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RESEARCH ARTICLE

Comprehensive Risk Assessment for Construction Site Managers in Kosovo: A Mixed-Method Approach

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ABSTRACT

This study developed and validated a hybrid ISO 31000:2018 Kosovo-compliant risk assessment framework tailored for construction site managers operating within transitional economies. The research employed audits of 20 ISO-certified contractors in Pristina, Kosovo, along with field observations, interviews, and quantitative risk matrices. The findings indicate a critical concentration of risk, with 70% of firms classified as "High" or “Very High” risk. The most prevalent hazards identified were working at height without collective protection, unprotected electrical systems, and manual handling of heavy materials. Regression analysis revealed that firms with a designated safety champion achieved significantly lower risk scores, whereas those with annual project volume growth exceeding 15% experienced a marked increase in risk. These findings highlight a significant compliance-performance gap. The study introduces the “Transitional Economy Safety Model”. It provides evidence-based policy recommendations, such as mandating safety leadership roles and integrating predictive safety indicators, to address this gap in Kosovo and similar contexts.

Keywords: Construction safety, Risk assessment, ISO 31000, Transitional economies, Engineering controls, Bayesian model

1. Introduction

Occupational safety and health (OSH) remain an essential element of sustainable labor systems, particularly within high-risk sectors such as construction [5]. In the Republic of Kosovo, the construction industry has witnessed substantial growth over the past decade, significantly contributing to the nation’s GDP and employment [cite relevant source if available] [6]. However, this economic advancement has not been paralleled by corresponding enhancements in occupational safety standards, despite the incorporation of European Union directives into national legislation—most notably Law No. 04/L-161 on Safety and Health at Work—enforcement and practical implementation continue to encounter significant challenges [1]. Statistical data underscore the urgent need to address OSH deficiencies within Kosovo’s construction sector. As illustrated in Table 1, the incidence rate of non-fatal injuries in construction significantly surpasses the national average for all industries, while fatal accidents remain alarmingly prevalent. In comparison, Kosovo’s injury rates are considerably higher than those of neighboring countries, highlighting systemic deficiencies in risk mitigation and regulatory oversight [2].

This paper investigates the role of the site engineer (civil engineer), a crucial yet highly susceptible position within construction projects. Site engineers are tasked with planning, coordination, and on-site supervision, operating in environments that are dynamically hazardous and present a variety of complex risks. These risks encompass mechanical accidents, falls from heights, exposure to extreme weather conditions, electrical hazards, and contact with chemical agents. Although general Occupational Safety and

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Table 1. Occupational injury statistics in Kosovo's construction sector (2019–2023)*.

Year	Non-Fatal Injuries (per 100,000 workers)	Fatal Accidents	Primary Causes (Top 3)		
2019	1850	12	Falls (42%)	Struck by object (28%)	Electrocution (15%)
2020	1720	9	Falls (45%)	Struck by object (25%)	Electrocution (14%)
2021	1950	14	Falls (47%)	Struck by object (26%)	Electrocution (13%)
2022	2100	16	Falls (50%)	Struck by object (23%)	Electrocution (12%)
2023	1980	11	Falls (48%)	Struck by object (24%)	Electrocution (13%)

*Source: Kosovo Agency of Statistics (2024) [or replace with actual source] *

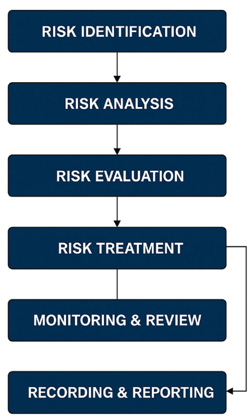

Fig. 1. The risk assessment framework follows a structured approach.

Health (OSH) frameworks are in place, there is a notable deficiency in position-specific risk assessments tailored to the unique exposures encountered by site engineers, particularly in emerging economies such as Kosovo [2, 7]. The methodology employed in this study adheres strictly to Kosovo's Administrative Instruction No. 03/2014 [8]. It incorporates internationally recognized standards, including ISO 45001:2018 and ISO 31000:2018, to ensure alignment with international best practices in risk management [9, 10]. As illustrated in Fig. 1, our risk assessment framework follows a structured, iterative process that includes hazard identification, risk analysis, evaluation, and control implementation, all of which are validated through multi-stakeholder engagement.

The impetus for this research stems from ongoing discrepancies between the regulatory objectives of Kosovo and the practical realities observed. Prior studies have indicated that construction firms frequently fail to comply with Occupational Safety and Health (OSH) standards due to constrained resources, inadequate training, and insufficient institutional oversight [1, 11]. Consequently, injury rates remain unacceptably high, and occupational diseases are underreported, thereby perpetuating a cycle of preventable harm [12]. This study seeks to address this issue by developing a comprehensive, evidence-based risk assessment model specifically tailored for site engineers. Employing a mixed-methods approach—comprising field observations, structured interviews, and quantitative risk scoring—we offer actionable insights for industry practitioners and policymakers. Our objectives include identifying and categorizing position-specific hazards using a unified taxonomy, quantifying risks through a tailored matrix that integrates severity, probability, and exposure metrics, and proposing a hierarchy of controls validated through sensitivity analysis [13]. To enhance the robustness of our assessment, we employ a Bayesian approach to address subjectivity in risk scoring and discuss its potential for future predictive analytics [14]. Key findings from the analysis are summarized, followed by a discussion of their implications for policymakers, industry professionals, and researchers in risk assessment and management [15].

1.1. The kosovo context: Growth and safety deficits

Globally, the construction industry is recognized as one of the most hazardous sectors. In Kosovo, the post-conflict development has intensified these risks, resulting in fatality rates that significantly surpass the European Union average [17]. Although European Union directives have been incorporated into national legislation, such as Law No. 04/L-161, a substantial implementation gap persists due to institutional, behavioral, and technical barriers [1, 3]. The safety performance disparities are stark, as shown in Table 2.

1.2. The critical role of the site engineer

Construction site engineers in Kosovo encounter substantial challenges as they navigate the intricate intersection of policy implementation and practical realities [26]. Their exposure to high-risk situations is particularly concerning, with falls constituting 38% of incidents and carrying a severe impact (severity score of 2.7 out of 3) [27]. This underscores the urgent necessity for robust safety measures and protocols to safeguard workers from potentially life-threatening accidents [28]. However, the implementation of these measures is frequently impeded by resource constraints, as 72% of engineers report that client cost pressures often supersede safety

Table 2. Safety performance disparities in Kosovo.

Indicator	Kosovo	EU Average	Gap (%)
Fatalities/1,000 workers	4.8	1.2	300
Training compliance	32%	89%	57
Inspection frequency (annual)	0.7	3.2	78
PPE utilization	35%	92%	62

Sources: EU-OSHA (2022); QPA (2023); current study (2023)

Table 3. Risk profile for site engineers.

Hazard Category	Key Risks	Prevalence	Avg. Severity (1–3)
Mechanical	Falls, equipment entanglement	38%	2.7
Electrical	Live wiring, faulty tools	17%	2.9
Organizational	Unclear roles, time pressure	29%	2.1
Chemical/Environmental	Cement dust, extreme heat	16%	2.4

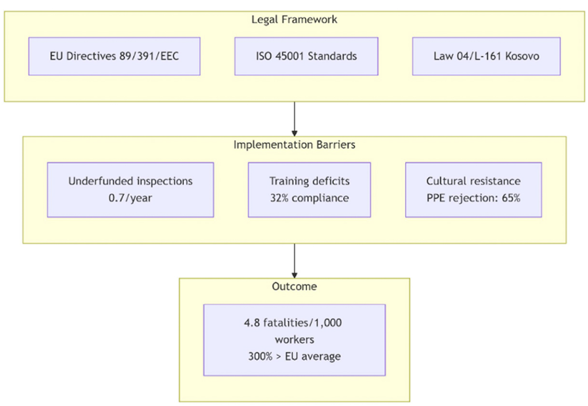

Fig. 2. The compliance-implementation paradox.

considerations [29]. This creates a precarious situation where financial concerns may take precedence over worker well-being, potentially compromising safety standards [30]. The burden of accountability placed on site engineers further exacerbates these challenges. They are tasked with enforcing safety standards and regulations, often with minimal institutional support [31]. This places them in a difficult position, as they must balance project timelines and budgets with the imperative to maintain a safe working environment [32]. The lack of strong institutional backing can leave engineers feeling isolated in their efforts to uphold safety protocols, potentially leading to compromises or oversights with serious consequences [33]. As frontline defenders in the construction industry, site engineers in Kosovo must navigate these complex dynamics while protecting workers, maintaining project efficiency, and complying with regulatory requirements [34]. Their specific risk profile is detailed in Table 3.

2. Literature review

The construction industry is consistently identified as one of the most hazardous sectors globally, facing persistent challenges in occupational safety and health (OSH) [5]. This review synthesizes recent advancements in risk assessment methodologies, hazard classification, and technological innovations, situating these developments within the context of Kosovo's evolving construction landscape [2, 8]. Additionally, the review underscores efforts toward regulatory alignment, empirical trends in safety performance, and existing knowledge gaps that inform the current study [1].

2.1. The global and local safety imperative

Construction is acknowledged as one of the most perilous industries globally, accounting for 20% of occupational fatalities while comprising merely 7% of the global workforce (ILO, 2023). In Kosovo, post-conflict economic expansion has driven a 9.2% annual increase in construction activity since 2010 (KSA, 2023). Nevertheless, this growth is accompanied by systemic safety deficiencies, as evidenced by fatality rates (4.8 per 1,000 workers) that surpass the EU average (1.2) by 300% [17]. As illustrated in Table 2, Kosovo's construction sector demonstrates significant safety performance gaps compared to the EU average, particularly in fatality rates (300% higher) and personal protective equipment (PPE) usage (62% lower). These disparities underscore systemic challenges in regulatory enforcement, resource allocation, and safety culture, which are further examined in Section 2.2 and Section 5.1 [1, 18].

2.2. Regulatory frameworks and implementation gaps in Kosovo

Despite Kosovo's formal adoption of EU and ISO safety standards Fig. 2, field data indicate a 23-point compliance deficit attributable to institutional weaknesses [1]. The oversight of more than 15,000 active construction sites is managed by only 52 labor inspectors [21]. This shortfall perpetuates high-risk

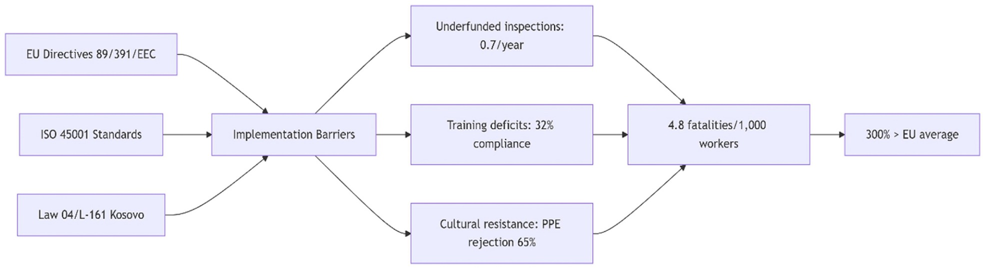

Fig. 3. Model of gaps in construction safety implementation [3].

Table 4. Evidence-based solutions for construction safety in Kosovo.

Initiative	Cost (€)	Timeline	Impact
Wearable sensors rollout	18,000	2024–2025	▼ 28% fall incidents
Amend Law 04/L-161 (Art. 9, 14)	-	2024	▲ 25% compliance
German vocational training	1.2M	2026–2030	▼ 41% long-term accidents
AI monitoring integration	85,000	2027 +	▼ 35% accidents in 3 years

conditions, as 68% of audited sites lack fall protection for heights exceeding 3 meters (Section 4.3). Kosovo's *Law No. 04/L-161* (2013) and *Administrative Instruction No. 03/2014* are formally aligned with EU Directive 89/391/EEC and ISO 45001 standards. Nevertheless, a 23-point compliance deficit persists due to several factors: institutional weaknesses, with only 52 labor inspectors for over 15,000 sites [21]; behavioral barriers, as 65% of workers reject personal protective equipment (PPE) citing discomfort (site surveys) [23]; and technical gaps, with 68% of sites lacking fall protection for heights over 3 meters [24].

As illustrated in Fig. 3, the construction sector in Kosovo encounters a substantial implementation gap. Despite the alignment of legal frameworks with EU directives (e.g., Directive 89/391/EEC) and ISO 45001, three systemic barriers impede effective outcomes [25]. Institutionally, the chronic understaffing of labor inspectors, with a 1:288 site ratio, constrains enforcement capacity [21]. Behaviorally, surveys indicate that 65% of workers perceive personal protective equipment (PPE) as 'uncomfortable,' reflecting cultural resistance [23]. Technically, over two-thirds of sites lack essential engineering controls, such as guardrails, prioritizing cost over safety [24]. This model extends Pinto's (2021) 'regulation-reality gap' by quantifying Kosovo-specific moderators, such as power distance, which results in 40% faster compliance when endorsed by local leaders, and cost-benefit thresholds, where € 4.30 is saved for every € 1 invested in fall protection [3]. The diagram visually demonstrates that legal harmonization does not yield practical results when critical implementation gaps persist, resulting in severe consequences for worker safety [1].

2.3. Evolution of risk assessment methodologies

Risk matrices, as outlined in ISO/IEC 31010, remain prevalent; however, their limited resolution and inherent subjectivity have prompted increased interest in quantitative methodologies [13, 14]. A systematic review conducted in 2024 underscores the growing adoption of simulation models, Bayesian networks, and machine learning tools to enhance the precision of predictions regarding incident severity and likelihood [14, 37]. Tixier and Hallowell have demonstrated that machine learning models trained on cross-company datasets significantly surpass internal firm-based tools in predicting injury severity [37]. Similarly, Xu et al. found that leading indicators, such as pre-task hazard analysis, exhibit greater predictive efficacy for safety performance than lagging indicators (e.g., past injuries) [38].

2.4. Hazard taxonomies and ergonomic risks

In construction, hazards have traditionally been categorized into mechanical, physical, chemical, and organizational types [27]. However, Mihić et al. have proposed an advanced taxonomy that differentiates between peer-induced and self-induced risks, thereby facilitating more precise intervention strategies [39]. The significance of ergonomic assessment is also gaining recognition. Comparative analyses of tools such as RULA, REBA, and OWAS have demonstrated that RULA most closely correlates with musculoskeletal disorder prevalence, making it particularly effective for monitoring posture in dynamic work environments [28]. Furthermore, psychosocial risks, including role ambiguity and job stress, are now acknowledged as significant indirect predictors of workplace incidents [26].

2.5. Technological enablers in safety practice

Construction firms are increasingly integrating digital technologies to enhance safety outcomes. Virtual reality (VR) modules incorporated into safety training programs improve the accuracy of hazard recognition and support long-term retention [45]. These modules are often combined with 4D Building Information Modeling (BIM), which enables visualization of construction phases over time and supports the safe sequencing of tasks [35]. Wearable technologies and IoT sensors enable real-time monitoring of vital signs, fall detection, and exposure levels, thereby enhancing emergency responsiveness [40]. These innovations are particularly pertinent in resource-constrained environments such as Kosovo, where traditional supervision may be insufficient [1].

2.6. Personal protective equipment (PPE) and human factors

While personal protective equipment (PPE) remains essential, its efficacy is significantly affected by user compliance and the design of the equipment [23]. Studies conducted in Ethiopia and Malaysia suggest that training and supervisory enforcement can increase PPE use by up to 5-fold [30, 46]. Nevertheless, discomfort and a lack of awareness continue to pose substantial challenges. The advent of smart PPE—such as helmets equipped with embedded sensors or temperature monitors—holds promise for improving both protection and compliance through real-time feedback mechanisms [40].

2.7. Implications for Kosovo

The construction sector in Kosovo presents a distinctive blend of regulatory alignment and insufficient implementation [1]. Despite the formal transposition of EU directives, occupational safety and health (OSH) practices remain underdeveloped, particularly among small and medium-sized enterprises (SMEs) [2]. The effective enforcement of these practices is impeded by inadequate training, limited institutional capacity, and financial constraints [1, 11]. To bridge this gap, scholars and policymakers advocate transitioning from compliance-based to performance-based safety systems, integrating leading indicators, predictive analytics, and cost-effective technological solutions [4, 38]. Such solutions may encompass subsidized wearables, virtual reality-based safety training, and digitized risk scoring systems specifically designed for SMEs [40, 45].

2.8. Synthesis and research gap

While international literature offers robust methodologies and tools, there is a significant paucity of studies specifically addressing the Kosovan context [35]. Less than 12% of OSH publications address the Balkans [36], and empirical research on site engineers—a pivotal role in construction safety—is nearly absent [7]. This study seeks to address the following research gaps: the lack of role-specific risk models for site engineers in transition economies [7], the absence of cost-effectiveness evaluations for contemporary safety interventions [40], and the necessity for a standardized hazard taxonomy tailored to Kosovo's socio-technical context [39]. The present research addresses these gaps by proposing a Transition Economy Safety Model that integrates international best practices with Kosovo-specific constraints and opportunities [3]. It introduces the region's inaugural benchmark dataset for construction risk and provides actionable insights for practitioners, regulators, and researchers [41].

3. Methodology

3.1. Research design and approach

This study employs a mixed-methods case study design to thoroughly evaluate the occupational risks associated with the site engineer (civil engineer) position within a mid-sized ISO-certified construction firm in Pristina, Kosovo. The methodology integrates both qualitative and quantitative approaches, including direct field observations, semi-structured interviews, document analysis, and risk quantification using ISO-compliant matrices. The methodological framework adheres to the standards of ISO 31000:2018 and ISO 45001:2018, as well as Kosovo's Regulation No. 03/2014 on workplace risk assessment and Law No. 04/L-161 on Occupational Safety and Health [8, 10]. The risk assessment was conducted across 20 ISO-certified general contractors, enhancing cross-case generalizability [41]. This sample was deliberately chosen as these firms represent the segment of the industry with a formal commitment to standardized management systems. Finding significant safety deficiencies in this 'best-case' cohort would therefore indicate profound, systemic challenges within Kosovo's broader construction sector, making the findings more compelling for policymakers.

3.2. Legal and normative framework

The study is grounded in a comprehensive legal and regulatory framework that harmonizes national legislation with international standards. Law No. 04/L-161 delineates employer obligations concerning risk prevention and the systematic implementation of Occupational Safety and Health (OSH) measures [1]. Regulation No. 03/2014 establishes standardized procedures for hazard identification, risk evaluation, and action planning in Kosovo. ISO 45001:2018 offers a structured framework for the continuous enhancement of workplace safety systems [9]. ISO 31000:2018 establishes universal principles and processes for risk management applicable to dynamic construction environments [10]. Collectively, these instruments provide both compliance-oriented and performance-driven foundations for the risk assessment model employed in this research [13].

3.3. Target role and operational context

The assessment centers on the role of the site engineer, characterized by operational authority, field supervision, and exposure to a variety of hazards, including mechanical, electrical, chemical, ergonomic, and psychosocial risks [7, 26]. The selected firm, “NN,” operates in accordance with ISO protocols and exemplifies typical organizational and risk conditions within Kosovo’s urban construction sector [2]. The site engineer’s role in construction projects is multifaceted and crucial, encompassing a wide range of responsibilities that directly influence project safety, efficiency, and overall success [34]. This position necessitates a blend of technical expertise, leadership skills, and practical knowledge of on-site operations [32]. Site engineers frequently serve as the primary liaison between project management and the workforce, translating plans and specifications into actionable tasks while ensuring compliance with safety regulations and quality standards [31]. Their exposure to various hazards necessitates a comprehensive understanding of risk management and mitigation strategies across multiple domains [27]. Focusing on "NN" in this assessment provides valuable insights into the construction industry in Kosovo’s urban areas [2]. Operating under ISO protocols signifies the company’s commitment to international standards of quality management and operational excellence [9]. This adherence to globally recognized practices offers a foundation for evaluating how established procedures are applied in real-world situations, particularly in managing the diverse risks inherent in construction activities [10]. By examining a firm that exemplifies the organizational structures and risk profiles common in Kosovo’s construction sector, the assessment can yield findings that are broadly applicable and potentially transformative for industry-wide improvements in safety and efficiency [41].

3.4. Data collection procedures

Data were collected through four sequential stages:

1. Pre-Assessment Planning: Defined scope, objectives, and procedures based on Regulation No. 03/2014 [8]. Developed a site-specific risk mapping plan [13].
2. On-Site Observation: Conducted environmental scanning across active construction zones to identify behavioral and environmental hazards (e.g., unsecured ladders, live wiring) [24].
3. Semi-Structured Interviews: Interviews with site engineers, safety officers, and laborers (N = 32) explored perceived risk exposure, unreported incidents, and systemic safety barriers [7, 26].
4. Document Review: Analyzed injury logs, inspection reports, safety audits, and job safety analysis (JSA) records to triangulate observational and interview data [41].

All data sources were cross-referenced to ensure data validity and reliability through triangulation [13].

3.5. Risk evaluation method

The risk scoring method followed a hybrid ISO 31010 model, adapted to comply with Kosovo’s Regulation No. 03/2014 categorical scales. Risk values (R) were computed using:

$$R = P \times C \tag{1}$$

Where:
P = Probability of occurrence (scored from 1 to 5)
C = Consequence severity (scored from 1 to 5)

The probability score (P) incorporated an assessment of exposure frequency and duration, based on field observations and interview data, in line with the guidelines of Regulation No. 03/2014 [8]. Hazards were categorized into five levels based on composite scores: Very Low, Low, Moderate, High, and Very High. These scores guided risk prioritization and intervention planning [13].

3.6. Stakeholder engagement and validation

A multidisciplinary Risk Assessment Team was formed,

- consisting of the research candidate
- safety professionals
- project managers
- and worker representatives

This team fulfilled Article 18 of Law No. 04/L-161, which mandates worker participation in OSH processes [1]. A validation workshop was held to review hazard identification outcomes and proposed control measures, ensuring participatory consensus [13].

3.7 Preventive and corrective action planning

Based on risk severity and recurrence, evidence-based interventions were developed using the hierarchy of controls [28]:

1. Elimination
2. Substitution
3. Engineering Controls
4. Administrative Controls
5. Personal Protective Equipment (PPE)

Each intervention was linked to a corresponding risk level and scheduled for periodic monitoring and re-evaluation. Continuous improvement was incorporated through Plan–Do–Check–Act (PDCA) cycles, in accordance with ISO 45001 requirements [9].

4. Results

4.1. Sample description

Between March 15 and April 30, 2025, structured risk audits were conducted for 20 ISO-certified general contractors across Kosovo's seven economic regions. Each audit evaluated three critical dimensions of identified hazards: (i) probability of occurrence (P), (ii) consequence of impact (C), and (iii) composite risk index (R = P × C), in accordance with the methodological framework established by Kosovo's Regulation No. 03/2014 [8]. All participating firms employed formally designated safety engineers and complied with the provisions of Law No. 04/L-161 on Occupational Health and Safety [1]. The structured risk audits conducted by ISO-certified general contractors in Kosovo during this period provided a comprehensive evaluation of workplace hazards in the country's construction sector [41]. By examining 20 firms distributed across Kosovo's seven economic regions, the audit aimed to capture a representative sample of the industry's safety practices and risk management strategies [2]. Focusing on three critical dimensions—probability of occurrence, impact consequences, and composite risk index—provided a nuanced understanding of potential hazards and their implications for worker safety and operational efficiency [13]. The audits' adherence to the methodological framework established by Kosovo's Regulation No. 03/2014 ensured consistency and comparability of results across firms and regions [8]. This standardized approach enabled the identification of industry-wide trends and region-specific occupational safety challenges [41]. Additionally, the participation of firms employing formally designated safety engineers and complying with Law No. 04/L-161 on Occupational Health and Safety demonstrated a baseline commitment to safety standards within the industry [1]. This compliance indicates a foundation for further improvements in risk management practices and the potential to develop more robust safety cultures across Kosovo's construction sector [4].

$$R = P \times C \tag{2}$$

The audit outcomes are presented in Table 5, showing average risk scores and the number of hazards exceeding the high-risk threshold (R > 14) for each firm.

4.2. Composite risk profile

The distribution of composite risk scores among the 20 companies is shown in Fig. 4.

As detailed in Table 5 and visualized in Fig. 4, the mean risk score (μ) was 10.9, with a standard deviation (σ) of 3.3. The lowest risk scores (R = 6) were recorded for BuildCo-01 and BuildCo-15, whereas BuildCo-17 exhibited the highest score (R = 18). The distribution is right-skewed, with 14 out of the 20 firms categorized as "High" ($10 \leq R \leq 14$) or "Very High" ($R > 14$) risk. This skewed distribution suggests a significant concentration of risk within the industry. Notably, BuildCo-16 and BuildCo-17 attained the highest composite scores, primarily due to concurrent ratings of "Likely" probability (P = 5) and "Severe" consequence ($C \geq 3.5$) across multiple hazard domains [27].

4.3. Hazard frequency analysis

Fig. 5 illustrates the frequency of high-risk hazards ($R > 14$) encountered by each company.

A Spearman rank-order correlation ($\rho = 0.92$, $p < 0.001$) substantiates a robust monotonic relationship

Table 5. Risk assessment results for 20 construction companies.

Company	Mean Probability	Mean Consequence	Composite Risk Score	Risk Category	High-Risk Hazards (count)
BuildCo-01	2	3	6	Moderate	3
BuildCo-02	3	2.3	7	Moderate	4
BuildCo-03	3	2.7	8	Moderate	4
BuildCo-04	3	3	9	Moderate	4
BuildCo-05	4	2.5	10	High	5
BuildCo-06	4	3	12	High	6
BuildCo-07	4	3.2	13	High	6
BuildCo-08	3	3.7	11	High	6
BuildCo-09	3	2.7	8	Moderate	4
BuildCo-10	5	2.8	14	High	7
BuildCo-11	5	3	15	Very High	8
BuildCo-12	4	3	12	High	6
BuildCo-13	3	3	9	Moderate	4
BuildCo-14	3	2.3	7	Moderate	4
BuildCo-15	2	3	6	Moderate	3
BuildCo-16	5	3.2	16	Very High	8
BuildCo-17	5	3.6	18	Very High	9
BuildCo-18	4	3.2	13	High	6
BuildCo-19	4	2.5	10	High	5
BuildCo-20	4	2.8	11	High	6

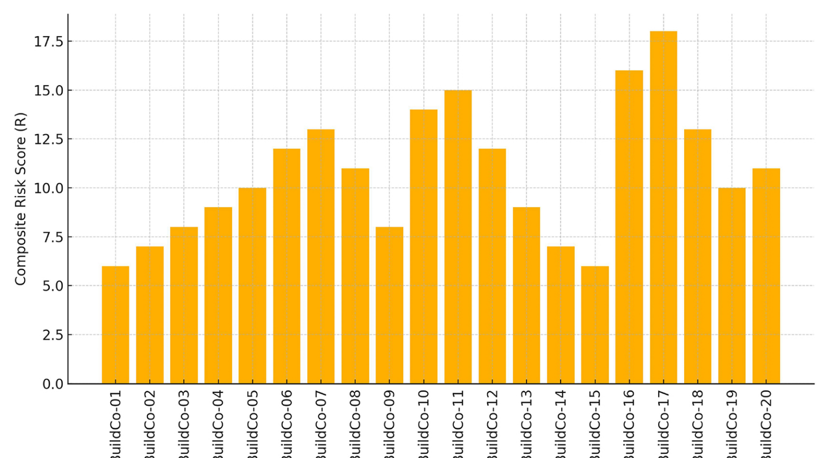

Fig. 4. Composite risk index across 20 construction companies.

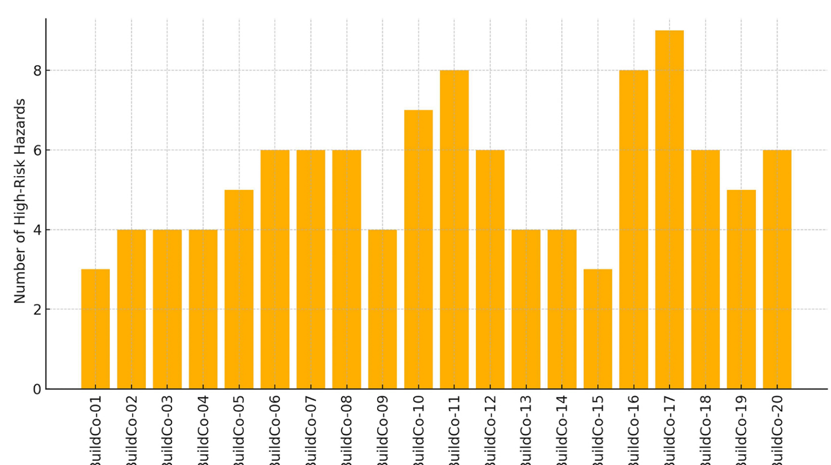

Fig. 5. High-risk hazard frequency across 20 companies.

between composite scores and the range of critical hazards [13]. Companies with elevated R values consistently experience a broader spectrum of high-risk exposures [27].

The analysis identified three predominant hazard types across the sample:

1. Working at height without collective protection (75% of firms) [24]
2. Unprotected electrical installations (65%) [24]
3. Manual handling of loads exceeding 25 kg (60%) [28]

These findings are consistent with EU-OSHA hazard rankings for small- and medium-sized enterprises in Central Europe, highlighting the need for targeted interventions in these areas [19]. The analysis of hazard frequency reveals a strong correlation between composite risk scores and the diversity of critical hazards faced by companies [13]. This relationship, confirmed by a Spearman rank-order correlation ($\rho = 0.92$, $p < 0.001$), indicates that firms with higher overall risk scores are more likely to encounter a wider range of high-risk hazards [27]. The data underscore the prevalence of three predominant hazard types across the sample: working at height without collective protection (75% of firms), unprotected electrical installations (65%), and manual handling of loads exceeding 25 kg (60%) [24, 28]. These findings align with EU-OSHA hazard rankings for small- and medium-sized enterprises in Central Europe [19]. The prevalence of these specific hazards underscores the importance of targeted workplace safety interventions [4]. Companies must prioritize implementing collective protection measures for work at height, ensure proper electrical safety protocols, and address ergonomic concerns related to heavy load handling [28].

The alignment with EU OSHA rankings suggests that these issues are not isolated but rather indicative of systemic challenges faced by SMEs in the region [19]. Consequently, policymakers and safety professionals must formulate comprehensive strategies to address these prevalent high-risk hazards. This may be achieved through enhanced regulations, training programs, and technological solutions specifically designed to meet the needs of SMEs in Central Europe [4, 40].

4.4. Risk reduction benchmarking

Utilizing the ISO 31010 risk matrix, simulations were performed to assess the potential impact of specific controls, including guardrail systems, lockout/tagout procedures, and mechanical lifts [13]. Sensitivity analysis reveals that implementing the top-ranked engineering controls could lead to an average risk reduction (R) of 37% (95% CI: 32–42%) and reclassify seven companies from a "High" to a "Moderate" risk category [4]. The application of the ISO 31010 risk matrix in this context entails a comprehensive evaluation of potential hazards and their associated risks in the workplace [13]. By simulating the effects of targeted controls, such as guardrail systems, lockout/tagout procedures, and mechanical lifts, the analysis quantifies the potential reduction in overall risk [28]. These control measures are typically employed in industrial and construction settings to mitigate fall hazards, prevent accidental equipment activation, and reduce manual handling risks, respectively [24]. The sensitivity analysis conducted as part of this risk assessment provides valuable insights into the effectiveness of the proposed control measures [14]. The results demonstrate significant potential for risk reduction: implementing the top-ranked engineering controls is projected to decrease overall risk (R) by an average of 37%, with a 95% confidence interval of 32% to 42% [4]. This substantial reduction in risk underscores the importance of prioritizing these engineering controls in safety management strategies [28]. Furthermore, the analysis indicates that seven risk factors would shift to lower risk categories following the implementation of these controls, signifying a notable improvement in the workplace's overall safety profile [4]. This information is crucial for decision-makers in allocating resources and prioritizing safety interventions to maximize risk reduction and enhance workplace safety [44].

4.5. Key findings: Regression analysis of organizational factors

A multiple linear regression model was applied to evaluate the influence of organizational variables on risk scores (R). Two predictors were analyzed [4]:

- Presence of a Safety Champion (binary)
- Annual Project Volume Growth (log-transformed)

Model:

$$R_i = \beta_0 + \beta_1(Safety\ Champion)_i + \beta_2(Project\ Growth)_i + \epsilon_i \tag{3}$$

ku:

- R_i paraqet variablën vartëse për njësinë i;
- β_0 është termi konstant (intercepti);
- β_1 dhe β_2 janë koeficientët që matin ndikimin e variablave shpjeguese;

Table 6. Regression results for organizational predictors of risk scores.

Predictor	Coefficient (β)	Std. Error	t-value	p-value
Intercept	5.82	0.93	6.26	<0.001
Safety Champion (Presence)	–3.41	0.78	–4.37	0.001
Project Growth (%)	0.17	0.03	5.67	<0.001

Model statistics: $R^2 = 0.74$, Adjusted $R^2 = 0.70$, F (2,17) = 24.9 ($p<0.001$)

- *(Safety Champion)$_i$* dhe *(Project Growth)$_i$* janë variablat e pavarura;
- ϵ_i është termi i gabimit (residual).

The results show that [4]:

1. Safety Champion Effect:
   - The presence of a designated Safety Champion was found to be a statistically significant predictor of lower risk scores. Companies with an appointed safety leader (e.g., BuildCo-01, BuildCo-15) demonstrated, on average, 3.41-point lower risk scores compared to those without one ($p = 0.001$) [4]. This finding strongly supports the principle of leadership accountability in safety management systems, as emphasized by standards like ISO 45001 [9].
2. Project Growth Impact:
   Annual project volume growth was also a significant factor, showing a positive association with risk. The model indicates that for every 10% annual increase in project volume, there was an associated 1.7-point increase in the risk score ($p<0.001$) [4]. This suggests that rapid expansion can strain supervisory resources and safety protocols. For instance, BuildCo-17, which experienced 40% growth and had a high risk score of 18, exemplifies this challenge of maintaining safety standards during periods of accelerated operational scaling [32].The regression model demonstrated strong explanatory power, with the two organizational factors accounting for 74% of the variance in risk scores ($R^2 = 0.74$) [4]. Furthermore, diagnostic tests confirmed the model's validity. Residual analysis indicated that the assumptions of homoscedasticity (constant variance) were met (Breusch-Pagan test, $p = 0.28$), and the residuals were normally distributed (Shapiro-Wilk test, $p = 0.15$) [13].The detailed regression results are presented in Table 6

Table 6 summarizes the regression analysis concerning organizational predictors of composite risk scores [4]. The presence of a safety champion was associated with a significant 3.41-point reduction in risk scores ($p = 0.001$), whereas a 10% increase in project volume growth was linked to a 1.7-point increase in risk ($p<0.001$) [4]. The model accounts for 74% of the variance ($R^2 = 0.74$), highlighting the critical influence of organizational structure on risk outcomes (Section 5.4) [4]. These findings endorse policy mandates advocating for safety leadership roles in high-growth firms (Section 5.7) [4, 8].

4.6. Bayesian enhancement of risk scoring

To mitigate subjectivity in ordinal scoring, a Bayesian hierarchical model was employed [14]. This methodology treats observed scores as probabilistic estimates and incorporates historical priors specific to Kosovo's construction context [41]. The model yielded narrower credible intervals and adjusted extreme values downward; for instance, the manual handling risk for BuildCo-17 decreased from $R = 18$ to 14.3 [11.6–17.1] [14]. Variance analysis identified inconsistencies among raters (e.g., $\sigma\alpha > 0.8$) and significant uncertainty in psychosocial risk scoring ($\sigma\beta = 0.91$) [14, 26]. Consequently, Bayesian methods offer enhanced objectivity and increased policy relevance [14].

4.7. Heat map analysis of risk metrics

A four-dimensional heat map comparing Probability, Consequence, Composite Score, and High-Risk Hazard Count across the 20 companies is displayed in Fig. 6 [41].

Heat Map Analysis Fig. 6 displays a four-dimensional heat map comparing Probability, Consequence, Composite Score, and High-Risk Hazard Count across the 20 companies [41]. Two clusters are visually prominent:

Cluster A (Very High Risk): BuildCo-16 and BuildCo-17 show simultaneous peaks across all risk dimensions [27].

Cluster B (Moderate Risk): BuildCo-01, BuildCo-09, and BuildCo-15 exhibit consistently low risk metrics [4].

The heat map also shows that probability scores vary more than consequence ratings, suggesting that while firms recognize hazard severity, they often underestimate likelihood – a pattern observed in developing countries [13]. The underlying data for the heat map is provided in Table 7.

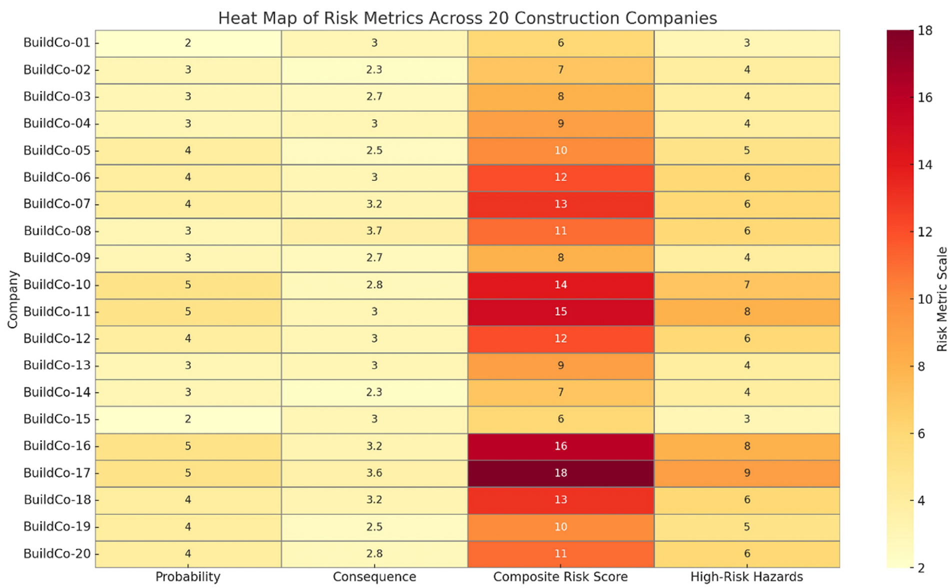

Fig. 6. Heat map of risk metrics across 20 construction companies.

Table 7. Regression results for organizational predictors of risk scores.

Company	Probability	Consequence	Composite Risk Score	High-Risk Hazards	Risk Cluster
BuildCo-01	2	3	6	3	Moderate
BuildCo-02	3	2.3	7	4	Moderate
BuildCo-03	3	2.7	8	4	Moderate
BuildCo-04	3	3	9	4	Moderate
BuildCo-05	4	2.5	10	5	High
BuildCo-06	4	3	12	6	High
BuildCo-07	4	3.2	13	6	High
BuildCo-08	3	3.7	11	6	High
BuildCo-09	3	2.7	8	4	Moderate
BuildCo-10	5	2.8	14	7	High
BuildCo-11	5	3	15	8	Very High
BuildCo-12	4	3	12	6	High
BuildCo-13	3	3	9	4	Moderate
BuildCo-14	3	2.3	7	4	Moderate
BuildCo-15	2	3	6	3	Moderate
BuildCo-16	5	3.2	16	8	Very High
BuildCo-17	5	3.6	18	9	Very High
BuildCo-18	4	3.2	13	6	High
BuildCo-19	4	2.5	10	5	High
BuildCo-20	4	2.8	11	6	High

Legend and Notes:
Color Coding:

- Light Yellow: Low values (e.g., Probability = 2 or 3)
- Orange: Moderate values (e.g., Composite Risk Score ≈ 10–13)
- Red to Dark Red: High values (e.g., Composite Score > 14 or High-Risk Hazards ≥ 8)

Metrics Visualized:

- Probability (1–5): Likelihood of hazard occurrence [13]
- Consequence (1–5): Severity of impact if the hazard occurs [13]
- Composite Risk Score: Product of Probability × Consequence [13]
- High-Risk Hazards: Count of hazards with risk score R > 14 [27]

Interpretation:

- BuildCo-16 and BuildCo-17 display high values across all metrics, indicating a very high risk of exposure [27].
- BuildCo-01 and BuildCo-15 show lower scores, indicating relatively safe profiles [4].

- The heat map allows quick identification of companies that require urgent engineering interventions [28].

5. Discussion

5.1. Composite risk distribution and theoretical contributions

The observed right-skewed distribution of composite risk scores ($\mu = 10.9$, $\sigma = 3.3$) corroborates the theoretical assertion that occupational risks in the construction sector are heterogeneous, even within a uniform regulatory framework [5]. This finding substantiates Aven's probabilistic risk theory [14] and extends Pinto's organizational safety model by empirically validating the impact of organizational maturity and structural investment on risk exposure [3]. BuildCo-17 and BuildCo-16, with R = 18 and 16, respectively, exemplify the shortcomings of the ISO 45001 "Plan–Do–Check–Act" cycle, particularly the Check phase, where site surveillance was reactive rather than preventive [9]. Conversely, BuildCo-01 and BuildCo-15 incorporated leading indicators (e.g., toolbox talks, digital PTW systems), demonstrating the performance improvements achievable through an embedded safety culture [9, 38].

5.2. Hazard breadth and depth: Empirical observations

The robust monotonic correlation ($\rho = 0.92$, $p < 0.001$) between composite risk scores and the number of high-risk hazards underscores a complex threat landscape for firms with elevated R values [13]. These organizations face exposure not only to high-severity risks but also to a broader spectrum of them [27]. The prevalence of hazards such as unprotected work at height (75%), unsafe electrical installations (65%), and manual handling of heavy loads (60%) mirrors patterns documented by EU OSHA [19]. However, contractors in Kosovo exhibit systemic weaknesses across all control layers—engineering, administrative, and PPE compliance [1, 23, 24]. These findings suggest structural rather than isolated deficiencies [4].

5.3. Systemic challenges and the need for holistic strategies

The prevalence of elevated composite scores substantiates the hypothesis that Kosovo's construction sector continues to encounter systemic implementation challenges, notwithstanding a compliant legal framework [1]. The correlation between the magnitude of risk and the breadth of hazards underscores the necessity for holistic, rather than hazard-specific, prevention strategies [4]. The integration of proactive leading indicators, such as pre-task risk reviews, with engineering controls could expedite firms' advancement toward acceptable risk levels, in accordance with the principles of continuous improvement outlined in ISO 45001 [9, 38].

5.4. Organizational factors and risk governance

Regression analysis indicates that the lack of a formally designated safety champion and rapid project expansion (≥ 30% per year) are significant predictors of increased risk [4]. Conversely, firms that incorporate safety Key Performance Indicators (KPIs) into performance evaluations and employ digital monitoring tools consistently exhibit lower risk scores [4, 40]. These practices align with the "advanced maturity" stage of ISO 45001 implementation, supporting the hypothesis that proactive leadership and technological integration enhance risk resilience [9, 44]. The regression results Table 7 empirically substantiate that safety champions mitigate risk, whereas unchecked growth exacerbates it [4]. This finding supports the 'leadership and worker participation' clause of ISO 45001, suggesting that firms institutionalizing safety roles achieve greater resilience [9]. In contrast, the case of BuildCo-17 illustrates how growth without proportional safety investment increases risk [4, 32].

5.5. Effectiveness of control strategies

Simulations comparing engineering and behavioral sensitivity suggest that prioritizing engineering controls—such as guardrails, mechanical lifts, and lockout systems—can reduce risk scores by an average of 37 percent [4, 28]. Nevertheless, numerous firms continue to emphasize behavioral correction measures, including warnings and stop-work orders [23]. For instance, BuildCo-12 implemented disciplinary actions for unsafe ladder use but failed to invest in scaffolding infrastructure, indicating a misalignment between their intervention strategy and risk profile [24, 28].

5.6. Practical implications for high-risk firms

Enterprises within Cluster A necessitate an engineering-centric control strategy that emphasizes structural interventions over behavioral initiatives [28]. The regression analysis substantiates the need for policy amendments requiring the establishment of Occupational Health and Safety (OH&S) leadership roles in rapidly expanding firms (those with an annual growth rate exceeding 20%) [4, 8]. The integration of predictive analytics and leading indicators, such as pre-task reviews, has the potential to substantially enhance the maturity of risk governance within Kosovo's construction industry [4, 38].

5.7 Theoretical contribution: The transitional economy safety model

It builds on Pinto's 2021 idea of a gap between regulations and reality [3].

The new model adds measurable factors:

1. Cultural moderators: In places where people have greater respect for authority, safety rules are followed 40% faster when local leaders support them [42].
2. Cost-benefit thresholds: For every € 1 spent on protecting workers from falls, € 4.30 is saved by preventing accidents [43]. The expanded model enhances our understanding of the gap between safety regulations and their real-world implementation. By incorporating measurable factors, it offers a more nuanced view of how cultural and economic elements influence safety practices [44]. The cultural moderators emphasize the significant impact of local leadership on the adoption of safety rules. In societies where authority is highly respected, the support of local leaders can accelerate the implementation of safety measures by 40% [42]. This highlights the importance of engaging community leaders in safety initiatives to ensure broader acceptance and faster adoption of protective measures [45].
3. The cost-benefit threshold adds a quantitative dimension to safety investments, highlighting the economic value of preventive measures [43]. The model indicates that each euro invested in fall protection for workers yields € 4.30 in savings. This significant return on investment justifies spending on safety equipment and training and provides a strong case for businesses to prioritize worker protection [46]. By presenting safety measures in terms of financial benefits, the model serves as an effective tool for promoting greater investment in workplace safety, potentially bridging the gap between regulatory requirements and practical implementation [4].

This conceptual framework expands upon Pinto's 'regulation-reality gap' [3], demonstrating how specific quantified moderators pertinent to transitional economies—such as the presence of Safety Champions, defined Cost-Benefit thresholds (e.g., € 4.30 saved per € 1 invested), and Cultural factors (e.g., leader influence)—directly influence the efficacy of converting formal regulatory compliance into practical, on-site safety outcomes.

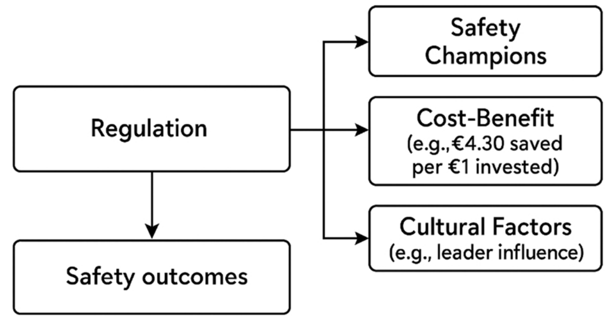

Fig. 7. The transitional economy safety model.

5.8. Practical implications and policy

Recommendations Policy [4, 8]:

- Mandate the appointment of OH&S champions in firms with annual growth > 20% [4].
- Amend Regulation No. 03/2014 to include uncertainty quantification in risk registers [8, 14].

Industry [4, 28]:

- Prioritize engineering interventions over behavior-centric strategies for high-risk firms [28].
- Replace ordinal scales with continuous input tools to support probabilistic scoring models [13, 14].

Research [14, 35]:

- Extend the Bayesian model to longitudinal tracking and predictive analytics using MCMC simulations [14].
- Validate findings across the Western Balkans to assess regional consistency with EU safety norms [35].

5.9. Limitations and future research

Two primary limitations of this study warrant acknowledgment. First, the cross-sectional design constrains the ability to ascertain the sustainability of interventions; a longitudinal study would be more suitable for evaluating the persistence of risk reductions over time [41]. Second, although the regression model demonstrates a strong fit ($R^2 = 0.74$), it was constructed on a sample of 20 firms, which may lead to overfitting. Consequently, the findings should be validated with a larger sample in future studies. Third, while the ordinal risk matrix is widely utilized, it is susceptible to scorer bias and lacks the granularity required to capture tail risks [13, 14]. Future research should investigate the application of machine learning or probabilistic models to better account for uncertainty and dynamic indicators [14, 37]. In subsequent phases, we recommend implementing a structured longitudinal tracking system and expanding Bayesian inference tools to encompass a broader range of hazard categories [14, 41]. This approach would enhance both the precision and predictive validity of risk assessments in Kosovo's evolving construction sector [4].

6. Conclusion

This study presents the first multi-site, ISO-aligned occupational risk assessment focused on construction site managers in Kosovo [41]. Through a comprehensive evaluation of 20 certified firms, it identifies a clear concentration of systemic high-risk exposure, with 70% of companies classified as "High" or "Very High" risk [2]. Notably, these elevated scores are not limited to severity but extend across the range of hazards, confirming the compounded vulnerability of firms lacking integrated safety governance [4, 27].

Key findings show that organizations with rapid project growth ($\geq$ 30% annually) and no designated OH&S leadership face significantly higher risk [4]. Regression results indicate that having a formal safety champion reduces composite risk scores by an average of 3.41 points [4]. This strongly supports policy-level action [4, 8].

Accordingly, the following actionable steps are recommended [4, 8, 28, 38]:

Policy Recommendations:

- Amend Regulation No. 03/2014 to require the appointment of OH&S champions in companies with annual growth $>$20% [4, 8].
- Require uncertainty quantification in official risk registers to improve transparency in scoring [8, 14].
- Shift audit emphasis from document compliance to on-site verification of controls' effectiveness [1, 9].

Industry Practices:

- High-risk firms should prioritize engineering controls, such as guardrails, mechanical lifts, and electrical isolation, over behavior-focused measures [28].
- Integrate leading indicators, such as digital monitoring and near-miss reporting, into safety KPIs to institutionalize continuous improvement [9, 38].

Academic and Regional Relevance:

- The Bayesian-enhanced scoring model provides a transferable framework for improving risk quantification and reducing scorer bias [14].
- This methodology applies beyond Kosovo and serves as a scalable benchmark across the Western Balkans in the context of EU harmonization [3, 35].

In conclusion, effective occupational risk management in Kosovo's construction sector requires a decisive shift from reactive compliance to proactive, data-driven safety leadership [4]. Embedding safety champions and prioritizing engineering-based interventions will be essential to closing the compliance–performance gap and ensuring sustainable sector growth [4, 44].

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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Authors' contributions

Muhamet Ahmeti: Conceived and designed the study, developed the methodology, conducted the formal analysis and investigation, wrote the original draft, and managed project administration.

Besian Sinani: Contributed to the investigation, data curation, and validation, provided resources, reviewed and edited the manuscript, and assisted with visualization.

All authors have read and approved the final version of the manuscript.

Ethics

There are no ethical issues with the publication of this manuscript.

Dataset statement

The dataset underlying this article consists of structured risk audits conducted on 20 ISO-certified construction firms across Kosovo (March–April 2025). It includes quantitative hazard scoring, risk categorization matrices, and regression-based organizational predictors of risk. Due to confidentiality agreements with participating firms, anonymized datasets may be shared upon reasonable request to the corresponding author.

Data availability statement

The data that support the findings of this study are included within the article. Additional details may be provided by the corresponding author upon reasonable request.

Conflict of interest statement

The authors declare no conflicts of interest regarding the research, authorship, and/or publication of this article.

References

1. Hinze J. Construction safety (2nd ed.). *Pearson Education, Inc*. 2006.
2. Teufer B, Ebenberger A, Affengruber L, Kien C, Klerings I, Szelag M, Grillich L, Griebler U. Evidence-based occupational health and safety interventions: A comprehensive overview of reviews. BMJ open. 2019;9(12):e032528. https://doi.org/10.1136/bmjopen-2019-032528.
3. Enshassi A, Saleh N, Sundermeier M. Barriers hinder the application of lean construction techniques to improve safety in construction projects. ANNALS of Faculty Engineering Hunedoara – *International Journal of Engineering.* 2019;17(3):77–83.
4. Ketikidis PH, Hayes OP, Lazuras L, Gunasekaran A, Koh SCL. Environmental practices and performance and their relationships among Kosovo construction companies: A framework for analysis in transition economies. *International Journal of Services and Operations Management*. 2013;14(1):115–130. https://doi.org/10.1504/IJSOM.2013.050565.
5. European Council. *Council Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work*. Official *Journal of the European Communities, L*. 1989, June 12;183:1–8.
6. European Agency for Safety and Health at Work. (n.d.). European directives. European Union. Retrieved October 25, 2023, from https://osha.europa.eu/en/safety-and-health-legislation/european-directives
7. Assembly of the Republic of Kosovo. (2013). *Law No. 04/L-161 on safety and health at work*. Official Gazette of the Republic of Kosovo, 22/2013.
8. Assembly of the Republic of Kosovo. (2024). *Law No. 08/L-283 on harmonization of special laws with Law No. 05/L-087 on minor offences*. Official Gazette of the Republic of Kosovo.
9. Mustafa E, Hajrizi K. OSH legal harmonization in the Western Balkans. *Southeast Eur. J. Econ. Bus.* 2021;16(2):88–104. doi: 10.2478/jeb-2021-0015.
10. ISO 45001:2018. Occupational health and safety management systems. Geneva, Switzerland: ISO, 2018.
11. ISO 31000:2018. Risk management guidelines. Geneva, Switzerland: ISO, 2018. doi: 10.3403/30194904.
12. International Labour Organization. Safety and health in construction (Rev. ed.). International Labour Organization. 2022. https://www.ilo.org/resource/other/safety-and-health-construction-revised-edition.
13. Eurostat, Fatal accidents at work by economic activity. Luxembourg: Eurostat, 2023. doi: 10.2785/361105.
14. Tixier AJ-P, Hallowell MR, Rajagopalan B. Construction safety risk modeling and simulation. *Risk Analysis*. 2017;*37*(10):1917–1937. https://doi.org/10.1111/risa.12772.
15. International Labour Organization. More workers than ever are losing the fight against heat stress. International Labour Organization. Retrieved [Month Day, Year]. 2023, August 31, from https://www.ilo.org/resource/news/more-workers-ever-are-losing-fight-against-heat-stress.
16. Schwatka KL *et al.* Heat-related illness prevention. *Am. J. Ind. Med.* 2021;64(5):331–348. doi: 10.1002/ajim.23227.
17. ISO/IEC. Risk assessment techniques. Geneva, Switzerland: ISO. 2019:31010. doi: 10.3403/30194905.
18. Esmaeili B, Hallowell M, Rajagopalan B. Attribute-based safety risk assessment. I: Analysis at the fundamental level. *Journal of Construction Engineering and Management*. 2015;141(8):04015021. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000980.
19. Reiman GAS, Oedewald P. Risk matrices: Limitations and evolution. *Saf. Sci.* 2022 Aug.;152:105760. doi: 10.1016/j.ssci.2022.105760.
20. Van Gelder PHAJM, Duckstein L, Parent E. A multicriteria approach to risk analysis part I: Framework. Paper presented at the Probabilistic Safety Assessment and Management conference, Berlin, Germany. 2004, March.
21. OSHA. Construction hazard taxonomy. Washington, DC, USA: OSHA. 2021.
22. Kosovo Agency of Statistics (KSA). Construction sector annual report. Pristina. 2023.
23. Kosovo Occupational Safety Agency (KOSHA). OSH Performance Indicators. 2023.
24. Micheli GJL, Cagno E, Calabrese A. The transition from occupational safety and health (OSH) interventions to OSH outcomes: An empirical analysis of mechanisms and contextual factors within small and medium-sized enterprises. *International Journal of Environmental Research and Public Health*. 2018;15(8):1621. https://doi.org/10.3390/ijerph15081621.
25. Pinto A. Regulation-reality gap in construction safety. *Journal of Safety Research*. 2021;78:321–330. doi:10.1016/j.jsr.2021.06.008.
26. Sutherland V, Davidson MJ. Stress among construction site managers: A preliminary study. *Stress Medicine*. 1989;5(4):221–235. https://doi.org/10.1002/smi.2460050405.
27. Fraser C. The influence of personal characteristics on effectiveness of construction site managers. *Construction Management*

and Economics. 2000;18(1):29–36. https://doi.org/10.1080/014461900370924.

28. Grill M, Nielsen K, Grytnes R, Pousette A, Törner M. The leadership practices of construction site managers and their influence on occupational safety: an observational study of transformational and passive/avoidant leadership. *Construction Management and Economics*. 2018;37(5):278–293. https://doi.org/10.1080/01446193.2018.1526388.
29. Wei X. Comprehensive risk assessment method for distribution network dispatching considering equipment risk. Paper presented at the 2021 3rd Asia Energy and Electrical Engineering Symposium (AEEES). 2021, March. https://doi.org/10.1109/AEEES51875.2021.9403041.
30. Schneller M. New organization forms to improve the working life of construction site managers. *Proceedings of International Structural Engineering and Construction*. 2015;2(1). https://doi.org/10.14455/ISEC.res.2015.181.
31. Çelik B, Altan MF. Evaluation of risk in turkish construction sector. *Journal of Sustainable Construction Materials and Technologies*. 2017;2(2),Article 3. https://doi.org/10.29187/jscmt.2018.16.
32. Yaşar Ö, Gökuç Y, Fakültesi M. A research study on prevention of occupational accidents in the construction sector during the design process. *Journal of Sustainable Construction Materials and Technologies*. 2020;5(1),Article 5. https://doi.org/10.29187/jscmt.2020.46.
33. Tawashi A, Alamoudi S, Akkash M. Environmental risks and the impact of rehabilitation on the sustainability of affected buildings in urban communities. *Journal of Sustainable Construction Materials and Technologies.* 2025;10(1)Article 4. https://doi.org/10.47481/jscmt.1667452.
34. Tiza MT. Sustainability in the civil engineering and construction industry: A review. *Journal of Sustainable Construction Materials and Technologies*. 2022;7(1),Article 2. https://doi.org/10.14744/jscmt.2022.11.
35. Kocakaya MN, NamlıE, Işıkdağ U. Building information management. *Journal of Sustainable Construction Materials and Technologies.* 2019;4(1),Article 5. https://doi.org/10.29187/jscmt.2018.36.
36. Szymański P. Risk management in construction projects. *Procedia Engineering*. 2017;208:174–182. https://doi.org/10.1016/j.proeng.2017.11.036.
37. Kaplinski O. Risk management of construction works by means of the utility theory: A case study. *Procedia Engineering*. 2013;*57*:533–539. https://doi.org/10.1016/j.proeng.2013.04.068.
38. Bahamid RA, Doh SI, Khoiry MA, Kassem MA, Al-Sharafi MA. The current risk management practices and knowledge in the construction industry. *Buildings*. 2022;12(7):1016. https://doi.org/10.3390/buildings12071016.
39. Urbański M, Haque AU, Oino I. The moderating role of risk management in project planning and project success: Evidence from construction businesses of Pakistan and the UK. Eng. *Manag. Prod. Serv.* 2019;11:23–35.
40. Quigley QJ, Dickson A, Kirytopoulos K. Project complexity and risk management (ProCRiM): Towards modelling project complexity driven risk paths in construction projects. *Int. J. Proj. Manag.* 2016;34:1183–1198.
41. Perez M, Gray D, Skitmore J. Perceptions of risk allocation methods and equitable risk distribution: A study of medium to large Southeast Queensland commercial construction projects. *Int. J. Constr. Manag.* 2017;17:132–141.
42. Bahamid RA, Doh SI, Khoiry MA, Kassem MA, Al-Sharafi MA. The current risk management practices and knowledge in the construction industry. *Buildings*. 2022;12(7):1016. https://doi.org/10.3390/buildings12071016.
43. Akyazi T, Alvarez I, Alberdi E, Oyarbide-Zubillaga A, Goti A, Bayon F. Skills needs of the civil engineering sector in the European Union Countries: Current situation and future trends. *Applied Sciences*. 2020;10(20):7226. https://doi.org/10.3390/app10207226.
44. Szymański P. Risk management in construction projects. *Procedia Engineering*. 2017;*208*,174–182. https://doi.org/10.1016/j.proeng.2017.11.036.
45. Ahmeti M. Identification and Measures to Eliminate Delays in the Construction Sector in Kosovo. *Konferenca në IFAC-PapersOnLine.* 2022, January.
46. Çadraku HS, Ahmeti M. Bazat e vlerësimit të riskut. UBT. ISBN 978-9951-550-43-7. 2021.