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Analysis of Factors Influencing the Implementation of Occupational Safety and Health (OSH) in the Electric Power Transmission Sector Using a Structural Equation Modeling Approach

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ABSTRACT

Occupational Safety and Health (OSH) implementation in the electricity transmission sector remains a critical issue due to the high level of workplace risks, including electrical hazards, work at heights, and dynamic field conditions. Strengthening OSH practices requires an understanding of the factors influencing workers' safety behavior. This study aims to identify and examine the factors affecting OSH implementation in the electricity transmission sector by analyzing the relationships among safety knowledge, safety culture, safety leadership, safety attitude, and safety citizenship behavior. A quantitative approach was employed using the Partial Least Squares Structural Equation Modeling (PLS-SEM) method. Data were collected through questionnaires distributed to 125 employees and outsourced personnel within the transmission management unit of PT PLN (Persero). The research model was evaluated through measurement model and structural model assessments, including validity, reliability, coefficient of determination (R^2), predictive relevance (Q^2), effect size, goodness-of-fit evaluation, and hypothesis testing using bootstrapping analysis. The results indicate that seven out of the eight proposed hypotheses were supported. Safety knowledge, safety leadership, and safety attitude significantly influenced safety citizenship behavior, with safety leadership demonstrating the strongest effect on safety culture ($\beta = 0.575$), and safety attitude significantly affecting safety citizenship behavior ($\beta = 0.544$). However, safety culture did not significantly influence safety attitude. The findings highlight that improving OSH implementation requires strengthening safety leadership, enhancing safety knowledge, and developing positive safety attitudes among workers. This study provides strategic recommendations for improving safety programs and supporting the achievement of zero accidents in the electricity transmission sector.

INTRODUCTION

The electricity sector is one of the essential elements of modern life, serving as an energy source for business centers, commercial activities, offices, residential areas, and various other activities (Golmohamadi, 2022). The electricity distribution process involves a relatively long chain, beginning with electricity generation, followed by transmission through the transmission network, and finally distribution to customers. However, its implementation involves several potential hazards that may lead to occupational accidents, including work under high-pressure conditions, work at heights, dynamic field environments, and social risks.

To minimize the occurrence of occupational accidents, a more comprehensive Occupational Safety and Health (OSH) implementation is required to enable early risk mitigation. According to the International Labour Organization (ILO), OSH refers to a series of efforts aimed at maintaining workers' health conditions, preventing work-related health problems, protecting workers from occupational risks, and creating a safe working environment (Dermawan & Sahri, 2022).

The electricity transmission sector has relatively higher occupational risks compared with the distribution sector. From the perspective of the work environment, transmission activities are conducted on transmission towers that are significantly higher than distribution networks. Furthermore, in terms of voltage levels, transmission systems involve higher electrical hazards, including 500 kV, 150 kV, and 70 kV systems, compared with distribution systems operating at 20 kV and 380 V. These differences in voltage levels indicate variations in work procedures, safety requirements, and potential risks associated with the activities performed.

Based on internal occupational accident data from PT PLN (Persero) for the period of 2024 to August 2025, within the transmission sector, approximately 17% of occupational accidents involved organic employees, who are expected to have a stronger understanding of and commitment to OSH implementation. The high proportion of incidents involving organic employees indicates that routine operational and maintenance activities in the transmission sector still have the potential to cause serious injuries and fatalities. Failure to comply with safe work procedures remains the primary cause of fatal occupational accidents, particularly incidents involving workers who disregard safe working distances and fail to ensure that work is performed under de-energized conditions (Chen et al., 2024).

Several previous studies have indicated that OSH implementation in the electricity sector generally involves a high risk of occupational accidents. Chen et al. (2024) reported that between 2012 and 2021, there were 235 incidents in electricity companies in China caused by falls from heights and electrical shocks, resulting in 257 fatalities and 19 injuries. Basahel (2021) emphasized that electricity construction projects are among the highest-risk projects in the industrial sector in Saudi Arabia. Unsafe work behavior has also been identified as one of the contributing factors to occupational accidents in this sector (Dai et al., 2023). However, previous research has not extensively examined the electricity transmission sector. Swanda and Basuki (2023) investigated safety issues in the electrical power distribution sector, whereas Basahel (2021) focused on transmission construction projects. Most previous studies have been conducted in the construction, transportation, and manufacturing sectors, while further investigation of OSH implementation, particularly in the electricity transmission sector, remains necessary.

Several previous studies have successfully applied Structural Equation Modeling (SEM) to examine relationships among safety leadership, safety attitude, safety culture, safety knowledge, and safety citizenship behavior variables. Basahel (2021) applied SEM to investigate the relationship between safety leadership and individual safety attitudes, demonstrating their impact on improving safety motivation and safety knowledge, which positively influence worker compliance. Adra et al. (2024) further stated that even a slight improvement in safety leadership can significantly enhance occupational safety performance. Lai et al. (2023) explained that safety attitude serves as an indicator of an organization's readiness to control and prevent incidents. Hien et al. (2024) stated that safety culture consists of technical activities, social behaviors, attitudes, beliefs, and norms aimed at minimizing the consequences of hazardous conditions. Zhao et al. (2021) described safety knowledge as the level of workers' understanding of safety-related information, procedures, and actions required to perform work safely. Occupational accident prevention can also be achieved by strengthening employees' voluntary safety-related behaviors, commonly referred to as safety citizenship behavior (Ulawia & Sudiarno, 2025).

The results of this study are expected to provide not only theoretical contributions to the development of OSH practices in the electricity transmission sector but also practical recommendations for improving the effectiveness of sustainable OSH implementation. Practically, this research is expected to support the zero-accident program in the electricity transmission sector by strengthening factors proven to significantly influence OSH implementation.

This study has several limitations that should be considered. First, the research object is limited to employees and outsourced personnel within the transmission management unit of PT PLN (Persero), meaning that the generalizability of the findings should be interpreted carefully when applied to different organizational contexts. Second, the data represent respondents' perceptions collected through questionnaires and do not incorporate long-term field observations or historical occupational accident records. Third, the study is limited to five latent variables, while other factors, such as intrinsic motivation, work environment conditions, and individual personality characteristics, were not included in the research model. Fourth, the cross-sectional research design limits the ability to capture changes in safety behavior over time. Nevertheless, the findings provide a significant contribution as a foundation for developing safety programs in the electricity transmission sector and may serve as a reference for future research with broader scopes.

To address these limitations, future research is recommended to expand the sample scope by involving multiple transmission management units across different regions to obtain a more nationally representative perspective. The application of mixed-method approaches that combine quantitative and qualitative methods, including in-depth interviews and field observations, is also recommended to provide a deeper understanding of the phenomenon under investigation. Furthermore, longitudinal research designs may be considered to examine changes in safety behavior over time and evaluate the long-term impact of the strategic recommendations proposed in this study.

This study employs a Structural Equation Modeling (SEM) approach, which enables simultaneous and comprehensive testing of relationships among latent variables. This method was selected because it can examine direct and indirect relationships among variables within complex predictive conceptual models (Pan & Wu, 2024). In addition, SEM is effective for testing and predicting relationships among variables under conditions involving non-normal data distributions, relatively small sample sizes, and exploratory or predictive research models (Demir & Uşak, 2025). Previous studies examining OSH implementation using SEM have primarily focused on the construction, transportation, and manufacturing sectors; therefore, specific research addressing the electricity transmission sector remains limited. This study focuses on identifying factors influencing OSH implementation by analyzing the relationships among safety knowledge, safety leadership, safety culture, safety attitude, and their implications for safety citizenship behavior in the electricity transmission sector. The objectives of this research are to: (1) identify and analyze factors influencing OSH implementation in the electricity transmission sector; (2) examine the relationships among these variables using the SEM approach; and (3) provide strategic recommendations to improve the effectiveness of OSH implementation.

METHOD

Research Design

This study employed a quantitative approach using the Partial Least Squares Structural Equation Modeling (PLS-SEM) method. The independent variables were safety knowledge (X1), safety culture (X2), and safety leadership (X3); safety attitude (Y1) served as the mediating variable; and safety citizenship behavior (Z1) was the dependent variable. Each construct was measured using reflective indicators adapted from previous studies. Safety knowledge was measured using three dimensions with nine indicators: safety procedures at work, hazard risk awareness, and safety coaching (Widyanty et al., 2021; Ulawia & Sudiarno, 2025). Safety culture was measured using three dimensions with ten indicators: communication, safety involvement, and a supervisory and supportive environment (Xu et al., 2025). Safety leadership was measured using four dimensions with eight indicators: role modeling, vision motivation, caring and respect, and performance control (Xu et al., 2025). Safety attitude was measured using three dimensions with eight indicators: safety awareness, safety behavior tendency, and safety emotion (Li et al., 2020). Safety citizenship behavior was measured using three dimensions with seven indicators adapted from Widyanty et al. (2021), Hien et al. (2024), and Ulawia and Sudiarno (2025).

Hypothesis Development

Based on a literature review and previous research, this study developed eight hypotheses as follows: H1: safety knowledge has a positive effect on safety culture (Carissa et al., 2025; Zhao et al., 2021); H2: safety leadership has a positive effect on safety culture (Xu et al., 2025; Amirah et al., 2024); H3: safety culture has a positive effect on safety attitude (Hien et al., 2024); H4: safety knowledge has a positive effect on safety attitude (Ulawia & Sudiarno, 2025); H5: safety leadership has a positive effect on safety attitude (Li et al., 2020); H6: safety attitude has a positive effect on safety citizenship behaviour (Hien et al., 2024); H7: safety knowledge has a positive effect on safety citizenship behavior (Laurent et al., 2020); and H8: safety leadership has a positive effect on safety citizenship behavior (Li et al., 2020).

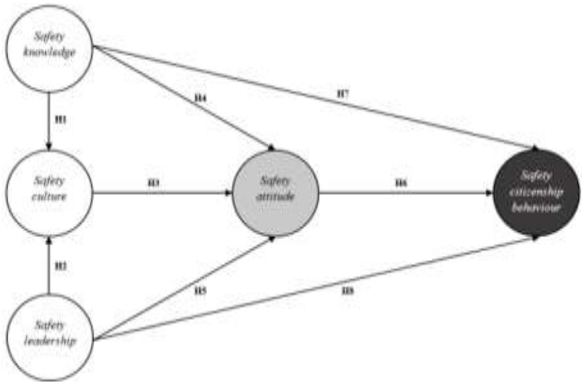


Figure 1. Conceptual model

Population, Sample, and Data Collection

The research population is employees and outsourced personnel (TAD) in the transmission management unit of PT PLN (Persero) who carry out high-risk operation and maintenance work. The sample selection used purposive sampling with a total of 125 respondents. The data was collected through a questionnaire with a 5-point Likert scale that was disseminated through a google form. Respondent profiles: the majority of organic employees (84.8%), D4/S1 educated (48.0%), male (92.0%), aged 31–40 years (58.4%), and working period >10 years (40.8%). The demographics show that respondents are experienced workers who are relevant to provide perceptions related to the implementation of K3 in the field of electricity transmission. In more detail, the characteristics of the respondents are conveyed in Table 1 below.

The diversity of respondents' characteristics in terms of education, age, and working period provides a more comprehensive perspective on the implementation of occupational safety, understanding of operational procedures, and safety behaviors at various levels of experience. Respondents with bachelor's education levels supported an understanding of technical and operational aspects, while respondents with vocational education provided a practical perspective of the implementation of work in the field.

Table 1. Respondent Demographics

Description	Variabel	Quantity	Percentage
Employment Status	Employees	106	84,8%
	Outsourced Power (TAD)	19	15,2%
Final Education	High School/SMK/D1/Equivalent	34	27,2%
	D3	22	17,6%
	D4/S1	60	48,0%
	S2	9	7,2%
Gender	Male – Male	115	92,0%
	Women	10	8,0%
Age Range	21 – 30 Years	48	38,4%
	31 – 40 Years	73	58,4%
	≥ 41 years old	4	3,2%
Tenure	1 – 5 Years	29	23,2%
	6 – 10 Years	45	36%
	> 10 Years	51	40,8%

Data Analysis Techniques

Data analysis using SmartPLS V.4.1.1.8 with stages: (1) multivariate assumption test including normality (Kolmogorov-Smirnov) and multicollinearity (VIF < 5); (2) evaluation of the measurement model (outer model) through convergent validity (loading factor ≥ 0.7 and AVE > 0.5), discriminant validity (Fornell-Larcker criterion and HTMT < 0.9), and reliability (composite reliability and Cronbach's alpha > 0.7); and (3) evaluation of structural model (inner model) through R^2, effect size (f^2), predictive relevance (Q^2), goodness of fit (SRMR < 0.08), and path coefficient through bootstrapping. Significance criteria: t-statistic ≥ 1.96 and p-value < 0.05.

RESULT AND DISCUSSION

Descriptive Analysis

Descriptive analysis showed that all research variables had high average indicator values (above 4.0 on a scale of 5). In the safety knowledge variable, the indicator of understanding the correct use of PPE (X1.2) obtained the highest mean of 4.656, while the indicator of understanding safe work steps according to procedures (X1.1) obtained a mean of 4.576. The indicator of identification of potential hazards (X1.4) obtained a mean of 4,600 and accident prevention measures (X1.3) obtained a mean of 4.584. These results show that workers have a good understanding of safety practices.

In the safety culture variable, the indicator of support between colleagues (X2.7) had a mean of 4.536, freedom of expression (X2.3) obtained a mean of 4.512, safety communication (X2.8) obtained a mean of 4.496, and the availability of adequate equipment (X2.10) obtained a mean of 4.480. The safety leadership variable showed that the leader exemplary indicator (X3.2) obtained the highest mean of 4,512, the special attention of the leader (X3.6) obtained a mean of 4,480, and the provision of discussion forums (X3.5) obtained a mean of 4,464. The safety attitude variable showed that the indicator of feeling calm when the procedure was implemented (Y1.7) obtained the highest mean of 4.680, the confidence in accident prevention (Y1.2) obtained the mean of 4.672, and the understanding of the importance of the procedure (Y1.1) obtained a mean of 4.608. The safety citizenship behaviour variable showed that the risk reporting indicator (Z1.4) obtained the highest mean of 4,656, the provision of input (Z1.5) obtained a mean of 4,568, and the sharing of experiences (Z1.7) obtained a mean of 4,560.

The high average score on all variables indicates that in general the respondents have a good level of knowledge, culture, leadership, attitude, and safety behavior. However, there are still variations between indicators that show room for improvement, especially in aspects that have a relatively lower mean value than other indicators in the same construct.

Evaluation of the Multicolinertity Test

The multicolliarity test was performed to ensure that there was no high correlation between latent constructs in the research model. If there is too strong a relationship between the constructs, it affects the stability of the model and reduces the accuracy of the relationship analysis. The results of the multicollinearity test were shown by the *Variance Inflation Factor* (VIF) value produced by the relationship between the latent constructs of the study with a threshold value below 5 (VIF < 5).

The results of the multicollinearity test in Table 2 obtained a VIF value between 2.004 and 4.454 which shows that it is still at the set limit so that the relationship between variables can be accepted. This indicates that each variable, namely *safety knowledge*, *safety leadership*, *safety culture*, and *safety attitude*, is a variable that can contribute independently to explaining the dependent variables in the research model.

Table 2. Multicollinearity Test Results

Variable Relationships	LIVE
Safety Leadership → Safety Culture	2,004
Safety Knowledge → Safety Culture	2,004
Safety Attitude → Safety Citizenship Behaviour	2,324
Safety Knowledge → Safety Citizenship Behaviour	2,364
Safety Leadership → Safety Citizenship Behaviour	2,421
Safety Knowledge → Safety Attitude	2,672
Safety Leadership → Safety Attitude	3,416
Safety Culture → Safety Attitude	4,454

Evaluation of Measurement Models (*Outer Model*)

Testing of the measurement model (*outer model*) to ensure latent construct relationships through the indicators used to measure them. In this study, the evaluation of the measurement model (*outer model*) uses several tests, including the indicator validity test (*convergent validity*), the *discriminant validity test*, and the reliability test.

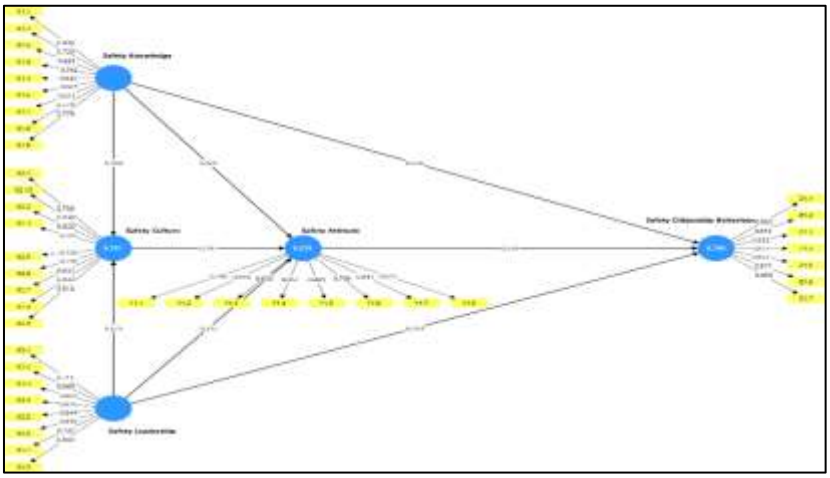
Convergent validity *testing* through *loading factor* in the first stage showed that one indicator (X2.4) had a value of 0.561 (< 0.7) so it was eliminated. After elimination, all 41 indicators had a *loading factor* ≥ 0.7 with a range of 0.705 (X2.3) to 0.882 (Z1.1) shown in Figure 2. In addition, *the results of the Average Variance Extracted* (AVE) test are between 0.619 to 0.747 with an AVE value threshold of > 0.5 and *the results of the Composite Reliability* (CR) test are between 0.936 – 0.954 with a CR value threshold between 0.7 – 0.95. These results show that all constructs have an excellent level of reliability so that they are declared to meet the *convergent validity* described in Table 3.

Furthermore, a *discriminant validity* test is carried out which aims to ensure that each latent construct has different characteristics and is able to represent the concept that is measured specifically compared to other constructs in the research model. This test was carried out using the *Fornell-Larcker approach* showing that the square root of the AVE of each construct was greater than the correlation between other constructs and *the Heterotrait-Monotrait Ratio* (HTMT) was < 0.9, so that the discriminant validity was met.

Table 3. Convergent Validity *Test Results*

Variabel	AVE	Composite Reliability	Cronbach's Alpha
Safety Knowledge (SK)	0,640	0,941	0,930
Safety Culture (SC)	0,619	0,936	0,924
Safety Leadership (SL)	0,650	0,937	0,924
Safety Attitude (SA)	0,673	0,943	0,932

Safety Citizenship Behaviour (SCB)	0,747	0,954	0,944



Gambar 2. *Outer loading*

Table 4. Results of the *discriminant validity* test (*Fornell-Larcker*)

	SA	SCB	SC	EN	SL
SA	0,82				
SCB	0,844	0,864			
SC	0,7	0,742	0,787		
EN	0,693	0,747	0,766	0,8	
SL	0,702	0,746	0,829	0,708	0,806

Tabel 5. Hasil Uji *discriminant validity* (*Heterotrait-Monotrait Ratio* / HTMT)

	SA	SCB	SC	EN	SL
SA					
SCB	0,897				
SC	0,744	0,789			
EN	0,738	0,797	0,817		
SL	0,749	0,792	0,889	0,755	

The results *of the Fornell-Larcker test* showed that there was a correlation between constructs that was greater than the square root of the AVE construct, namely the correlation between *safety attitude* (SA) and *safety citizenship behaviour* (SCB) of 0.844 and the correlation between *safety culture* and *safety leadership* (SL) of 0.829 as shown in Table 4. This condition indicates that the conceptual proximity between constructs is strong enough that the validity of the discriminator based on the *Fornell-Larcker* criteria is not fully optimal in some correlations between constructs. According to the discriminant J. F. Hair et al. (2021) *validity test, the* Heterotrait-Monotrait Ratio *(HTMT) approach should be used* so that the resulting assessment is more valid. This is reinforced by the *Fornell-Larcker* method also having a lower sensitivity to detect the problem of discriminant validity.

The results *of the Heterotrait-Monotrait Ratio* (HTMT) test in Table 5 show that all constructs have a ≤ value of 0.9 which indicates a good level of discriminant validity because each variable represents a different or empirically unique concept and does not experience conceptual overlap between constructs. This shows that *discriminant validity* is fulfilled so that the research is continued to the next stage, namely the evaluation of the structural model (*inner model*).

Evaluation of Structural Models (*Inner Model*)

Evaluation of structural models (*inner models*) which aims to test the relationships between latent constructs in the research model and assess the model's ability to explain the influence between latent constructs. This test can be known through the relationship between exogenous variables and endogenous variables and endogenous variables with other endogenous variables. In order to measure the structural model (inner model), several tests were carried out, including *the coefficient of determinant* (R2), *predictive relevance* (Q2), *effect size* (f2), *goodness of fit* (GoF), and *path coefficient*.

The coefficient of determinant (R2) is used to measure the ability of exogenous variables to explain the endogenous variables contained in the research model. The value of R2 indicates the large proportion of variations in endogenous constructs that can be explained by exogenous constructs that affect them in the conceptual model that is created so that the higher the R2 value, the better the model.

The *safety citizenship behaviour variable* had the highest R^2 of 0.780, indicating that 78% of the variation could be explained by exogenous variables. This means that *safety knowledge, safety leadership,* and *safety attitude* together have a very good ability to explain changes in voluntary behavior in worker safety. The *safety culture* variable obtained an R^2 of 0.751 (strong category) which indicates *that safety knowledge* and *safety leadership* are able to explain 75.1% of the variation in safety culture. The *safety attitude* variable obtained an R^2 of 0.579 (medium category). All endogenous variables had a $Q^2 > 0$ with a large category, indicating the model's excellent predictive capabilities. An SRMR value of 0.071 (< 0.08) indicates a good and ideal fit model.

In more detail, the Q2 value for the *safety culture* variable obtained the highest value of 0.720, indicating that the construct that affects the variable has a very large predictive ability for the formation of a work safety culture. The *safety citizenship behavior* variable obtained a Q2 of 0.623, showing that the relationship between latent constructs is able to represent empirical conditions well in predicting the voluntary behavior of workers to work safely. The *safety attitude* variable obtained a Q2 of 0.524, indicating a strong predictive ability for the formation of safety behavior in the electricity transmission work environment. The results of the R2 and Q2 tests are presented in Table 5 below.

Table 5. R2 and Q2 results

Variable endogenous	R^2	Category R^2	Q^2	Category Q^2
Safety Attitude (SA)	0,579	Medium	0,524	Large
Safety Citizenship Behaviour (SCB)	0,780	Strong	0,623	Large
Safety Culture (SC)	0,751	Strong	0,720	Large

The largest influence was found in the relationship *between safety leadership* and *safety culture* ($f^2 = 0.662$) and *safety attitude* to *safety citizenship behaviour* ($f^2 = 0.578$), both of which were in the large category. *Safety knowledge* of safety *culture* has a moderate *effect size* ($f^2 = 0.257$), while the relationship between other variables is included in the small category.

The finding that *safety leadership* has the largest *effect size* on safety culture ($f^2 = 0.662$) has important implications for organizational management. This shows that if the *safety leadership* variable is eliminated from the model, the model's ability to explain *safety culture* will decrease significantly. Thus, an organization's investment in the development of safety leadership capabilities is the most effective strategy to build a strong safety culture. Similarly, safety attitudes had a large *effect size* on *safety citizenship behaviour* ($f^2 = 0.578$), indicating that the formation of a positive attitude towards safety is the main key to encouraging safety voluntary behaviour in the work environment. Meanwhile, relationships with *small effect sizes* suggest that although statistically significant, the direct influence of these exogenous variables is relatively small and is likely mediated by other variables in the model. The results of *the effect size* test are described in Table 6.

In order to provide an overview of the quality and feasibility of the research model, a *Goodness of Fit* (GoF) evaluation was carried out which was assessed through several indicators such as *Standardized Root mean Square Residual* (SRMR) and *Normed Fit Index* (NFI). According to the limit of the SRMR value used as a reference is below 0.08 so it can be said that the research model is in the good category. Meanwhile, the NFI value according to states that a model is declared good if it has an NFI value close to 1 or above 0.9. The Guenther et al. (2023) Dash & Paul (2021) *Goodness of Fit* (GoF) test is presented in Table 7

Table 6. Effect Size (f^2) Test Results

Variable Relationships	f^2	Category
Safety Leadership (SL) → Safety Culture (SC)	0,662	Large
Safety Attitude (SA) → Safety Citizenship Behaviour (SCB)	0,578	Large
Safety Knowledge (SK) → Safety Culture (SC)	0,257	Medium
Safety Knowledge (SK) → Safety Attitude (SA)	0,099	Small
Safety Knowledge (SK) → Safety Citizenship Behaviour (SCB)	0,098	Small
Safety Leadership (SL) → Safety Citizenship Behaviour (SCB)	0,078	Small
Safety Leadership (SL) → Safety Attitude (SA)	0,070	Small
Safety Culture (SC) → Safety Attitude (SA)	0,022	Small

Table 7. Goodness of Fit *(GoF)* Test Results

Goodness of Fit Index	Value	Remarks
Standarized Root Mean Square Residual (SRMR)	0,071	Good fit model
Normed Fit Index (NFI)	0,651	Moderate

Judging from the SRMR value of 0.071, it indicates that the research model has a good and ideal level of suitability, so that there is a relatively small difference between the observed correlation matrix and the correlation matrix studied. The NFI value produced was 0.651 so it did not meet the minimum recommended standard. However, NFI is not the only basis for determining *model fit*, so that the low NFI value in PLS-SEM is a common condition because it is not the main criterion for assessing the feasibility of the model. Therefore, the research model can still be accepted and continued as long as other indicators such as SRMR, R2, and Q2 are indicated to be good.

Further testing *path coefficient* It was carried out to analyze the direction and strength of correlations between latent constructs. Hypothesis testing through *bootstrapping* by considering the value of *t-statistic* and *p-value* which indicates that the construct has a significant correlation if it meets the set criteria so that the hypothesis is declared accepted or rejected with the results contained in Table 8 below.

Of the 8 hypotheses tested, as many as 7 hypotheses were declared accepted while 1 hypothesis was rejected (H3) until it was stated that *safety culture* did not have a positive effect on *safety attitude*. The hypotheses that were accepted and showed the strongest were *safety leadership* towards *safety culture* (β = 0.575) and *safety attitude* towards *safety citizenship behaviour* (β = 0.544)

Table 8. Path Coefficient *Test Results* and Hypothesis Testing

H	Variable Relationships	b	t-stat	p-value	Verdict
H1	Safety Knowledge (SK) → Safety Culture (SC)	0,358	3,667	0,000	Accepted
H2	Safety Leadership (SL) → Safety Culture (SC)	0,575	7,123	0,000	Accepted
H3	Safety Culture (SC) → Safety Attitude (SA)	0,192	1,044	0,296	Rejected
H4	Safety Knowledge (SK) → Safety Attitude (SA)	0,325	2,189	0,029	Accepted
H5	Safety Leadership (SL) → Safety Attitude (SA)	0,313	1,965	0,049	Accepted
H6	Safety Attitude (SA) → Safety Citizenship Behaviour (SCB)	0,544	5,511	0,000	Accepted
H7	Safety Knowledge (SK) → Safety Citizenship Behaviour (SCB)	0,226	2,772	0,006	Accepted
H8	Safety Leadership (SL) → Safety Citizenship Behaviour (SCB)	0,204	2,031	0,042	Accepted

Discussion of Hypothesis Testing

The Influence *of Safety Knowledge* and *Safety Leadership* on *Safety Culture* (H1 and H2).

The test results showed that *safety knowledge* (β = 0.358; p = 0.000) and *safety leadership* (β = 0.575; p = 0.000) had a positive and significant effect on *safety culture*. *Safety leadership* was the strongest predictor with a large *effect size* ($f^2 = 0.662$), suggesting that safety-first leadership directly encourages the formation of a safety culture in the workplace. The leader's ability indicator provides an example of compliance with safety regulations (X3.2) obtained the highest *mean* of 4.512, indicating that the leader's example has gone well. In the *safety culture variable*, the indicator of support between colleagues (X2.7) had a *mean* of 4.536 and freedom to express opinions on safety issues (X2.3) obtained a *mean* of 4.512, indicating that the work environment has implemented open safety communication. These results are in line with Xu et al. (2025) who stated that effective leadership patterns can instill safety values and shape safe work behaviors, and Carissa et al. (2025) who show that *safety knowledge* has a significant effect on *safety culture* in high-risk industries.

The Effect of *Safety Culture* on *Safety Attitude* (H3)

Safety culture had a positive but insignificant effect on *safety attitude* (β = 0.192; t = 1.044; p = 0.296). Although the *safety culture* indicator shows a high average value, the existing safety culture has not had a significant effect on the formation of individual safety attitudes. This is likely because *safety attitudes* in transmission workers are more influenced by individual factors such as direct work experience in the field, perception of personal risks, and intrinsic motivation. In high-risk jobs, experienced workers often form safety attitudes through direct experience so that the influence of organizational culture becomes less dominant. These findings are different from Hien et al. (2024) in the oil and gas industry and Alsobou et al. (2025) in the health sector, indicating that the context of electricity transmission has unique characteristics. Organizations need to strengthen other approaches such as *safety training for managers*, personal coaching through *counseling, coaching, mentoring* (CMC), and increasing the direct involvement of workers in safety programs.

The Effect *of Safety Knowledge* and *Safety Leadership* on *Safety Attitude* (H4 and H5)

Safety knowledge (β = 0.325; p = 0.029) and *safety leadership* (β = 0.313; p = 0.049) had a positive and significant effect on *safety attitude*. Employees who understand safety procedures, hazard identification, and risk control show a positive attitude towards K3. The indicator of correct use of PPE (X1.2) obtained the highest *mean* of 4.656, while the indicator of feeling calmer when safety procedures were applied (Y1.7) obtained a *mean* of 4.680. Leaders who set an example, build consistent communication, and become effective *role models* increase worker awareness. These findings are consistent with Ulawia & Sudiarno (2025), Rizky et al. (2025), and Li et al. (2020) who found that safety knowledge and leadership have a significant effect on the formation of worker safety attitudes.

More deeply, the relationship between safety knowledge and safety attitude can be explained through cognitive mechanisms where workers who have adequate knowledge about the consequences of unsafe behavior will form a more accurate risk assessment. Such accurate risk assessments further form a positive attitude towards safety because workers understand that compliance with procedures is not just an administrative obligation, but an effort to protect themselves and their colleagues. In the context of electricity transmission, where the consequences of non-compliance can be fatal, a deep understanding of the hazards is the foundation for the formation of a strong safety attitude. Meanwhile, safety leadership forms safety attitudes through social mechanisms where workers tend to adopt the values and behaviors shown by their leaders. Leaders who consistently put safety as a top priority will create positive social pressure that encourages workers to have similar attitudes.

Pengaruh *Safety Attitude* terhadap *Safety Citizenship Behaviour* (H6).

Safety attitude had a positive and significant effect on *safety citizenship behavior* (β = 0.544; p = 0.000) with a large *effect size* (f^2 = 0.578). This is the second strongest relationship, showing *safety attitude* as the main psychological factor driving safety voluntary behavior. Workers who have a strong belief in the importance of safety are more likely to voluntarily provide safe work examples, report hazards, share knowledge, and actively participate in safety improvements even if the actions are outside the *job description*. The risk reporting responsibility indicator (Z1.4) obtained the highest *mean* of 4,656 and the safety input indicator (Z1.5) obtained a *mean* of 4,568. In line with Ulawia & Sudiarno (2025), Hien et al. (2024), and Basahel (2021) who stated that workers with a high awareness of safety will be more motivated to take voluntary actions to support the creation of a safe work environment.

The mechanism of the influence of safety attitude on safety citizenship behavior in the field of electricity transmission can be understood through the perspective of the theory of planned behavior (Theory of Planned Behavior). Workers who have a positive attitude towards safety (affective component) and belief that safety measures will provide benefits (cognitive component) tend to have a strong intention to take proactive safety actions. This intention is then manifested in the form of voluntary behavior such as hazard reporting, knowledge sharing, and providing input for improvements. In the electricity transmission sector which is a high-reliability organization, voluntary safety behavior is very crucial because not all potential hazards can be anticipated by formal procedures. Workers who voluntarily report unsafe conditions or provide feedback on improvements contribute directly to the prevention of accidents that may not be detected by formal systems.

The Effect *of Safety Knowledge* and *Safety Leadership* on *Safety Citizenship Behavior* (H7 and H8).

Safety knowledge (β = 0.226; p = 0.006) and *safety leadership* (β = 0.204; p = 0.042) had a positive and significant effect on *safety citizenship behavior*. Workers who understand the consequences of risk tend to take proactive actions beyond the *job description*, such as reporting hazards, sharing experiences, and providing safety feedback. Leaders who consistently demonstrate a commitment to safety through exemplary (X3.2), special attention (X3.6), and facilitation of learning (X3.5) directly impact risk reporting (Z1.4), knowledge sharing (Z1.7), and providing safety feedback (Z1.5). Laurent et al. (2020) show that *safety knowledge* plays a significant role in encouraging *safety citizenship behavior*, while Li et al. (2020) stated that *safety leadership* is an important factor through communication, support, and example.

Widyanty et al. (2021) found that workers who have high safety knowledge show a greater willingness to make voluntary contributions in supporting occupational safety. Safety knowledge helps individuals understand the consequences of unsafe actions so as to increase concern for mutual safety. Basahel (2021) also showed that workers who understand the consequences of work risks have higher motivation to create a safe work environment. In the context of electricity transmission, the ability to recognize potential hazards such as induction voltage, arc *flash* hazards, and the risk of falling from heights is the main trigger for the emergence of proactive behavior. Workers who have in-depth knowledge of these hazards not only keep themselves safe, but also actively warn co-workers and report potentially dangerous conditions. This shows that investment in comprehensive and sustainable safety training programs is an effective strategy to improve safety citizenship behaviour in the electricity transmission sector.

Strategic Recommendations

Based on the test results, strategic recommendations were formulated for the implementation of K3 in the field of electricity transmission. To strengthen the relationship between *safety attitude → safety citizenship behavior* which has a large *effect size*: (a) *routine safety sharing* periodically in the field of transmission as a lesson *learned* media; (b) *Hazard Reporting culture campaigns through* online *written reporting* and communication groups; (c) *Safety Champion* program with *a reward* system for workers who implement safety well; and (d) *Near Miss* and *Unsafe Conditions* discussion forums to prevent similar incidents and formulate preventive measures.

In order to strengthen *safety leadership → safety culture* as the strongest relationship: (a) *safety leadership training* for managers and supervisors to be able to be role models, build effective communication, and encourage worker involvement; (b) inspection of K3 management on routine work in the substation environment; and (c) integration *of K3 maturity level* in organizational KPIs as an achievement enhancer. To strengthen *safety knowledge*: periodic K3 *refreshments* include the preparation of HIRARC and JSA, technical competency certification (working at height, rescue from height), and emergency response simulation (equipment fire, electric shock handling, worker evacuation).

Furthermore, to strengthen the relationship that has not yet been significant (*safety culture → safety attitude*): (a) open two-way communication between management and workers; (b) *Safety Culture Internalization Program* that emphasizes safety as a shared responsibility; (c) *safety observation and feedback* through observation of work behavior in the field with direct feedback; and (d) the involvement of workers in the preparation of safe work procedures based on direct experience in the field.

The successful implementation of these strategic recommendations requires a strong commitment from all levels of the organization, from top management to workers in the field. Leaders at all levels must demonstrate a real commitment to safety through adequate resource allocation, active participation in safety programs, and consistency in enforcing safety procedures without compromise. With consistent support from leaders, improving safety competencies, and strengthening safety culture and attitudes, it is hoped that the implementation of K3 in the field of electricity transmission will be able to create a safe, reliable, and consistent work environment that supports the achievement of the zero accident target. In addition, the application of digital technology in supporting K3 such as the development of applications for HIRARC (*Hazard Identification Risk Assessment and Risk Control*), JSA (*Job Safety Analysis*), and *Working Permit* inputs digitally needs to be prioritized to shorten K3 communication and increase the accessibility of safety information for all workers in the field.

The findings of the rejection of H3 are one of the important contributions of this study because it shows that in the specific context of the field of electricity transmission, the mechanism for forming worker safety attitudes has a different path than other industrial sectors. In the oil and gas industry (Hien et al., 2024) and the health sector (Alsobou et al., 2025), a strong organizational culture has been proven to be able to shape individual attitudes because workers tend to follow group norms. However, in the field of electricity transmission, where workers often work in isolated conditions in transmission towers or substations far from direct supervision, individual factors such as experience of dealing with emergency situations, personal risk perception of high-voltage hazards, and intrinsic motivation to maintain personal safety become more dominant in shaping safety attitudes than the influence of the organization's culture as a whole.

The implication of these findings is that organizations in the electricity transmission sector cannot solely rely on strengthening safety cultures to shape worker safety attitudes. A more personalized and experience-based approach is needed, such as mentoring programs between senior and junior workers, real-life incident-based case studies in the transmission environment, and personal coaching through counseling and coaching tailored to the characteristics and experiences of each worker. This approach is expected to complement the influence of a safety culture that has been running well so that worker safety attitudes can be formed more comprehensively.

CONCLUSION

Based on the results of hypothesis testing, the following conclusions can be drawn. First, the factors influencing OSH implementation in the electricity transmission sector, as represented by safety citizenship behavior, were directly affected by safety knowledge, safety leadership, and safety attitude. Among the eight proposed hypotheses, seven were supported, while one was rejected, namely the relationship between safety culture and safety attitude, which was found to be insignificant. Second, safety citizenship behavior was the largest endogenous variable, with an R^2 value of 0.780, indicating that 78% of its variance was explained by the proposed model, while the remaining 22% was explained by other variables outside the model. The strongest relationships were observed between safety leadership and safety culture ($\beta = 0.575$) and between safety attitude and safety citizenship behavior ($\beta = 0.544$). Third, strategic recommendations include strengthening safety communication and knowledge-sharing activities, improving hazard reporting systems, conducting safety leadership training, implementing regular OSH refreshment programs, enhancing competency certification, conducting emergency response simulations, and strengthening safety culture through safety observations, feedback mechanisms, and worker involvement in developing safe work procedures.

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