Transferability of Rail-Road Level Crossing Safety: A Case Study of South Sumatra, Indonesia

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ABSTRACT

South Sumatra has 40 active crossings and 71 passive crossings. The number of accidents at level crossings is significant, with 24 accidents resulting in 5 fatalities and 19 injuries. This demonstrates the importance of discovering solutions to enhance safety at level crossings. One approach to identifying a solution is to adopt solutions from other countries that have been effectively implemented, a process known as policy transfer. The solutions selected for adaptation each address one aspect of The Three Es Theory (Engineering, Enforcement, and Education). Those solutions are changing gate barrier design to full barrier from engineering aspect, camera law enforcement for enforcement aspect, and education and socialization to school and public from education aspect. The three solutions were tested with stakeholder perspectives to assess their appropriateness for adaptation in South Sumatra. The results showed that education received the highest appropriateness level with six supports from stakeholders, and changing to full barrier received five supports, indicating that both solutions have the potential to improve safety at level crossings. However, camera law enforcement showed the opposite, with only two supports, indicating that this solution is inappropriate for the adaptation.

Keywords: Policy Transfer, Level Crossing Safety, The Three Es Theory

1 INTRODUCTION

1.1 Research Background

The same issue also occurred in South Sumatra. South Sumatra has 111 level crossings (LCs) (SSPTA, 2024). Among these, there are 40 active crossings and 71 passive crossings (SSPTA, 2024). With the high number of LCs, many accidents occur at these places. In 2023, 24 incidents happened, resulting in 5 fatalities and 19 injuries (KAI, 2023). 83% of these accidents are caused by drivers who disregard crossing signs (KAI, 2023). In addition, many violations also occur because motorcyclists lift the crossing barriers. In 2018-2023, 58% of accidents involved motorcyclists (KAI, 2023). Furthermore, the high number of violators at LCs is attributed to inadequate law enforcement despite legislation governing penalties for trespassers.

Several countries are actively seeking measures to mitigate the frequency of accidents occurring at level crossings. These solutions are based on The Three Es, which stands for Engineering, Enforcement, and Education (Kamphuis, 2021). For instance, in the engineering aspect, to decrease accidents at level crossings, UK and US have modified the design of the barrier, transforming it from a half barrier to a full barrier (Liu and Khattak, 2017; Dent and Marinov, 2019). This solution has the potential to decrease the probability of accidents by up to 16% (Network Rail, 2019). Both Taiwan and Croatia reduced their violation at level crossing rates by 50% and 60%, respectively, due to implementing camera enforcement to strengthen law enforcement. (Hu and Lin, 2013; Starčević et al., 2016). In terms of education, Operation Lifesaver conducted level-crossing safety education programmes in schools and the public across the US starting in 1972 (OLI, 2024). They claimed that their programme has contributed to the decrease of level crossing accidents by around 40% in US from their initial years (Savage, 2006).

The success of those countries in enhancing safety at level crossings encourages the implementation of similar solutions in South Sumatra. Many countries are presently implementing ideas or policies from other nations to tackle similar issues. (Canitez, 2020) indicates that policy transfer is an efficient method of overcoming problems by adapting best practices from origin to receptor place. It is motivating to identify and adapt several effective solutions from various countries in the areas of engineering, law enforcement, and education to reduce the number of violations and accidents at level crossings in South Sumatra. This dissertation will collect and analyse stakeholders' perspectives regarding those solutions. The potential success of each solution to enhance safety at level crossings can be identified by considering stakeholders' perspectives. Thus, policymakers can choose several solutions to reduce accident rates at level crossings in South Sumatra.

2 LITERATURE REVIEW

2.1 Engineering Solution

The potential to reduce accident rates exists by changing the half barrier to a full barrier. In their study, Singh et al. (2022) presented evidence that the effectivity of accident reduction on half barrier is 78%. Meanwhile, the full barrier is 82%. This is because the usage of a full barrier can mitigate the chance of drivers entering a barrier that has begun to close. According to Liu and Khattak (2017), implementing four-quadrant gates in four different regions in the United States led to a 9.21% decrease in the likelihood of accidents when compared with using two-quadrant gates. These results suggest that replacing the barrier will significantly reduce the likelihood of incidents.

Other measures involve integrating it with technology, such as obstacle detection. Glover (2009) stated that obstacle detection operates to detect the presence of vehicles, humans, or animals at the crossing as the train approaches. This information is promptly sent to the train driver, enabling them to reduce speed or stop the train. The technology employed is LiDAR (Light Imaging Detection and Ranging), which is used at level crossings to detect obstacles by utilising lasers. Alternatively, it can utilise CCTV cameras, infrared thermal imaging, and ultrasonic sensors (Dent and Marinov, 2019). Nevertheless, according to Glover (2009), this technology is less reliable than conventional gates. This is due to the potential risk of "false alarms" that can be hazardous for vehicles traversing level crossings. Dent and Marinov (2019) indicated that the effectiveness of obstacle detection can be enhanced through its integration with a full barrier. Furthermore, they highlighted that the integration of obstacle detection with automatic trains improves safety, diminishes train operation costs, increases train speeds, and reduces waiting durations for pedestrians and drivers. The UK has substituted certain MCB-CCTV systems with MCB-OD (Manually Controlled Barrier-Obstacle Detection with Obstacle Detection) (Dent and Marinov, 2019). Nakasone et al. (2020) stated that 90% of level crossings in Japan are automatic barriers using obstacle detection.

2.2 Enforcement Solution

Technology is utilised in law enforcement to manage level crossings. Starčević et al. (2016) stated that using camera-based law enforcement measures leads to in a 60% reduction in trespassers at level crossings in Croatia. Carroll and Warren (2002) indicated that the introduction of RLSE (Red Light Safety Equipment) at rail-highway level crossings in the United States has resulted in a decrease in incidents varying from 34% to 92%. Taiwan likewise saw the beneficial effects of camera enforcement. Hu and Lin (2013) observed a reduction in trespassers from 3,700 to 1,800 violations/year, representing a decrease of over 50%. This evidence demonstrates that implementing camera enforcement substantially affects diminishing accidents and violations at level crossings. Combining camera enforcement with strong law enforcement and deterrent sanctions can enhance driver compliance in obeying traffic signs.

Police attendance with vehicle observations at level crossing is used in the first stage to enhance law enforcement in the UK. Network Rail and the British Transport Police are collaborating to enhance law enforcement at level crossings. Network Rail provides 15 Mobile Safety Vehicles equipped with automatic number plate recognition cameras (Network Rail, 2019). In 2012, the operation led to the capture of 2,452 people who were captured on cameras in London and Scotland.

2.3 Education Solution

United States partners with a non-governmental organization (NGO) known as Operation Lifesaver (OL) to provide public education on safety measures at level crossings. During its initial years, they claimed that education had the potential to reduce a 40% decline in fatalities occurring at level crossings (Savage, 2006). OL has a volunteer over 3000 people, capable of conducting 30,000 presentations, engaging approximately 1.5 million attendees (Savage, 2006). OL volunteers include people employed in the transportation sector, police, and various residents who are interested in level crossing safety. OL activities include delivering presentations to students, conducting driver education courses, and engaging with communities (Savage, 2006). OL also provides educational materials through print-based and other media for public distribution. This organisation receives funding from the government and several stakeholders, but in a relatively modest amount of approximately $5 million each year. Savage (2006) conducted a study on OL, it was found that education had a quantifiable impact on changing driver behaviours and enhancing safety.

3 METHODOLOGY

3.1 Data Collection

The primary and secondary data used in this study were obtained from a variety of sources. The primary data collection process involved interviewing six respondents to gather information about the issues at level crossings and their perspectives on the proposed solutions. Journals, websites, and documents given by informants were secondary data sources.

3.2 Research Parameters

The parameter in transferability research is the degree of appropriateness of a solution for adaptation. In transferability research, ex-ante assessments are conducted before implementation, utilising stakeholder perspectives as an indicator for evaluation. In the research conducted by Timms (2014), the degree of appropriateness is assessed by the amount of stakeholder support for the solution's potential to address the problem if adapted. If the majority of stakeholders support the solution, the solution's appropriateness level is high. To facilitate analysis of the results from interviews with six stakeholders, the categories are used in this study as follows:

1. Majority = if ≥ 5 stakeholders answer on the same side
2. Average = if 4 stakeholders answer on the same side
3. Minority = if ≤ 3 stakeholders answer on the same side

3.3 Analysis Method

The data collected from interviews will be analysed using thematic analysis. Bryman (2016) stated that thematic analysis has been a widely utilized tool in qualitative research in the last few decades. Thematic analysis involves creating codes or themes from interview results. These codes are then used to organise and analyse the data. Moreover, this method is commonly used in transferability research, such as has been done by Kadhim (2022) and Mandal (2022). Braun and Clarke (2006) introduced a six-step guide to conducting a thematic analysis of collected data to identify patterns within the data, as shown in Table 1.

Table 1. Six Steps for Conducting Thematic Analysis

Steps		Description
1	Understand the data	Make notes and re-reading the data
2	Create initial codes	Coding helps the organisation and systemization of data. Codes can align with research questions
3	Conduct a theme search	Examine and combine the codes that show similar patterns to fit together into a theme
4	Review themes	Revise and develop the initial themes
5	Define themes	Refine and identify the essence of each theme
6	Write the report	Write and report the results of an analysis

4 RESULT AND DISCUSSION

4.1 Problems and Causes in South Sumatra Level Crossings

One stakeholder stated that law enforcement remains low at level crossings because operators, not the police, provide the crossing gate guards. To supervise level crossings, the police require a letter from the operator (KAI). Furthermore, the attendance of police personnel at each level crossing needs many personnel. Moreover, the police do not have data on violations at level crossings. This implies that law enforcement on violations at level crossings is low in South Sumatra. Moreover, drivers, especially motorcyclists, easily violate the crossing gates currently in use. This is especially true at crossings near the station, where drivers think they can cross before the train departs so they can watch trains leaving the station.

Regarding education and safety campaigns, 5 stakeholders reported that they frequently conducted safety socialisation at level crossings in high schools because students would apply for a driving license. However, cooperation between NGOs and the government in safety socialization is still lacking. The absence of cooperation in level-crossing socialization between the central government and NGOs indicates this. To conclude, stakeholders validated that the problems were drivers' lack of awareness about safety at level crossings, weak law enforcement,

lack of facilities due to the minimal budget allocated for transportation, and the view that motorcyclists can easily lift and violate the current gate design.

4.2 Transferable Solutions

A comparison of the positive, negative, legal basis and characteristics of South Sumatra is used to select the solutions. The proposed solutions must have a legal basis to be implemented and budgeted. The entire solution can be implemented from a legal perspective, as all solutions offered have a legal basis that is applicable in Indonesia. Next, the solutions are evaluated in relation to the positive, negative, and characteristics of South Sumatra, as shown in Table 2. After comparing each solution to the attributes of South Sumatra. In the engineering context, the decision was made to replace the gate barrier design with a full barrier rather than LiDAR detection. This was done because LiDAR detection will be more effective when installed alongside a full barrier. Due to financial limitations, only one engineering solution was initially selected in South Sumatra. Furthermore, the enforcement cameras over police attendance due to the limited number of police personnel. An enforcement camera was selected as a transferable solution due to its simplicity of implementation.

Table 2 Comparison Between Positive and Negative sides of solutions and Characteristics of South Sumatra

Solution	Positive	Negative	South Sumatra's characteristics	Origin
Engineering				
LiDAR Obstacles Detection	Identify objects at level crossings and notify the train driver to reduce speed.	It is highly maintained and more effective with a full gate barrier.	Currently, the gate design is a half barrier, and the violations are quite high, which will increase disruption and confuse the train driver.	• UK • Japan
Changing gate barrier design	Fully covered level crossing, easy and cheaper construction costs than grade separation.	If damaged, the repair cost will be higher than half barrier.	With the large number of motorcyclists, it can reduce violators who lift the barriers.	• UK • US
Enforcement				
Police Attendances (Mobile Safety Enforcement)	Law enforcement will be effective because action will be taken immediately.	Requires many police personnel.	A letter from the operator is needed to have police on guard at level crossings, and the number of police personnel is limited.	UK
Enforcement Camera/ Photo	Easy to implement and can accommodate limited police personnel.	If the system operates well and drivers pay taxes in compliance, enforcement cameras will also run effectively.	Currently, enforcement cameras are installed at traffic lights. The system can easily be implemented in level crossings.	• Croatia • United States • Taiwan • UK
Education				
Level Crossings Safety Campaign and education for School and Public	Easy to implement, a key part of improving safety.	Require good communication and contract with NGO.	Currently, safety campaigns and socialisation are organised by the government and operators.	• United States • UK

4.3 Stakeholder Perspectives on Changing Half Barrier to Full Barrier

Only one stakeholder criticizes this solution, while the remaining five support it. Most stakeholders believe that this solution has the potential to reduce the likelihood of motorists lifting the barrier to pass through the crossing. This solution aligns with the KNKT (National Transportation Safety Committee) idea, which suggested applying grease under the barrier at the crossing. Conversely, one stakeholder argues that this concept will generate another problem if funding and maintenance remain unclear. He believes that utilising a full barrier will increase replacement and

maintenance costs, as the current half barrier is made of wood, while the full barrier is made of iron. This is because the stakeholder, as a rail service operator, prioritizes the maintenance of level crossing gates, as any damage to these signs can potentially disrupt train operations.

4.4 Stakeholder Perspectives on Camera Law Enforcement

Two stakeholders supported this resolution, while four others opposed it. The four stakeholders stated that Camera Law Enforcement does not have a deterrent effect on violators. This is because the current implementation at numerous traffic lights is tricked by drivers who attempt to hide plate numbers when they are about to be captured on camera, do not pay vehicle taxes, or change their plate numbers. In addition, a stakeholder stated that the presence of police to observe and take direct action is more effective in increasing law enforcement. This is because drivers in South Sumatra are more obedient when they see a police presence at the location. Additionally, a stakeholder criticized the possibility that this solution may be successful in Europe and developed countries because their systems are robust and their drivers are tax compliant. Consequently, law enforcement can be easily implemented using cameras. Nevertheless, in South Sumatra, the data system has not yet been integrated, and drivers are not tax compliant. Consequently, the use of cameras by law enforcement is ineffective, and it has reverted to police attendance for on-the-spot action.

In contrast, the two stakeholders expressed different views. According to one stakeholder, law enforcement in South Sumatra utilizes cameras, which rank among the top five in Indonesia. He claims that implementing this system at level crossings may yield similar results. Furthermore, using cameras law enforcement has the potential to address the challenges posed by personnel limitations and complicated bureaucratic processes. Furthermore, a stakeholder indicated that they had proposed the installation of cameras for law enforcement to the police. However, they noted no sign of follow-up action, attributing this to insufficient funding for establishing camera law enforcement at level crossings.

4.5 Stakeholder Perspectives on Safety Education

All stakeholders support this solution to decrease the number of accidents and violators at level crossings. Therefore, three government stakeholders and one NGO have implemented this education in schools surrounding the crossing, resulting in a 1% reduction in violations at level crossings in 2022-2023.

4.6 Appropriateness Level

An assessment of transferable solutions has been performed, with results detailed above. The initiative to convert the half barrier to a full barrier received support from five stakeholders. This shows that the level of appropriateness of this solution for adaptation is relatively high and has the potential to overcome problems at level crossings. Similar to the change of the barrier, the safety education solution got positive responses from all stakeholders. In the Camera Law Enforcement solution, just one governmental institution and one NGO supported this solution, indicating its low level of appropriateness for adaptation in South Sumatra. Table 3 illustrates the degree of appropriateness of all transferable solutions.

Table 3 Appropriateness Level

Measures	Perspectives	Comments
Changing half barrier to full barrier	+ + + + + -	This solution can mitigate motorcycle driver violations related to the existing barrier design (half barrier); however, it is essential to ensure its maintenance to prevent disruption due to barrier errors.
Camera Law Enforcement	+ + - - - -	The system is prepared for installation; however, the current implementation at traffic lights is not optimal in increasing public compliance.
Level Crossing Safety Education for the School and Public	+ + + + + +	Safety education has been conducted and has shown positive results. To be optimal, it just needs synergy between NGO and the government.

(+) means support; (-) means criticize.
More (+) means highly appropriate; More (-) means highly inappropriate.

5 CONCLUSION

The study's findings suggest that the primary factors contributing to accidents at level crossings in South Sumatra are the lack of awareness among drivers regarding safety at these crossings, the inadequate enforcement of the law, the inadequate infrastructure as a result of the limited transportation budget, and motorcyclists can easily lift and violate the current gate. The solutions selected in response to these issues are providing safety education, implementing camera law enforcement, and replacing the gate barrier to a full barrier. The results of stakeholder perspectives demonstrate that the alteration of the full barrier and safety education has a high level of appropriateness, suggesting that this solution is worthy of adaptation. Nevertheless, the camera law enforcement system demonstrates the opposite, indicating that the implementation of this solution does not have a substantial impact on the enhancement of safety at level crossings.

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