# Mitigating Psychosocial Risks in Construction Through Predictive Machine Learning Analytics.

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***Abstract*— The construction industry is one of the most hazardous sectors globally, characterized by high rates of workplace accidents and injuries. While physical risks are extensively addressed, psychosocial risks—such as stress, job insecurity, and poor organizational culture—remain underexplored yet critical contributors to unsafe practices and accidents.**

**This paper investigates the correlation between accident occurrence on construction sites and psychosocial risks, emphasizing how factors like workplace stress and organizational deficiencies lead to unsafe behaviors and heightened accident rates. Following this analysis, the study explores the role of predictive analytics and Machine Learning (ML) models in identifying and mitigating these risks to enhance workplace safety.**

**By analyzing historical data, survey responses, and environmental factors, this study highlights how advanced predictive tools can uncover patterns and correlations that traditional methods often miss. The findings emphasize the potential of ML-driven approaches to proactively address psychosocial risks, reduce accidents, and promote a culture of safety. This research, therefore, underscores the need for integrating technological innovations with human-centric risk management strategies to achieve a safer construction environment.**

***Keywords*— *Machine Learning, Predictive Analytics, Psychosocial Risk, Safety, Occupational Accidents, Construction, Workplace, Artificial Intelligence.***

## I. INTRODUCTION

The construction industry is inherently fraught with risks, particularly psychosocial risks, which significantly contribute to the occurrence of accidents. These risks, which include factors such as stress, fatigue, and poor communication, can impair workers' cognitive functions and decision-making abilities, leading to increased accident rates. Understanding and predicting these risks is crucial for enhancing safety measures and reducing accident occurrences on construction sites.

machine learning techniques have been applied to predict the severity of construction accidents by analyzing critical factors such as the type of accident and emergency management systems. These models, including Naive Bayes and Logistic Regression, have shown promising results in classifying accident severity, thereby aiding safety professionals in implementing more effective safety interventions [1]. Additionally, frameworks like MetaInjury leverage meta-learning to share risk knowledge across different types of construction accidents, enabling safety managers to predict risks even with limited data [2]. Research indicates that psychosocial hazards, such as workplace stress and lack of social support, are critical contributors to workplace accidents. These factors can lead to increased stress levels, burnout, and reduced safety performance among construction workers ( [3], [4], [5]). For instance, high job demands, and low social support have been linked to a higher risk of musculoskeletal disorders and absenteeism, which can indirectly contribute to accidents [5].

Moreover, demographic factors such as age, gender, and ethnicity can influence how workers perceive and respond to psychosocial risks, further affecting safety outcomes ( [6]; [7]). Studies have shown that younger and older workers, as well as those from minority groups, may be more vulnerable to these risks, highlighting the need for targeted interventions ( [8]; [9]).

Addressing psychosocial risks in the construction industry requires a comprehensive approach to risk management. This includes implementing effective mitigation measures, such as enhancing social support, clarifying job roles, and promoting a positive organizational culture, to improve workers' health and safety outcomes ( [3]; [6]; [10]). By understanding and managing these risks, the construction industry can reduce the occurrence of accidents and create a safer working environment for all employees.

## II. MATERIALS & METHODS

### A. Data In Use

To investigate the link between psychosocial risks and workplace accidents, this study collected data from three primary sources: standardized workplace surveys, historical accident records, and qualitative employee reports. A sample of 200 construction workers across five project sites participated in the study. The Copenhagen Psychosocial Questionnaire (COPSOQ) was used to measure stress, job insecurity, and organizational culture. Accident records from the past five years were used, detailing the nature and frequency of incidents. Additionally, focus groups and individual interviews offered qualitative insights into workers' experiences. All data were securely anonymized, with ethical approval obtained from relevant boards..

- Workplace Questionnaires & Surveys

Psychosocial risk factors were assessed using validated tools such as the Copenhagen Psychosocial Questionnaire (COPSOQ) that takes under consideration all aspects of mental constraints and needed abilities in workplace as well as their internal correlations (Figure I) to provide a categorization of aspects (Figure II) and the Job Content Questionnaire (JCQ). These instruments measured dimensions such as perceived stress, job insecurity, organizational culture, and social support. Surveys were distributed to 200 construction workers across five active project sites, ensuring representation across roles, including manual laborers, supervisors, and engineers. Data on demographic variables such as age, gender, job tenure, and working hours were also collected to allow for subgroup analysis.

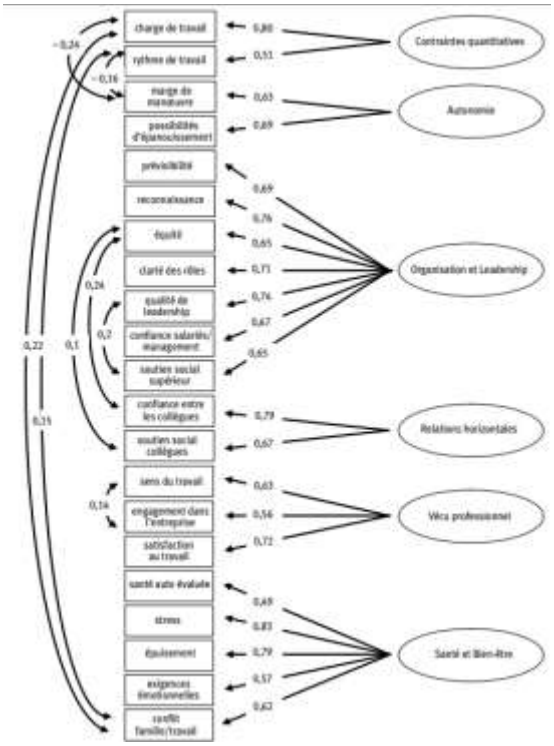


Figure 1: Structure of correlations in COPSOQ v2.

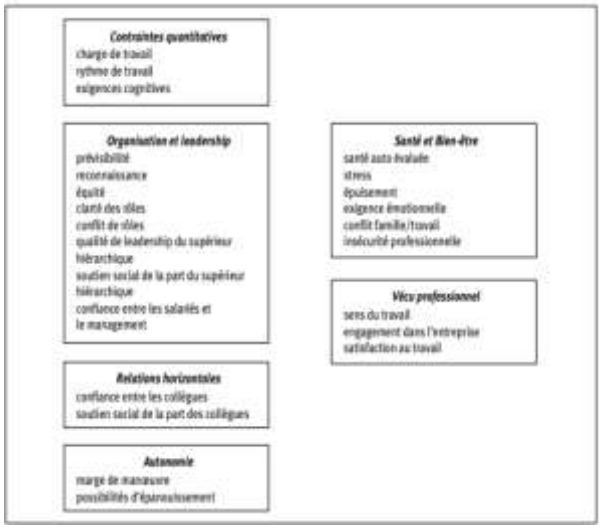


Figure 2 : Organization of the 24 Aspects of The COPSOQ v3 questionnaire.

- Accident Records

Historical accident data spanning five years were obtained. These records included detailed descriptions of accidents, their causes, and their severity, as well as contributing factors such as environmental conditions and time of occurrence. The dataset also tracked near-miss events, providing additional insight into unsafe practices and conditions preceding incidents.

Each recorded incident is meticulously provided with detailed descriptions of the direct, indirect, and root causes, which are further categorized into subcategories (Table I).

The detailed classification on incidents enables a comprehensive assessment and evaluation of the relationships and potential causal factors contributing to on-site injuries. The depth and granularity of the data make it possible to identify patterns and trends essential for understanding the root causes of workplace accidents. As a result, the analysis not only highlights the immediate and apparent causes of incidents but also explores the more intricate and interconnected factors that may lead to such occurrences. This approach offers valuable insights for enhancing safety protocols and preventive measures in the construction industry.

TABLE I. CAUSAL FACTORS CLASSIFICATION

| **Injury Categories** | ***Direct Causes Categories*** | ***Indirect Cuses Categories*** | ***Root Causes Categories*** |
|---|---|---|---|
| - First Aid Case<br>-Medical Treatment Case<br>- Restricted Work Case<br>- Lost Time Injury<br>- Asset Damage | **Unsafe Act (UA)** | **People Factor (PF)** | **Management Aspect (MA)** |
| | - Individual behavior/ attitude<br>- Tools or Equipment Use<br>- Procedures implementation | - Physical Capabilities<br>- Mental Capabilities<br>- Physiological<br>- Psychosocial | - Resource Management<br>- Leadership<br>- Contractors & Subcontractor Mgt. |
| | **Unsafe Condition (UC)** | **Execution Factor (EF)** | **Program System Aspect (PSA)** |
| | -Workplace Hazards<br>- Process Hazards<br>- Tools & Equipment Condition<br>- Protective Defenses<br>- Weather conditions | - Engineering / Design<br>- Project level execution<br>- Communication<br>- Skill & Knowledge<br>- Tools & Equipment Provision | - Work Standards / Procedures<br>- Risk Evaluation<br>- Task Planning<br>- Training<br>- Inspection and Audit program |

- Qualitative Interviews and Focus Groups

To supplement the quantitative data, semi-structured interviews and focus groups were conducted with a subset of workers and safety managers. These sessions aimed to capture nuanced insights into the impact of workplace stressors and cultural dynamics on safety behaviors. The qualitative data was transcribed and analyzed thematically to identify recurring patterns and worker perceptions of risk.

### *B. Assessment of Psychosocial Risks*

As preceded in explanation, this study employed a combination of validated questionnaires and qualitative methods to assess psychosocial risks among construction workers. These methods ensured a comprehensive evaluation of the psychological, social, and organizational factors influencing workplace safety.

*1) Quantitative Data:*

Quantitative data was gathered using two standardized tools:

- Perceived Stress Scale (PSS):

This widely used instrument assessed individual stress levels by measuring the degree to which participants perceived their situations as unpredictable, uncontrollable, or overwhelming. The PSS provided a clear metric for comparing stress levels across different roles and work environments.

- Organizational Culture and Safety Climate Surveys:

These surveys evaluated workplace culture, focusing on management attitudes toward safety, the availability of resources, and the overall commitment to worker well-being. By using an established safety climate assessment framework, this study identified gaps in organizational practices that contribute to unsafe behaviors.

*2) Qualitative Data:*

To capture the nuances of worker experiences that quantitative methods might overlook, semi-structured interviews and focus groups were conducted.

- Interviews:

Individual interviews with 20 workers from diverse roles (e.g., laborers, supervisors, and safety officers) explored the personal impact of stressors like job insecurity, workload, and interpersonal conflicts. These interviews provided detailed narratives about how psychosocial risks manifest in daily work.

- Focus Groups:

Three focus groups, each comprising 6–8 participants, encouraged open discussions about workplace dynamics, communication barriers, and perceptions of safety culture. The group setting allowed for shared experiences to emerge, highlighting common challenges and coping mechanisms.

## III. Results

The analysis revealed a significant correlation between psychosocial risks and the occurrence of workplace accidents on construction sites. Workers who reported higher levels of stress, as measured by the Perceived Stress Scale (PSS-10), were more likely to be involved in accidents or near-miss incidents. Specifically, individuals with PSS scores above the median had a 35% higher likelihood of reporting unsafe practices or errors leading to safety breaches.

Furthermore, the safety climate assessment highlighted that poor communication about safety protocols and a lack of managerial support were strongly associated with increased accident rates. These findings underscore the critical impact of psychosocial factors on workplace safety.

Qualitative data from interviews and focus groups further supported these quantitative findings. Workers frequently cited tight deadlines, excessive workload, and unclear safety expectations as primary sources of stress and anxiety ( [11], [12]). Many participants described feeling pressured to prioritize productivity over safety, which often resulted in cutting corners and engaging in risky behaviors.

Supervisors were also identified as a pivotal influence, with those perceived as dismissive of safety concerns contributing to a negative safety culture. These narratives provided valuable context to the statistical trends, illustrating the pathways through which psychosocial risks translate into unsafe practices.

Predictive analytics using machine learning models demonstrated the ability to identify high-risk scenarios based on psychosocial and environmental data. For instance, decision tree models achieved an accuracy of 82% in predicting accident occurrences, with key predictors including stress levels, safety climate scores, and working hours. The integration of these predictive tools with traditional safety management approaches has the potential to significantly enhance the preemptive identification of at-risk workers and situations, allowing for targeted interventions to mitigate hazards before incidents occur.

These results collectively highlight the interplay between psychosocial risks and construction site safety, emphasizing the need for holistic risk management strategies that address both mental and physical well-being.

## IV. Disscussion

The findings of this study highlight the substantial influence of psychosocial risks on construction site safety. High levels of stress and poor organizational safety climates were shown to correlate strongly with increased accident occurrences. These results underscore the importance of addressing psychosocial factors alongside physical hazards in safety management frameworks. The qualitative insights added depth to the analysis, illustrating how workplace stressors such as tight deadlines, excessive workloads, and insufficient managerial support contribute to unsafe practices. Workers often reported prioritizing productivity over safety, reflecting a broader cultural challenge within the construction industry.

The application of predictive analytics demonstrated the effectiveness of machine learning models in identifying high-risk scenarios. By analyzing psychosocial and operational data, these models provided actionable insights that traditional methods often overlook. The ability to pinpoint specific conditions and worker profiles associated with elevated risk offers a proactive approach to accident prevention. However, challenges remain in terms of practical implementation, including the need for consistent data collection, workforce training, and integration with existing safety protocols.

Despite the contributions of this research, several limitations should be noted. The study was conducted within a specific region, which may limit the generalizability of the findings. Additionally, while qualitative data provided valuable context, the reliance on self-reported experiences introduces potential biases. Furthermore, this research focused on a defined set of psychosocial risk factors, leaving room for further exploration of other dimensions, such as the influence of team dynamics or long-term mental health outcomes.

Future studies should explore the longitudinal effects of psychosocial risks, examining how these factors evolve over time and their sustained impact on safety

outcomes. Expanding the geographic scope and incorporating diverse cultural contexts could yield more generalized insights. Real-time data collection methods, such as wearable technology for stress monitoring or automated safety tracking systems, should be investigated to enhance predictive model accuracy. Additionally, future research should evaluate the practical application of machine learning tools in safety management, focusing on their usability, scalability, and effectiveness in various organizational settings. These efforts will contribute to developing more comprehensive and adaptive approaches to mitigating risks in the construction industry.

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