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Evaluation of the Implementation of Occupational Safety and Health in the Construction of a Four-Storey Building (Case Study: Construction of the Ishk Tolaram Eye Clinic in Batu City)

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Abstract: Construction remains a highly hazardous industry, and strengthening Occupational Safety and Health (OSH) is urgent to reduce injuries and occupational illnesses while sustaining productivity. However, in four-storey construction, OSH is often treated as compliance, and evidence is limited on its measurable contribution to workforce effectiveness and on which OSH factors should be prioritized. This study evaluated OSH implementation in the Ishk Tolaram Eye Clinic (four-storey) project in Batu City, Indonesia, using observations and questionnaires from supervisors and artisans/forepersons, analyzed with SEM-PLS. The structural model shows a strong, positive, and significant effect of OSH implementation on workforce effectiveness (path coefficient = 0.76; t = 13.46; p = 0.00). OSH implementation explains 58.0% of the variance in workforce effectiveness (R^2 = 0.58); occupational health is the most dominant OSH dimension (loading = 0.72), and adequate sanitation conditions (X2.4) are the key leverage point (loading = 0.80). This research contributes a multidimensional, evidence-based evaluation framework that converts OSH from a checklist into prioritized drivers linked to workforce outcomes. In practice, contractors should prioritize occupational health controls, especially sanitation, alongside training and PPE discipline, to improve safety performance and reliable productivity across comparable four-storey projects in Indonesia.

Keywords: Adequate sanitation; Occupational health; OSH implementation; SEM-PLS; Workforce effectiveness

Introduction

Occupational Safety and Health (OSH) is widely recognized as a critical component of construction management because it operationalizes structured risk management and supports the development of a safety-oriented workplace culture. When OSH policies are implemented consistently, they reduce exposure to hazards inherent to construction activities, thereby lowering the likelihood of injuries and occupational illnesses while also helping to maintain productivity and continuity during project delivery (Abdelrahim et al., 2023; Kathayat et al., 2025; Miño-Terrancle et al., 2023; Oktavera et al., 2025). Nevertheless, translating OSH standards into daily site practices remains difficult in many projects because construction work is dynamic, distributed across multiple teams, and highly sensitive to operational disruptions.

The challenge is particularly salient in building projects where structural, architectural, and mechanical, electrical, and plumbing (MEP) activities overlap and must be coordinated under tight time constraints. In such contexts, safety risks, especially falls, struck-by incidents, and poor housekeeping, tend to intensify as schedule pressure increases and labor turnover reduces the stability of work practices and supervision (Azmi et al., 2020; Baghdadi, 2024). Beyond physical hazards, the effectiveness of OSH is also shaped by organizational

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processes. Communication failures within project teams can lead to inconsistent understanding of procedures, delayed hazard reporting, and the neglect of OSH protocols, collectively increasing the likelihood of accidents and weakening the performance of safety management systems (Makki & Mosly, 2020; Muhammad & Marsuki, 2024; Zara et al., 2023). These conditions are commonly observed in mid-rise building construction, including four-storey developments, where multiple work fronts are active simultaneously, and site congestion may further amplify exposure to health-related risks such as inadequate housekeeping and sanitation (Ridawati et al., 2023).

Despite the acknowledged importance of OSH, project-level implementation is often approached as a compliance obligation rather than as a managerial mechanism that directly shapes workforce effectiveness. Consequently, the measurable contribution of OSH implementation to workforce effectiveness, and the specific OSH factors that should be prioritized for improvement, remain insufficiently evidenced in practice, particularly in four-storey building projects with overlapping activities and complex coordination demands. This study addresses this problem by testing the hypothesis that stronger OSH implementation has a positive and significant influence on project workforce effectiveness. In contrast, the null hypothesis states that OSH implementation does not significantly influence workforce effectiveness. In line with the literature that emphasizes the need for more resilient and adaptive safety management approaches under operational pressures (Azmi et al., 2020; Baghdadi, 2024; Zara et al., 2023). This research proposes an evaluation framework that quantifies the strength of the OSH-effectiveness relationship and identifies the most influential OSH dimensions and indicators as practical levers for improvement.

Accordingly, this study aims to evaluate OSH implementation in the construction of a four-storey building project and to examine its influence on project workforce effectiveness using a quantitative explanatory approach. Data are collected through field observations and structured questionnaires administered to key site actors, including supervisors and skilled workers/foremen. The analysis employs Structural Equation Modeling-Partial Least Squares (SEM-PLS) to assess both the measurement model (indicator validity and reliability) and the structural model (path significance and explanatory power), thereby enabling the identification of key OSH drivers and the development of evidence-based recommendations that support safer operations and more effective workforce performance in building construction projects (Abdelrahim et al., 2023; Kathayat et al., 2025; Miño-Terrancle et al., 2023).

Despite the introduction of regulations and standards intended to improve Occupational Safety and Health (OSH) performance in the construction sector, outcomes in practice often remain suboptimal. A recurring cause is incomplete compliance with OSH requirements, accompanied by weak safety discipline on site (Nasution et al., 2023; Suralaga et al., 2024), which manifests in inconsistent use of personal protective equipment (PPE) and limited continuity of safety training programs (Khairil et al., 2024; Khairudin et al., 2021; Kusuma et al., 2025; Purnomo & Prisilia, 2025). In many projects, workers' awareness and understanding of PPE requirements are still insufficient, and this behavioral gap is consistently associated with elevated accident rates (Ashuro et al., 2021; Boakye et al., 2022; Indriati & Jasmi, 2022). Moreover, safety motivation and adherence frequently decline under time pressure and demanding production targets, further weakening the practical effectiveness of OSH controls (Purnomo & Prisilia, 2025; Simeon & Soyingbe, 2023).

From a research perspective, studies on OSH in Indonesian building projects have primarily focused on descriptive assessments (e.g., reporting compliance levels, incident frequencies, or stand-alone control measures) (Mariam et al., 2023), and therefore provide limited evidence on how OSH implementation translates into workforce effectiveness. This creates a critical research gap because the causal mechanisms linking OSH implementation to workforce outcomes are rarely examined rigorously in complex building-project environments (Abdelwahed & Soomro, 2023; Chinnasamy et al., 2024). Addressing this gap is important for project management because workforce effectiveness is not determined solely by technical competence; it is also shaped by consistent safety behaviors, stable health protection measures, and a work environment that enables workers to perform reliably under operational constraints.

To advance both evidence and practice, a multidimensional, SEM-based approach can model OSH implementation as a structured construct encompassing work safety, occupational health, and the broader work environment, while simultaneously testing its relationships with workforce effectiveness outcomes. Such a model enables systematic identification of which OSH dimensions and indicators contribute most strongly to workforce performance, supporting more targeted interventions than single-factor or purely descriptive evaluations (Abdelwahed & Soomro, 2023). Accordingly, this study positions a multidimensional explanatory framework as a means to quantify the relationship between OSH implementation and workforce effectiveness in building construction, generating actionable priorities for improving compliance, strengthening safety discipline, and sustaining protective practices under real project pressures (Khairudin et al., 2021; Purnomo & Prisilia, 2025; Simeon & Soyingbe, 2023).

In four-storey building construction, the extent to which Occupational Safety and Health (OSH) implementation influences workforce effectiveness is increasingly recognized as substantial, because OSH functions not only as a regulatory requirement but also as an operational enabler of project performance. When OSH is embedded in daily site routines through robust training, consistent Personal Protective Equipment (PPE) use, and an internalized safety culture, it is measurably associated with improved workforce performance, fewer accidents, and higher overall project efficiency (Ghofur et al., 2024; Purnomo & Prisilia, 2025; Yusriyanto & Asran, 2025). This perspective positions OSH as a managerial instrument that strengthens morale, supports sustained productivity, and contributes directly to project success rather than serving solely as compliance documentation.

However, effectiveness gains from OSH implementation are unlikely to be uniform across all safety initiatives; therefore, prioritizing the most influential OSH dimensions is required. Evidence suggests that interventions centered on continuous and competency-oriented training, effective communication mechanisms, and the reliable provision and use of adequate PPE are among the most impactful levers for improving both safety outcomes and work performance (Tanjung & Susilawati, 2024; Tsanyan et al., 2025; Widiatmoko et al., 2025). These dimensions are particularly relevant in four-storey building projects where work fronts often overlap, and site conditions can change quickly, requiring workers to adapt their practices while maintaining consistent adherence to safety procedures.

To move from general recommendations to actionable priorities, OSH-effectiveness relationships should be evaluated using a structured framework that quantifies the contribution of each OSH dimension and its indicators to workforce outcomes. Such a framework can operationalize OSH implementation through measurable indicators, for example, training outcomes, PPE compliance rates, and incident reporting patterns, so that project teams can identify which practices most strongly drive effectiveness in construction settings (Karim, 2025; Ramadhan et al., 2025). By translating OSH implementation into quantifiable dimensions and indicators, organizations can allocate resources to interventions with the highest expected return, achieving measurable improvements in safety standards while also strengthening workforce productivity and project delivery performance (Ghofur et al., 2024; Purnomo & Prisilia, 2025).

Therefore, this study aims to evaluate the implementation of OSH in the construction of the Ishk Tolaram Eye Clinic (four-storey building) in Batu City and to examine its influence on project workforce effectiveness. Data were collected through quantitative field research using direct observations and questionnaires administered to project supervisors and artisans/forepersons. The analysis applies Structural Equation Modeling-Partial Least Squares (SEM-PLS) to assess the measurement model (validity and reliability of indicators) and the structural model (path significance and explanatory power), enabling a rigorous identification of key OSH drivers and evidence-based recommendations for improving OSH implementation in building construction projects.

Method

Research Type

This study employed a quantitative, explanatory survey design grounded in the positivist paradigm to test a priori hypotheses about the relationship between Occupational Safety and Health (OSH) implementation and construction workforce effectiveness. A quantitative approach is appropriate because OSH practices and performance outcomes can be operationalized as measurable indicators, allowing objective estimation of effect sizes and statistical significance. Consistent with prior empirical work linking OSH practices to performance outcomes in construction and related project contexts, the study used structured questionnaires as the primary instrument to capture perceptions and experiences of supervisors and artisans/forepersons directly involved in the Ishk Tolaram Eye Clinic (four-storey) project (Bustamin et al., 2023; Fanani & Budiono, 2025). To improve contextual accuracy and reduce measurement ambiguity, questionnaires were complemented by site observations and document review, aligning with standard data acquisition practices in construction project studies (Delimar & Pamekas, 2020; Susilowati et al., 2023). The dependent construct is project workforce effectiveness, while the independent construct is OSH implementation, conceptualized as a multidimensional managerial practice implemented in daily site operations.

Research Stages

The research was conducted at the Ishk Tolaram Eye Clinic construction site (Jalan Jack D., Pesanggrahan Village, Batu District, Batu City, East Java, Indonesia; 65315), a ~3,200 m² development designed as a four-storey facility, with fieldwork implemented from April to July 2025. The study followed four stages. First, the research problem and hypotheses were specified (H0:

OSH implementation does not significantly influence workforce effectiveness; H1: OSH implementation has a positive and significant influence) (Santikanuri et al., 2025). Second, constructs and indicators were operationalized to guide measurement and data collection, consistent with variable operationalization principles (Sutrisno et al., 2024). Third, data were acquired through (i) structured site observations to document OSH routines and controls and (ii) structured questionnaires distributed to eligible supervisors and artisans/forepersons who were actively assigned during the study period; short clarification interviews were used only to interpret observed site practices. Fourth, data were cleaned and coded, then organized for SEM-PLS modeling. The hypothesized relationship is summarized in Figure 1 (conceptual framework), and the construct structure is specified in Figure 2 (measurement model).

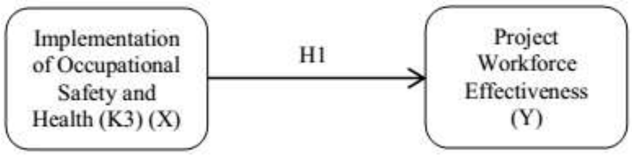

Figure 1. Conceptual framework of the effect of Occupational Safety and Health (OSH) implementation on project workforce effectiveness

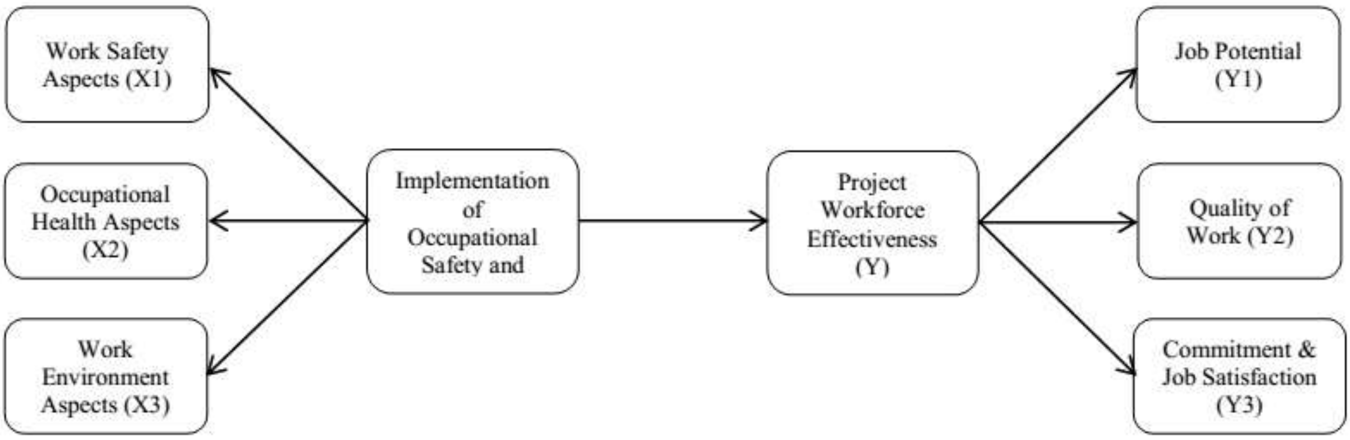

Figure 2. Measurement model of Occupational Safety and Health (OSH) implementation dimensions (X1–X3) and project workforce effectiveness dimensions (Y1–Y3)

Research Validators

Instrument and model validation were implemented through complementary procedural and statistical checks to meet rigorous Scopus-Q1 reporting expectations. First, content and face validity were established by expert review (e.g., construction management and OSH practitioners/academics) to ensure that each item was relevant, clearly worded, and context-appropriate for a four-storey building project, and revisions were made based on consensus feedback (Delfianza et al., 2023). Second, the measurement model was validated using SEM-PLS criteria, focusing on indicator reliability and construct validity; items were evaluated for adequacy through loading strength, internal consistency reliability (e.g., composite reliability), and convergent validity (e.g., AVE), followed by discriminant validity checks to confirm conceptual distinctness across dimensions (Sutrisno et al., 2024). Third, procedural bias controls were applied during data collection (e.g., anonymity/confidentiality assurances and structured questionnaire flow) to reduce socially desirable responses and common method bias in survey-based designs. These validation steps ensured that the indicators used to represent OSH implementation and workforce effectiveness were both credible and statistically defensible for subsequent hypothesis testing (Anggraini et al., 2025).

Data Analysis

Data were analyzed using Structural Equation Modeling-Partial Least Squares (SEM-PLS) to estimate both the measurement (outer) model and the structural (inner) model in a single coherent framework, consistent with prior construction-safety studies using PLS-SEM to test relationships among latent constructs (Astriawati et al., 2023; Damayanti et al., 2022, 2023). SEM-PLS was selected because it is well-suited for explanatory modeling with latent variables, accommodates complex models with multiple indicators, and performs robustly under realistic field constraints such as limited sample sizes, while remaining effective for theory testing and prediction. Outer-model evaluation examined indicator loadings, reliability, and validity to confirm that indicators appropriately measure OSH and effectiveness constructs (Susandi et al., 2025; Sutrisno et al., 2024). Inner-model evaluation tested the hypothesized path from OSH implementation to workforce effectiveness, reporting the path coefficient (β) and significance using bootstrapping (α = 0.05), alongside explanatory and predictive indices such as R^2, Q^2, and effect size (f^2) where applicable (Sutiyono et al., 2024). This analytic strategy enables both rigorous hypothesis testing and the practical identification of the most influential OSH dimensions for managerial prioritization in building project delivery (Putro & Suharjito, 2025).

Result and Discussion

Linearity and Model Suitability

Table 1 indicates that the relationship between Occupational Safety and Health (OSH) implementation (X) and project workforce effectiveness (Y) is linear in this dataset, supporting the use of SEM-PLS to estimate the directional effect in a positivist, hypothesis-testing design. The linear pattern implies that incremental strengthening of OSH practices is followed by incremental gains in effectiveness across the observed range, rather than a threshold response. This assumption is important because PLS-SEM is optimized for prediction and variance explanation, and its interpretation becomes more defensible when the core relationship is not strongly non-linear. Within the study context, a linear specification also offers a transparent managerial interpretation: each improvement in OSH (e.g., clearer procedures, healthier work routines, better field controls) is expected to contribute to workforce effectiveness additively. Methodologically, the model choice aligns with contemporary guidance on using PLS for confirmatory and explanatory research when the goal is to maximize explained variance and interpret path coefficients in an applied setting (Benitez et al., 2020). The evaluation is also consistent with measurement model confirmation recommendations for PLS-SEM, which emphasize establishing model adequacy before substantive interpretation (Hair et al., 2020).

Table 1. Linearity Assumption Test Results

Relationship pattern variables Causal variables	>	Consequence variables	P-Value linearity	Conclusion
Implementation of occupational safety and health (OSH) (X)	>	Project workforce effectiveness (Y)	0.00	Linear

Measurement Model Quality and Dominant Dimensions

Table 2 and Table 3 demonstrate that the measurement model meets convergent validity and reliability thresholds, and highlight which dimensions and indicators contribute most strongly in this project. At the first-order level (Table 2), all dimension loadings exceed the minimum acceptable threshold, with the occupational health aspect (X2) loading most strongly on OSH (0.72) and the quality-of-work dimension (Y2) loading most strongly on workforce effectiveness (0.75). Across constructs, AVE values exceed 0.50 and composite reliability values exceed 0.70, indicating that items cohere and capture their intended latent dimensions. The second-order results (Table 3) clarify operational leverage points: the sanitation condition indicator (X2.4) shows the highest loading within occupational health (0.79), while indicator Y3.5 shows the highest loading within commitment and job satisfaction (0.82). Substantively, these loadings suggest that basic welfare conditions and perceived fairness/attachment to the project are the most information-rich signals of OSH and effectiveness in this setting. The modeling approach is consistent with recommended procedures for specifying and validating higher-order constructs in PLS-SEM, which stress assessing first-order measurement quality before interpreting higher-order relationships (Sarstedt et al., 2019). The interpretation of loadings, AVE, and composite reliability also follows best-practice guidance for confirmatory composite analysis in PLS measurement model evaluation (Hair et al., 2020).

Table 2. Summary of Measurement Model Evaluation/Outer Model Stage 1 (1st Order Outer Model)

Latent variable (Primary construct)	Manifest variables (Aspects/ dimensions)	(LF > 0.50 = valid) Loading factor	Conclusion	Rank	Validity of convergent (AVE > 0.50 = valid) AVE	Loading factor	Composite reliability (CR > 0.70) Conclusion	Conclusion
Implementation of occupational safety and health (OSH) (X)	Work safety aspects (X1)	0.66	Valid	2				
	Occupational health aspects (X2)	0.72	Valid	1	0.63	Valid	0.87	Reliable
	Work environment aspects (X3)	0.60	Valid	3				

Latent variable (Primary construct)	Manifest variables (Aspects/ dimensions)	Validity of convergent (LF > 0.50 = valid) Loading factor	Conclusion	Rank	(AVE > 0.50 = valid) AVE	Loading factor	Composite reliability (CR > 0.70) Conclusion	Conclusion
Project workforce effectiveness (Y)	Job potential (Y1)	0.71	Valid	3	0.59	Valid	0.85	Reliable
	Quality of work (Y2)	0.75	Valid	1				
	Commitment and job satisfaction (Y3)	0.73	Valid	2				

Table 3. Evaluation of Stage 2 Measurement Model (2nd Order Outer Model)

Variable	Dimensions/ aspects	Factor	Validity of convergent (LF > 0.50 = valid) Loading factor	Conclusion	Ranking	(AVE > 0.50 = valid) AVE	Conclusion	Composite reliability (CR > 0.70) CR	Conclusion
Implementation of occupational safety and health (OSH) (X)	Work safety aspects (X1)	X1.1	0.76	Valid	4	0.55	Valid	0.92	Reliable
		X1.2	0.78	Valid	2				
		X1.3	0.74	Valid	7				
		X1.4	0.78	Valid	3				
		X1.5	0.75	Valid	6				
		X1.6	0.79	Valid	1				
		X1.7	0.75	Valid	5				
		X1.8	0.71	Valid	8				
		X1.9	0.69	Valid	9				
		X1.10	0.65	Valid	10				
	Occupational health aspects (X2)	X2.1	0.66	Valid	8	0.51	Valid	0.91	Reliable
		X2.2	0.73	Valid	4				
		X2.3	0.76	Valid	3				
		X2.4	0.79	Valid	1				
		X2.5	0.72	Valid	5				
		X2.6	0.78	Valid	2				
		X2.7	0.72	Valid	6				
		X2.8	0.62	Valid	9				
		X2.9	0.61	Valid	10				
		X2.10	0.69	Valid	7				
	Work environment aspects (X3)	X3.1	0.74	Valid	7	0.57	Valid	0.93	Reliable
		X3.2	0.80	Valid	1				
		X3.3	0.79	Valid	4				
		X3.4	0.77	Valid	5				
		X3.5	0.79	Valid	2				
		X3.6	0.73	Valid	8				
		X3.7	0.79	Valid	3				
		X3.8	0.74	Valid	6				
		X3.9	0.71	Valid	9				
		X3.10	0.69	Valid	10				
Project workforce effectiveness (Y)	Job potential (Y1)	Y1.1	0.70	Valid	8	0.53	Valid	0.92	Reliable
		Y1.2	0.77	Valid	2				
		Y1.3	0.75	Valid	4				
		Y1.4	0.76	Valid	3				
		Y1.5	0.71	Valid	7				
		Y1.6	0.66	Valid	9				
		Y1.7	0.74	Valid	5				
		Y1.8	0.73	Valid	6				
		Y1.9	0.78	Valid	1				
		Y1.10	0.63	Valid	10				
	Quality of work (Y2)	Y2.1	0.65	Valid	9	0.52	Valid	0.92	Reliable
		Y2.2	0.62	Valid	10				
		Y2.3	0.80	Valid	2				
		Y2.4	0.66	Valid	8				

Variable	Dimensions/ aspects	Factor	Validity of convergent (LF > 0.50 = valid) Loading factor	Conclusion	Ranking	(AVE > 0.50 = valid) AVE	Conclusion	Composite reliability (CR > 0.70) CR	Conclusion
		Y2.5	0.70	Valid	6				
		Y2.6	0.84	Valid	1				
		Y2.7	0.74	Valid	5				
		Y2.8	0.79	Valid	3				
		Y2.9	0.75	Valid	4				
		Y2.10	0.70	Valid	7				
	Commitment and job satisfaction (Y3)	Y3.1	0.68	Valid	7	0.51	Valid	0.91	Reliable
		Y3.2	0.63	Valid	10				
		Y3.3	0.73	Valid	5				
		Y3.4	0.65	Valid	9				
		Y3.5	0.82	Valid	1				
		Y3.6	0.73	Valid	4				
		Y3.7	0.67	Valid	8				
		Y3.8	0.70	Valid	6				
		Y3.9	0.78	Valid	2				
		Y3.10	0.75	Valid	3				

Discriminant Validity and Construct Distinctiveness

Table 4 confirms that the OSH dimensions (X1–X3) and the workforce effectiveness dimensions (Y1–Y3) are empirically distinct, a requirement before attributing variance in effectiveness to OSH rather than to measurement overlap. All Heterotrait–Monotrait (HTMT) ratios are below the conservative cut-off of 0.90, and the strongest observed associations remain within acceptable bounds, suggesting that each dimension contributes unique information to the model. In practical terms, the result means that occupational health, work safety, and work environment aspects are related but not interchangeable constructs; similarly, job potential, quality of work, and commitment/job satisfaction reflect different facets of effectiveness. This distinction strengthens the credibility of subsequent structural inferences by reducing the risk that poorly separated measures inflate the X→Y relationship. The decision rule aligns with the widely cited HTMT criterion for variance-based SEM, developed to address limitations of the Fornell-Larcker approach and cross-loading checks (Henseler et al., 2015). The conclusion is further supported by subsequent methodological work proposing refinements to HTMT to achieve more robust discriminant validity assessment under realistic measurement conditions (Roemer et al., 2021).

Table 4. Discriminant Validity Test (HTMT)

	Work safety aspects (X1)	Occupational health aspects (X2)	Work environment aspects (X3)	Commitment and job satisfaction (Y3)	Quality of work (Y2)
Occupational health aspects (X2)	0.41				
Work environment aspects (X3)	0.24	0.39			
Commitment and job satisfaction (Y3)	0.26	0.37	0.75		
Quality of work (Y2)	0.26	0.74	0.23	0.25	
Job potential (Y1)	0.64	0.48	0.30	0.30	0.26

Structural Model Strength and Explained Variance

Tables 5 and 6 show that the structural model has substantial explanatory power for the case project. OSH implementation explains 58% of the variance in workforce effectiveness ($R^2 = 0.58$), which is categorized as moderate using the study's global optimization criteria. This magnitude indicates that OSH is not merely a compliance activity; it functions as a central managerial lever shaping how effectively supervisors and artisans translate time and resources into work outcomes. The remaining 42% of the variance plausibly reflects influences outside the current model, such as planning reliability, skill heterogeneity, leadership style, wage and incentive structures, and material/logistics constraints. Interpreting R^2 in this way is consistent with construction productivity research showing that labor performance is multifactorial and that working conditions represent only one (yet important) cluster of determinants in structural equation models of productivity (Durdyev et al., 2018). From a safety and health perspective, the result is also compatible with synthesis work, indicating that safety climate and related OSH perceptions meaningfully relate to safety behavior and organizational outcomes in construction, even though effect sizes vary with measurement and context (Chen et al., 2021).

Table 5. Coefficient of Determination

Influence			R square	1-R-square
Implementation of occupational safety and health (OSH) (X)	>	Project workforce effectiveness (Y)	0.58	0.42

Table 6. Structural Model Strength Level (Global Optimization)

Standard criteria R-square Interval	Categories	R-square total (Q^2)	Explanation
0.00 - 0.29	Very weak	0.58	Moderat
0.30 - 0.49	Weak		
0.50 - 0.69	Moderat		
0.70 - 1.00	Strong		

Meanwhile, based on the SEM-PLS GoF calculation in this research, the value is as follows.

$$GoF\ Y = \sqrt{AVE \times R^2} \quad (1)$$

$$GoF\ Y = \sqrt{0.59 \times 0.58}$$

$$GoF\ Y = 0.59$$

The GoF criterion is considered small if the value is 0.1, medium if it is 0.25, and high if it is 0.38. According to the GoF calculation above, the Project Labor Effectiveness (Y) measurement has a GoF of 0.59, which is higher than the 0.38. This means the model's accuracy test indicates it is good and worthy of testing as a hypothesis.

Hypothesis Testing and Practical Implications

This section focuses on the evaluation of coefficients indicating the influence or causal relationship between latent variables. If the t statistic is between -1.96 and 1.96 at the 0.05 significance level, then the existence of a causal relationship is considered insignificant. The results estimate the crucial ratio values for the structural model using the PLS software. In conclusion, the following table displays the findings from the calculation of these coefficients (Kamranfar et al., 2023; Mirhosseini et al., 2022).

Table 7 and Figure 3 provide direct evidence that OSH implementation has a strong, statistically significant positive effect on workforce effectiveness (path coefficient = 0.76; t = 13.46; p = 0.00). The significant coefficient indicates that strengthening OSH practices is likely to produce practically meaningful performance gains, not only through incident prevention but also through improved work organization and stronger worker engagement, as reflected in the effectiveness dimensions in Table 2 and the dominant items in Table 3. The indicator pattern offers a concrete prioritization rule for managers: adequate sanitation conditions (X2.4) emerge as the most influential item within the occupational health dimension, implying that welfare and hygiene facilities may be a high-leverage, low-regret intervention on site. This interpretation is consistent with evidence that safety management system implementation in construction is positively associated with both safety and operational outcomes when modeled with structural equation approaches (Yiu et al., 2019). The sanitation emphasis is also biologically and behaviorally plausible because occupational exposure to inadequate sanitation is linked to elevated risks of gastrointestinal and respiratory illness, which can undermine attendance and on-task capacity in labor-intensive work (Oza et al., 2022).

Table 7. SEM-PLS Path Analysis Results

Influence between latent variables Exogenous variables	>	Endogenous variables	Path coefficient	t-value	p-value	Conclusion
Implementation of occupational safety and health (OSH) (X)	-->	Project workforce effectiveness (Y)	0.76	13.46	0.00	Significant

Path analysis in Table 7 and Figure 3 confirms a strong, positive, and statistically significant effect of OSH implementation (X) on project workforce effectiveness (Y) (β = 0.76; t = 13.46; p = 0.00), consistent with the moderate explanatory power in Table 5 (R^2 = 0.58). Measurement results identify the occupational health aspect (X2) as the most dominant OSH dimension (loading = 0.72; Table 2), while the second-order model isolates adequate sanitation conditions (X2.4) as the highest-loading indicator within X2 (loading = 0.80; Table 3). These convergent patterns provide evidence-based justification for positioning sanitation as the most defensible KPI for immediate evaluation and corrective action. Sanitation can be operationalized as a controllable site input (toilet availability, adequacy, accessibility, and maintenance; handwashing points; and drinking-water provision), enabling routine auditing and explicit budget allocation. The finding indicates that OSH effectiveness in this project is most sensitive to concrete welfare conditions rather than abstract policy statements, which mirrors the wider construction safety-climate view that observable management practices are the strongest signals shaping workforce outcomes (Chen et al., 2021).

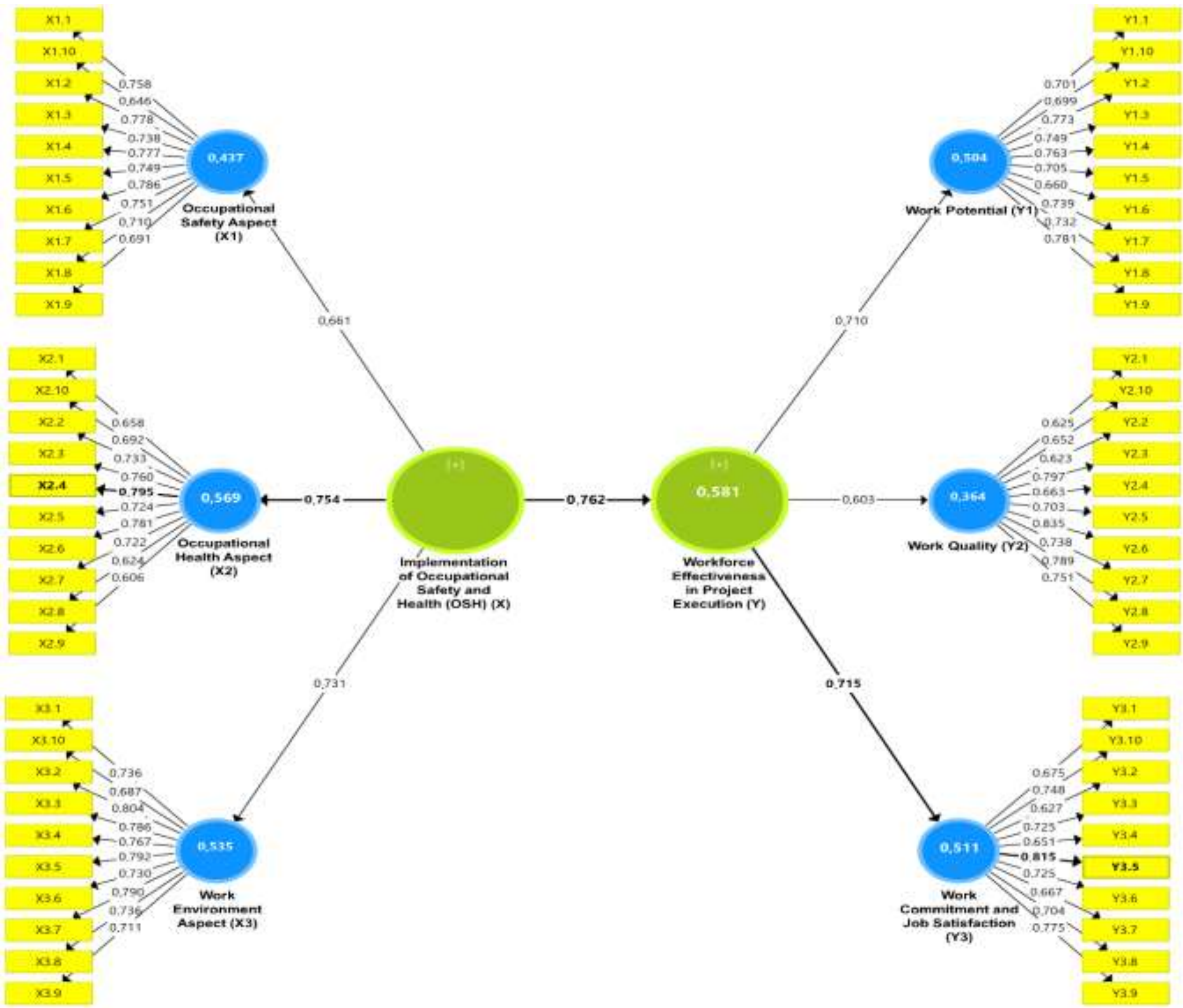

Figure 3. SEM-PLS results for the OSH (K3) implementation–workforce effectiveness model: outer loadings, path coefficients, and explained variance (R^2) across dimensions (X1–X3; Y1–Y3)

Adequate sanitation conditions (X2.4) appear to influence workforce effectiveness through a welfare-driven mechanism that stabilizes physical capacity and supports psychosocial readiness under intensive site routines. The outer-model structure shows that sanitation (X2.4; 0.80) anchors the occupational health aspect (X2), while project sustainability commitment (Y3.5) is the strongest indicator of the commitment and job satisfaction dimension (Y3) (loading = 0.82; Table 3). This pattern suggests that sanitation is not only associated with immediate comfort; it aligns most strongly with the attitudinal component that sustains persistence, cooperation, and willingness to remain engaged throughout project delivery. Poor sanitation plausibly increases discomfort, elevates the risk of hygiene-related illnesses, and undermines perceived dignity, which can accumulate into chronic stress and reduced motivation, thereby lowering discretionary effort and reliability. Improved sanitation functions as a preventive OSH control that supports attendance and uninterrupted concentration, strengthening satisfaction and commitment alongside health protection. The health relevance of sanitation exposure is consistent with evidence that sanitation-related occupational hazards are associated with adverse health outcomes that can reduce work capacity (Oza et al., 2022).

Field observations reinforce the statistical prioritization by indicating that sanitation facilities are often treated as discretionary, particularly when cost-efficiency pressures dominate short-term decision-making. Deficits such as insufficient portable toilets, limited handwashing stations, and inconsistent access to clean drinking water can trigger measurable productivity losses through time wastage, fragmented task flow, and reduced concentration, while also shaping negative interpretations of management priorities. The empirical linkage between sanitation (X2.4) and sustainability commitment (Y3.5) implies that welfare neglect is interpreted as organizational indifference, reducing engagement and lowering willingness to maintain long-term project affiliation. Systemically, sanitation deficits can propagate a domino effect by weakening occupational health (X2), degrading overall OSH implementation (X), and lowering workforce effectiveness (Y), while simultaneously increasing dissatisfaction-driven withdrawal and turnover pressure. A strategic policy that institutionalizes sanitation as a non-negotiable budget line and audit criterion can therefore generate multiplier benefits: reduced absenteeism, improved morale, more stable commitment, and stronger delivery reliability. The inferred retention pathway aligns with construction evidence that psychosocial safety conditions shape workers' intent to stay through job-satisfaction mechanisms (Xie et al., 2024).

Conclusion

This study aimed to evaluate OSH implementation in a four-storey building project and to examine its influence on project workforce effectiveness. SEM-PLS results confirm that OSH implementation has a strong, positive, and statistically significant effect on workforce effectiveness (path coefficient = 0.76; t = 13.46; p = 0.00), indicating that improvements in site OSH practices translate into measurable performance gains. The model explains a substantial proportion of the outcome variance ($R^2 = 0.58$), indicating that 58% of workforce effectiveness is accounted for by OSH implementation. In comparison, the remaining 42% is attributable to other project factors not modeled in this study. Global model fit is high (GoF = 0.59), supporting the adequacy of the proposed framework for explaining OSH-effectiveness linkages in mid-rise building construction. Among OSH dimensions, occupational health is the most dominant contributor (loading = 0.72), and "adequate sanitation conditions" (X2.4) emerges as the key leverage point (loading = 0.80), with practical implications for prioritizing sanitation facilities as a project KPI to strengthen health, motivation, and sustained productivity. A key limitation is the single-project, cross-sectional design; future work should validate the framework across multiple sites and time periods and include additional determinants of effectiveness.

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Conceptualization, F.D. (lead), H.S.W. and S. (supporting); methodology, F.D. (lead), H.S.W. and S. (supporting); software, F.D.; validation, F.D. (lead), H.S.W. and S (supporting).; formal analysis, F.D.; investigation, F.D.; resources, F.D.; data curation, F.D.; writing-original draft, F.D.; writing-review & editing, F.D. (lead), H.S.W. and S. (supporting); visualization, F.D.; supervision, F.D. (lead), H.S.W. and S. (supporting); project administration, F.D. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest. The funders had no role in the design of the study, the collection, analysis, or interpretation of data, the writing of the manuscript, or the decision to publish the results.

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