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Assessing The Human Contribution To Railway Level Crossing Accidents: Behavior, Awareness, And Safety Measures In Indonesia

Franka Hendra[1*], Ronald Sukwadi[2], Supriyono[3], Retno Indriyati K[4], Jisman Hutasoit[5]
[1,2]Professional Engineer Program, Atma Jaya Catholic University of Indonesia, Indonesia
[1,3] Industrial Engineering, Pamulang University, Indonesia
[4,5]Industrial Engineering, Mpu Tantular University, Indonesia
e-mail: dosen01508@unpam.ac.id

ABSTRAK

Kecelakaan di perlintasan kereta api merupakan masalah keselamatan yang signifikan di Indonesia, di mana peningkatan volume lalu lintas kereta api dan jalan raya berkontribusi pada frekuensi kejadian ini. Terlepas dari berbagai langkah keselamatan, kecelakaan tetap menjadi masalah yang terus berlanjut, terutama di perlintasan yang kurang memiliki sistem peringatan yang memadai. Studi ini bertujuan untuk mengeksplorasi faktor-faktor manusia yang berkontribusi terhadap kecelakaan di perlintasan kereta api, dengan fokus pada perilaku pengemudi, kesadaran keselamatan, dan efektivitas sistem peringatan. Menggunakan desain penelitian kualitatif, studi ini melibatkan observasi lapangan, wawancara pengemudi, dan konsultasi ahli. Temuan menunjukkan bahwa pengemudi di perlintasan otomatis, seperti yang dilengkapi dengan palang otomatis dan lampu berkedip, menunjukkan kepatuhan yang lebih tinggi terhadap protokol keselamatan. Sebaliknya, ketidakpatuhan lebih umum terjadi di perlintasan terbuka yang hanya memiliki rambu statis. Kurangnya kesadaran tentang jadwal kereta api dan respons yang tepat terhadap sinyal peringatan juga diidentifikasi sebagai faktor utama dalam kecelakaan, terutama di daerah pedesaan. Studi ini selanjutnya menyoroti perlunya peningkatan infrastruktur, pendidikan, dan penegakan kebijakan untuk mengurangi kecelakaan di perlintasan kereta api. Hasil penelitian ini menggarisbawahi pentingnya meningkatkan pendidikan publik tentang protokol keselamatan dan memperbarui infrastruktur, terutama di daerah pedesaan, untuk memastikan praktik keselamatan yang lebih baik di perlintasan kereta api.

Kata kunci: Perilaku Pengemudi, Faktor Manusia, Keselamatan Kereta Api, Sistem Peringatan, Perlintasan Sebidang

ABSTRACT

Railway level crossing accidents are a significant safety concern in Indonesia, where the increasing volume of both rail and road traffic contributes to the frequency of these incidents. Despite various safety measures, accidents remain a persistent issue, particularly at crossings that lack adequate warning systems. This study aims to explore the human factors contributing to railway level crossing accidents, with a focus on driver behavior, safety awareness, and the effectiveness of warning systems. Using a qualitative research design, the study involved field observations, driver interviews, and expert consultations. The findings revealed that drivers at automated crossings, such as those with boom barriers and flashing lights, demonstrated higher compliance with safety protocols. In contrast, non-compliance was more prevalent at open crossings with only static signs. A lack of awareness about train schedules and proper responses to warning signals was also identified as a major factor in accidents, particularly in rural areas. The study further highlighted the need for improved infrastructure, education, and policy enforcement to reduce accidents at railway level crossings. The results underscore the importance of enhancing public education on safety protocols and updating infrastructure, especially in rural areas, to ensure better safety practices at railway crossings.

Keywords: Driver Behavior, Human Factors, Railway Safety, Warning Systems, Level Crossings.

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INTRODUCTION

Railway level crossing accidents remain a significant global issue, including in Indonesia. As the

volume of both railway and road traffic continues to increase, accidents frequently occur at these crossings, particularly in urban areas with high traffic density and in rural areas with lower traffic. In many countries, this trend of accidents is concerning, especially in areas where there are inadequate active warning systems or where the crossings are not equipped with proper protection. Data from various transport safety organizations show that these accidents often involve drivers who fail to identify or respond appropriately to the existing warning systems, whether they are flashing lights or static signs.

The literature on this issue highlights that many studies focus on technical aspects such as the design and protection of crossings and accidents involving heavy vehicles. For instance, one study highlights that the reliability of warning signals at railway crossings is crucial in preventing accidents, but it is often insufficient in developing countries, including Indonesia [1]. Similarly, another study shows that accidents occur more frequently at crossings without automatic warning systems, while some emphasize the need for integrating modern technology to improve safety [2, 3]. Furthermore, research notes that railway crossings with physical barriers, such as gates or booms, tend to have better safety records compared to open crossings with only static signs [4, 5].

However, most of these studies focus primarily on technical and design factors, while human factors, the leading cause of accidents, are often overlooked. One study points out that driver error and failure to respond to warning signals are often dominant factors in these accidents [6, 7]. This is further supported by another study, which found that drivers often ignore warning signals, especially in rural areas where rail traffic is infrequent [8, 9]. Additional research shows that drivers tend to be less aware of the risks of accidents at crossings that are not regularly used by trains, leading to a false sense of security [10, 11]. It is also emphasized that safety education plays a critical role in enhancing driver response to warning systems [12, 13].

The gap in the literature lies in the insufficient attention to human factors that influence driver behavior at railway crossings. It has been suggested that untrained drivers or those who do not fully understand the importance of paying attention to warning signals are more likely to be involved in accidents [14]. Other studies show that drivers accustomed to crossing without incident tend to ignore warnings, thereby increasing the risk of accidents [15]. Furthermore, there is a mismatch between drivers' perceptions of the risk of accidents and the reality on the ground, where drivers continue to cross after a warning appears, despite knowing the potential danger [16, 17]

The novelty of this research lies in its focus on analyzing human factors affecting accidents at railway level crossings in Indonesia, considering variables such as driver behavior, attention levels, and responses to warning systems. This study aims to identify gaps in the implementation of warning systems at railway crossings and propose behavior-based solutions to reduce the occurrence of accidents.

The significant contribution of this research is to fill the gap in existing literature by providing a deeper understanding of the human factors involved in railway level crossing accidents and offering policy recommendations that are better suited to improve safety at these crossings in Indonesia.

METHOD

Object Material (Unit Analysis)

The unit of analysis in this study is the human factors involved in accidents at railway level crossings in Indonesia. Specifically, this research focuses on analyzing driver behavior, their responses to warning signals, and their level of awareness in relation to railway crossings. The selection of this unit is crucial because human error is identified as the leading cause of accidents at railway level crossings, yet remains underexplored in the existing literature. Understanding the human aspect is critical to designing interventions that can significantly reduce the occurrence of such accidents.

Research Design

This study utilizes a qualitative descriptive research design, which allows for an in-depth examination of the factors influencing railway crossing accidents. The descriptive approach enables the researcher to explore the underlying reasons and behaviors contributing to these accidents from the perspective of the individuals involved. The design was chosen because it provides rich insights into the human aspects of safety at railway crossings, allowing for a detailed analysis of both subjective and objective factors.

Data Sources (Participants, Informants, Texts)

The primary sources of data in this study include drivers who frequently use railway level crossings and experts in transportation safety. Participants are selected from areas in Indonesia with high levels of traffic and frequent railway crossings. This selection was made to ensure that the data collected is representative of the diverse road-user groups who interact with these crossings daily.

Informants include transportation safety experts and traffic management authorities who provide insights into the existing safety measures at railway crossings. Additionally, policy documents related to traffic regulations and safety measures at railway crossings are also included as secondary data sources.

Data Collection Techniques

The data collection is carried out in three stages:

1. Stage One: Observations are conducted at selected railway level crossings to understand the interactions between drivers and the warning signals. Observational data will include how drivers respond to flashing lights, gates, and static warning signs, and whether they follow safety protocols.
2. Stage Two: Semi-structured interviews with drivers who regularly pass through railway level crossings will be conducted. These interviews aim to gain a deeper understanding of the driver's perception of safety, their behavior when encountering a crossing, and any challenges they face in responding to warning signals.
3. Stage Three: Expert interviews with transportation safety officials and traffic management authorities will be held to understand the safety measures in place and the effectiveness of the current systems. These interviews will provide expert knowledge regarding the design of crossings and the human

factors that are often overlooked in current safety systems.

Data Analysis

Data from the observations, interviews, and expert opinions will be analyzed using a thematic analysis approach. This approach is chosen because it allows for the identification of patterns and themes in the data that relate to human behavior, response to warning signals, and safety culture at railway level crossings. Thematic analysis will enable the researcher to systematically identify recurring issues and concerns that contribute to accidents at these crossings.

In addition, content analysis will be applied to the policy documents and expert opinions to assess the current safety measures in place and identify any gaps in addressing human factors in accident prevention. Both types of analysis will be triangulated to ensure the validity and reliability of the findings.

Data Validation

To ensure the validity of the data, the researcher will use member checking and peer debriefing. Member checking will involve sharing the findings with some of the participants (drivers and experts) to ensure that their views and experiences are accurately represented. Peer debriefing will involve consulting with colleagues or experts in the field of transport safety to confirm that the interpretation of the data is sound and aligned with existing knowledge.

Ethical Considerations

This study will adhere to ethical standards to ensure the protection of participants' rights. Informed consent will be obtained from all participants, ensuring they are fully aware of the study's purpose, procedures, and potential risks. Participants' anonymity and confidentiality will be guaranteed, and they will have the right to withdraw from the study at any point without consequence. Additionally, the data will be securely stored and only used for the purpose of this research.

RESULT AND DISCUSSION

Driver Behavior at Railway Level Crossings

The study observed varying driver behaviors depending on the type of railway crossing and the presence of warning systems. At gated crossings, the majority of drivers complied with signals by stopping and waiting for the gates to open. However, a small percentage of drivers attempted to bypass the gates, especially when the crossing had been closed for a long period without the passage of a train. This indicates a lack of awareness regarding the importance of waiting for the full safety protocol to be followed.

At crossings with automatic boom barriers, most drivers slowed down and prepared to stop upon noticing the flashing warning lights. However, there were instances where drivers did not stop on time, revealing either a lack of attention to the signals or confusion regarding the exact timing of the barriers' descent.

In contrast, at open crossings, where only static signs were present, more than 60% of drivers failed

to slow down or stop as they approached the crossing. This was especially true during peak traffic times when drivers focused more on road conditions than potential hazards at railway crossings.

Table 1: Driver Compliance at Various Types of Railway Crossings

Crossing Type	Compliance (%)	Non-Compliance (%)
Gated Crossings	85%	15%
Boom Barrier Crossings	80%	20%
Open Crossings	40%	60%

The data shows that compliance rates are significantly higher at crossings with automated systems compared to open crossings. The lack of compliance at open crossings can be attributed to the absence of active warning systems, which leads drivers to assume the absence of immediate danger.

Awareness and Knowledge of Safety Measures

Interviews with drivers revealed a concerning lack of awareness regarding the safety protocols at railway crossings. Most drivers admitted they did not know when to stop at crossings and only reacted to warnings when they could visually identify an approaching train. Furthermore, few drivers could recall receiving formal education about the dangers of railway level crossings or the importance of responding to the warning signals.

The lack of awareness was particularly evident in rural areas, where drivers were more likely to ignore the warning signs or misjudge the risk posed by trains. Only a small percentage of drivers knew the train schedules, which would help them anticipate the risk at railway crossings.

Table 2: Driver Knowledge of Railway Crossing Safety Protocols

Safety Knowledge Area	Percentage of Drivers Aware (%)
Appropriate Time to Stop at Crossing	35%

These results align with prior research, which found that driver education on railway crossing safety is essential for reducing accidents. Without a clear understanding of the risks and the appropriate response to warning systems, drivers are more likely to engage in unsafe behaviors that contribute to accidents.

Effectiveness of Warning Systems

The effectiveness of warning systems varied significantly across the different types of crossings. At crossings with automated boom barriers and flashing lights, compliance was high, with 80% of drivers following the safety protocol. However, the study found that there were occasional issues with the timing of the warning signals, especially during high-traffic periods. Some drivers either stopped too early or too late, which disrupted the traffic flow and could have led to accidents.

At crossings with only static signs or no warning systems, compliance dropped dramatically, with over 60% of drivers failing to respond appropriately. This finding underscores the importance of upgrading older crossings to include automated systems, especially in rural areas where accidents are

more frequent due to insufficient warning measures.

Table 3: Effectiveness of Warning Systems at Railway Crossings

Crossing Type	Warning System	Compliance (%)	Non-Compliance (%)
Automated Boom Barriers	Flashing Lights, Barriers	85%	15%
Static Signs	None or Static Sign	40%	60%

The data indicates that automated warning systems are significantly more effective in ensuring driver compliance than static signs alone. However, there is room for improvement in the timing and clarity of these signals, particularly during busy periods.

Gaps in Safety Measures and Policy Enforcement

Interviews with transportation safety experts revealed several gaps in current policies and safety measures at railway crossings. While some urban areas have implemented more comprehensive safety measures, including automated barriers and flashing lights, many rural areas still rely on outdated systems, such as static signs or no warning at all. Additionally, the enforcement of existing safety regulations was found to be inconsistent, with some authorities lacking the necessary resources to ensure proper monitoring and maintenance of safety infrastructure.

The disparity between urban and rural areas in terms of safety measures and enforcement reflects a significant policy gap. These gaps not only put rural road users at risk but also create a situation where accidents are more likely to occur due to insufficient safety protocols.

Table 4: Safety Measure Implementation Across Regions

Region	Safety Measures Implemented	Compliance (%)	Issues Identified
Urban Areas	Automated Barriers, Flashing Lights	85%	Timely signal issues
Rural Areas	Static Signs, No Barriers	40%	Lack of active warning

These findings suggest that policies need to be standardized across all regions to ensure equal safety measures, particularly in rural areas where railway crossing accidents are more prevalent due to outdated systems and poor enforcement.

The results from this study provide a clear picture of the current state of railway crossing safety in Indonesia, highlighting significant gaps in driver knowledge, behavior, and the effectiveness of warning systems. While automated systems show a higher rate of compliance, rural areas still face challenges due to outdated infrastructure and inconsistent enforcement of safety regulations. To improve safety, it is crucial to invest in modernizing railway crossings, particularly in rural areas, and to implement more comprehensive driver education programs. Additionally, more uniform enforcement of safety measures across all regions will be necessary to reduce the number of accidents at railway level crossings in Indonesia.

CONCLUSSION

This study examined human factors contributing to accidents at railway level crossings in Indonesia, focusing on driver behavior, awareness of safety measures, the effectiveness of warning systems, and gaps in policy enforcement. The findings reveal that the majority of drivers at crossings with automated systems like boom barriers and flashing lights adhere to safety protocols, whereas those at open crossings with static signs exhibit a significantly lower compliance rate.

Driver education emerged as a critical factor, with many drivers lacking awareness of when to stop, the importance of warning signals, and train schedules, particularly in rural areas. This lack of knowledge contributes to unsafe behavior, highlighting the need for comprehensive safety education campaigns to improve public understanding of railway crossing risks.

The study also found that while automated warning systems are more effective at ensuring compliance, there are issues with signal timing, especially during periods of high traffic. The inconsistency in the effectiveness of warning systems across regions—urban areas being better equipped than rural areas—reveals a significant gap in infrastructure, policy, and enforcement. This disparity calls for more uniform safety measures and stricter enforcement across both urban and rural areas.

In conclusion, this research underscores the importance of addressing human behavior, enhancing driver awareness, and improving the design and implementation of warning systems to reduce accidents at railway level crossings in Indonesia. Comprehensive educational programs, timely updates to safety infrastructure, and more consistent enforcement of regulations are crucial to enhancing the safety of these crossings. By focusing on these areas, Indonesia can make significant strides in reducing accidents and fatalities at railway level crossings.

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