Risk perception in the Costa Rican construction industry: The role of co-workers' behavior and regional differences

Percepción de riesgo en la industria de la construcción costarricense: el papel del comportamiento de los compañeros de trabajo y las diferencias regionales

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Abstract: Accident prevention in the construction industry depends not only on managing objective hazards but also on how workers perceive risks. In this sense, the influence of peers' behavior and regional context remain less understood. This study investigates how coworkers' safety practices and territorial differences shape risk perceptions among Costa Rican construction workers. We collected survey data in 2024 from 194 employees across 23 sites in two Costa Rican provinces, Cartago (Central Valley) and Limón (Caribbean coast). A confirmatory factor analysis validated a second-order construct of perceived risk encompassing falls, struck-by hazards, and machinery-related risks, and OLS regressions were estimated to test the influence of social and contextual factors on perceived risk. The results indicate that coworkers' safety behavior significantly influences individual risk awareness, consistent with social learning theories that highlight peer norms as powerful cues. In addition, regional heterogeneity also emerged as a key factor explaining differences in perceived risk: workers in Limón reported systematically lower risk perceptions than those in Cartago, underscoring the role of local safety cultures and enforcement environments. These findings suggest that effective interventions should combine peer-led initiatives with region-sensitive policies, offering new insights for advancing occupational health and safety practice.

Keywords: Risk perception, workplace safety, Construction industry, co-workers' behavior, Costa Rica.

Resumen: La prevención de accidentes en la industria de la construcción depende no solo de la gestión de los peligros objetivos, sino también de cómo los trabajadores perciben los riesgos. Trabajos anteriores han enfatizado la cognición individual, pero la influencia del comportamiento de los compañeros y el contexto regional sigue siendo menos comprendida. Este estudio investiga cómo las prácticas de seguridad de los compañeros de trabajo y las diferencias territoriales dan forma a las percepciones de riesgo entre los trabajadores de la construcción costarricenses. Recopilamos datos de encuestas en 2024 de 194 empleados en 23 sitios en dos provincias costarricenses, Cartago (Valle Central) y Limón (costa Caribe). Un análisis factorial confirmatorio validó un constructo de segundo orden del riesgo percibido que abarca caídas, peligros de golpes y riesgos relacionados con la maquinaria, y se estimaron regresiones de mínimos cuadrados ordinarios para probar la influencia de los factores sociales y contextuales en el riesgo percibido. Los resultados indican que el comportamiento de seguridad de los compañeros de trabajo influye significativamente en la conciencia individual del riesgo, en consonancia con las teorías de aprendizaje social que destacan las normas de los compañeros como señales poderosas. Además, la heterogeneidad regional también surgió como un factor clave que explica las diferencias en el riesgo percibido: los trabajadores de Limón informaron percepciones de riesgo sistemáticamente más bajas que los de Cartago, lo que subraya el papel de las culturas de seguridad locales y los entornos de cumplimiento. Estos hallazgos sugieren que las intervenciones efectivas deben combinar iniciativas dirigidas por pares con políticas sensibles a la región, ofreciendo nuevos conocimientos para avanzar en la práctica de salud y seguridad ocupacional.

Palabras clave: Percepciones de riesgo, seguridad en el trabajo, industria de la construcción, comportamiento de los compañeros, Costa Rica.

1. Introduction

Researchers and practitioners increasingly recognize that preventing workplace accidents depends not only on controlling objective risks but also on understanding how those risks are perceived by people exposed to them. Risk perception—a worker's subjective judgment of both the likelihood of and the severity resulting from a work accident—has been linked to safety-related intentions and behaviors across a wide range of occupations (Gierlach et al., 2010; Caponecchia & Sheils, 2011). The importance of risk perceptions becomes acute in the construction industry, where workers have to identify, interpret, and respond to potentially dangerous situations. Several studies have shown that a low-risk perception is significantly correlated with unsafe behavior, incorrect use of personal protective equipment, and failure to follow established protocols (e.g., Caponecchia & Sheils, 2011; Abbas et al., 2018; Lee et al., 2021).

Besides, the construction industry remains as one of the world's most hazardous industries despite decades of technological and regulatory advances (Lafuente & Abad, 2018; 2021). International statistics made available by the World Health Organization (WHO) consistently rank construction among the top industries for work accidents and fatalities (https://www.who.int/tools/occupational-hazards-in-health-sector/occupational-injuries), and Costa Rican data reveal a similarly troubling pattern (National Institute of Statistics (INEC), 2023). Consequently, scholars have turned to the social factors that shape workers' interpretations of risk, arguing that *how dangerous a task is perceived* can be as decisive as *how dangerous it actually is*.

While individual appraisal is crucial, conceiving workers as a homogeneous group neglects an equally important dimension, namely contextual diversity. Modern construction sites bring together employees who might differ in language, ethnicity, training background, and regional work culture. Migrant labor, subcontracting chains, and varying enforcement regimes give rise to 'microsystems' in which identical risks can be interpreted in markedly different ways by workers. Cross-cultural investigations conducted in Europe, Asia, and the Middle East show that national values, local enforcement standards, and even climate conditions systematically influence perceived work-related vulnerabilities (Martínez-Fiestas et al., 2017; Ricci et al., 2019). Within-country variation is equally relevant. In the specific context analyzed in this study—i.e., Costa Rica—these factors combine in a particularly challenging way in the construction industry, where many workers come from diverse socio-cultural backgrounds, with disparate educational levels and discontinuous career paths. This diversity generates heterogeneity in work risk perceptions and limits the effectiveness of preventive strategies. Furthermore, the pressure to meet contractual deadlines, subcontracting chains on site, and an organizational culture that often prioritizes productivity over safety contribute to normalizing dangerous practices and undermining informed risk-related decision making.

If scholars and policy makers seek to design interventions that resonate across such heterogeneous settings, it is therefore essential to examine not only '*what*' workers perceive but also '*where*' those perceptions take shape. The present study addresses this gap through a cross-regional analysis of 194 Costa Rican construction workers from (Central region) and Limón (Caribbean region) for 2024. A validated instrument captured perceptions relating to falls, struck-by hazards, and machinery entanglements, while additional items were included to measure co-workers' safety conduct, work stress, and key socio-demographic variables. The results of the empirical exercise, based on OLS regression models, highlight the importance of coworkers' behavior in shaping individual risk perceptions: workers who report that their co-workers routinely follow safety practices at work perceive significantly higher levels of risks than those who observe lax behaviors among coworkers. This finding aligns with social-learning frameworks that position construction crews as primary socialization agents for safety and complements evidence that peer norms often outweigh managerial signals in shaping cognitive safety outcomes (Andersen et al., 2015).

In addition, the study provides evidence of marked regional heterogeneity, in terms of risk perceptions. This finding supports the view that regional working climate—defined by enforcement capacity, labor-market composition, and cultural orientation—imprint distinct subjective meanings onto the same objective risks. Such results extend international cross-cultural research by demonstrating that salient contextual discontinuities can exist inside national borders, necessitating

spatially nuanced policy responses (Martínez-Fiestas et al., 2017). This study contributes to the literature in two main ways. On the one hand, it underscores the value of integrating coworkers' behavior into models of risk perception traditionally dominated by individual cognition. On the other hand, the proposed cross-regional analysis of Costa Rican regions suggests that training programs or awareness campaigns targeting 'high-risk demographics' might be less effective than initiatives that mobilize crew-level role models or that adapt communication strategies to local cultural frames. Thus, peer-led interventions and region-specific strategies emerge as promising levers for elevating risk awareness in a sector pivotal to national development yet persistently vulnerable to accidents.

The remainder of the article is organized as follows. Section 2 presents the literature review and synthesizes the empirical determinants of risk perception. Section 3 describes the data, variables, and the econometric strategy. Section 4 presents the regression results, and Section 5 presents the concluding remarks, the implications, and future research avenues.

2. Related literature

2.1 Conceptual foundations and theoretical lenses

Risk perception refers to individuals' subjective judgment regarding the likelihood of and the severity resulting from a work accident (Gierlach et al., 2010). In occupational settings, and particularly in high-risk industries like construction, risk perception plays a critical role in shaping safety-related behaviors and decisions. Risk perceptions are not merely a reflection of risks' objective characteristics but a cognitive process influenced by personal experience, social environment, and cultural context.

Building on the Theory of Planned Behavior (TPB) (Ajzen, 2005), risk perception is conceptualized as a key antecedent of safety intentions and subsequent behavior, influenced by personal attitudes, subjective norms, and perceived behavioral control (Man et al., 2021b). The Protection Motivation Theory (PMT) expands on this framework by distinguishing between threat appraisal—comprising perceived severity and vulnerability—and coping appraisal, which reflects perceived response efficacy and self-efficacy (Taylor & Snyder, 2017; Man et al., 2021a). PMT has proven particularly useful in explaining why some workers choose to engage in protective behaviors while others do not.

From a more socially embedded perspective, the Social Identity Theory suggests that individuals' risk perceptions are shaped by their identification with specific workgroups (Andersen et al., 2015). In this view, social norms and collective practices within the work environment significantly influence how hazards are perceived and acted upon. This perspective is particularly salient in construction, where tasks are often carried out in teams under peer supervision rather than direct managerial oversight.

Finally, the Dual-Pathway Model of Risk Perception integrates affective and cognitive components, positing that emotional responses to risk (e.g., fear, worry) can operate independently of rational probability assessments and might even override them under certain conditions (Gierlach et al., 2010). This framework has been influential in recognizing the role of emotional intelligence and situational awareness in occupational safety contexts.

Taken together, these theoretical approaches highlight that risk perception is not a fixed personal trait but a multidimensional process shaped by individual, social, organizational, and cultural factors. In what follows, based on insights linked to the above-mentioned theoretical lenses, I present an overview of the determinants of workers' risk perceptions.

2.2 Determinants of construction workers' risk perception

A substantial body of empirical research has investigated the main determinants of workers' risk perception (e.g., Caponecchia & Sheils, 2011; Rodríguez-Garzón et al., 2016; Ricci et al., 2019; Xia et al., 2020; Lee et al., 2021). These factors can be grouped into different interrelated domains; however, for the purposes of this research, in this study I focus on the role over risk perception of variables related to personal characteristics, work stress, coworkers' behavior, and cultural or regional-specific factors.

Labor experience and demographic characteristics.—Early studies examined the influence of various individual profile characteristics on risk perception, including age, marital status, and labor experience. While intuitive, the reported findings have been inconsistent. For example, Caponecchia and Sheils (2011) observed that older and more experienced workers tend to perceive less risk than their younger counterparts, an effect attributed to the greater level overconfidence in the former group as a result of their experience. In contrast, younger or less experienced workers often demonstrate heightened sensitivity to work risks and hazards, particularly in their first years in the industry. However, these trends are not uniform across research analyses. Several studies have indicated that individual personality traits, such as cognitive reflection, might moderate the relationship between experience and perceived risk (Ricci et al., 2019). Furthermore, socio-demographic factors such as marital status and educational attainment also show mixed effects. Specifically, evidence suggests that married workers may express greater risk awareness, potentially due to family responsibilities, although these associations tend to dilute once workplace and group-level variables are accounted for (Caponecchia & Sheils, 2011).

Coworkers' behavior.—Social influence—especially from peers—has emerged as a crucial factor shaping individuals' risk perception. Unlike manufacturing environments where supervision is often direct and formal, construction workers primarily operate semi-autonomously, relying heavily on peer coordination and informal norms (Lafuente et al., 2018). Xia et al. (2020) demonstrate that coworkers' attitudes and behaviors regarding safety significantly impact how individual workers assess work risks. For example, when peers regularly wear personal protective equipment (PPE), follow safety procedures, and speak openly about work risks, others are more likely to interpret risks as real and imminent; whereas when risky behaviors go unchallenged they become normalized, leading to a collective underestimation of danger.

This social modeling effect is underpinned by both observational learning and the desire for group acceptance. Workers often calibrate their risk perceptions based on what is seen as 'acceptable' within the group (Andersen et al., 2015). Arguments rooted in the theory of planned behavior support this mechanism, positing that subjective norms—i.e., beliefs about what others expect—directly shape behavioral intentions. In the construction industry, this means that if coworkers signal indifference to safety, others might internalize similar perceptions, regardless of their formal training or personal beliefs (Xia et al., 2020). Leadership also plays a role in shaping peer behavior. Studies have shown that when supervisors foster a positive safety climate—by recognizing safe acts, encouraging reporting, and intervening consistently—peer norms tend to align with safety objectives. However, in environments with weak or inconsistent supervision, peer norms often take precedence, for better or worse (Choi et al., 2019). These dynamics underscore the importance of leveraging coworkers' influence in safety interventions and recognizing the group as a critical unit of risk perception formation.

Work stress.—Occupational stress can distort risk perceptions. Stress is induced by factors such as time pressure, heavy workload, lack of control, and poor organizational support (e.g., Gómez-Bull et al., 2023; Mastrantonio et al., 2024). When demands overwhelm available coping resources, stress levels rise, leading to diminished situational awareness, tunnel vision, and impaired hazard recognition (Zong et al., 2025). Research indicates that high stress levels impair safety behavior and can reduce perceived risk, for example, because workers tend to normalize unsafe conditions to manage emotional load. Additionally, psychosocial safety climate—workers' collective belief that their psychological wellbeing is valued—can buffer these effects, reinforcing accurate risk interpretation even under stress (Zong et al., 2025).

Cultural or territorial differences.—Cultural frameworks and regional differences shape how individuals interpret risk messages and respond to them. Martínez-Fiestas et al. (2017) show that in collectivist cultures, workers might perceive

higher social costs for deviating from group norms, even when their own safety is at stake. In contrast, more individualistic contexts might encourage personal risk assessment but also produce fragmented safety cultures. Within countries, regional variations in enforcement, training availability, and labor-market structures further modulate risk perceptions. Ricci et al. (2019) observed that migrant or ethnic minority workers often exhibit distinct patterns of risk appraisal, reflecting both language barriers and differing prior experiences with regulatory systems. These contextual factors interact with personal and social variables to produce nuanced, often region-specific, configurations of risk perceptions. In Costa Rica, contrasts between regions such as Cartago and Limón offer fertile ground for exploring how differing institutional environments and work cultures shape safety-related attitudes.

In summary, risk perception among construction workers is a complex, multidimensional process influenced by a variety of factors (e.g., individual profile, work stress, coworkers' behavior, and cultural o territorial differences). Understanding these dynamics is essential for developing context-sensitive interventions that address not only individual awareness but also the collective practices that determine how risks are perceived and managed on the ground. The theory and evidence presented in this section provides the foundation for the present empirical investigation, which explores how coworkers' behavior, work stress, and regional setting jointly influence risk perception among Costa Rican construction workers.

3. Data and Method

3.1 Data

The data used in this study were collected through an on-site survey conducted between June and October 2024, as a part of a research project carried out by researchers from the Costa Rica Institute of Technology. The survey instrument was administered directly by the team of researchers at active construction sites, and the data collection process followed a protocol designed to ensure informed access and high response reliability.

Prior to visiting each site, the research team contacted the project manager or person in charge of the construction project to request permission to conduct the survey among workers. Upon obtaining consent, the questionnaire was administered in the field under the full supervision of the research team, ensuring consistency and adherence to ethical standards throughout the data collection process.

The final sample includes information for 194 construction workers drawn from 23 distinct construction sites located in two Costa Rica provinces (regions): 128 respondents from Cartago, a region in the Central Valley, and 66 respondents from Limón, located along the Caribbean coast. Notice that the vast majority of the sampled construction workers are men (97.94%), and they are primarily employed as construction worker (46.34%), electrician (26.83%), welder (7.32%), and carpenter (6.10%). The site distribution reflects the regional construction activity patterns, with 6 construction sites sampled in Cartago and 17 in Limón. Notably, construction sites in Cartago are significantly larger than those in Limón: average number of workers in Cartago's sites is 49.70, compared to 16.77 in Limón (t-test= 8.91, p-value < 0.000). This descriptive result highlights regional disparities in project scale and workforce deployment across regions.

The survey instrument captured data on workers' perceptions of occupational risk across three types of scenarios, as well as relevant individual characteristics and contextual influences, including perceived stress and influence of coworkers' behaviors. The design and administration procedures aimed to minimize measurement error and ensure that the responses reliably reflect the perceptions of workers operating in diverse real-world construction settings.

Following the temporal separation approach (Podsakoff et al., 2012), we used the non-parametric Mann-Whitney U test to evaluate whether the distribution of responses by early (first 10%) and late (last 10%) respondents are drawn from the same

sample, that is, whether the two response vectors share the same distribution. This procedure was applied to the variables for age, labor experience, marital status (dummy variables distinguishing between single, married, unmarried/cohabitating, and divorced), work stress, and coworkers' safety behavior. As shown in Appendix 2, of the eight analyzed variables, a significant difference in response distribution was only found in two cases: age and labor experience. This result only indicates that late respondents are significantly younger than early respondents. Therefore, the comparisons between early and late respondents corroborate that the distribution of the main variables does not raise early-response bias concerns.

3.2 Variables

Dependent variable (risk perceptions).—The dependent variable, risk perceptions, is constructed as a second-order latent variable derived from a covariance-based structural equation modeling (CB-SEM) framework. A confirmatory factor analysis (CFA) was first performed to validate the measurement structure of three distinct but related first-order constructs: perceived risk related to falls, struck-by objects, and misuse of machines and equipment. In line with prior research, these three dimensions represent critical risk categories in the construction industry, and are theorized to load onto a broader, higher-order factor capturing workers' general risk perception (e.g., Caponecchia & Sheils, 2011; Rodríguez-Garzón et al., 2016; Ricci et al., 2019; Xia et al., 2020; Lee et al., 2021).

The CFA model confirms that the three first-order constructs are internally consistent and valid indicators of the overarching risk perception construct. Details of the factor structure and model fit statistics are reported in Table 1. The measurement items for each risk dimension are listed in Appendix 1, which outlines the scenarios used to evaluate workers' perceived risk for each risk type: 'Falls', which includes scenarios such as working on a flat roof without guardrails or harness and working on an unstable ladder; 'Objects', including scenarios involving unstable material stockpiles and working beneath suspended loads; and 'Machines and equipment', which includes scenarios linked to use of electrical equipment with damaged cables and walking within vehicle circulation paths.

The construction of this second-order risk perception variable allows for a comprehensive analysis of how workers integrate different types of risks into a unified subjective assessment.

Table 1: Confirmatory factor analysis (CFA): Factor loadings and reliability assessment

Construct items	Mean (S.D.)	Standardized factor loading (t-value)	Composite reliability	Average variance extracted	Cronbach's alpha
Panel A: Falls (KMO= 0.76 / Bartlett test= 227.83, p-value < 0.001)			0.79	0.49	0.79
FA1	3.90 (1.26)	0.73 (19.55)			
FA2	3.91 (1.06)	0.64 (13.03)			
FA3	3.72 (1.22)	0.78 (20.15)			
FA4	3.56 (1.21)	0.67 (13.71)			
Panel B: Objects (KMO= 0.70 / Bartlett test= 201.74, p-value < 0.001)			0.80	0.60	0.81
OB1	3.91 (1.25)	0.84 (29.55)			
OB2	3.93 (1.20)	0.79 (23.84)			
OB3	3.46 (1.17)	0.66 (14.45)			
Panel C: Machines and equipment (KMO= 0.67 / Bartlett test= 157.65, p-value < 0.001)			0.77	0.53	0.77
ME1	3.90 (1.18)	0.71 (16.13)			
ME2	3.96 (1.17)	0.77 (20.37)			
ME3	3.70 (1.14)	0.69 (15.94)			

Goodness of fit statistics of the CFA model: Chi2 test (d.f.= 32)= 94.19 (p< 0.000), RMSEA 90% confidence interval= 0.077-0.124, RMSEA= 0.10, SRMR= 0.054, and comparative fit index (CFI)= 0.933. All standardized factor loadings are significant at 1% level. The description of the analyzed items is presented in Appendix 1.

An additional inspection of the data presented in Figure 1 suggests large discrepancies, in terms of the analyzed risk perception constructs, between workers developing their activity in urban and rural settings. The results of the Kolmogorov-Smirnov (K-S) test of equality of distributions presented in Table 2 and Figure 1 confirm that workers in Cartago have significantly higher levels of risk perception, compared to the values reported among Limón workers.

Figure 1: Distribution of risk perceptions among construction workers (Cartago and Limón)

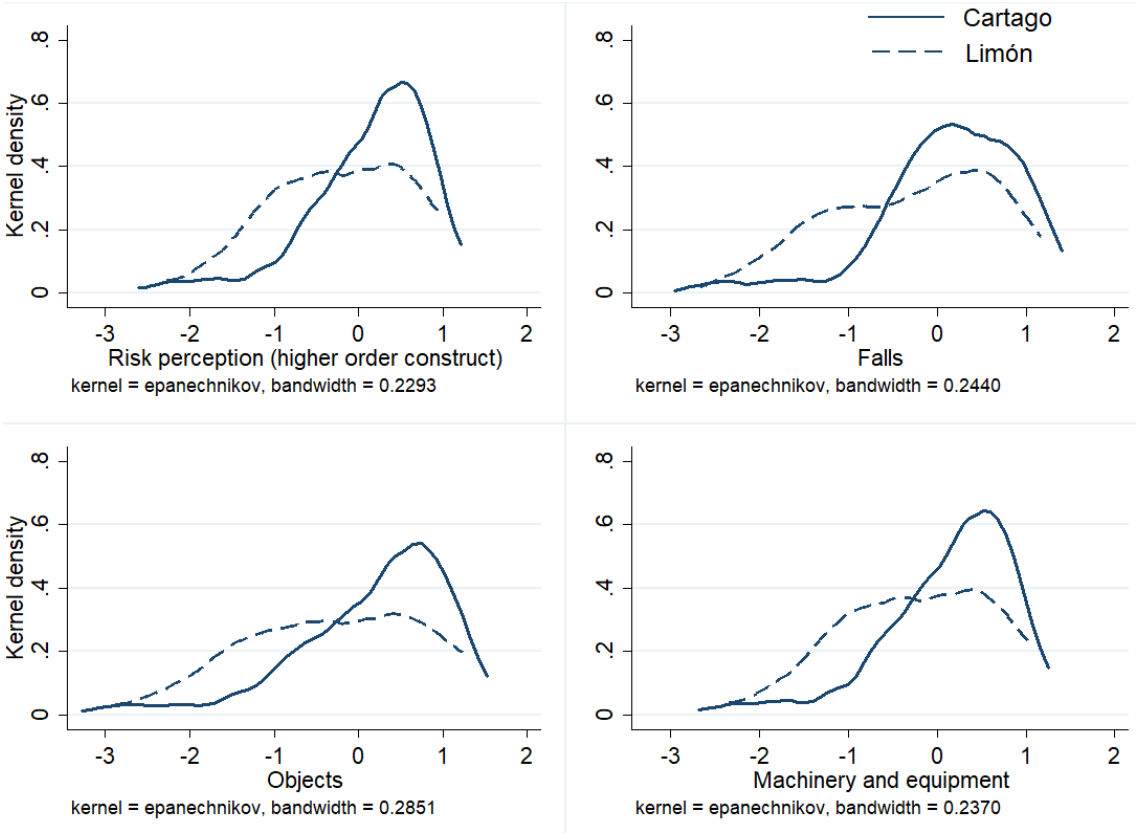

Table 2: Kolmogorov-Smirnov (K-S) test of equality of distributions: Summary results

Constructs	Cartago	Limón	K-S test (p-value)
Risk perception	0.13 (0.70)	–0.24 (0.82)	0.2685 (p-value=0.004)
Risks: Falls	0.14 (0.78)	–0.27 (0.94)	0.2708 (p-value=0.001)
Risks: Objects	0.16 (0.90)	–0.32 (1.06)	0.2685 (p-value=0.004)
Risks: Machinery and equipment	0.13 (0.72)	–0.25 (0.84)	0.2785 (p-value=0.002)
Observations	128	66	194

Work stress.—Work stress was measured using a binary (dummy) variable that takes the value of 1 if the respondent reported that a stressful work environment conditions or affects their risk perceptions. This variable captures the role of psychosocial stress in shaping cognitive evaluations of workplace hazards, consistent with research on stress-risk perception interactions in high-risk settings like construction sites (Gómez-Bull et al., 2023; Mastrantonio et al., 2024).

Coworkers' safety behavior.—To measure the influence of coworkers' safety behaviors, a dichotomous variable taking the value of 1 if the respondent indicated that coworkers' behavior conditions their risk perception was added to the analysis. This variable is grounded in social learning and group norm theories, which posit that peer behavior serves as a salient cue in environments where safety routines are frequently informal and collectively negotiated (Xia et al., 2020).

Control variables.—Similar to prior work, all model specifications control for a set of demographic and experiential characteristics (e.g., Caponecchia & Sheils, 2011; Lafuente et al., 2018; Ricci et al., 2019). Individual's age was measured, whereas labor experience is measured in years of labor market experience. Both age and labor experience variables are logged to reduce skewness. Finally, a set of dummy variables linked to individuals' marital status (single, married, unmarried/cohabitating, and divorced) was added to the models ('single' is the reference category). Descriptive statistics for all independent and control variables are presented in Table 3.

Table 3: Descriptive statistics for the selected variables

	Cartago	Limón	Overall
Work stress (dummy)	0.66 (0.47)	0.71 (0.46)	0.68 (0.47)
Coworkers' safety behavior (dummy)	0.52 (0.50)	0.58 (0.50)	0.54 (0.50)
Age (years)	37.20 (12.60)	38.36 (16.11)	37.60 (13.86)
Labor experience (years)	12.08 (11.29)	11.59 (10.29)	11.92 (10.94)
Single	0.40 (0.49)	0.41 (0.50)	0.40 (0.49)
Married	0.27 (0.44)	0.17 (0.38)	0.23 (0.42)
Unmarried / cohabitating	0.30 (0.46)	0.36 (0.48)	0.32 (0.47)
Divorced	0.03 (0.17)	0.06 (0.24)	0.04 (0.20)
Observations	128	66	194

Standard deviation is presented in parentheses. For all variables, the difference in values reported between workers in Cartago and Limon are not statistically significant.

3.3 Method

To assess the relationship between the explanatory variables and the dependent constructs linked to risk perceptions, a series of ordinary least squares (OLS) regression models were estimated. Standard errors were estimated using conventional heteroskedasticity-robust procedures to account for potential variance irregularities across respondents. The analyzed relationships are represented in a model with the following form:

$$\begin{aligned}&\text{Perceived risk}_i \\ &= \beta_0 + \beta_1 \text{Co-workers' safety behavior}_i + \beta_2 \text{Work stress}_i \\ &+ \beta_3 \text{Region}_i + \beta_4 \text{Controls}_i + \varepsilon_i \quad (1)\end{aligned}$$

In equation (1), *i* indexes workers, is the intercept, is the vector of coefficients estimated via ordinary least squares, and is the normally distributed error term. The dependent variables—i.e., 'Perceived risk'—is the set of factor scores generated via the SEM model, as described in section 3.2. The key independent factors include the dummy variables linked to 'co-workers' safety behavior', 'work stress', and the regional effect (Cartago is the reference category). 'Controls' is the vector of control variables accounting for potential individual-specific effects on risk perception (i.e., age, labor experience, and marital status).

4. Results

Table 4 reports the results of the OLS specifications. The first column shows the findings when the higher-order construct (i.e., 'risk perception') is the dependent variable, whereas the remaining three specifications test the effect of the explanatory variables over the three risk dimensions analyzed in the study, namely 'falls', 'objects', and 'machines and equipment'. Notice that variance inflation factor (VIF) values were computed for all explanatory variables, and the average VIF is 1.41 (range: 1.03-1.77). This result confirms that the estimations in Table 4 are not contaminated by multicollinearity.

Concerning the key findings of the study, from Table 4 it can be seen that, for all model specifications, the dummy variable capturing the effect of co-workers' safety behavior is positive and statistically significant. This result suggests that workers tend to follow social norms within their work environment and, for better or worse, they routinely imitate their peers' safety behaviors (Andersen et al., 2015; Xia et al., 2020). The stability of the coefficient across the three risk groups indicates that the peer signal is not risk-specific but generalizes to the overall safety environment on site.

In addition, contrary to prior work drawn from the job-demands literature (e.g., Gómez-Bull et al., 2023; Mastrantonio et al., 2024), in all model specifications the dummy variable linked to work stress is negative but not significant. One interpretation for the lack of significance is that the relationship between work stress and perceived risk might be more complex than initially expected. For example, the literature indicates that stress can impair situational awareness (in this case, on site) and reduce the ability to evaluate risks accurately (Taylor & Snyder, 2017). Related, stress might reduce or minimize engagement with safety behaviors, but only in cases where the work environment is plagued with poor safety practices or lack supervisory support (Lee, 2022).

Table 4: OLS results

	Risk perception	Falls	Objects	Machines and equipment
Coworkers' safety behavior (dummy)	0.22 (0.11)**	0.28 (0.13)**	0.29 (0.14)**	0.23 (0.11)**
Work stress (dummy)	–0.03 (0.12)	–0.04 (0.13)	–0.04 (0.15)	–0.03 (0.12)
Region (Limón)	–0.40 (0.12)***	–0.46 (0.13)***	–0.53 (0.15)***	–0.42 (0.12)***
Age (ln years)	0.06 (0.22)	0.17 (0.24)	0.12 (0.29)	0.07 (0.23)
Labor experience (ln years)	0.03 (0.07)	0.01 (0.08)	0.04 (0.09)	0.03 (0.07)
Married	–0.13 (0.16)	–0.21 (0.19)	–0.19 (0.21)	–0.13 (0.17)
Unmarried / cohabitating	0.05 (0.15)	0.01 (0.15)	0.07 (0.19)	0.05 (0.15)
Divorced	0.37 (0.22)*	0.32 (0.26)	0.48 (0.29)	0.39 (0.23)*
Intercept	–0.25 (0.69)	–0.53 (0.75)	–0.46 (0.89)	–0.25 (0.71)
F test	2.89***	2.30**	2.43**	2.28**
Adjusted R2	0.06	0.05	0.06	0.05
Observations	194	194	194	194

*Average VIF= 1.41 (range: 1.03-1.77). Robust standard errors adjusted by heteroskedasticity are presented in parentheses. *, **, ***= significant at the 10%, 5%, and 1%, respectively.*

Finally, the results show that the variable linked to the regional effect (Limón) is negative and highly statistically significant in all models. The findings for the coefficients indicate that, for the analyzed risk scenarios (Appendix 1), workers in Limón perceive substantially less risk than their counterparts in Cartago. The result corroborates descriptive evidence of lower means and distinct distributions for all risk perception constructs (the three first-order and the higher-order construct) (Table 2), and underscores the influence of contextual factors such as enforcement intensity, subcontracting chains, and local work culture on perceived risk (Ricci et al., 2019).

5. Concluding remarks and future research

5.1 Conclusion

This study sought to explain how social and regional forces shape construction workers' perceptions of occupational risk—operationalized through three key risk dimensions related to falls, accidents caused by objects, and machinery use. Survey evidence from 194 Costa Rican employees across 23 sites shows that peers' behavior and regional location are powerful predictors of risk perceptions.

Additionally, regional differences emerged as a significant determinant of risk perception. Workers in rural settings (Limón province) consistently reported lower level of risk perception than those among Cartago workers, a finding that suggests that the influence of local safety and enforcement environments condition individuals' risk awareness and perception. On contrary, variables related to individual demographics and self-reported work stress levels do not explain differences in risk perceptions among the sampled individuals.

These findings highlight the importance of contextualizing risk perception research within both the social dynamics of workgroups and the regional environment in which construction projects take place.

5.2 Implications

The results of this research have relevant implications for scholar, policy makers, and practitioners. First, the evidence presented in this study invite scholars to enrich prevailing cognitive models with multi-level perspectives that position co-workers' norms and regional safety environment as critical antecedents of risk perception. Incorporating cross-level interactions into structural models could clarify why individuals with similar demographics report divergent risk perceptions under different contextual configurations.

Second, policy makers should complement national standards with region-sensitive enforcement strategies. In Limón, a region characterized by its rural environment and where perceived risk is systematically lower, targeted audits, multilingual safety campaigns, and incentives for formal subcontracting could elevate risk awareness among workers. At a national level, funding mechanisms that reward contractors for demonstrable peer-driven safety initiatives might contribute to leverage the social diffusion pathways—i.e., the peer effect—identified in this study. Related, co-workers' habits and peer norms, in particular, wield powerful influence on others' opinion and risk perceptions, often eclipsing formal training or demographic attributes. The consulted literature suggests that well-designed interventions in construction safety must adopt a systemic perspective—one that cultivates positive peer norms, addresses occupational stress through resource provision and psychosocial safety climate, and tailors approaches to the specific cultural and regional contexts of work crews.

Finally, contractors and site managers can harness peer influence by formalizing safety champions within each construction crew, pairing new employees with high-compliance and experienced role models, and publicizing peer-to-peer observations during toolbox talks to equip workers with safety knowledge related to practices on site. Because perception hinges on what workers see each other do, interventions that make safe behavior visible—rather than relying solely on managerial directives or informative talks—are likely to produce greater perceptual alignment and, ultimately, safer behaviors among workers.

5.3 Future research

This study opens several promising avenues for future research. First, although stress showed no direct effect, future specifically designed laboratory or field studies could test whether stress moderates the influence of peers' behavior or mediates relations between variables related to safety environment and risk perceptions.

Second, future work should take into account that workers are nested within crews and firms, while incorporating regional indices of enforcement. The proposed multilevel analyses would help to clarify how macro- and micro-level covariates inform and explain differences in individuals' risk perception.

Finally, randomized controlled trials comparing peer-champion schemes with standard training programs across different regions could establish causal effects on both risk perception and accident rates, equipping practitioners and policy makers with valuable and actionable evidence that might contribute to unveil the complexity of risk perception and its determinants.

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Appendix

Appendix 1: List of items associated with the studied risk scenarios

Scenario	Code	Description
		Falls
1	FA1	Working on a flat roof without perimeter guardrails and without wearing a harness attached to an anchor point or lifeline
2	FA2	Working on an unstable ladder
3	FA3	Picking up materials from an unprotected loading/unloading platform located on the second floor of a structure
4	FA4	Walking over an area where oil has been spilled
		Objects
5	OB1	Working near unstable material stockpiles
6	OB2	Working beneath the path of a tower crane with suspended load
7	OB3	Working inside an unshored trench dug in loose soil
		Machines and equipment
8	ME1	Using electrical equipment with damaged cables
9	ME2	Working with a handheld cutting machine without a protective guard
10	ME3	Walking within vehicle circulation paths on the construction site

Appendix 2: Early response bias test: Mean comparison of variables (early respondents vs. late respondents)

	Early wave (first 10%)	Late wave (last 10%)	Mann-Whitney U test
Work stress (dummy)	0.7391 (0.4490)	0.7391 (0.4490)	0.000 (p = 0.000)
Coworkers' safety behavior (dummy)	0.6087 (0.4990)	0.5652 (0.5069)	0.296 (p = 0.767)
Age (years)	48.04 (22.61)	31.52 (7.53)	3.189 (p = 0.001)
Labor experience (years)	19.26 (14.65)	9.19 (7.40)	2.179 (p = 0.029)
Single	0.2609 (0.4490)	0.3478 (0.4870)	–0.634 (p = 0.526)
Married	0.3478 (0.4870)	0.2609 (0.4490)	0.634 (p = 0.526)
Unmarried / cohabitating	0.3478 (0.4870)	0.3913 (0.4990)	–0.302 (p = 0.763)
Divorced	0.0435 (0.2085)	0.0000 (0.0000)	1.000 (p = 0.317)
Observations	23	23	

Standard deviation is presented in parentheses.