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The Role of Road Users' Discipline in Mediating The Equipment Function and Gatekeeper Competence on Level Crossing Safety in 2025 (Case Study: Jpl No. 46 Pondok Jati, East Jakarta)

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Abstract: Level crossing safety has become a critical issue in urban transportation systems, as these points serve as direct intersections between railway lines and road users. Amidst the high volume of daily mobility, level crossings not only contribute to traffic congestion but also pose a high risk of fatal accidents, especially when not supported by effective safety systems and disciplined user behavior. A clear example of this issue can be seen at the Direct Level Crossing (JPL) No. 46 Pondok Jati in East Jakarta, which is characterized by high traffic density, limited space, and frequent violations by road users. This study aims to analyze the mediating role of road user discipline in the relationship between the functionality of safety equipment and the competence of crossing guards on level crossing safety in 2025. A quantitative approach was used with Structural Equation Modeling based on Partial Least Squares (SEM-PLS) and 333 respondents. The analysis tested both direct and indirect relationships among the variables. The results show that the competence of crossing guards significantly influences both safety and user discipline. Discipline also plays a significant role in improving safety. Conversely, the functionality of safety equipment did not show a significant direct influence on discipline. Discipline was found to mediate the relationship between guard competence and safety, but not between equipment functionality and safety.

Keywords: Road Users' Discipline, Equipment Function, Gatekeeper Competence, Level Crossing Safety.

INTRODUCTION

Railway transportation is one of the main modes within the national transportation system, recognized for its efficiency, capacity for mass transport, and relative safety. The advantages of railways include dedicated tracks separate from public roads, affordable fares, and reliable travel time. However, railway safety is not solely determined by tracks and rolling stock; it is also influenced by points of interaction with other transportation modes, particularly at level crossings (Law of the Republic of Indonesia No. 23 of 2007 on Railways [(Undang-Undang Nomor 23 Tahun 2007 tentang Perkeretaapian]).

A level crossing is an intersection where a railway line and a roadway meet at the same grade (Regulation of the Minister of Transportation of the Republic of Indonesia No. PM 94 of 2018 on Enhancing Safety at Level Crossings Between Railway Tracks and Roads [(Peraturan Menteri Perhubungan Republik Indonesia Nomor PM 94 Tahun 2018 Peningkatan Keselamatan Perlintasan Sebidang Antara Jalur Kereta Api Dengan Jalan]). These locations are considered accident-prone due to the direct interaction between trains and road users without vertical separation. In practice, various accidents and near-miss incidents still occur frequently, even when the crossings are guarded and equipped with safety devices. A notable example is the Direct Crossing Point (JPL) No. 46 at Pondok Jati, East Jakarta, which, despite being equipped with automatic gates and 24-hour guard service, has continued to show an accident trend over the past five years.

Field data indicate that accidents at JPL No. 46 generally involve violations of road user discipline, such as breaching the gate or stopping too close to the tracks. This suggests that the presence of safety equipment and personnel alone is insufficient to ensure safety without the support of disciplined behavior among road users. This fact reinforces the hypothesis that level crossing safety results from interactions among multiple elements: safety equipment functionality, the competence of crossing gate operators, and the behavior of road users.

A level crossing is an intersection where a railway track and a road meet at the same grade. This location is considered accident-prone due to the direct interaction between trains and road users. According to the *Law of the Republic of Indonesia No. 23 of 2007 on Railways* (Undang-Undang Nomor 23 Tahun 2007 tentang Perkeretaapian) and the *Regulation of the Minister of Transportation of the Republic of Indonesia No. PM 94 of 2018 on Enhancing Safety at Level Crossings Between Railway Tracks and Road* (Peraturan Menteri Perhubungan Republik Indonesia Nomor PM 94 Tahun 2018 Peningkatan Keselamatan Perlintasan Sebidang Antara Jalur Kereta Api Dengan Jalan) The construction of a level crossing is only permitted when it is not feasible to build a grade-separated crossing. Furthermore, it must comply with technical safety requirements, be equipped with proper devices and personnel, and adhere to the established Standard Operating Procedures (SOP).

Function of Safety Equipment, based on the *Law of the Republic of Indonesia No. 23 of 2007 on Railways* (Undang-Undang Nomor 23 Tahun 2007 tentang Perkeretaapian) and the *Regulation of the Minister of Transportation of the Republic of Indonesia No. PM 94 of 2018 on Enhancing Safety at Level Crossings Between Railway Tracks and Roads* (Peraturan Menteri Perhubungan Republik Indonesia Nomor PM 94 Tahun 2018 Peningkatan Keselamatan Perlintasan Sebidang Antara Jalur Kereta Api Dengan Jalan), every level crossing must be equipped with safety devices such as protective barriers, light and sound signals, and automated control systems. According to Collins (2022) and Patel et al. (2022), safety equipment—whether manual or technology-based—functions to detect hazards, provide early warnings, and manage risks efficiently. The *Law of the Republic of Indonesia No. 22 of 2009 on Road Traffic and Transportation* (Undang-Undang Republik Indonesia Nomor 22 Tahun 2009 tentang Lalu Lintas dan Angkutan Jalan) also regulates the presence of traffic signs, markings, and control devices that must be obeyed by road users. Cui (2020) emphasizes the importance of incorporating safety facility design from the outset to prevent accidents. Therefore, safety equipment at level crossings serves as both a preventive and reactive protection system to ensure the safety of road users.

The competence of railway crossing gate operators is a critical ability required to ensure the safety of train operations and road users to ensure the safety of train operations and road users. According to the *Law of the Republic of Indonesia No. 13 of 2003 on Manpower*

(Undang-Undang Nomor 13 Tahun 2003 tentang Ketenagakerjaan) Competence encompasses knowledge, skills, and work attitudes in accordance with established standards. The *Regulation of the Minister of Transportation of the Republic of Indonesia No. PM 19 of 2011 on Railway Crossing Gate Operator Competency Certificates, as amended by Regulation No. PM 24 of 2023* (Peraturan Menteri Perhubungan RI Nomor PM 19 Tahun 2011 tentang Sertifikat Kecakapan Penjaga Perlintasan Kereta Api sebagaimana telah diubah dengan Peraturan Menteri Perhubungan RI Nomor PM 24 Tahun 2023 tentang Perubahan atas Peraturan Menteri Perhubungan Nomor PM 19 Tahun 2011 tentang Sertifikat Kecakapan Penjaga Perlintasan Kereta Api) stipulates that operator competence includes knowledge, technical skills, and professional attitudes that must be regularly updated in line with technological and regulatory developments. Spencer (as cited in Wardani and Fatimah, 2020) defines competence as a fundamental characteristic that determines performance effectiveness, while Dessler (2017) describes competence as a combination of knowledge, skills, behaviors, and leadership that contribute to job effectiveness. Furthermore, Wibowo (as cited in Masruroh et al., 2023) adds that competence refers to the ability to perform tasks based on skills, knowledge, and attitudes that meet job requirements.

Safety at Level Crossings. Workplace safety is part of human resource management, which is responsible for creating safe and injury-free working conditions through policies, training, and effective supervision (Mathis and Jackson, 2020). Hudson (2017) states that safety is the result of values, beliefs, and routine practices within an organization that shape a safety culture aimed at reducing risks. Bird and Germain (as cited in Ratnawati, 2021) emphasize that many accidents are caused by unsafe actions and hazardous environmental conditions. According to the *Regulation of the Minister of Transportation of the Republic of Indonesia No. PM 94 of 2018 on Enhancing Safety at Level Crossings Between Railway Tracks and Roads* (Peraturan Menteri Perhubungan Republik Indonesia Nomor PM 94 Tahun 2018 Peningkatan Keselamatan Perlintasan Sebidang Antara Jalur Kereta Api Dengan Jalan), Level crossing safety is defined as the fulfillment of technical requirements and traffic management measures at the intersection of railway tracks and roads to prevent accidents.

Road user discipline is a crucial factor in ensuring traffic safety and order. Mathis and Jackson (2020) describe discipline as consistent compliance behavior with regulations to create a safe and productive environment. Robbins and Coulter (2021) define discipline as the process of maintaining desired behavior and eliminating undesired behavior through consistent rules and consequences. Hasibuan (2021) defines work discipline as awareness and willingness to adhere to rules and social norms. Bejo Siswanto (as cited in Lisawanto, 2021) adds that discipline is an attitude of respect, obedience, and readiness to comply with both written and unwritten rules, as well as to accept sanctions if violations occur. According to the *Law of the Republic of Indonesia No. 22 of 2009 on Road Traffic and Transportation* (Undang-Undang Republik Indonesia Nomor 22 Tahun 2009 tentang Lalu Lintas dan Angkutan Jalan). Traffic discipline is reflected in the obligation to comply with traffic signs, road markings, signals, and instructions from officers to ensure safety and traffic flow.

Previous studies have examined each of these variables separately. However, research exploring the mediating role of road user discipline as a link between equipment functionality and operator competence in ensuring safety remains limited. Such an integrated approach is crucial to identify the most effective interventions to reduce accident rates. Therefore, this study aims to develop an empirical model of causal relationships among these variables, focusing on the case of JPL No. 46 at Pondok Jati, East Jakarta. The conceptual framework of this research is presented in Figure 1. Based on empirical evidence and theoretical foundation, the following hypotheses are proposed:

H1: Equipment Function affects the Level Crossing of Road Users
H2: Equipment Function affects the Discipline of Road Users

H3: Gatekeeper Competence affects the Level Crossing Safety.
H4: Gatekeeper Competence affects the Discipline of Road Users
H5: The Discipline of Road Users affects the Level Crossing Safety.
H6: Equipment Function has an indirect effect on the Level Crossing Safety through the Discipline of Road Users
H7: Equipment Function has an indirect effect on the Level Crossing Safety through Gatekeeper Competence

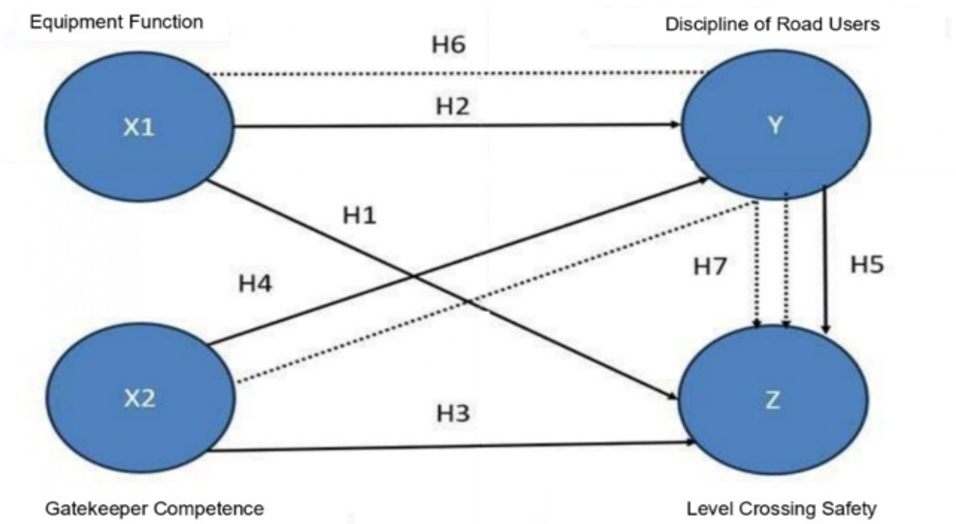

Figure 1: Conceptual Framework

METHOD

Data analysis in this study was carried out after all data from respondents had been collected, encompassing processes of grouping, tabulation, presentation by variable, and hypothesis testing (Sugiyono, 2020). This research employs a causal associative method aimed at analyzing the influence of the functionality of safety equipment and the competence of railway crossing gate operators on level crossing safety, with road user discipline serving as a mediating variable (Sugiyono, 2019).

The analytical method employed is Structural Equation Modeling–Partial Least Squares (SEM-PLS) using SmartPLS software version 4.1. SEM-PLS was selected because it is suitable for data that do not follow a normal distribution, involves a relatively moderate sample size, and accommodates models with simultaneous relationships among latent variables, including mediation. This approach emphasizes predictive capability and the explanation of variance in dependent variables (R^2) rather than solely assessing overall model fit (Hair et al., 2022). The research model consists of four latent constructs safety equipment functionality, gatekeeper competence, road user discipline, and level crossing safety that are analyzed to examine both direct and indirect effects.

Model testing was carried out in two stages. The first stage involved evaluating the measurement model (outer model) to assess the validity and reliability of the indicators. Convergent validity was determined based on an outer loading value of at least 0.70 and an Average Variance Extracted (AVE) of at least 0.50, while discriminant validity was assessed using the Heterotrait-Monotrait Ratio (HTMT) method with a threshold of <0.90 for the general standard or <0.85 for a more conservative approach. Construct reliability was evaluated using Cronbach’s Alpha and Composite Reliability (CR) with a minimum threshold of 0.70, although values between 0.60 and 0.70 are still acceptable for exploratory research (Hair et al., 2022).

The second stage involved testing the structural model (inner model) to evaluate the strength and direction of relationships among latent constructs. This evaluation included assessing multicollinearity using the Variance Inflation Factor (VIF) with values below 5, examining the coefficient of determination (R^2) to measure the proportion of variance explained by the model, calculating effect size (f^2) to determine the contribution of each independent variable, and testing predictive relevance (Q^2) through the blindfolding technique. Out-of-sample predictive ability was assessed using the Cross-Validated Predictive Ability Test (CVPAT), with evaluation criteria including a Q^2 predict value greater than zero and prediction errors lower than those of the benchmark model (linear model) (Hair et al., 2022).

Next, causal relationships were tested using path coefficients estimated through the bootstrapping technique, where relationships among constructs were considered significant when the t-statistic exceeded 1.96 and the p-value was less than 0.05. Mediation analysis was conducted to evaluate the role of road user discipline as an intervening variable between the safety equipment function and the competence of level crossing gatekeepers on level crossing safety. Mediation was deemed significant if the indirect effect met the significance criteria, allowing the determination of whether the mediation effect was full, partial, or insignificant (Hair et al., 2022). The indicators used to measure the variables in this study are presented in Table 1.

Table 1. Variable Measurement

Variable	Statements
Equipment Function	1. The siren is audible even in a noisy environment. 2. The warning light is clearly visible even during the daytime. 3. The warning light remains on long enough before the train passes. 4. The gate barrier is sturdy enough to prevent road users from crossing. 5. The gate barrier is sufficient to cover the entire width of the road.
Gatekeeper Competence	1. The guard is present at the crossing. 2. The guard is firm when stopping vehicles. 3. The guard responds quickly when the crossing equipment malfunctions. 4. The guard behaves politely toward road users.
Discipline of Road Users	1. Road users stop when the warning signals are activated. 2. Road users wait until the gate is fully open. 3. Road users follow the guard's instructions when a train is about to pass. 4. Road users stop at a safe distance from the tracks when the train is approaching.
Level Crossing Safety	1. I feel safe crossing because the safety equipment functions properly. 2. The presence of guards makes me feel secure when crossing. 3. I feel relatively safe because most road users are cautious when crossing. 4. I rarely witness dangerous situations at this crossing.

RESULTS AND DISCUSSION

Respondent Profile

The characteristics of respondents in this study include age, gender, and education level of 333 road users selected through purposive sampling, with the criterion of being active users who regularly cross at Level Crossing JPL No. 46. The characteristics of the respondents are presented in Table 2. Of the 333 respondents who participated, the majority were male, totaling 242 individuals (72.67%), while females accounted for 91 individuals (27.33%). In terms of age, most respondents were within the productive age range. The largest group was aged 31–40 years (34.53%), followed by those aged 41–50 years (27.63%) and 20–30 years (26.13%). Meanwhile, respondents under 20 years old (7.51%) and those over 50 years old (4.20%) represented the smallest groups. This indicates that road users at JPL No. 46 are predominantly individuals with high daily mobility. Regarding education level, the majority of respondents had at least a secondary education, with high school (SMA/SMK) graduates dominating (52.25%), followed by bachelor's degree holders (S1) at 26.13% and diploma holders (D3) at 13.81%. Respondents with junior high school education (SMP) accounted for 7.51%, and only 0.30% had a master's degree (S2). Despite the relatively high level of formal education, numerous violations still occur at the crossing, suggesting that formal education does not always correlate with traffic discipline.

Table 2. Respondent Profile

Variable	Frequency	%
Gender		
Male	242	72,67
Female	91	27,33
Total	333	100,00
Age		
<20 years	25	7,51
20-30 years	87	26,13
31-40 years	115	34,53
41-50 years	92	27,63
>50 years	14	4,20
Total	333	100,00
Education Level		
Junior High School	25	7,51
Senior High School / Vocational (SMA/SMK)	174	52,25
Diploma (D3)	46	13,81
Bachelor's Degree (S1)	87	26,13
Master's Degree (S2)	1	0,30
Total	333	100

Measurement Model Evaluation

This study analyzed the data using Structural Equation Modeling based on Partial Least Squares (SEM-PLS) through SmartPLS version 4.1 software. SEM-PLS was chosen because it is capable of handling simultaneous relationships among latent variables, both direct and indirect, including the role of mediating variables, and is effective for data that do not meet normality assumptions with a moderate sample size. The SEM-PLS analysis process was carried out in stages, starting with the evaluation of the outer model to assess the validity and reliability of the indicators, followed by the evaluation of the inner model to examine the strength of relationships among latent constructs as well as the significance of direct and indirect (mediating) effects. In addition, the model's predictive ability for new (out-of-sample) data was assessed using the Cross-Validated Predictive Ability Test (CVPAT), following the predictive evaluation approach outlined by Hair et al. (2022). All indicator loading factor values exceeded 0.70, which is above the minimum threshold of 0.70, and the Average Variance Extracted (AVE) values were greater than 0.50. Therefore, it can be concluded that the indicators in this study meet the criteria for convergent validity. Furthermore, all items measuring each construct were declared reliable, as the Composite Reliability (CR) values ranged from 0.874 to 0.896, which is above the minimum threshold of 0.70 as recommended by Hair et al. (2022). The conclusion from the measurement model evaluation is that the constructs are valid and reliable. The results of the convergent validity and construct reliability tests are presented in Table 3.

Meanwhile, the results of discriminant validity using the Heterotrait-Monotrait Ratio of Correlations (HTMT) indicate that each reflective construct is most strongly associated with its own indicators, with correlation values below 0.90 (Hair et al., 2022). Furthermore, the results of the discriminant validity test using the HTMT method are presented in Table 4.

Table 3. Convergent validity and reliability

Variable	Code	Outer Loading	AVE	CR
Equipment Function	X1_FP1	0.758	0.582	0.874
	X1_FP2	0.729		
	X1_FP3	0.701		
	X1_FP4	0.823		
	X1_FP5	0.799		
Gatekeeper Competence	X2_KP1	0.846	0.714	0.909
	X2_KP2	0.809		
	X2_KP3	0.831		
	X2_KP4	0.893		
Level Crossing Safety	Y_KPS1	0.831	0.679	0.894
	Y_KPS2	0.834		
	Y_KPS3	0.708		
	Y_KPS4	0.901		
Discipline of Road Users	Z_KPJ1	0.832	0.683	0.896
	Z_KPJ2	0.847		
	Z_KPJ3	0.776		
	Z_KPJ4	0.849		

Table 4. Discriminant Validity – Heterotrait-Monotrait Ratio *(HTMT)*

	Equipment Function	Gatekeeper Competence	Level Crossing Safety	Discipline of Road Users
Equipment Function				
Gatekeeper Competence	0.783			
Level Crossing Safety	0.703	0.845		
Discipline of Road Users	0.322	0.375	0.449	

Structural Model Evaluation

After the measurement model (outer model) was confirmed to be valid and reliable, the next step was to analyze the structural model (inner model) to evaluate the strength, direction, and significance of the relationships among the latent variables in the model. The results of the SEM-PLS analysis, which display the estimated paths between variables, are shown in Figure 2. The evaluation includes tests for multicollinearity (VIF), coefficient of determination (R^2), effect size (f^2), and predictive relevance (Q^2). Furthermore, hypothesis testing and the significance of both direct and indirect relationships (mediation test) were conducted. An effect is considered significant if the t-statistic value is greater than 1.96 and the p-value is less than 0.05. In addition, the model's predictive capability was tested using the Cross-Validated Predictive Ability Test (CVPAT) to ensure its accuracy for new data (Hair et al., 2022).

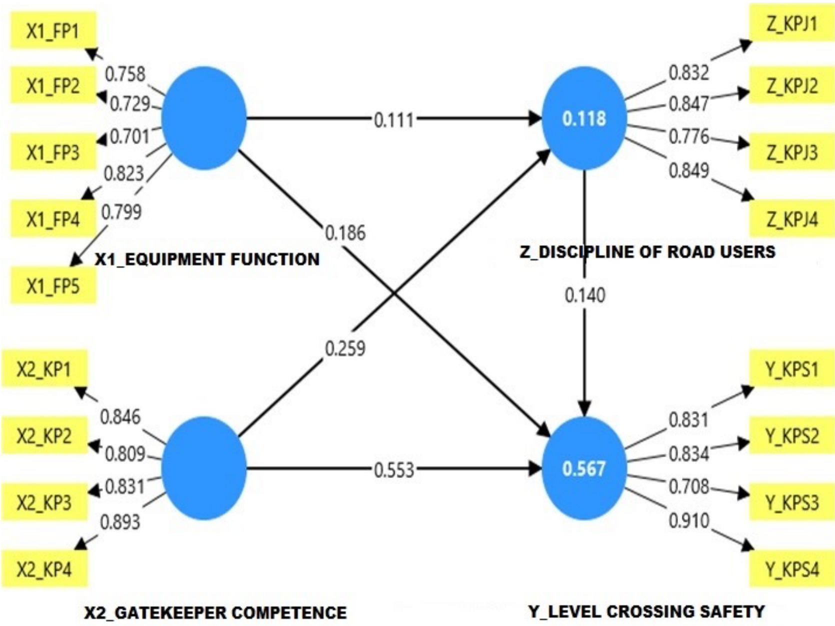

Figure 2: SEM-PLS Results

The research findings indicate that the equipment function has a positive and significant effect on level crossing safety, with a sample mean of 0.189, VIF of 1.870, a T-statistic of 3.545, and a p-value of 0.000. However, the equipment function only has a positive but not significant effect on road user discipline, as reflected by the sample mean of 0.114, VIF of 1.856, T-statistic of 1.812, and p-value of 0.070. On the other hand, the competence of the gatekeeper has a very strong positive and significant effect on level crossing safety, with a sample mean of 0.552, VIF of 1.932, T-statistic of 11.312, and p-value of 0.000. The gatekeeper's competence also has a positive and significant effect on road user discipline, with a sample mean of 0.259, VIF of 1.856, T-statistic of 4.452, and p-value of 0.000. In addition, road user discipline itself was found to have a positive and significant effect on level crossing safety, with a sample mean of 0.140, VIF of 1.134, T-statistic of 3.357, and p-value of 0.001. It can be concluded that gatekeeper competence is the factor that contributes the most to improving level crossing safety compared to other variables. Therefore, the hypothesis regarding the effect of equipment function on road user discipline is rejected. The results of the hypothesis testing for the direct effects between variables are presented in Table 5.

Table 5. The Hypothesis Testing Result

Relationship	VIF	Sample mean (M)	STDEV	T statistics	P values
Equipment Function → Level Crossing Safety	1.870	0.189	0.053	3.545	0.000
Equipment Function → Discipline of Road Users	1.856	0.114	0.061	1.812	0.070
Gatekeeper Competence → Level Crossing Safety	1.932	0.552	0.049	11.312	0.000

Gatekeeper Competence → Discipline of Road Users	1.856	0.259	0.058	4.452	0.000
Discipline of Road Users → Level Crossing Safety	1.134	0.140	0.042	3.357	0.001

The effect size (f^2) of each variable can be seen in Table 6. The next analysis involves evaluating the f-square values. The effect of the equipment function on level crossing safety has a value of 0.043, indicating a small effect. Meanwhile, the effect of the equipment function on road user discipline is only 0.008, which is considered very small. The competence of the gatekeeper has a medium effect on level crossing safety, with a value of 0.365; however, its effect on road user discipline is relatively small, with a value of 0.041. Additionally, the effect of road user discipline on level crossing safety is 0.040, which also indicates a small effect.

Table 6. F-Square

	Level Crossing Safety	Discipline of Road Users
Equipment Function	0.043	0.008
Gatekeeper Competence	0.365	0.041
Discipline of Road Users	0.040	-

The next analysis was conducted to evaluate the R-Square (R^2) value for each endogenous construct. The values of the coefficient of determination (R^2) and predictive relevance (Q^2) are presented in Table 7. The R^2 value indicates the extent to which the exogenous variables can explain the endogenous variables. The results show that level crossing safety has an R^2 value of 0.567, which falls into the moderate category. This means that equipment function, gatekeeper competence, and road user discipline together can explain 56.7% of the variance in level crossing safety. Meanwhile, road user discipline has an R^2 value of 0.118, which falls into the very weak category, indicating that the variables equipment function and gatekeeper competence can only explain 11.8% of the variance in road user discipline.

In addition, the Q-Square (Q^2) test was conducted to assess the model's predictive ability. The analysis results indicate that level crossing safety has a Q^2 value of 0.543, which falls into the strong category, signifying that the model has good predictive capability for this variable. Conversely, road user discipline obtained a Q^2 value of 0.109, which falls into the weak category, indicating that the model's predictive ability for this variable is relatively low. These results suggest that the research model possesses good predictive power in accordance with the proposed framework.

Table 7. R-Square and Q-Square

	R-Square	Decision	Q-Square	Decision
Level Crossing Safety	0.567	Moderate	0.543	Strong
Discipline of Road Users	0.118	Very Weak	0.109	Weak

The results of the indirect effect (mediation) analysis are presented in Table 8. Based on the mediation test results, the indirect path from equipment functionality through road user discipline to level crossing safety has a coefficient of 0.016 with a p-value of 0.111, indicating that this mediating effect is not significant. Conversely, the indirect path from gatekeeper competence through road user discipline to level crossing safety has a coefficient of 0.037 with a p-value of 0.016, indicating a significant mediating effect.

After testing the significance of relationships among constructs, the final stage of evaluating the inner model is to measure the model's predictive ability for new data (out-of-sample prediction). This test is conducted using the Cross-Validated Predictive Ability Test (CVPAT) via the PLSpredict feature in SmartPLS. CVPAT serves to compare the predictive ability of the structural model with that of a benchmark model (Hair et al., 2022). The results of the predictive ability test using CVPAT are presented in Table 9. A negative CVPAT value indicates that the structural model has a smaller prediction error compared to the benchmark model, which suggests superior predictive ability. Accordingly, the negative CVPAT value in this study indicates that the proposed model can provide more accurate predictions than a simple benchmark model.

Table 8. Indirect Effect Test

	Sample Mean (M)	STDEV	T statistics	P values
Equipment Function -> Discipline of Road Users -> Level Crossing Safety	0.016	0.010	1.592	0.111
Gatekeeper Competence -> Discipline of Road Users -> Level Crossing Safety	0.037	0.015	2.410	0.016

Table 9. ***Cross-Validated Predictive Ability Test (CVPAT)***

	ALD	T Statistics	P Value
Level Crossing Safety	-0.369	10.146	0.000
Discipline of Road Users	-0.078	2.608	0.010
Overall	-0.223	8.075	0.000

Discussion

Theoretical Implications

The results of this study provide a significant theoretical contribution to the development of literature related to railroad level crossing safety by incorporating the role of road user discipline as a mediating variable. These findings extend and confirm transportation safety theory, road user behavior theory, and competency theory.

First, the finding that the function of equipment has a direct effect on level crossing safety ($\beta = 0.189$; $p = 0.000$) is consistent with the Regulation of the Minister of Transportation of the Republic of Indonesia No. PM 94 of 2018 on Enhancing Safety at Level Crossings Between Railway Tracks and Roads (Peraturan Menteri Perhubungan Republik Indonesia Nomor PM 94 Tahun 2018 Peningkatan Keselamatan Perlintasan Sebidang Antara Jalur Kereta Api Dengan Jalan), which emphasizes the importance of physical infrastructure such as barriers, signals, and traffic signs. This result supports the studies by Fadhli (2021) and Zuhdan et al. (2021), which indicate that the availability of safety facilities such as markings, warning lights, and gates is a vital factor in preventing accidents.

Second, the significant influence of gatekeeper competence on safety ($\beta = 0.552$; $p = 0.000$) and on road user discipline ($\beta = 0.259$; $p = 0.000$) reinforces Competence Theory, which emphasizes the importance of officers' knowledge, skills, and attitudes. These findings are consistent with Oktaria (2022), Iswanto et al. (2024), and Oktaria et al. (2022), who stated that training, legal understanding, and professionalism of gatekeepers are key determinants of safety at level crossings. Theoretically, these results confirm that officer competence not only directly enhances safety but also shapes road user discipline through interaction and situational control.

Third, the positive influence of road user discipline on level crossing safety (β = 0.140; p = 0.001) aligns with traffic behavior theory, which emphasizes compliance with regulations as a key factor in accident prevention. These findings confirm the results of Kristo et al. (2021), Sidjabat and Mulyani (2023), and Swasti et al. (2022), who found that low compliance of road users with signs and officer instructions increases the risk of violations and accidents.

Fourth, the mediation finding that road user discipline significantly mediates the influence of gatekeeper competence on safety (β = 0.037; p = 0.016) provides a novel contribution to the development of the conceptual model. This indicates that the effect of gatekeeper competence is not only direct but also operates through shaping road user discipline. In contrast, the mediation of discipline in the relationship between equipment function and safety is not significant (β = 0.016; p = 0.111), confirming that equipment plays a more dominant role through direct influence.

Practical Implications

The results of this study provide important practical implications for managing the safety of level crossings, particularly at JPL No. 46 Pondok Jati, East Jakarta. Field data recorded several accident incidents, most of which were caused by road user violations, even though the gate system functioned properly. SEM-PLS analysis shows that gatekeeper competence has the greatest influence on crossing safety (β = 0.552, p < 0.000) and significantly improves road user discipline (β = 0.259, p < 0.000). Additionally, road user discipline has a positive effect on safety (β = 0.140, p = 0.001) and mediates the relationship between gatekeeper competence and safety (β = 0.037, p = 0.016). On the other hand, equipment function directly affects safety (β = 0.189, p < 0.000) but is not significant in influencing road user discipline.

Based on these findings, improving level crossing safety requires a combination of technical and non-technical approaches. From a technical perspective, PT. Kereta Api Indonesia (Persero) and the Directorate General of Railways are advised to enhance the design quality and strength of the gates, accompanied by regular maintenance to maintain optimal performance. Operational managers of crossings, namely PT. Kereta Api Indonesia (Persero) needs to strengthen staff training and competency evaluation systems, increase personnel during peak hours, and reinforce field supervision. From a non-technical perspective, DJKA, PT. Kereta Api Indonesia (Persero), the Transportation Agency, local governments, and the police can collaborate on traffic discipline education programs, regular safety campaigns, enhanced monitoring through CCTV and ETLE, and consistent law enforcement. Cross-agency coordination based on data is also key to ensuring effective interventions.

These measures are expected to reduce violations and accidents, both at JPL No. 46 Pondok Jati and at other level crossings with similar characteristics. To broaden the applicability of these research findings, further studies in different locations with varied traffic conditions and environments are needed so that the resulting recommendations can serve as a reference for improving level crossing safety nationwide.

CONCLUSION

This study analyzed the role of road user discipline in mediating the effect of safety equipment functionality and level crossing gatekeeper competence on level crossing safety, using JPL No. 46 Pondok Jati, East Jakarta, as a case study in 2025. Employing a quantitative approach based on Structural Equation Modeling – Partial Least Squares (SEM-PLS) with 333 respondents and a Likert scale, the study tested seven hypotheses involving the variables of equipment functionality, gatekeeper competence, road user discipline, and level crossing safety. The results indicate that equipment functionality has a significant direct effect on level crossing safety but does not significantly affect road user discipline. Gate keeper competence has a significant direct effect on both level crossing safety and road user discipline. Road user discipline also has a significant impact on level crossing safety. Regarding indirect effects, equipment functionality through road user discipline does not significantly influence safety, whereas gatekeeper competence through road user discipline has a positive and significant effect on level crossing safety. These findings emphasize that improving gatekeeper competence and road user discipline is more effective in enhancing safety than relying solely on equipment.

This study has limitations in terms of location scope, variables, and measurement. The research focused only on key equipment (gates, warning lights, and sirens), gatekeeper competence, and road user discipline at JPL No. 46 Pondok Jati. Additionally, the study emphasized respondents' perceptions without measuring technical conditions of the transport environment, such as traffic density, vehicle restrictions, or supporting infrastructure.

Based on these findings, PT. Kereta Api Indonesia (Persero) and the Directorate General of Railways are advised to enhance the design quality, strength, and maintenance of level crossing equipment, strengthen training, evaluation, and increase personnel during peak hours, as well as expand education programs, safety campaigns, and technology-based monitoring. Local governments, transportation agencies, and the police are expected to improve coordination in supervision and law enforcement at level crossings. Furthermore, future studies are recommended to be conducted at crossings with different characteristics so that the results can serve as a reference for broader improvements in level crossing safety.

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