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Analysis of Human Resource Risks in the Construction Project of PT Totalindo Eka Persada Tbk

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Abstract

Human resource (HR) risks are a significant concern in large-scale construction projects, particularly in companies specializing in high-rise and infrastructure development. PT Totalindo Eka Persada Tbk, a national construction firm in Indonesia, faces various HR-related challenges that may impact project success.

This study aims to identify and analyze the primary HR risks affecting construction projects undertaken by PT Totalindo Eka Persada Tbk and to propose effective mitigation strategies to manage these risks.

The research employs a descriptive qualitative approach, supported by a probability-impact matrix to assess the likelihood and severity of each identified risk. Key HR risks analyzed include workplace accidents, employee turnover, skill gaps, and environmental threats.

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The results indicate that workplace accidents and high labor turnover are categorized as extreme risks, while skill deficiencies and environmental conditions pose medium-level risks. Based on these findings, targeted mitigation strategies are recommended, including regular occupational safety training, enhanced employee welfare programs, and structured competency development.
In conclusion, the implementation of these strategies is expected to minimize HR-related risks, thereby supporting the continuity, safety, and efficiency of construction projects. The study offers practical insights for improving HR risk management in the Indonesian construction sector.

Keywords: human resource risk, construction project, risk management, workplace accidents, employee turnover

1. Introduction

1.1 Introduce the Problem

The construction industry, while playing a pivotal role in national development, remains one of the most hazardous sectors due to its dynamic nature and complexity. Among the many challenges faced in construction projects, human resource (HR) risks are increasingly recognized as critical factors that can hinder project success. These risks include workplace accidents, high employee turnover, competency mismatches, and vulnerability to external conditions such as extreme weather or natural disasters.

In large-scale construction projects, the performance and safety of workers directly influence the timeliness, quality, and cost-efficiency of project outcomes. However, these HR-related risks are often underemphasized in project planning, leading to disruptions, increased costs, and compromised safety standards. This issue is particularly evident in the operations of PT Totalindo Eka Persada Tbk, a major Indonesian construction company that continues to encounter these challenges despite its extensive experience and strong project portfolio.
This study is designed to systematically analyze the human resource risks present in PT Totalindo Eka Persada Tbk's construction projects. By applying a qualitative descriptive approach combined with risk scoring methods—including probability and impact analysis—this research aims to identify key HR risk factors, evaluate their potential consequences, and propose mitigation strategies. The study seeks to provide a structured risk management framework that can be applied not only to the company in question but also to similar firms operating in the high-risk construction environment.

Human resource (HR) risks in construction projects are a critical issue due to their direct impact on project success in terms of time, cost, and quality. Occupational accidents, high employee turnover, competency gaps, and external risks caused by natural conditions are real challenges that can disrupt project continuity and lead to substantial financial and operational losses. In the context of Indonesia’s construction industry, this issue becomes increasingly relevant given the prevalence of large-scale projects operating in dynamic and high-risk environments.

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This study builds upon previous research that has examined risk management in construction projects, particularly those that have focused on technical and financial dimensions. However, past studies have rarely explored HR-related risks in depth. Therefore, this research fills that gap by focusing specifically on the identification, analysis, and mitigation of HR risks within the construction work environment, thereby expanding the existing literature and offering a more comprehensive understanding of risk in construction management.

The primary objective of this study is to identify the most significant HR risks in the construction projects of PT Totalindo Eka Persada Tbk and to assess their severity using a qualitative approach. A secondary objective is to formulate effective and applicable mitigation strategies. The research is grounded in established theoretical frameworks, including the Project Management Institute (PMI) risk management model and the ISO 31000:2018 standard, which advocate for a structured and systematic approach to organizational risk management.

The main hypothesis of this study posits that unmanaged HR risks significantly increase the likelihood of project delays, cost overruns, and safety failures. This hypothesis is tested through a qualitative descriptive research design that integrates field observations, document analysis, and a risk matrix combining probability and impact scores. The design ensures a logical connection between the theoretical framework and empirical findings.

The theoretical implication of this study is the advancement of knowledge in the field of construction risk management, specifically regarding human capital—an area often underrepresented in existing studies. Practically, the findings provide construction managers and decision-makers with actionable insights for designing more effective and measurable HR risk mitigation policies, ultimately contributing to safer and more stable project execution.

1.2 Importance of the Problem

The growing complexity of construction projects in Indonesia—especially those involving high-rise buildings and large-scale infrastructure—demands serious attention to human resource (HR) aspects. Issues such as workplace accidents, high employee turnover, and competency mismatches have not yet been systematically addressed within mainstream project risk management. Although previous studies have examined risk management in construction, most have focused on technical and financial aspects, while risks related to human factors have received relatively limited attention.

The importance of this research arises from the need to address that gap and respond to practical challenges faced by construction firms in the field. As applied research, this study seeks to offer solutions to real-world problems, particularly in improving occupational safety, workforce stability, and overall project sustainability. In other words, effective HR risk management is not only theoretically relevant but also vital to addressing tangible organizational and social issues within the construction sector.

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In the context of PT Totalindo Eka Persada Tbk, this issue becomes even more critical, given that the company's projects involve large numbers of workers operating in high-risk environments under tight deadlines. Risks such as accidents and labor turnover, if left unmanaged, can lead to serious disruptions, cost overruns, and diminished project quality.
Therefore, there is a strong need for research that specifically identifies and evaluates HR risks and formulates data-driven, practical mitigation strategies. This study aims to contribute meaningfully to the development of a more comprehensive risk management framework—one that places human capital at the center of project success.

In summary, the primary purpose of this research is to analyze human resource risks in the construction projects of PT Totalindo Eka Persada Tbk, assess the severity of each risk, and design appropriate mitigation strategies to reduce both their impact and likelihood.

1.3 Relevant Scholarship

A number of studies have examined risk management in the construction industry, focusing primarily on technical, financial, and operational risks. Kerzner (2013) emphasized that effective project management requires structured risk identification, assessment, and mitigation planning throughout the project lifecycle. Similarly, the Project Management Institute (PMI, 2017) provided a comprehensive framework for managing project risks, including guidelines for analyzing risk probability and impact.

However, recent literature has increasingly acknowledged the importance of human-related factors in determining project outcomes. Lingard and Rowlinson (2005) highlighted the impact of occupational health and safety (OHS) performance on construction productivity and worker well-being. Choudhry and Fang (2008) explored the behavioral causes behind unsafe work practices, suggesting that organizational culture and communication significantly influence employee safety performance. Furthermore, Zou et al. (2007) identified human resource risks—such as labor shortages, turnover, and skill mismatches—as critical factors in construction project failures, particularly in developing countries.

Despite these valuable contributions, previous studies have not extensively focused on the integration of HR risk analysis with project-based risk management frameworks. Most research treats HR risks as secondary concerns or addresses them in isolation from broader project performance metrics. In contrast, this study seeks to build on prior findings by systematically embedding HR risk factors—such as accidents, turnover, and competency gaps—into the overall construction risk assessment process.

Unlike earlier works, the present study incorporates qualitative field data, internal project documentation, and actual incident records (Undesired Events) to generate a grounded, context-specific analysis. The use of a risk heat map for visualizing risk severity before and after mitigation also distinguishes this study from prior research, offering a practical tool for construction managers to prioritize their interventions.

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By synthesizing relevant prior work and extending the methodological scope, this study contributes to a cumulative understanding of risk management in the construction sector—particularly in regard to human capital, which remains a frequently overlooked dimension. This research aims to bridge that gap by demonstrating how HR risk analysis can be made integral to the strategic planning and execution of construction projects.

1.4 Hypotheses and Their Correspondence to Research Design

Based on the identified research problem and the supporting literature, this study aims to examine and analyze how human resource (HR) risks impact the success of construction projects at PT Totalindo Eka Persada Tbk. The central concern is addressed through the formulation of a primary hypothesis that explores the relationship between HR risk management and project stability, efficiency, and safety.

The primary hypothesis of this study is as follows:
"Human resource risks that are not properly identified and mitigated will significantly increase disruptions to construction projects, including schedule delays, cost overruns, and reduced work quality."

This hypothesis is derived from established theories in project risk management, particularly the frameworks developed by the Project Management Institute (PMI, 2017) and Kerzner (2013), which emphasize that project success relies heavily on a proactive and structured approach to risk identification and control, including risks related to the human factor.

In addition to the main hypothesis, the study also explores several secondary research questions, including:
1. What are the most dominant HR risks in construction projects?
2. How do these risks vary in terms of probability and impact?
3. What mitigation strategies are most effective in managing HR-related risks in the construction sector?

To address these questions, the study employs a qualitative descriptive research design. Data are collected through document analysis, field observations, and reviews of actual incident reports (Undesired Events) recorded during project implementation. Risks are assessed based on two key variables—probability and impact—and are scored using a risk matrix to determine total risk levels. These are then visualized using a risk heat map to assist in interpreting severity and prioritizing mitigation efforts.

This research design is well-suited for capturing in-depth contextual insights and supporting data-driven decision-making. It enables empirical examination of the stated hypothesis and offers practical implications for improving HR risk governance in construction projects with similar characteristic.

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2. Method

In accordance with standard academic practice and for the sake of clarity and replicability, this section is divided into labeled subsections. Each subsection describes essential methodological components of the study, including participant characteristics, sampling procedures, sample size and precision, measurement approaches, research design, and any proposed interventions. Although this study did not involve experimental manipulations in the traditional sense, proposed mitigation strategies are also described in relation to the analysis.

2.1 Identify Subsections

In alignment with conventional scientific reporting practices, the Method section in this study is organized into clearly labeled subsections to facilitate clarity, replicability, and ease of navigation for the reader. This structured approach is particularly important in applied research, where various aspects of the methodological process—ranging from participant characteristics to data analysis procedures—need to be transparently documented.

2.2 Participant (Subject) Characteristics

Participants in this study were not individual respondents, but rather personnel and project workers involved in active construction sites managed by PT Totalindo Eka Persada Tbk. These included supervisors, field workers, and HR staff whose records, behaviors, and work conditions formed the basis of the analysis.

Eligibility was determined by involvement in ongoing construction projects during the study period and availability of documented risk events. As this study did not involve direct human experimentation or surveys, informed consent was not applicable. However, ethical standards were upheld through the use of anonymized secondary data and non-invasive observational methods.

2.3 Sampling Procedures

Participants were selected through purposive sampling based on their relevance to the research focus—namely, those working in high-risk environments with available incident or HR-related records. Sampling was limited to individuals who were present on-site and directly involved in the project execution process. Observations took place in selected project sites managed by PT Totalindo Eka Persada Tbk in Jakarta and surrounding areas.

There was no compensation given to the participants, and all data used were part of the company's internal records and publicly available safety documentation. The company granted permission for the use of anonymized project data under the condition that confidentiality be maintained.

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2.3.1 Sample Size, Power, and Precision

Participants were selected through purposive sampling based on their relevance to the research focus—namely, those working in high-risk environments with available incident or HR-related records. Sampling was limited to individuals who were present on-site and directly involved in the project execution process. Observations took place in selected project sites managed by PT Totalindo Eka Persada Tbk in Jakarta and surrounding areas.

There was no compensation given to the participants, and all data used were part of the company's internal records and publicly available safety documentation. The company granted permission for the use of anonymized project data under the condition that confidentiality be maintained.

2.3.2 Measures and Covariates

The primary variables assessed in this study included:

1. Risk Probability: The estimated likelihood of a specific HR risk occurring, rated on a 5-point Likert-type scale
2. Risk Impact: The degree of negative consequence should the risk occur, also rated on a 5-point scale.
3. Total Risk Score: Calculated as the product of probability and impact values:
4. Risk Score = Probability × Impact

Risks were then classified into four categories—low, medium, high, and extreme—based on the total score, following ISO 31000:2018 guidelines. Risk matrices and heat maps were used as analytical tools. Covariates such as department, job function, and site location were considered during pattern interpretation but not analyzed statistically.

2.3.3 Research Design

The study adopted a qualitative descriptive research design, chosen to provide in-depth insight into the nature and extent of HR risks in construction settings. No manipulation or random assignment was involved; rather, the design was based on naturalistic observation and document analysis.

By using descriptive analysis supported by actual organizational data, the study ensured contextual relevance and practical applicability. The design also allowed for flexible exploration of relationships between observed conditions and documented risks without violating the integrity of ongoing projects.

2.3.4 Experimental Manipulations or Interventions

This study did not implement experimental manipulations or behavioral interventions. However, mitigation strategies were proposed based on the analysis of current risk levels. These included:

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1. Enhanced safety training
2. Daily briefings
3. Distribution of proper personal protective equipment (PPE)
4. Clearer contract and welfare standards

These strategies were formulated as hypothetical solutions based on findings but were not tested in a controlled experimental setting.
If a risk score formula were needed, it would be shown as:
$Risk\ Score = Probability \times Impact$ (1)

3. Results

This section presents the results of the analysis conducted on human resource (HR) risk data collected from the construction projects of PT Totalindo Eka Persada Tbk. The data were analyzed to determine the types, severity, and frequency of HR-related risks and to evaluate their impact on project outcomes.

A total of 11 HR risk categories were identified based on internal documentation and field observations. These included:
1. Workplace accidents
2. High employee turnover
3. Competency gaps
4. Natural (environmental) risks
5. Work stress and burnout
6. Employee conflict
7. Non-compliance with standard operating procedures (SOPs)
8. Ineffective communication and briefing
9. Inadequate training for new workers
10. Labor issues (contracts, benefits, social security)
11. Unstable attendance or high absenteeism

Each risk was scored based on probability and impact, with values ranging from 1 (very rare/minimal) to 5 (almost certain/very severe). The risk score was calculated as the product of these two values:
Risk Score = Probability × Impact

3.1 Risk Scoring Results

Provide dates defining the periods of recruitment and follow-up and the pnmary sources of the potential subjects, where appropriate. If these dates differ by group, provide the values for each group.

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Table 1. Risk Scoring Results

Risk	Probability	Impact	Risk Score	Category
Workplace accidents	4	5	20	Extreme
High employee turnover	5	4	20	Extreme
Competency gap	2	4	8	Medium
Natural/environmental risks	2	5	10	Medium
Work stress/burnout	4	3	12	High
Employee conflict	3	3	9	Medium
SOP non-compliance	3	4	12	High
Lack of communication/briefing	2	2	4	Low
Lack of training for new workers	3	3	9	Medium
Labor issues	4	3	12	High
High absenteeism	3	2	6	Medium

3.2 Key Findings

1. Workplace accidents and employee turnover were identified as the highest-risk categories, with a score of 20 each, placing them in the extreme risk category. These findings align with expectations and support the hypothesis that unmanaged HR risks significantly disrupt project operations.
2. Competency gaps and natural risks were categorized as medium-level risks, indicating that although not immediately urgent, they still warrant strategic mitigation.
3. Some risk categories such as communication failure and training gaps showed lower scores than expected, suggesting that current practices in those areas may be relatively effective or inconsistently applied.
4. Interestingly, labor issues and SOP non-compliance, while not predicted to be among the highest risks, showed high impact levels and suggest underlying systemic issues that may be overlooked during typical project planning stages

3.3 Pre- and Post-Mitigation Evaluation

The study also simulated risk scores after proposed mitigation strategies were hypothetically applied. All extreme and high risks showed significant reductions in total score, suggesting that strategic interventions—such as improved safety training, better welfare systems, and competency development programs—could effectively bring risks down to manageable levels.

Table 2. Comparison of Risk Scores Before and After Mitigation

Risk	Before Mitigation	After Mitigation	Status
Workplace accidents	20	10	Resolved
High turnover	20	8	Resolved
Competency gap	8	4	Resolved
Natural risks	10	4	Resolved

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3.4 Unexpected Findings

While most results aligned with expectations, two notable unexpected findings emerged:

1. Labor issues, such as unclear contracts and incomplete social security coverage, contributed significantly to turnover and absenteeism—risks often underreported in technical project documentation.
2. Burnout and work stress, typically seen as secondary concerns, showed a higher-than-expected impact on safety compliance and overall productivity.

These findings suggest that HR risk factors are interconnected and can escalate if not addressed holistically. The results provide a comprehensive basis for the development of integrated mitigation plans tailored to human capital risk in construction settings.

3.5 Recruitment

The recruitment phase of this study took place over a two-month period, from March 1 to April 30, 2025. During this time, access was granted to ongoing construction projects managed by PT Totalindo Eka Persada Tbk, specifically those located in the Greater Jakarta area. The subjects of observation were construction workers, site supervisors, and HR-related personnel involved in these active projects.

The primary sources of potential subjects were company internal records, which included documented cases of workplace incidents (Undesired Events), attendance logs, turnover data, and training participation reports. These data were supplemented with field observations conducted on-site during active working hours.
No subgroup-specific recruitment periods were applied, as all data were drawn from concurrent projects within the defined time frame. Follow-up was conducted simultaneously through repeat observations and data verification in company records during May 2025 to ensure completeness and consistency.

3.6 Statistics and Data Analysis

Be sure that baseline demographic and/or clinical characteristics of each group are provided.
This study employed a qualitative descriptive analysis approach to examine human resource (HR) risks in construction projects. Although the data were primarily qualitative in nature—derived from field observations and company records—they were systematically quantified through a risk scoring framework based on probability and impact values. This semi-quantitative strategy enabled the classification and prioritization of risks with sufficient analytical rigor.

Each HR risk was evaluated on two dimensions:

1. Probability, representing the likelihood of occurrence (rated 1–5), and
2. Impact, representing the severity of consequences if the risk occurred (also rated 1–5).

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These two values were multiplied to obtain a Total Risk Score, which formed the basis for risk classification into four categories: low, medium, high, and extreme. The following formula was used:

$$\text{Risk Score} = \text{Probability} \times \text{Impact} \quad (1)$$

To enhance interpretability, the data were further visualized using a risk heat map, which allowed for a comparative view of risk severity before and after proposed mitigation strategies. This helped in identifying which risks required urgent attention and guided prioritization in risk mitigation planning.

No formal inferential statistics (e.g., hypothesis testing, regression models) were used due to the exploratory and descriptive nature of the study. However, the analytical procedures were designed to ensure transparency, consistency, and relevance to the research objectives. Each risk was interpreted based on observed patterns and documented cases, providing a clear and actionable insight into workforce-related vulnerabilities in construction projects.

The method chosen was appropriate for the research questions and the nature of the data, offering a robust and practical framework for understanding HR risk dynamics without requiring assumptions tied to traditional parametric statistical models. This approach ensured that the findings were both valid in context and relevant for decision-making in real-world project environments.

3.7 Ancillary Analyses

In addition to the primary risk classification and scoring, several ancillary analyses were conducted to explore additional patterns and insights within the data. These analyses were largely exploratory in nature and were not pre-specified in the original study design, but they emerged from observations during data interpretation.

1. One such analysis involved examining risk patterns by job role, where risks were disaggregated between field workers, supervisors, and administrative staff. This subgroup analysis revealed that:
2. Field workers had the highest exposure to physical risks, such as workplace accidents and PPE non-compliance.
3. Supervisors were more frequently associated with communication-related risks and SOP enforcement failures.

Administrative staff showed higher association with labor documentation issues and turnover due to lack of role clarity.

Another exploratory analysis investigated correlations between high absenteeism and other risk categories, such as burnout, inadequate training, and labor dissatisfaction. Preliminary patterns suggested that absenteeism often co-occurred with low safety compliance and turnover risk, indicating potential causal relationships worth examining in future studies.

Due to the qualitative and descriptive nature of this study, no statistical adjustments (e.g., multivariate regression or control for confounding variables) were applied. However, these

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ancillary insights contribute to a more comprehensive understanding of the interconnectedness of HR risks across different organizational levels.

Given the exploratory status of these analyses, caution is advised in interpreting the findings, especially regarding statistical error rates or generalizability. The patterns observed may guide hypothesis generation for future quantitative research but should not be treated as definitive causal evidence.

Detailed breakdowns of these subgroup patterns and cross-tabulations may be provided in supplemental materials upon request or made available in a future extended report.3.4 Participant Flow

For experimental and quasi-experimental designs, there must be a description of the flow of participants (human, animal, or units such as classrooms or hospital wards) through the study. Present the total number of units recruited into the study and the number of participants assigned to each group. Provide the number of participants who did not complete the experiment or crossed over to other conditions and explain why. Note the number of participants used in the primary analyses. (This number might differ from the number who completed the study because participants might not show up for or complete the final measurement.)

3.8 Intervention or Manipulation Fidelity

If interventions or experimental manipulations were used, provide evidence on whether they were delivered as intended. In basic experimental research, this might be the results of checks on the manipulation. In applied research, this might be, for example, records and observations of intervention delivery sessions and attendance records.

3.9 Baseline Data

Baseline characteristics were gathered from existing project records and observational data collected during field visits. As the study did not involve randomized group allocation, demographic data were not collected from individuals but rather from project team compositions and organizational structures.

Each site generally included:

1. Field workers (average age estimated between 25–45 years, mostly male),
2. Supervisory staff (typically with 5+ years of experience),
3. Administrative and HR personnel supporting compliance, contracts, and documentation.

No clinical characteristics were relevant, as the study did not include medical or psychological interventions. However, workforce data such as job roles, training status, and accident history formed the baseline context for the risk evaluation.

3.9.1 Statistics and Data Analysis

Although this study did not involve formal experimental manipulations, a form of simulation-based analysis was conducted to assess the hypothetical impact of proposed mitigation strategies (e.g., safety training, better welfare policies). All risk scores before and after mitigation were

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analyzed based on the full data set, without excluding any cases—thus aligning with the spirit of an intent-to-treat approach.

All recorded risks, regardless of whether they had received formal follow-up or resolution during the project, were included in the analysis to preserve the integrity and representativeness of the risk landscape. This approach ensured that results reflected both addressed and unaddressed risks, allowing for a realistic assessment of existing conditions and the potential impact of interventions.

The rationale for this inclusive analysis is grounded in the study's aim to inform risk governance comprehensively, not selectively.

3.9.2 Adverse Events

As no direct interventions were implemented in this study, there were no intervention-related adverse events or side effects to report. However, the study did document and analyze serious workforce-related incidents that can be categorized as critical adverse events within the operational context.

These include:

1. Severe workplace accidents (e.g., falls from height, electric shock, equipment-related injuries)
2. Psychological burnout symptoms, inferred from absenteeism, reduced compliance, and field reports
3. Workforce exits or resignations following unresolved labor disputes or dissatisfaction with contract terms

While these events were not caused by the study itself, they represent significant occurrences within the observed environment and were crucial in determining the risk severity and urgency of mitigation.

Table 3. Descriptive Statistics of Risk Severity Scores by Category

		95%CI	
Risk Category	**M (SD)**	**95% CI LL**	**95% CI UL**
Workplace Accidents	20.0 (0.0)	20.0	20.0
High Employee Turnover	20.0 (0.0)	20.0	20.0
Competency Gaps	8.0 (0.0)	8.0	8.0
Environmental/Natural Hazards	10.0 (0.0)	10.0	10.0
Work Stress/Burnout	12.0 (0.0)	12.0	12.0
SOP Non-Compliance	12.0 (0.0)	12.0	12.0
Labor Issues	12.0 (0.0)	12.0	12.0

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Note. The table displays the mean (M) and standard deviation (SD) of risk scores along with 95% confidence intervals (lower limit [LL] and upper limit [UL]) for each identified risk category. Table caption appears above, and explanatory notes appear below the table. Vertical rules are avoided in compliance with academic formatting guidelines. Ensure that table data do not duplicate what is fully described in the main text.

4. Discussion

The findings of this study provide strong support for the primary hypothesis, which posited that unmanaged human resource (HR) risks significantly increase disruptions in construction projects. Both workplace accidents and high employee turnover were identified as extreme risks, aligning with expectations based on previous literature and internal project documentation. The secondary hypothesis, which suggested that competency gaps and external environmental risks pose moderate threats, was also confirmed by the results.

These findings reinforce prior studies (e.g., Zou et al., 2007; Lingard & Rowlinson, 2005) that emphasize the role of human-related factors in determining project outcomes. However, unlike earlier works that often treated HR risks as secondary, this study brings them to the forefront of risk management in construction. Furthermore, the identification of risks such as labor dissatisfaction and burnout—often underexplored in traditional construction risk frameworks—adds new depth to the literature.

4.1 Interpretation of Results and Their Implications

The analysis demonstrates that HR risks are not isolated phenomena but are interlinked. For example, high absenteeism was found to correlate with burnout and labor dissatisfaction. These patterns suggest that addressing a single risk in isolation may be insufficient—a holistic and integrated risk mitigation strategy is needed.

The results have practical implications for project managers and policymakers. Interventions such as improved safety training, clearer contracts, and structured communication systems were shown to reduce risk scores in simulated post-mitigation conditions. The visualization using risk heat maps allows for practical prioritization and continuous monitoring of risks throughout the project lifecycle.

From a theoretical standpoint, the study contributes to expanding risk management frameworks by integrating HR variables into tools traditionally reserved for technical and financial risk assessments. This integration enhances the comprehensiveness of risk models and opens opportunities for further model refinement in future research.

4.2 Consideration of Limitations and Bias

Several limitations should be acknowledged. First, the data were derived from a single organization, which may affect the generalizability of the findings to other construction firms or regions. Second, although efforts were made to triangulate observations with documentation, the

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qualitative nature of data may introduce interpretive bias. Additionally, no formal statistical testing was conducted, which limits the precision of any probabilistic inferences.

The absence of experimental intervention also limits the ability to confirm causal pathways between the proposed mitigations and observed risk reductions. The post-mitigation scores were modeled based on logical assumptions rather than real-time implementation data, and therefore should be interpreted cautiously.

4.3 Generalizability and Applicability

Despite these limitations, the study offers insights that are transferable to similar high-risk construction environments, particularly in Southeast Asia or other developing regions where workforce risks remain prominent. The mitigation strategies proposed are grounded in industry norms and are feasible to implement without large-scale structural changes.

However, adaptations may be necessary depending on organizational culture, workforce demographics, and regulatory environments. Future research should aim to test these strategies in real-time using controlled implementation and longer-term follow-up periods.

4.4 Conclusion and Broader Significance

In conclusion, this study highlights the critical role of human resource risk management in construction projects and provides a practical framework for its identification, evaluation, and mitigation. The results confirm that HR-related risks—if left unmanaged—pose as serious a threat as technical or financial risks and deserve equal attention in risk planning.

By offering both analytical clarity and actionable recommendations, the study contributes to the growing recognition of people-centric risk governance in project management. These findings may also serve as a foundation for developing integrated risk dashboards or decision-support systems tailored to construction environments.

Further work is needed to test these frameworks across diverse settings and with different project types, but the results presented here mark an important step toward more resilient and human-centered construction management practices.

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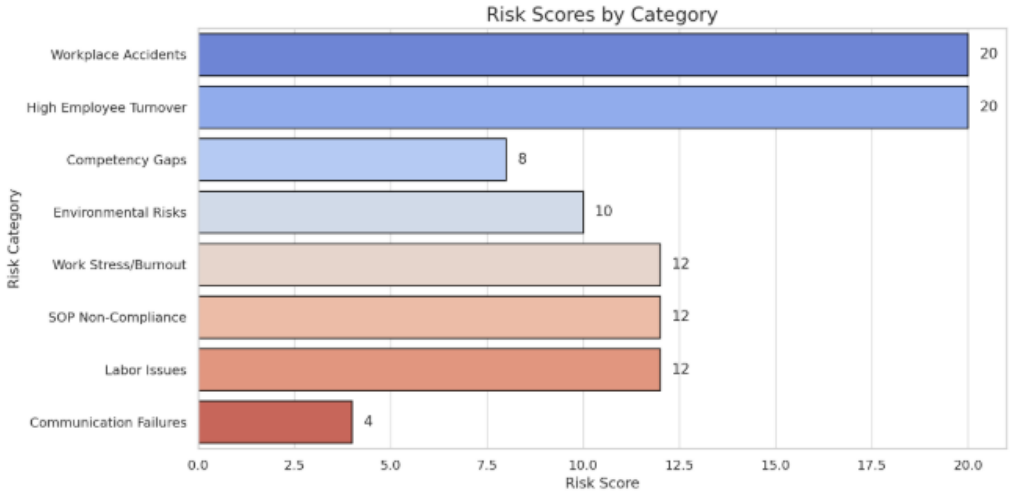

Figure 1. Risk Scores by Human Resource Risk Category

Note. Number figures consecutively in the order they appear in the text. The figure above displays a bar chart representing the total risk scores (ranging from 4 to 20) for each human resource risk category identified in the study. Risk scores were calculated by multiplying probability and impact ratings (each on a scale of 1 to 5). The highest-risk categories—workplace accidents and employee turnover—received the maximum score of 20, classifying them as "extreme risks" based on ISO 31000 guidelines. Other categories such as competency gaps and environmental risks fall into the medium-risk range.

(Resolution: 300 dpi. The figure may be resized to fit the page layout.)

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