in established theories of risk management and safety science, particularly the principles of hazard identification, risk evaluation, and risk prioritization. The conceptual foundation is based on the Risk Matrix Assessment (RMA) framework, which integrates quantitative risk analysis by evaluating the likelihood and severity of hazards. Additionally, the study draws upon human factor theory, which emphasizes the role of worker behavior, training, and decision-making in accident causation, as well as systems theory, which considers the interaction between organizational, environmental, and regulatory elements in shaping safety outcomes. These theoretical perspectives provide a comprehensive lens for analyzing construction accident risks and support the structured evaluation adopted in this research. This study carried out to systematically assess the severity of factors contributing to construction accidents in Sindh, Pakistan, using the Risk Matrix Assessment (RMA) approach. The scope of this research is limited to the analysis of three primary dimensions, namely human factors, workplace conditions, and regulatory and operational challenges, based on existing literature published between 2017 and 2025. By focusing on these dimensions, the study evaluates how different risk factors influence accident severity and prioritizes them using a structured risk assessment framework. The findings are intended to support policymakers, safety practitioners, and construction stakeholders in developing targeted strategies to enhance construction safety performance in Sindh.

Risk Factors Contributing to Construction Accidents

A comprehensive understanding of risk factors in construction accidents is essential for developing effective mitigation strategies. The construction industry in Sindh, Pakistan, faces numerous challenges, many of which stem from a combination of human-related issues, hazardous workplace conditions, and regulatory failures (Shaikh et al., 2024; Tarique, 2021). These risk factors contribute to frequent accidents, resulting in injuries, fatalities, and financial losses. The identification and analysis of these factors allow for the implementation of structured safety measures aimed at reducing workplace hazards and improving worker safety (Lakhiara et al., 2021).

Human Factors

Human error plays a critical role in construction accidents, with many incidents occurring due to inadequate training, fatigue, and negligence. A significant portion of the workforce in the Sindh construction industry consists of unskilled or semi-skilled laborers who lack formal safety training (Memon et al., 2018). Many workers are unaware of hazard identification, risk management, and emergency response procedures, making them highly vulnerable to accidents. Without comprehensive training programs, workers are unable to adopt preventive measures, increasing the likelihood of workplace injuries. Fatigue and overwork further contribute to the high rate of accidents (Qayoom & Hadikusumo, 2019). The construction sector often requires long working hours in physically demanding conditions. Many laborers are subjected to extended shifts without adequate rest periods, leading to exhaustion, impaired judgment, and slower reaction times (Abrar et al., 2017). This condition heightens the probability of mistakes, which can result in falls, electrocutions, and equipment-related injuries. Overworked employees are more likely to overlook safety precautions, thereby increasing overall site risk (Zahoor et al., 2017).

Negligence and risk-taking behavior among workers and site managers exacerbate safety challenges. To meet tight deadlines and control costs, safety protocols are sometimes disregarded

(Minchin, 2021). Workers may take shortcuts, ignore safety guidelines, or use unsafe practices, while supervisors may fail to enforce proper safety standards. The pressure to complete projects on time often results in non-compliance with safety regulations, increasing accident occurrences. Without strong managerial oversight and accountability, human-related risks remain a major challenge in the industry (Tarique, 2021).

Workplace Conditions

The physical working environment significantly affects construction safety. One of the most common hazards in Sindh's construction industry is the lack of proper infrastructure and scaffolding. Many construction sites operate without adequate safety equipment, such as properly installed scaffolding, guardrails, and fall protection systems (Zahoor et al., 2017). In high-rise construction projects, the absence of secure platforms increases the likelihood of falls, which are among the leading causes of construction-related fatalities (Tarique, 2021). Personal Protective Equipment (PPE) non-compliance is another major issue affecting construction safety. Despite the availability of safety gear such as helmets, gloves, and harnesses, many workers fail to wear it due to discomfort, lack of enforcement, or unavailability. Exposure to hazardous materials is also a prevalent risk in the construction sector. Workers frequently handle materials such as cement dust, asbestos, and volatile

chemicals, which can lead to respiratory diseases, skin conditions, and long-term health complications. Improper storage, handling, and disposal of these materials further increase exposure risks. Many construction sites lack adequate ventilation and protective measures to minimize the harmful effects of hazardous substances, leading to chronic health conditions among workers (Memon et al., 2018).

Regulatory and Operational Challenges

Regulatory enforcement remains weak in Pakistan's construction sector, with many companies failing to adhere to established safety standards. While there are occupational health and safety laws in place, enforcement agencies often lack the resources or authority to monitor compliance effectively. Corruption and administrative inefficiencies further hinder the implementation of safety regulations, resulting in unregulated construction sites where worker safety is compromised. Without stringent regulatory oversight, many contractors continue to operate without proper safety frameworks, leading to an increased number of accidents (Tarique, 2021). Another critical issue is the lack of emergency preparedness in construction projects. Many sites do not have fire extinguishers, first-aid stations, or clearly defined emergency evacuation plans (Abid et al., 2020). In the event of an accident, the absence of immediate medical assistance can exacerbate injuries, leading to severe consequences for affected workers. The failure to establish comprehensive emergency response procedures results in delayed reaction times, further worsening the impact of construction-related incidents (Baghdadi, 2024).

Equipment failures and poor maintenance practices significantly contribute to construction hazards. Many construction companies rely on outdated, malfunctioning, or improperly maintained machinery, which increases the likelihood of mechanical failures leading to accidents (Memon et al., 2018). Heavy equipment, such as cranes, bulldozers, and scaffolding must undergo regular inspections and maintenance to ensure operational safety. However, in many cases, these checks are either irregular or completely overlooked, posing severe risks to workers operating or working near such equipment (Zahoor et al., 2017). Construction accidents in Sindh, Pakistan, result from a combination of human factors, hazardous workplace conditions, and ineffective regulatory enforcement (Baghdadi, 2024). Addressing these issues requires a multifaceted approach that includes comprehensive safety training programs, stringent enforcement of PPE compliance, regular maintenance of equipment, and the establishment of emergency response protocols (Qayoom & Hadikusumo, 2019). By implementing structured risk assessment methods such as the Risk Matrix Assessment, construction firms can systematically evaluate accident risks and develop targeted interventions to enhance workplace safety.

Construction Safety Challenges in Sindh, Pakistan

Pakistan's construction industry has experienced rapid growth over the past two decades due to urbanization and large-scale infrastructure projects, particularly in Sindh province, which includes major cities like Karachi, Hyderabad, and Sukkur (Memon et al., 2023). While this expansion has boosted economic development, it has also led to a rise in construction-related accidents, revealing critical safety challenges. Key issues include weak regulatory enforcement, where established safety laws are poorly implemented due to resource constraints, bureaucratic inefficiencies, and corruption (Qayoom & Hadikusumo, 2019). Many construction firms neglect safety guidelines, resulting in hazardous working conditions.

Additionally, the industry's reliance on daily wage laborers with minimal formal training contributes to safety risks, as many workers lack essential safety knowledge and practices (Shaikh et al., 2024). A poor safety culture within construction firms, driven by a focus on productivity over safety, leads to negligence in hazard management and unreported violations (Shaikh et al., 2024). The limited use of structured risk assessment tools, such as the Risk Matrix Assessment (RMA), further exacerbates these risks, as traditional safety measures fail to provide a thorough evaluation of hazards (Khahro et al., 2021). To address these issues, there is a critical need to strengthen regulatory enforcement, enhance worker training, and adopt systematic risk assessment methodologies like RMA, which could help identify and prioritize risks, develop data-driven safety policies, and significantly improve workplace safety in Sindh's construction sector (Zahoor & Chan, 2019).

Research Gap and Rationale

Despite growing attention to occupational safety in construction, there remains a significant gap in region-specific research on Sindh, Pakistan. While global studies extensively explore construction site hazards and accident prevention, in Pakistan's construction industry is underexplored (Khahro et al., 2021). Existing research often provides a broad analysis of occupational risks without addressing the specific socio-economic, infrastructural, and regulatory challenges unique to Sindh, such as informal labor practices and inconsistent regulatory oversight (Baghdadi, 2024). Key research gaps include the limited availability of empirical data on construction accident severity levels and the absence of structured risk assessment models tailored to Sindh's construction sector (Bhangwar, 2022). While developed countries widely apply RMA and other quantitative tools to evaluate risks based on likelihood and severity, Pakistan's construction firms largely rely on unstructured safety inspections, leading to inconsistent safety practices and a reactive approach to accident prevention (Almaskati et al., 2024; Memon et al., 2023). Additionally, the effectiveness of Pakistan's safety regulations in preventing accidents remains poorly evaluated, with inconsistent compliance and enforcement, especially in Sindh (Qayoom & Hadikusumo, 2019). This study aims to address these gaps by applying RMA to assess construction accident severity, offering a data-driven approach to improving workplace safety and developing tailored safety management strategies for Sindh's construction industry.

Objective of the Study

The primary objective of this review article is to analyze the severity levels of construction accident factors in Sindh, Pakistan, using the Risk Matrix Assessment approach. This study aims to:

1. Identify the most common causes of construction-related accidents in Sindh.
2. Evaluate the effectiveness of the Risk Matrix Assessment method in categorizing accident severity.
3. Compare safety challenges in Sindh with those in other regions and global best practices.
4. Provide recommendations for improving risk management strategies in Pakistan's construction sector.

To achieve the above objectives, this paper is structured into five main sections. Section 2: Literature Review examines existing studies on construction accidents, risk assessment techniques, and the application of the Risk Matrix Assessment in safety management. Section 3: Methodology explains the Risk Matrix Assessment framework and its application in

analyzing construction accidents. Section 4: Findings and Discussion analyze the key factors contributing to construction accidents in Sindh and evaluate risk severity levels based on existing data. Section 5: Conclusion and Recommendations summarizes key findings and provides recommendations for improving construction safety through risk assessment and policy interventions. By conducting a comprehensive review of existing research and case studies, this paper aims to contribute to the ongoing discussion on enhancing workplace safety in the construction industry, particularly in developing regions like Sindh, Pakistan.

Definition of Key Variables

Table 1.1 enlists the variables that play a crucial role in assessing construction accident risks in Sindh. By defining them in detail, this study provides a structured approach to identifying high-risk factors and their impact on workplace safety. The analysis of these variables within the framework of Risk Matrix Assessment enables the classification of hazards based on their severity and likelihood, which is essential for developing targeted safety interventions in the construction sector.

Table 1.1

Enlists the variables that play a crucial role in assessing construction accident risks.

Variable	Definition
Human Error	The unintentional mistakes made by workers due to fatigue, stress, misjudgment, or lack of awareness, leading to workplace accidents.
Safety Training & Awareness	The level of formal training and awareness programs implemented to educate workers about occupational hazards, risk prevention, and emergency protocols.
Personal Protective Equipment (PPE) Compliance	The adherence to wearing safety gear such as helmets, gloves, and harnesses, which are crucial in reducing workplace injuries.
Site Management & Supervision	The effectiveness of project managers and site supervisors in implementing and enforcing safety regulations to minimize risks on construction sites.
Regulatory Compliance	The degree to which construction firms and workers adhere to national and international occupational safety laws, labor standards, and building codes.
Equipment Failure & Maintenance	The impact of malfunctioning tools, machinery, or lack of regular maintenance on workplace safety, which can lead to serious accidents.
Hazardous Material Handling	Proper storage, transportation, and disposal of hazardous construction materials that may pose health and safety risks.
Emergency Preparedness	The availability of emergency response plans, first aid facilities, fire safety measures, and disaster management strategies at construction sites.

Method

This study employs a systematic review methodology to assess the severity of construction accident risk factors in Sindh, Pakistan, using the Risk Matrix Assessment (RMA) approach. The research is designed as a review article, integrating qualitative and quantitative data from peer-reviewed journals, government reports, and safety guidelines. The study focuses on analyzing existing literature to identify common causes of construction accidents, evaluate the effectiveness of RMA, compare safety practices with global standards, and develop

strategic recommendations for the construction sector in Pakistan. To conduct a comprehensive review of construction accident risks and risk management strategies in Sindh, Pakistan, data was gathered from a variety of academic and institutional sources. The study utilized academic databases such as Scopus, Web of Science, Science Direct, and IEEE Xplore, which are recognized for their high-quality research on construction safety, risk assessment, and occupational health.

In addition to academic literature, the study incorporated government reports from Pakistan’s regulatory bodies, including the Pakistan Engineering Council (PEC) and National Institute of Labour Administration Training (NILAT). These reports provided valuable insights into national safety standards, compliance practices, and construction sector performance. Furthermore, international guidelines from occupational safety organizations such as OSHA (Occupational Safety and Health Administration), ILO (International Labour Organization), and ISO 45001 were reviewed to align the study’s findings with global best practices in safety management. Table 2.1 illustrates the comprehensive keyword strategy used to identify relevant studies on construction safety and risk assessment in Sindh, Pakistan. By targeting specific databases, the study ensures the inclusion of recent and region-specific literature.

Table 2.1
Search String (Keyword Analysis in International Journals, 2017–2025)

Source	Search String
ScienceDirect	("Construction Safety" OR "Risk Matrix Assessment" OR "Accident Severity" OR "Workplace Safety" OR "Construction Accidents" OR "Risk Management" OR "Sindh" OR "Pakistan" OR "Occupational Hazards" OR "Safety Training" OR "Regulatory Compliance" OR "Equipment Maintenance" OR "Emergency Preparedness")
Web of Science	(TITLE-ABS-KEY ("Construction Sector" AND "Risk Assessment") AND (LIMIT-TO (PUBYEAR, 2025, 2024, 2023, 2022, 2021, 2020, 2019, 2018,2017) AND ("Sindh Province" OR "Safety Culture" OR "Human Factors" OR "Regulatory Challenges" OR "Site Management" OR "Accident Prevention" OR "Risk-Based Analysis" OR "Safety Protocols" OR "Construction Risk Factors"
Scopus	(TITLE-ABS-KEY ("Construction Accidents" OR "Risk Matrix Model") AND (LIMIT-TO (PUBYEAR, 2025, 2024, 2023, 2022, 2021, 2020, 2019, 2018,2017) AND ("Risk Severity" OR "Accident Analysis" OR "Construction Sector Pakistan" OR "Safety Measures" OR "Workplace Hazards" OR "Accident Prevention" OR "Safety Management Systems" OR "Mitigation Strategies"

During the research process, most relevant studies were sourced from Scopus, with Web of Science and Science Direct also contributing significantly to the data pool. This demonstrates the prominence of Scopus as a valuable resource for studies related to construction safety and risk assessment. By focusing on these high-impact academic databases, the study ensured access to recent and relevant publications within the construction industry. The selected studies were published between 2018 and 2025, capturing the latest trends and practices in construction safety and risk management. A comprehensive keyword strategy was employed to identify studies specifically related to construction accidents, safety protocols, and RMA. Keywords such as “Construction Safety,” “Risk

Matrix Assessment,” “Accident Severity,” “Regulatory Compliance,” “Safety Training,” and “Workplace Hazards” were utilized. Boolean operators (AND, OR, NOT) were applied to refine search results, ensuring a focused and relevant dataset.

Specific inclusion and exclusion criteria were applied to maintain the relevance and rigor of the selected studies. The inclusion criteria encompassed studies focusing on construction risk factors, safety practices, and RMA implementation within Sindh, Pakistan. The study prioritized peer-reviewed empirical studies, case studies, and systematic reviews that analyzed the impact of risk management strategies on safety outcomes. The exclusion criteria eliminated studies outside the construction sector, non-English publications, and articles focusing on unrelated safety aspects.

Following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, a structured screening and selection process was implemented. This process involved three stages: initial screening, abstract review, and full-text analysis. During initial screening, duplicates and irrelevant records were removed based on titles and keywords. The abstract review evaluated alignment with inclusion criteria, narrowing down the selection to relevant studies. Finally, the full-text analysis confirmed the inclusion of studies for thematic analysis, resulting in a robust and comprehensive dataset. The flowchart illustrates the systematic screening process applied in this study, starting with 2,490 records from leading academic databases. Following duplicate removal, title and abstract screening, and full-text review, the selection was refined to 120 studies that align with the research focus on construction accident risks and safety management in Sindh, Pakistan.

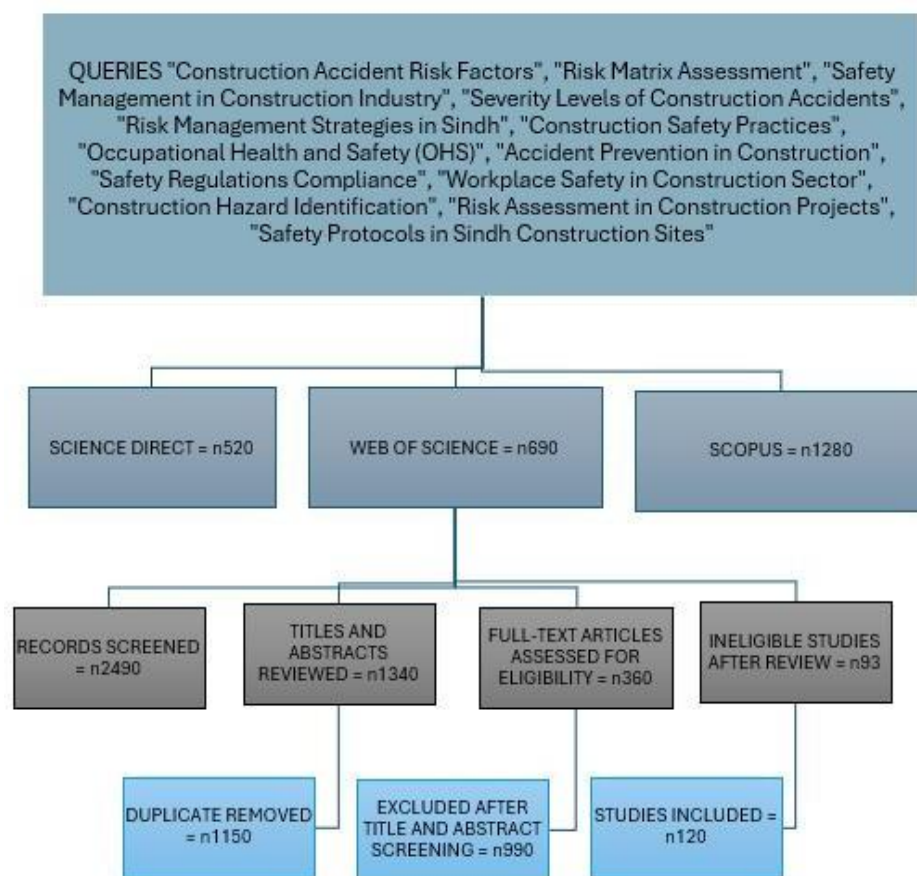


Figure 2.1 The detailed screening process of the latest articles

A standardized data extraction template was utilized to ensure uniformity across the selected studies, supporting a cohesive thematic analysis. The extracted data included study title, authors, publication year, and the source journal. The study types reviewed encompassed empirical studies, case studies, and systematic reviews. The research context focused on the construction industry within Sindh, Pakistan, examining factors such as accident severity, safety practices, and risk management strategies. Key elements collected included quantitative data on accident statistics, qualitative insights into safety culture, and evaluations of risk matrix assessment effectiveness. To ensure relevance and quality table 2.2 enlists the criteria that the review applied:

Table 2.2

Inclusion and exclusion criteria.

Criteria	Inclusion	Exclusion
Publication	Peer-reviewed journals, industry	Non-academic sources,
Type	reports	opinion pieces
Publication Date	Studies published between 2015 - 2025	Older studies unless highly cited and relevant
Geographical Focus	Global studies with emphasis on Pakistan & developing countries	Studies focusing on unrelated industries
Language	English-language publications	Non-English sources (unless translated)

The selected studies were analyzed using the Risk Matrix Framework, focusing on two key dimensions:

Likelihood (Probability of Hazard Occurrence) Categorized from Very Unlikely (1) to Very Likely (5). Severity (Impact of Hazard on Workers & Projects) Ranging from Minor (1) to Catastrophic (5).

Each study's findings were categorized based on the Risk Matrix Model, allowing for a comparative analysis of common accident causes and risk levels in the construction industry.

Literature Review

Overview of Construction Accidents and Their Causes

Construction accidents have been a subject of extensive research due to their high frequency and severe consequences. Several studies highlight that construction sites are among the most dangerous workplaces globally, with accidents often resulting from factors such as falling from heights, electrical hazards, collapsing structures, equipment malfunctions, and human errors (Almaskati et al., 2024). According to a report by the International Labour Organization (ILO), construction accounts for nearly 30% of occupational fatalities worldwide, making safety risk assessment a critical issue (Abdalla et al., 2017). Research by Baghdadi, (2024) suggests that accidents are often linked to poor planning, inadequate training, lack of supervision, and unsafe working conditions. Another study by Xia et al. (2023) emphasizes the role of safety culture, stating that workers' attitudes towards safety and the enforcement of safety regulations significantly impact accident rates.

In developing countries, including Pakistan, these challenges are further intensified due to weak safety regulations, lack of advanced equipment, and minimal worker protection policies.

Studies specific to Pakistan's construction industry (Khokhar et al., 2019; Lakhiara et al., 2021; Memon et al., 2023; Shaikh et al., 2024) indicate that many accidents occur due to poor enforcement of labor laws, absence of personal protective equipment (PPE), and a general disregard for safety procedures.

Table 3.1

Common Causes of Construction Accidents and Their Frequency (Based on literature review findings)

Cause of Accident	Description	Estimated Frequency
Falls from Heights	Workers falling from scaffolding, ladders, or rooftops	High (~35% of cases)
Electrocution	Contact with live wires or faulty electrical equipment	Moderate (~15%)
Heavy Machinery Accidents	Equipment malfunctions, vehicle collisions	Moderate (~20%)
Structural Collapses	Building failures, excavation cave-ins	Low (~10%)
Hazardous Material Exposure	Inhalation of toxic fumes, chemical burns	Low (~5%)
Lack of Safety Gear	Absence of PPE, improper safety harness usage	High (~30%)

Human error is a leading cause of construction accidents, often resulting from inadequate safety training, negligence, fatigue, and non-compliance with safety protocols. Workers' behavior and attitudes towards safety significantly impact the likelihood of accidents (Memon et al., 2018). Studies indicate that training programs and awareness initiatives can reduce human error and enhance overall safety. Unsafe working environments, including poor infrastructure, lack of personal protective equipment (PPE), and exposure to hazardous materials, contribute to construction accidents (Qayoom & Hadikusumo, 2019). In Sindh, the absence of standardized safety practices and inconsistent use of PPE have been identified as major risk factors (Abrar et al., 2017). Regulatory challenges in Sindh include weak enforcement of safety laws, insufficient emergency preparedness, and inadequate equipment maintenance. The lack of stringent regulatory oversight allows construction firms to cut corners on safety measures, leading to higher accident rates (Minchin, 2021; Zahoor et al., 2017). The figure 3.1. shows the percentage distribution of construction accident causes. The leading cause is "Falls from Heights" at 30.4%, followed by "Lack of Safety Gear" at 26.1%, and "Heavy Machinery Accidents" at 17.4%. Other causes include "Electrocution," "Structural Collapses," and "Hazardous Material Exposure."

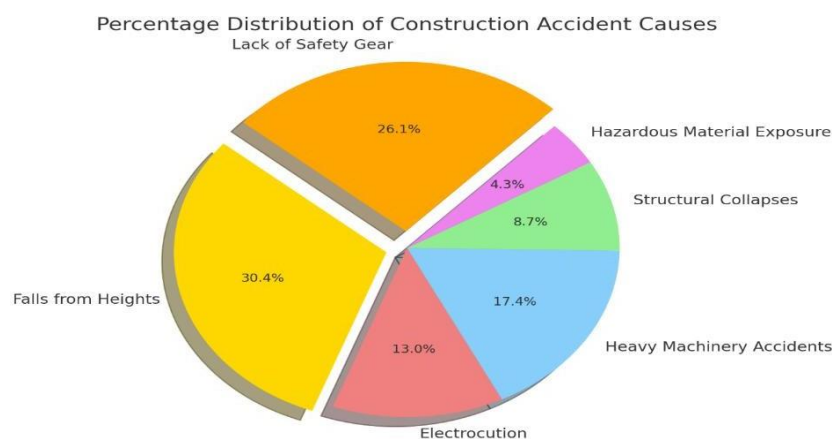


Figure 3.1 Percentage Distribution of construction accident causes in Sindh (Based on literature review findings)

Impact of Key Variables on Construction Accident Severity

In Sindh, human factors significantly contribute to the severity of construction accidents. Limited access to safety training and awareness programs exacerbates human error, leading to unsafe practices on construction sites. Many workers are hired on a temporary or contractual basis, often bypassing formal safety orientations and skill assessments. This situation increases the likelihood of accidents due to a lack of understanding of safety protocols. For instance, Zahoor et al. (2017) highlighted that majority of construction-related accidents in Sindh involved untrained or inadequately trained workers, demonstrating a critical gap in safety education and risk awareness. Workplace conditions play a pivotal role in determining accident severity in Sindh's construction sector. Hazardous site conditions, including inadequate scaffolding, poor lighting, insufficient signage, and congested workspaces, contribute to frequent accidents (Tarique, 2021). Lakhira et al. (2021) identified a direct correlation between poor workplace conditions and higher accident rates.

The lack of proper Personal Protective Equipment (PPE) and failure to maintain safety equipment further aggravate risks. Studies also indicate that workers often prioritize productivity over safety, particularly under tight project deadlines, which compromises safe work practices and heightens accident risks. The regulatory framework governing construction safety in Sindh is marked by inconsistent enforcement of safety standards and regulations (Memon et al., 2023). Inspections by regulatory bodies are sporadic, and penalties for non-compliance with safety guidelines are not stringent enough to enforce behavioral change among contractors and site managers. Qayoom & Hadikusumo (2019) noted that weak regulatory oversight creates an environment where safety violations are common and often go unaddressed. This gap in governance allows hazardous work conditions to persist, undermining the effectiveness of safety initiatives and exposing workers to preventable risks. Strengthening regulatory mechanisms and increasing the frequency of site inspections could help mitigate these issues and promote safer construction practices in the region.

Risk Assessment Methods in Construction Safety

Risk assessment is a fundamental approach to minimizing accidents by identifying hazards, evaluating risks, and implementing preventive measures (Khahro et al., 2021). Qualitative risk assessment methods, including safety checklists and expert judgments, provide a basic evaluation of potential risks. However, they are often subjective and may lack the precision needed for high-risk environments like construction sites (Ilbahar et al., 2018). Quantitative approaches, such as probability analysis and statistical models, require extensive data but offer more objective insights into risk levels. These methods help in accurately predicting accident probabilities and assessing the impact of various risk factors (Hubbard, 2020). Risk Matrix Assessment (RMA) combines elements of both qualitative and quantitative methods. It categorizes risks based on their likelihood and severity, providing a clear visual representation of risk priorities. The method is particularly effective in construction safety management, offering a balanced approach to risk evaluation (Hubbard, 2020).

Table 3.2

Comparison of Risk Assessment Methods. Source:(Hubbard, 2020)

Method	Advantages	Disadvantages	Suitability
Safety Checklists	Simple, quick to use	Subjective, lacks depth	Small-scale projects
Probability Analysis	Quantitative, uses data-driven risk prediction	Requires historical data, complex calculations	Large infrastructure projects
Risk Matrix Assessment	Easy visualization, balances severity & likelihood	Can oversimplify risk ranking	Medium-to-large projects
Fuzzy Logic Models	Handles uncertainty well, flexible	Requires expert input, complex implementation	High-risk projects

The Risk Matrix Assessment (RMA) was first introduced as a tool for safety management in industries requiring structured hazard evaluation. It has since been adopted in construction, aviation, and chemical industries for its effectiveness in ranking risks. Research by Sembiring & Wiharni, (2019) demonstrates that the Risk Matrix Assessment provides a systematic way to prioritize safety measures by categorizing risks into Low, Medium, High, and Critical levels. The method is particularly beneficial for construction sites, where risks vary depending on the nature of work being performed. A study by Taibi et al., (2022) highlights the advantage of the risk matrix in simplifying complex risk evaluations, making it accessible to safety managers and construction site supervisors. However, some researchers, such as Krisper, (2021), argue that risk matrices can sometimes oversimplify risk assessment, leading to potential misclassification of hazards if not used properly.

Application of Risk Matrix Assessment in Developing Countries

Risk Matrix Assessment (RMA) is a widely adopted tool in construction safety management that helps systematically evaluate workplace hazards and assess the severity and likelihood of associated risks (Khahro et al., 2021). By categorizing risks into levels ranging from low to critical RMA aids safety managers in prioritizing safety measures based on the urgency and potential impact of risks (Sembiring & Wiharni, 2019). The matrix approach involves plotting the likelihood of an event occurring against the severity of its potential consequences, offering a clear visualization of risk exposure. Internationally, RMA has been effectively utilized in countries like Australia and the United Kingdom to enhance construction safety protocols. In Australia, RMA has contributed to a reduction in construction site accidents over five years by enabling safety managers to focus on high-risk activities, such as working at

heights and machinery operation (Cleary, 2024). The UK construction industry has also leveraged RMA within the framework of regulatory standards such as the Construction (Design and Management) Regulations 2015.

Through structured risk assessments, RMA has facilitated targeted safety interventions, including improved safety training and enhanced personal protective equipment (PPE) protocols, leading to a measurable decline in accident rates (McKinnon, 2024). In Pakistan, and specifically in Sindh, RMA is still considered an emerging practice within the construction sector. While larger, more established firms with international ties are beginning to adopt RMA, smaller local firms often lack the resources or awareness to implement this assessment method effectively (Khokhar et al., 2019). Pilot projects in Sindh have demonstrated that when RMA is properly integrated into safety management systems, it can significantly improve safety outcomes. Despite its benefits, RMA's adoption in Sindh faces several challenges. These include a lack of standardized safety protocols, insufficient training for safety managers, and resistance to change among construction firms accustomed to traditional safety practices (Bhangwar, 2022). However, with proper training, regulatory support, and awareness campaigns, RMA has the potential to become a cornerstone of construction safety in the region (Khahro et al., 2021). Its ability to provide a structured, data-driven approach to risk management aligns well with international best practices and offers a scalable solution to enhance worker safety and reduce accident severity in Sindh's construction sector.

Challenges and Mediating Factors in Construction Risk Management

Risk assessment in Sindh's construction sector faces numerous challenges that hinder the adoption and implementation of robust safety measures. These barriers can be broadly categorized into cultural, infrastructural, and regulatory challenges. Figure 3.2 enlists the challenges in construction risk management in Sindh, Pakistan.

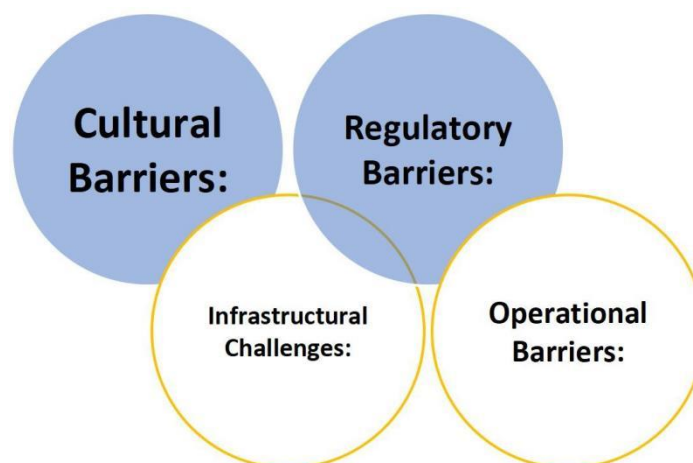


Figure 3.2 Challenges in Construction Risk Management (Based on literature review findings)

The construction industry in Sindh often lacks a strong safety culture. Many workers and site managers prioritize productivity over safety, leading to complacency regarding risk assessment procedures (Bhangwar, 2022). There is also a prevalent resistance to change, particularly when new safety protocols require additional time or resources. This attitude is exacerbated by a hierarchical management structure where workers may feel uncomfortable

voicing safety concerns. Many construction sites in Sindh operate with outdated equipment and inadequate safety gear. Limited access to advanced safety technologies, such as hazard detection systems and emergency response tools, restricts the effectiveness of risk assessments (Baig et al., 2024). In addition, construction projects often face budget constraints, leading to cost-cutting measures that impact safety investments, including risk assessment tools and training programs (Baghdadi, 2024). The regulatory framework governing construction safety in Sindh is often fragmented and inconsistently enforced. Safety guidelines are not always clearly communicated to construction firms, resulting in varying interpretations of safety requirements (Khokhar et al., 2019).

Moreover, safety inspections are infrequent, and penalties for non-compliance are not stringent enough to deter unsafe practices. This regulatory gap not only undermines safety initiatives but also allows hazardous work environments to persist (Abdalla et al., 2017). Many construction firms, particularly smaller ones, lack formalized safety management systems. Risk assessments, when conducted, are often treated as a formality rather than a critical safety practice. This approach leads to inadequate documentation, poor communication of safety protocols, and a reactive rather than proactive approach to hazard management (Lakhiara et al., 2021). Despite the challenges, several mediating factors can significantly improve the effectiveness of risk management strategies in the construction sector. Figure 3.3 enlists the mediating factors in the construction sector Risk Management in Sindh, Pakistan.



Figure 3.3 Mediating Factors for Successful Risk Management (Based on literature review findings)

The role of management is crucial in promoting a culture of safety. Firms with leadership that prioritizes safety are more likely to implement comprehensive risk assessments and follow through with necessary safety interventions (Jaafar et al., 2017). Management support also involves allocating sufficient resources for safety training and equipment, which directly enhances worker safety (Grill & Nielsen, 2019). Regular and targeted training programs equip workers with the knowledge and skills needed to recognize and respond to workplace hazards. Effective training includes not only technical safety protocols but also soft skills such as communication and teamwork, which are critical for maintaining safety on dynamic construction sites. Training programs should be designed to address specific risks identified through risk assessments, ensuring that safety measures are relevant and practical (Afzal & Shafiq, 2021).

Strong and consistent regulatory oversight is a critical mediating factor. When regulations are clear and enforcement is stringent, construction firms are more likely to comply with safety standards. International studies show that regions with well-defined safety protocols and rigorous inspection regimes tend to experience fewer workplace accidents (Maliha et al., 2021). For instance, in countries like Singapore and Germany, strict regulatory frameworks coupled with regular inspections have significantly reduced construction-related accidents (Dyrborg et al., 2022; Rafindadi et al., 2022). Developing a proactive safety culture involves creating an environment where safety is embedded in everyday practices. This can be achieved through regular safety meetings, encouraging workers to report hazards without fear of reprisal, and rewarding safe practices (Duryan et al., 2021). Construction firms that establish a safety-first mindset among workers and management often exhibit better safety performance and a lower incidence of accidents (Mudashiru et al., 2021). Utilizing RMA as part of a broader safety management system can help firms systematically assess risks and prioritize safety interventions. When combined with strong regulatory support and effective training programs, RMA can serve as a practical tool to bridge the gap between safety policies and on-site practices, particularly in resource-constrained environments like Sindh (Kima et al., 2024)

Comparative Analysis of Global Best Practices

Sindh's construction sector faces persistent safety challenges, including inconsistent regulatory enforcement, limited safety training, and a lack of advanced safety technologies. Many construction firms in the region primarily focus on project deadlines and cost efficiency, often at the expense of safety protocols (Ahmed et al., 2024). This situation has contributed to a relatively high rate of construction accidents, as evidenced by the frequency of incidents related to falls, heavy machinery accidents, and exposure to hazardous materials (Asad et al., 2020). Malaysia has established a robust framework for construction safety through its Occupational Safety and Health Act (OSHA). The country mandates, Construction sites undergo frequent safety inspections to ensure compliance with safety standards (Abdul Hamid, 2022). Workers are required to complete certified safety training programs before employment. Malaysia utilizes digital tools such as Building Information Modeling (BIM) and safety management software to identify risks and manage safety protocols in real time (Othman et al., 2021). These measures have significantly reduced construction-related accidents by fostering a proactive safety culture where risks are managed systematically rather than reactively.

Hong Kong employs a multi-tiered approach to construction safety. The government requires detailed risk assessments at the planning stage of construction projects (Faqih et al., 2021). Automated monitoring systems and wearable safety devices enhance hazard detection and worker safety. Strict penalties for safety violations, including fines and suspension of licenses, create a strong incentive for compliance. Hong Kong's emphasis on accountability and the use of advanced technologies serves as an effective model for improving safety standards (Yiu et al., 2018).

Table 3.3

Key Differences Between Sindh and Best Practice Regions (Based on literature review findings)

Aspect	Sindh	Malaysia	Hong Kong
Regulatory	Inconsistent	Regular audits and strict fines	High accountability
Enforcement			
Training Programs	Limited and informal	Mandatory certified training	Specialized safety education
Technology Integration	Minimal	Digital safety management tools	Wearable devices, automation
Safety Culture	Reactive approach	Proactive safety culture	Strong focus on risk management

Implementing stringent safety standards with clear guidelines, coupled with consistent enforcement and meaningful penalties for non-compliance. Establishing a system for scheduled and surprise safety inspections to maintain high safety standards on construction sites. Introducing mandatory safety training and certification for all construction workers, like Malaysia's approach. (Yap et al., 2022). Utilizing tools like Risk Matrix Assessment (RMA), safety management software, and wearable safety devices to monitor and manage construction site safety effectively. Encouraging open communication about safety issues, rewarding safe practices, and integrating safety considerations into everyday operations (Tarique, 2021). By adopting practices from Malaysia and Hong Kong, Sindh's construction industry could significantly improve its safety performance, reduce accident rates, and create a safer working environment for all stakeholders (Faqih et al., 2021; Yiu et al., 2018)

Summary of Key Findings and Research Gaps

Human factors such as inadequate safety training, lack of awareness, and unsafe work practices significantly contribute to construction accidents. Many workers are employed on a temporary or contractual basis without sufficient orientation or safety education, leading to higher risks of incidents on construction sites (Lee et al., 2018). The prevalence of hazardous site conditions, including improper scaffolding, poor lighting, and insufficient safety signage, directly correlates with increased accident rates. These environmental factors often compound the risk posed by human errors, creating a dangerous work environment (Williams et al., 2018). Sindh's regulatory environment is marked by inconsistent safety inspections and weak enforcement of safety standards.

The lack of stringent penalties for non-compliance undermines safety initiatives and allows hazardous practices to persist. Regulatory challenges also include vague safety guidelines and insufficient resources allocated to safety management (Winge et al., 2019). While the Risk Matrix Assessment (RMA) is a proven method for evaluating and prioritizing risks in construction safety globally, its application in Sindh is minimal. Only a few construction firms in the region have piloted this method, and widespread adoption remains limited. Successful use of RMA in pilot projects indicates its potential for improving safety outcomes if integrated into broader safety management systems (Sanni-Anibire et al., 2020).

Table 3.4

Summary of key findings

Key Area	Findings	Supporting References
Human Factors	High accident rates due to inadequate safety training, lack of awareness, and unsafe work practices.	Lee et al. (2018)
Workplace Conditions	Unsafe site conditions, such as poor scaffolding, lighting, and signage, increase accident risks.	Williams et al., (2018)
Regulatory Framework	Inconsistent enforcement of safety standards and weak penalties for non-compliance undermine safety.	Winge et al. (2019)
Risk Matrix Assessment (RMA)	Limited application of RMA in Sindh, with pilot projects showing potential for improved safety.	Sanni-Anibire et al. (2020).
Global Comparison	Sindh lags regions like Malaysia and Hong Kong in safety standards, audits, and technology use.	Faqih et al. (2021); Yiu et al. (2018)
Research Gaps	Need for tailored RMA, adaptation of global practices, and more longitudinal safety studies.	Various studies, suggested focus

Despite the insights gained, several critical research gaps remain. There is a noticeable gap in studies that explore the application of Risk Matrix Assessment within Sindh's construction sector. Most research has focused on identifying accident causes rather than systematically assessing risks using structured methodologies. Future studies should address this gap by tailoring RMA to the specific safety challenges of Sindh. While countries like Malaysia and Hong Kong have successfully implemented advanced safety protocols and technologies, there is limited research on how these global best practices could be adapted to Sindh's context. Studies are needed to explore the feasibility and impact of adopting practices such as regular safety audits, mandatory safety certifications, and advanced safety technologies in the region. Most existing studies provide a snapshot of safety challenges but do not offer long-term analyses of safety interventions' effectiveness. Research focusing on longitudinal studies could provide valuable insights into how sustained safety initiatives impact accident rates over time. Research is required to develop safety management strategies that account for the unique cultural, economic, and regulatory environment of Sindh. This includes exploring how to overcome resistance to safety culture changes and identifying practical approaches to enhance worker safety training and awareness.

Future Research Directions

To address these gaps, future research should focus on:

- **Implementing and Evaluating RMA:** Conducting studies that apply RMA in real-world construction projects in Sindh to evaluate its effectiveness in reducing accidents.
- **Exploring Adaptability of Global Practices:** Analyzing how successful safety models from other countries can be customized to fit the regional context.
- **Developing Tailored Safety Programs:** Designing safety training programs that consider the skill levels and educational backgrounds of local construction workers.
- **Strengthening Regulatory Measures:** Researching ways to improve the enforcement

of safety regulations and introduce accountability measures that deter unsafe practices.

Conclusion

The construction industry in Sindh faces significant safety challenges, primarily driven by human factors, suboptimal workplace conditions, and a fragmented regulatory framework. The review highlights that while global construction markets increasingly adopt structured risk assessment methods such as Risk Matrix Assessment (RMA), Sindh's construction sector still lags in implementing such systematic approaches. The limited adoption of RMA, coupled with cultural and infrastructural barriers, constrains the effectiveness of existing safety management strategies. A comparative analysis with global best practices demonstrates that regions with robust safety cultures, advanced training programs, and stringent regulatory oversight achieve lower accident rates. Therefore, integrating these elements into Sindh's construction safety protocols could substantially mitigate accident risks.

Future research should focus on adapting RMA specifically to the regional context of Sindh, addressing identified research gaps, and developing customized safety interventions. By aligning local practices with international safety standards and enhancing regulatory enforcement, the construction sector in Sindh can create a safer working environment, reduce accident severity, and promote a culture of safety and resilience. This paper not only underscores the critical need for a structured risk assessment approach but also offers a foundation for further studies aimed at enhancing safety outcomes in Pakistan's construction industry.

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