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Original Article

From Compliance to Fatigue? Assessing the Effectiveness of ETLE in Indonesia's Traffic Law Enforcement

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Abstract

This study evaluates the effectiveness of Electronic Traffic Law Enforcement (ETLE) in Indonesia from 2019 to 2024, focusing on its role in increasing compliance within the framework of Deterrence Theory. Drawing on violation data from 12 urban jurisdictions (including Jakarta, Surabaya, and Denpasar) where ETLE has been implemented, the findings indicate that the system enhances the certainty of punishment, particularly in detecting administrative violations such as helmet infractions and missing documentation. However, its long-term effectiveness remains inconsistent, as fluctuations in violations suggest behavioral adaptation and deterrence fatigue. While ETLE initially led to a surge in detected violations, compliance declined in later years due to uneven enforcement between urban and rural areas, as well as limitations in addressing behavioral infractions such as reckless and distracted driving. These findings primarily reflect urban contexts, highlighting a need for broader geographic inclusion in future evaluations to ensure national applicability. The study suggests that certainty alone is insufficient for sustained deterrence without complementary measures such as effective penalty enforcement, geographic expansion, and public awareness campaigns. To maximize its impact, ETLE must be integrated with traditional law enforcement methods and adaptive policy strategies to ensure lasting compliance. Future research should assess ETLE's direct influence on accident rates and long-term driver behavior, with particular attention to expanding the geographic scope to improve national representativeness and policy relevance.

Keywords: Automated Law Enforcement, Deterrence Theory, Electronic Traffic Law Enforcement (ETLE), Road Safety Compliance, Traffic Violations.

1. Introduction

Traffic issues in Indonesia have become a critical challenge, significantly affecting public safety and transportation efficiency. Traffic violations, such as running red lights, speeding, failing to wear helmets, and illegal parking, are among the primary causes of accidents (Korlantas Polri, 2020). In 2020, the Traffic Corps (Korlantas Polri) reported over 100,000 traffic accidents, resulting in tens of thousands of fatalities and substantial material losses (Anisarida & Santosa, 2019). These violations, often considered trivial by road users, highlight deeper systemic issues such as low public discipline and inadequate law enforcement. Addressing these challenges is essential to reducing accidents and improving overall urban mobility.

The root causes of these violations lie in the low level of legal awareness and public discipline. Many road users fail to adhere to basic regulations, such as wearing helmets or

obeying traffic signals, reflecting weak understanding and respect for traffic laws (Wirna et al., 2023). Additionally, law enforcement practices in Indonesia are often inconsistent, leading to a lack of deterrence and the recurrence of violations (Pratiwi & Agustiwi, 2023). These patterns are further exacerbated by congestion in major cities like Jakarta, Surabaya, and Denpasar, where violations contribute to gridlock and reduced quality of life. Improving public education and strengthening enforcement mechanisms are critical steps toward resolving these issues.

Technological advancements have brought promising solutions to improve traffic law enforcement, particularly through the implementation of Electronic Traffic Law Enforcement (ETLE) (Suriadi et al., 2022). ETLE is an innovative system that uses information technology to enhance transparency and efficiency in handling traffic violations (Abdullah & Windiyastuti, 2022). The system relies on surveillance cameras and network-based devices to automatically detect and record violations, reducing direct interaction between violators and officers. By minimizing opportunities for bribery, ETLE promotes accountability and fairness in law enforcement. This technology-based approach represents a significant shift from traditional manual methods to modern, transparent enforcement practices.

The Indonesian government has positioned ETLE as a key strategy for improving traffic law enforcement. Initially tested in Jakarta and Surabaya in 2018, the program was expanded nationally in 2021 under the leadership of National Police Chief General Listyo Sigit Prabowo (Saputra, 2021). ETLE focuses on areas with high rates of traffic violations, such as Jakarta's Sudirman-Thamrin corridor, utilizing advanced surveillance technology integrated with digital systems. By 2023, the program had been implemented in 12 regional jurisdictions with 244 active surveillance cameras, reflecting its growing adoption and effectiveness (Abdullah & Windiyastuti, 2022). This expansion underscores ETLE's potential as a cornerstone of Indonesia's traffic management system.

The ETLE system utilizes Automatic Number Plate Recognition (ANPR) technology to detect violations, such as not wearing helmets, lane breaches, and mobile phone use while driving. Once detected, violation data is transmitted directly to the Electronic Registration and Identification (ERI) database, enabling automated processing without manual intervention (Pratiwi & Agustiwi, 2023). This system ensures accurate and consistent enforcement while reducing the potential for human error and bias. Furthermore, violators receive evidence in the form of photos or videos, enhancing the transparency and accountability of the enforcement process (Pratiwi & Agustiwi, 2023). These features build public trust in the legal system and promote a culture of compliance.

The application of ETLE aligns closely with deterrence theory, which emphasizes the certainty, swiftness, and severity of punishment as key factors in preventing violations. ETLE strengthens the certainty of punishment by using Automatic Number Plate Recognition (ANPR) technology and surveillance cameras to detect violations with precision. The system operates continuously, leaving little room for offenders to evade enforcement. Swift action is another hallmark of ETLE, as violations are automatically recorded and linked to the offender's data in the Electronic Registration and Identification (ERI) database. Notifications, complete with photo or video evidence, are sent promptly to violators, reinforcing the immediate connection between the offense and the penalty. This mechanism ensures consistent and objective enforcement, fostering a heightened perception of risk among road users and encouraging better compliance with traffic rules.

While deterrence theory also considers the severity of punishment, ETLE focuses on fairness and proportionality rather than excessively harsh penalties. The system's consistent and transparent enforcement creates a strong deterrent effect without undermining public trust. By eliminating subjective judgments and opportunities for corruption inherent in

manual ticketing, ETLE enhances the credibility of law enforcement (Andriyani, 2024). This approach supports both general deterrence—deterring the general public by increasing the perceived likelihood of punishment—and specific deterrence, which reduces the likelihood of repeat offenses among violators. Together, these elements align ETLE with the principles of deterrence theory, contributing to the creation of a more disciplined and accountable road user culture in Indonesia.

The limitations of traditional manual ticketing systems highlight the urgent need for modern, technology-based solutions like ETLE. Manual enforcement often relies on subjective judgments by officers during interactions with violators, leading to inconsistencies in how penalties are applied. This subjectivity can result in perceived unfairness, where violators may feel that the decisions are arbitrary or influenced by personal bias (Andriyani, 2024). These inconsistencies undermine public trust in the enforcement process, reducing the perceived legitimacy of traffic laws. Additionally, the reliance on human judgment creates opportunities for corruption, as direct interactions between officers and violators often involve negotiations that may lead to bribery or informal settlements.

Beyond these integrity concerns, manual ticketing systems are inefficient and resource-intensive. The process of issuing a violation ticket requires officers to manually document offenses, a time-consuming task that can lead to bottlenecks in enforcement, especially in high-traffic areas. This inefficiency is compounded by the requirement for violators to appear in court or designated payment centers to settle their fines, which is burdensome for both the public and the judicial system (Pratiwi & Agustiwi, 2023). Such delays not only reduce the swiftness of punishment, a critical component of deterrence, but also limit the capacity of law enforcement agencies to address multiple violations effectively. Furthermore, the use of physical documentation for recording violations increases the risk of data loss or inaccuracies, further complicating enforcement and record-keeping.

The reliance on manual systems also poses logistical challenges in managing and analyzing violation data. Officers often struggle to maintain organized records of violations, making it difficult to track repeat offenders or identify trends that could inform preventive policies (Abdullah & Windiyastuti, 2022). The lack of centralized, digitized databases limits the ability to generate actionable insights from violation data, hindering efforts to address systemic issues or implement targeted interventions. This absence of data integration also weakens collaboration between law enforcement agencies and other stakeholders, such as urban planners and policymakers.

Another significant drawback of manual systems is their limited capacity to scale enforcement efforts across large and densely populated urban areas. With finite human resources, law enforcement agencies can only monitor a small fraction of traffic violations, leaving many offenders unpunished. This creates an environment where violators perceive a low likelihood of being caught, undermining the deterrent effect of enforcement (Mahamud et al., 2022). In addition, manual ticketing systems are less effective in addressing violations in real-time, such as speeding or illegal parking, which often require immediate detection and action.

Finally, manual enforcement systems fail to address the broader need for public transparency and accountability in traffic law enforcement. The absence of clear, evidence-based processes makes it difficult for violators to verify the legitimacy of their penalties, leading to disputes and dissatisfaction (Andriyani, 2024). This lack of transparency not only erodes public trust but also diminishes the broader cultural acceptance of traffic laws. Without a reliable and objective system, public scepticism toward traffic law enforcement remains a significant barrier to achieving widespread compliance.

These numerous shortcomings illustrate why a transformation to technology-based systems like ETLE is essential. By addressing issues of subjectivity, inefficiency, corruption, and limited scalability, ETLE provides a robust alternative that aligns with modern expectations of fairness, transparency, and effectiveness. The automation and centralization inherent in ETLE not only streamline enforcement but also establish a foundation for data-driven policymaking, ultimately creating a safer and more disciplined traffic environment in Indonesia.

International experiences with technology-based traffic enforcement offer valuable lessons for Indonesia. In Australia, speed-detection cameras have reduced accidents by up to 30%, showcasing the effectiveness of automated systems (Statkiene, 2022). Similarly, Singapore's transparent and integrated traffic enforcement systems have significantly improved public compliance with traffic laws (Liu et al., 2020). Malaysia's Automated Awareness Safety System (AWAS) achieved a 90% reduction in speeding violations within the first six months of implementation (Mahamud et al., 2022). These success stories highlight the potential for Indonesia to optimize ETLE's implementation and achieve similar results.

Public education and outreach are critical for enhancing the effectiveness of ETLE. Lessons from Lithuania demonstrate that combining enforcement with education-based strategies fosters greater public compliance and legal awareness (Statkiene, 2022). In Indonesia, similar approaches could address misconceptions about ETLE while emphasizing its role in improving road safety and fairness. Campaigns should highlight the system's benefits, including reduced corruption and streamlined enforcement, to build public trust and support. Effective communication strategies are key to maximizing ETLE's impact.

This study aims to evaluate the effectiveness of ETLE in reducing traffic violations and influencing driver behaviour. Using a combination of normative juridical and empirical approaches, it examines violation data, public perceptions, and enforcement outcomes to identify areas for improvement. The findings are expected to provide actionable recommendations for optimizing ETLE's implementation. By addressing gaps and leveraging technology effectively, this study supports the development of a more sustainable and effective traffic management system in Indonesia.

Evaluating the Electronic Traffic Law Enforcement (ETLE) system is critical to understanding its effectiveness and ensuring its sustainability as a modern traffic law enforcement tool. While ETLE addresses many shortcomings of manual ticketing systems, such as inefficiency and corruption, its implementation must be assessed to determine whether it truly achieves its goals of enhancing transparency, improving compliance, and fostering public trust. This evaluation is essential to identify gaps or weaknesses in its operation, such as errors in violation detection, limited public understanding, or uneven application across different regions. These insights are vital for improving the system and ensuring it remains a reliable and trusted solution for addressing traffic violations. Understanding these elements directly supports the objectives of this research, which aims to analyze ETLE's effectiveness in reducing violations and influencing driver behaviour.

This research is also important because ETLE's success depends on its adaptability to Indonesia's diverse geographic, social, and technological contexts. Currently, ETLE operates primarily in urban areas with advanced infrastructure, leaving rural regions underrepresented (Fadlan, 2023). Evaluating its scalability and ability to function in areas with limited connectivity or unique road conditions is necessary to achieve nationwide impact. Moreover, assessing ETLE's influence on driver behaviour—whether it fosters lasting compliance or only deters violations in monitored areas—can provide a basis for designing complementary interventions, such as education campaigns or policy adjustments. By addressing these

aspects, this research not only evaluates ETLE but also offers strategic recommendations for enhancing its long-term effectiveness and equity.

Finally, this research is significant because it links ETLE to broader considerations of financial sustainability and strategic integration within Indonesia's traffic governance framework. Maintaining ETLE requires significant investment in technology, infrastructure, and public outreach, making it crucial to evaluate its cost-effectiveness and return on investment. Understanding how well ETLE integrates with other traffic management systems and policies also supports its optimization and future-proofing. As a pioneering initiative, ETLE's success can serve as a model for leveraging technology to address other governance challenges, reinforcing its role as a transformative step in modernizing Indonesia's public systems. By focusing on these dimensions, this research contributes not only to improving ETLE but also to advancing the broader goals of public safety, accountability, and innovation.

2. Literature Review

2.1. Introduction to Electronic Traffic Law Enforcement (ETLE) in Indonesia

The implementation of Electronic Traffic Law Enforcement (ETLE) in Indonesia marks a critical advancement in traffic law enforcement, utilizing technology to enhance efficiency, transparency, and accountability. ETLE was first introduced as a pilot project on October 1, 2018, and by March 2021, it had been implemented nationally to address widespread traffic violations and improve public discipline in road use (Abdullah & Windiyastuti, 2022).

ETLE operates under a legal framework provided by several key regulations. Law No. 22 of 2009 on Traffic and Road Transport serves as the primary legal basis, particularly Article 272, which authorizes the use of electronic devices for traffic law enforcement. Additionally, Government Regulation No. 80 of 2012 outlines procedures for motor vehicle inspections and enforcement of traffic violations (Gazali, 2022). Together, these regulations ensure that ETLE aligns with national legal standards while fostering fair and equitable enforcement practices.

The system's operational mechanism involves detecting violations through strategically placed CCTV cameras equipped with Automatic Number Plate Recognition (ANPR) technology. These cameras capture evidence of violations, such as running red lights, not wearing helmets, or using mobile phones while driving. The violation data is then transmitted to the Regional Traffic Management Center (RTMC) for verification. Subsequently, a notification or summons is sent to the violator's registered address, allowing them to confirm or dispute the violation before paying the fine online (Hidayat et al., 2022; Leonita et al., 2022).

ETLE addresses a wide range of traffic violations, including running red lights, which carries a maximum fine of IDR 500,000 or two months of imprisonment, and using mobile phones while driving, which can result in fines of up to IDR 750,000 or three months of imprisonment. These sanctions are designed to deter unsafe driving behaviours and encourage compliance with traffic regulations (Abdullah & Windiyastuti, 2022).

Despite its benefits, ETLE faces several challenges in its implementation. Infrastructure limitations, such as insufficient cameras and technological equipment, hinder its full-scale adoption nationwide. Moreover, public awareness and understanding of the system remain low, requiring extensive socialization efforts to foster compliance and support (Hidayat et al., 2022; Leonita et al., 2022). Addressing these challenges is crucial to achieving ETLE's long-term goals of reducing traffic violations and creating safer roads.

By minimizing direct interactions between law enforcement officers and violators, ETLE has proven effective in curbing bribery and corruption. This digital system not only ensures fairness in law enforcement but also fosters a culture of accountability and respect for traffic laws, contributing to broader efforts to modernize Indonesia's traffic management system (Abdullah & Windiyastuti, 2022; Gazali, 2022).

2.2. Deterrence Theory

Deterrence theory is one of the foundational frameworks in criminology, emphasizing that individuals' decisions to commit crimes or violations are influenced by their perceptions of punishment. The theory highlights three main components that determine its effectiveness: certainty, swiftness, and severity of punishment. These elements work collectively to deter individuals from engaging in unlawful behaviour by creating a rational fear of the consequences (Nagin, 2013).

2.2.1. Certainty of Punishment

The certainty of punishment refers to the likelihood that a violation will be detected and penalized. It is widely regarded as the most important component of deterrence theory because individuals are less likely to engage in unlawful behaviour if they believe there is a high probability of being caught. Research shows that visible enforcement mechanisms, such as traffic cameras, police patrols, or automated systems, significantly increase compliance.

For example, in Malaysia, the implementation of automated enforcement systems like the Automated Awareness Safety System (AwAS) led to a 71% reduction in speeding violations at monitored locations (Mahamud et al., 2022). Similarly, Indonesia's Electronic Traffic Law Enforcement (ETLE) enhances the certainty of punishment by using digital systems that immediately notify violators of their offenses. These systems include photo and video evidence, reinforcing the perception that violators cannot evade detection (Wirna et al., 2023).

2.2.2. Swiftness of Punishment

Swiftness refers to the speed at which punishment is administered after a violation occurs. The closer the temporal connection between the offense and the punishment, the stronger the deterrent effect. This concept aligns with psychological reinforcement theories, which state that immediate consequences have a greater impact on behaviour than delayed ones.

In China, studies found that reducing the time between a traffic violation and the imposition of penalties enhanced compliance (Wang et al., 2024). Automated systems like ETLE excel in this aspect by streamlining administrative processes, allowing violators to receive notices within hours or days. This immediacy strengthens the association between the violation and its consequences, minimizing the likelihood of repeat offenses.

Conversely, delays in punishment weaken this association and may lead individuals to believe they can avoid consequences altogether. Manual enforcement systems, which often require offenders to appear in court or navigate bureaucratic processes, tend to have a weaker deterrent effect due to such delays.

2.2.3. Severity of Punishment

Severity relates to the harshness of the penalty imposed for a violation. While severe penalties can deter behaviour, they must be perceived as proportional and fair. Overly harsh punishments can undermine public trust in the legal system, while overly lenient ones fail to create a meaningful deterrent effect (Wang et al., 2024).

In Iran, research showed that point-based penalties (e.g., accumulating penalty points that can lead to license suspension) were more effective than monetary fines. This is because

penalty points carry long-term consequences, such as the inability to renew licenses, which offenders take more seriously (Khojastehpour et al., 2024). Similarly, Indonesia's ETLE system applies fines proportionate to the offense, ensuring fairness while maintaining its deterrent impact (Wirna et al., 2023).

Deterrence theory identifies two primary objectives in preventing unlawful behaviour: general deterrence and specific deterrence. General deterrence aims to discourage the broader population from committing violations by demonstrating the consequences of such actions. This approach often relies on visible enforcement mechanisms, such as marked police vehicles, publicized use of traffic cameras, or automated systems, which serve as a constant reminder of the potential repercussions of breaking the law. Conversely, specific deterrence targets individuals who have already committed violations, imposing penalties like fines, license suspensions, or mandatory re-education programs to prevent repeat offenses. For instance, the Electronic Traffic Law Enforcement (ETLE) system implemented in Indonesia effectively utilizes both these approaches. By broadcasting the presence of surveillance cameras and maintaining high visibility, ETLE deters potential violators. At the same time, the system records detailed data on repeat offenders, enabling targeted interventions to address recurring violations and reinforce specific deterrence (Khojastehpour et al., 2024).

The integration of technology has significantly transformed the practical application of deterrence theory, particularly in traffic law enforcement. Technological advancements have allowed for the development of automated systems like Indonesia's ETLE and Malaysia's Automated Awareness Safety System (AwAS), which enhance the certainty and swiftness of punishment while minimizing the risk of human error and corruption. For example, AwAS cameras have been shown to reduce speeding behaviour by 92.2% within six months of implementation, demonstrating the profound impact of technology-driven enforcement on road safety (Mahamud et al., 2022). These systems not only improve enforcement efficiency but also enhance transparency. By providing offenders with clear evidence of their violations, such as time-stamped photographs or video footage, disputes are minimized, and public trust in law enforcement mechanisms is strengthened. Additionally, these technologies facilitate data collection and analysis, enabling policymakers to identify high-risk areas, analyze trends, and implement tailored strategies to address specific challenges in traffic management.

Despite its effectiveness, deterrence theory is not without its limitations. A key assumption of the theory is that individuals act rationally, weighing the potential costs and benefits of their actions. However, this assumption does not always align with real-world behaviour, as emotions, habits, and social factors often influence decision-making. For example, a driver may disregard the risk of punishment due to emotional stress or habitual recklessness. Furthermore, the effectiveness of deterrence varies across cultural and economic contexts. Penalties that are considered severe in one country might be seen as negligible in another, depending on income levels and societal norms. This disparity highlights the need for enforcement strategies to be context-specific and sensitive to local conditions. Research in China has shown that delayed penalties weaken the deterrent effect, as the association between the offense and the punishment becomes less impactful over time (Wang et al., 2024). Similarly, while technology has improved the efficiency of enforcement, it may not address underlying social and cultural factors that influence compliance.

Overall, deterrence theory provides a robust framework for understanding and influencing behaviour through law enforcement. By focusing on the certainty, swiftness, and severity of punishment, the theory offers practical strategies for designing effective enforcement systems. Programs like ETLE in Indonesia illustrate how technology can operationalize these principles to create transparent, equitable, and efficient systems for

managing traffic violations. These programs not only improve compliance but also build public trust in the legal system by reducing the potential for human bias and corruption. As enforcement systems continue to evolve, future research should explore how these principles can be adapted to diverse cultural and economic contexts. Additionally, long-term studies are needed to assess how deterrence-based strategies influence behaviour over time and to identify complementary measures, such as education and community engagement, that can enhance the effectiveness of deterrence. By integrating these elements, policymakers can develop more holistic and sustainable approaches to fostering compliance and improving road safety.

2.3. Previous Research

Numerous Several studies have examined the implementation and effectiveness of Electronic Traffic Law Enforcement (ETLE), focusing on its impact on traffic violations, public compliance, legal frameworks, and technological integration. Research findings highlight ETLE's potential to enhance enforcement efficiency, reduce corruption, and improve compliance, while also revealing challenges related to public awareness, infrastructure limitations, and regulatory inconsistencies.

In Indonesia, Saibi & Sihombing (2024) found that ETLE improved compliance in Medan but required further socialization efforts and infrastructure enhancements. Kristanto et al. (2024) emphasized ETLE's role in reducing corruption but identified legal ambiguities that need resolution. Fadlan (2023) highlighted issues such as vehicle ownership transfer delays and network accessibility, which hinder enforcement efficiency. Mahamud et al. (2022) compared Malaysia's Automated Awareness Safety System (AWAS) with Indonesia's ETLE, concluding that strict enforcement and public awareness programs significantly enhance compliance, as demonstrated by Malaysia's 90% reduction in speeding violations within six months.

From a deterrence perspective, research shows that certainty, severity, and swiftness of punishment play crucial roles in compliance. Abroodi et al. (2012) found that stricter traffic laws in Tehran led to fewer violations, reinforcing the need for strong deterrent mechanisms. Davey & Freeman (2011) emphasized that enforcement visibility strengthens deterrence, while Bates & Anderson (2019) noted that young drivers often attempt to circumvent automated enforcement. Khojastehpour et al. (2024) further linked socioeconomic status, technology adoption, and legal clarity to perceptions of deterrence.

Challenges in ETLE enforcement remain a recurring theme in previous studies. Rahman (2024) found that low fine payment rates undermine the system's effectiveness, suggesting a need for ETLE integration with vehicle registration systems to enforce compliance. Hadju (2024) emphasized the benefits of Automatic Number Plate Recognition (ANPR) in increasing compliance rates but pointed out infrastructure inconsistencies. Primasyena (2023) observed a decline in repeat offenses after ETLE implementation, indicating its effectiveness in behavior modification, though resistance among digitally unskilled drivers remains an issue. Kuncoro (2022) stressed that while ETLE strengthens punitive measures, public education and awareness campaigns are necessary for fostering voluntary compliance.

Overall, previous research highlights ETLE's strengths in increasing enforcement efficiency and compliance, but also underscores the need for technological improvements, policy adjustments, and public education to maximize its impact. Future studies should focus on long-term assessments of ETLE's effect on traffic safety and comparative evaluations with automated enforcement systems in other countries.

3. Methods

This study adopts a quantitative approach to assess the effectiveness of Electronic Traffic Law Enforcement (ETLE) in Indonesia between 2019 and 2024. Secondary data were obtained from national law enforcement records managed by the Indonesian National Traffic Police (Korlantas Polri), encompassing trends in traffic violations, offender demographics, and vehicle involvement before and after the nationwide rollout of ETLE. A comparative analysis was conducted between the pre-ETLE period (2019–2020) and the post-ETLE period (2021–2024), allowing for an evaluation of behavioral shifts over time.

The research population consists of all recorded traffic violations captured through automated surveillance systems, including Automatic Number Plate Recognition (ANPR) cameras, closed-circuit television (CCTV), and monitoring by Regional Traffic Management Centers (RTMCs). A complete enumeration sampling method was employed, meaning all recorded violations within the specified timeframe were included in the analysis without any selection bias.

To address potential regional bias and reflect contextual diversity across Indonesia, the study incorporated two supplementary components. First, a regional enforcement intensity mapping was conducted by categorizing provinces into three tiers—high, medium, and low—based on the density of surveillance cameras per 10,000 registered vehicles. This stratification aimed to approximate the varying intensity of ETLE implementation across regions. Second, while not the primary focus, the study incorporated available public perception data from the National Transportation Safety Committee (2023), which surveyed levels of awareness and acceptance of ETLE in five major urban centers.

Data collection followed the standard operational workflow of ETLE, in which detected violations, such as riding without a helmet, speeding, and running red lights are automatically transmitted to the RTMC for verification before being registered in the national enforcement database. This workflow ensured accuracy and procedural consistency in the data used for analysis.

Despite its nationwide dataset, the study acknowledges several limitations. First, the distribution of ETLE infrastructure remains uneven, with a strong urban bias: approximately 78% of surveillance devices are concentrated in Java, while only 22% are distributed across other islands. Second, the public perception data analyzed are geographically limited to major metropolitan areas and do not represent rural or under-monitored regions. Third, variations in local enforcement priorities and discretion, though relevant but not reflected in the centralized database used for this study.

Overall, the methodological framework provides a replicable structure for national-level evaluation while incorporating critical contextual considerations. Future research should aim to integrate more granular regional comparisons, qualitative insights, and systematic tracking of public sentiment to develop a more comprehensive understanding of ETLE's long-term impact on traffic law compliance in Indonesia.

4. Results and Discussion

4.1. Research Results

4.1.1. Overall Trend of Traffic Violations (2019-2024)

Traffic violations have fluctuated significantly over the years, influenced by external factors such as the COVID-19 pandemic and the introduction of Electronic Traffic Law Enforcement (ETLE). The following figure presents the overall trend of recorded violations

from 2019 to 2024, highlighting the impact of these events on compliance and enforcement effectiveness.

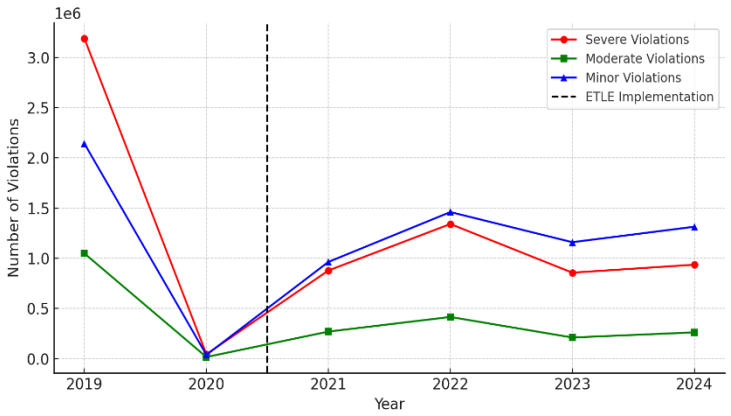

Figure 1. Trend of Total Violations (2019-2024)

The figure above illustrates the fluctuation in recorded traffic violations before and after the implementation of Electronic Traffic Law Enforcement (ETLE). In 2019, before the pandemic and the introduction of automated enforcement, there were 5,646,206 recorded violations nationwide. However, in 2020, this number dropped dramatically to 121,257 cases, likely due to reduced mobility and limited law enforcement activities caused by COVID-19 restrictions. The significant decrease across all violation categories suggests that movement restrictions and a reduction in physical enforcement resulted in an artificial decline in reported infractions.

Following the easing of pandemic restrictions, ETLE was progressively implemented in 2021, leading to a sharp rise in violations, reaching 1,768,759 cases. The upward trend continued in 2022, peaking at 2,725,728 violations, marking the highest recorded figure during the observed period. The sharp increase suggests that ETLE significantly improved the detection of infractions, particularly those that previously relied on manual enforcement. The ability of automated surveillance to capture violations systematically, without requiring direct interaction between officers and drivers, contributed to this surge in reported infractions.

In 2023, the total number of violations declined to 1,855,025 cases, reflecting a notable 32% decrease compared to the previous year. Several factors could explain this decline, including increased driver awareness and adaptation to ETLE, where motorists became more mindful of monitored locations and adjusted their driving behavior accordingly. The expansion of ETLE coverage may have also led to a deterrent effect, discouraging violations in areas where enforcement had become more predictable. Additionally, stricter penalties and administrative measures, such as improved fine collection and digital ticketing, could have reinforced compliance among road users.

Despite this decrease, the number of violations rose again in 2024 to 2,100,142 cases, showing a 12% increase from the previous year. This resurgence may be attributed to the expansion of ETLE coverage and upgrades in technology, enabling more accurate detection of infractions. It is also possible that some drivers, having adapted to the system, began to take risks once the immediate impact of stricter enforcement started to fade. Changes in traffic volume due to increased post-pandemic economic activity may have further contributed to the higher number of recorded violations, as more vehicles on the road naturally lead to a greater likelihood of infractions being committed.

A comparative assessment of the pre-ETLE and post-ETLE periods highlights a distinct shift in traffic law enforcement. Before ETLE, violations were largely dependent on manual enforcement, with a significant decline observed in 2020 due to external factors such as pandemic-related mobility restrictions. In the years following ETLE implementation, the number of recorded violations increased considerably, demonstrating the system's effectiveness in identifying infractions that may have previously gone undetected. The post-ETLE phase also shows fluctuations in recorded violations, suggesting that driver behavior, enforcement expansion, and policy adjustments all play a role in shaping long-term compliance trends.

This pattern suggests that ETLE initially enhanced violation detection, leading to a sharp rise in recorded cases. However, as the system matured and drivers adapted to automated enforcement mechanisms, fluctuations began to emerge. The data indicate that while ETLE is effective in enforcing compliance, its long-term impact depends on how drivers internalize the rules, the consistency of enforcement policies, and the ability of the system to evolve in response to new traffic challenges.

4.1.2. Traffic Violations by Vehicle Type

Different types of vehicles exhibit varying patterns of traffic violations, with motorcycles consistently accounting for the highest number of infractions. The implementation of ETLE has influenced violation trends across different vehicle categories, particularly for motorcycles, mini buses, and pickup trucks, which are more frequently involved in infractions. The figure below illustrates the distribution of recorded violations by vehicle type over the observed period.

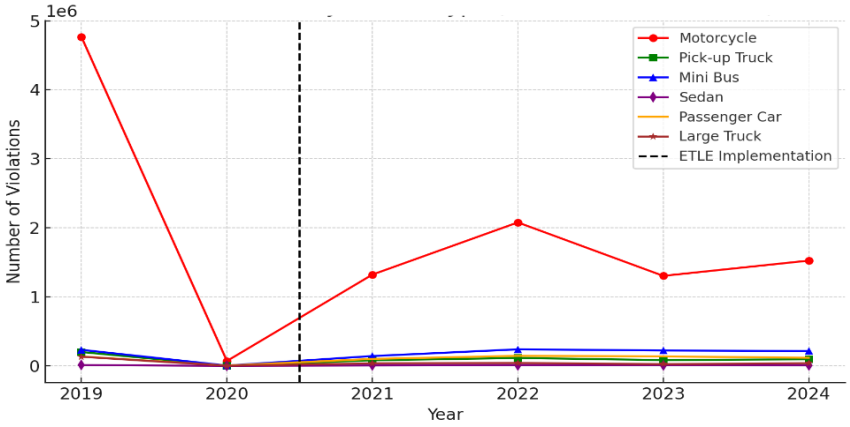

Figure 2. Traffic Violations by Vehicle Type (Pre-ETLE vs Post ETLE)

The figure above provides a breakdown of traffic violations by vehicle type, showing that motorcycles consistently account for the highest number of infractions, far surpassing all other vehicle categories. In 2019, motorcycles were responsible for 4,765,712 violations, making up nearly 85% of all recorded traffic infractions. However, in 2020, the number of motorcycle violations dropped significantly to 71,145 cases, largely due to the pandemic's impact on mobility and enforcement. As restrictions eased and ETLE was introduced, the number of recorded motorcycle violations surged, reaching 1,322,720 cases in 2021 and peaking at 2,078,718 cases in 2022. Despite a slight decline in 2023, when the number fell to 1,304,341 cases, motorcycle violations increased again in 2024 to 1,525,306 cases, suggesting continued challenges in enforcing compliance within this category.

Among four-wheeled vehicles, mini buses and pickup trucks consistently recorded the highest number of infractions. Mini buses accounted for 232,884 violations in 2019, but this

figure dropped drastically to 5,163 cases in 2020 due to the pandemic. After the introduction of ETLE, the number increased significantly, reaching 239,720 cases in 2022, highlighting the system's role in capturing violations more effectively. Pickup trucks exhibited a similar trend, with 200,794 violations in 2019, a substantial decline during the pandemic, and then a rise to 114,719 cases in 2022. The increase in violations for both vehicle types suggests that ETLE has had a stronger impact on public transport and light commercial vehicles, which are more frequently monitored due to their operational roles in urban and intercity mobility.

The number of violations committed by sedans, jeeps, and taxis remained relatively low throughout the observed period, indicating either higher compliance levels or lower detection rates in these vehicle categories. Larger commercial vehicles, such as trucks and buses, exhibited fluctuating trends, with some years showing an increase in violations and others reflecting a decline. This variability suggests that ETLE enforcement has had a more noticeable impact on passenger and smaller commercial vehicles, while larger freight transport may require additional regulatory measures to ensure compliance. The data indicate that while ETLE has been effective in monitoring certain vehicle types, further improvements may be needed to enhance enforcement across all categories, particularly in detecting infractions among commercial and heavy-duty vehicles.

4.1.3. Types of Violations Committed

Traffic violations vary in nature, with some infractions being more commonly recorded than others. The introduction of ETLE has significantly influenced the detection of specific violations, particularly those that are easily captured through automated surveillance, such as helmet violations, missing documentation, and traffic marking infractions. The figure below provides an overview of the most frequently detected traffic violations over the six-year period.

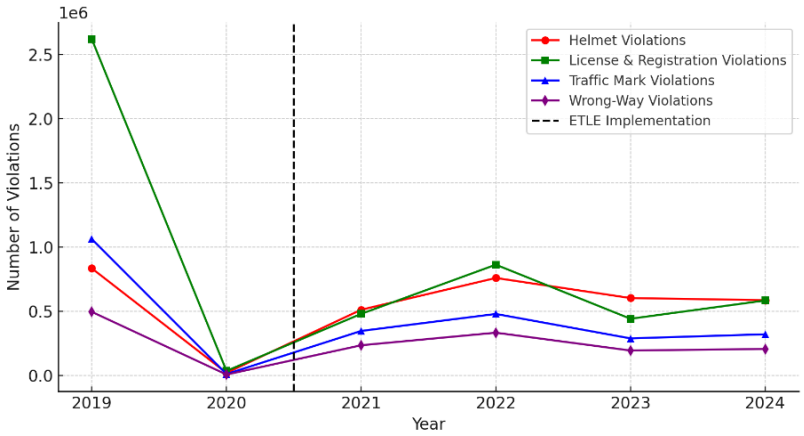

Figure 3. Traffic Violations by Type (Pre-ETLE vs Post ETLE)

Traffic violations vary in nature, with some infractions being more commonly recorded than others. The introduction of ETLE has significantly influenced the detection of specific violations, particularly those that are easily captured through automated surveillance, such as helmet violations, missing documentation, and traffic marking infractions. The figure below provides an overview of the most frequently detected traffic violations over the six-year period.

The figure above highlights the most commonly recorded types of traffic violations, revealing several key patterns. Helmet violations consistently rank among the most frequently detected infractions, particularly among motorcycle riders. In 2019, there were 835,022 recorded cases of helmet violations, but this number dropped significantly to 20,925 in 2020 due to reduced mobility and law enforcement during the pandemic. After the introduction of ETLE, helmet violations surged once again, reaching 760,245 cases in 2022. A decline was

observed in 2023, with 603,754 recorded cases, followed by a slight decrease to 587,438 cases in 2024.

Failure to carry valid vehicle documentation, such as a driver's license or vehicle registration, was another major offense. In 2019, there were 2,620,174 cases of missing documentation. This number dropped to 36,361 cases in 2020 but surged again to 863,747 cases in 2022 following the introduction of ETLE. Although the figure declined in 2023 and 2024, it remained relatively high, with 584,878 recorded cases in the most recent year.

Violations related to road markings and driving against the flow of traffic were also commonly detected. Traffic marking violations peaked at 480,172 cases in 2022, indicating widespread non-compliance with lane discipline and other road regulations. Similarly, counterflow violations reached 334,128 cases in the same year before experiencing a slight decline in subsequent years.

Interestingly, violations related to drunk driving and drug use remained consistently low, suggesting that these types of infractions are more difficult to detect using ETLE. In 2019, only 283 cases of drunk driving were recorded, and even after ETLE was implemented, the numbers remained below 100 cases per year. This trend indicates that while ETLE is effective in capturing visible infractions, additional enforcement mechanisms may be necessary to address violations that require behavioral assessments or direct law enforcement intervention.

4.1.4. Deterrence Fatigue in the Implementation of ETLE

Electronic Traffic Law Enforcement (ETLE) was introduced as a strategy to improve compliance by ensuring the certainty of punishment through automated monitoring. The system initially demonstrated a significant impact, as the number of recorded violations increased substantially after its implementation. However, an analysis of long-term trends suggests fluctuations in compliance, with a decline in recorded violations in some years followed by a resurgence in others.

The year-over-year change in recorded traffic violations provides insight into how compliance patterns evolved over time. The following graph illustrates the percentage change in violations from 2019 to 2024, highlighting key shifts before and after the nationwide rollout of ETLE.

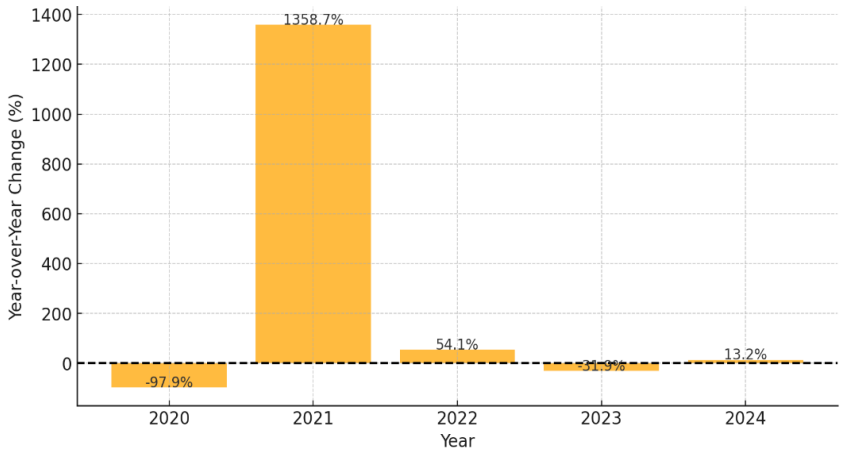

Figure 4. Annual Percentage Change in Traffic Violations (2019-2024)

The graph presents the year-over-year percentage change in recorded traffic violations from 2019 to 2024. The most notable fluctuation occurred between 2019 and 2020, when violations decreased by nearly 98%, primarily due to the impact of COVID-19 restrictions that significantly reduced traffic volume and enforcement activities. In contrast, 2021 recorded a

dramatic 1,358% increase following the national expansion of ETLE, reflecting the system's ability to detect more infractions compared to manual enforcement.

This upward trend continued in 2022, with violations increasing by 54%, indicating further improvements in ETLE coverage and its enforcement capacity. However, in 2023, the number of violations dropped by 32%, suggesting that compliance improved as drivers became more familiar with ETLE-monitored locations and adjusted their behavior accordingly.

Despite this decline, 2024 recorded a 12% increase, reversing the previous year's trend. This suggests that the compliance improvements observed in 2023 were not sustained, as violations began to rise again. The fluctuation in violation patterns highlights changes in driver behavior over time, as well as the evolving impact of ETLE on traffic law enforcement.

4.2. Discussion

The implementation of Electronic Traffic Law Enforcement (ETLE) in Indonesia marks a shift toward a technology-driven deterrence model aimed at improving compliance with traffic laws. Deterrence Theory posits that individuals are less likely to commit violations when the certainty, severity, and swiftness of punishment are high. ETLE primarily enhances the certainty of punishment by automating the detection process, thereby reducing discretionary enforcement. However, the long-term effectiveness of ETLE is uncertain, as compliance patterns fluctuate over time. While the system initially led to a surge in recorded violations due to increased detection efficiency, the recent resurgence of infractions suggests that deterrence fatigue may be weakening its impact.

One of the most immediate effects of ETLE was the initial increase in recorded violations following its national expansion in 2021, a trend consistent with deterrence theory's prediction that heightened enforcement visibility leads to higher detection rates. This rise does not necessarily indicate a spike in traffic infractions but rather reflects ETLE's ability to capture violations that previously went undocumented under manual enforcement. The peak in 2022 further demonstrated that ETLE successfully reinforced the certainty of punishment, prompting road users to recognize that violations would be automatically detected and sanctioned.

However, certainty alone is not sufficient to sustain compliance in the long run. The decline in violations observed in 2023 suggests that many drivers had adjusted their behavior in response to ETLE's presence. This could indicate that drivers were either complying with regulations in monitored areas or learning to exploit enforcement gaps. Yet, the subsequent increase in violations in 2024 raises concerns about deterrence fatigue, a phenomenon where compliance diminishes over time as drivers become desensitized to enforcement mechanisms. This aligns with rational choice perspectives, which argue that individuals calculate enforcement risks and adjust behavior accordingly. If drivers perceive ETLE as predictable and learn to selectively comply only in high-surveillance areas, the system's overall deterrent effect weakens.

The resurgence of violations in 2024 suggests that ETLE's deterrent effect may be temporary unless continuously reinforced. This decline in long-term deterrence can be attributed to several factors. First, behavioral adaptation plays a significant role, as drivers become familiar with monitored zones and modify their behavior only where enforcement is active. Second, the perceived severity and swiftness of punishment impact compliance levels. If fines are viewed as minor inconveniences rather than meaningful deterrents, individuals may accept them as an expected cost rather than a punishment. Additionally, delays in penalty processing could weaken the psychological link between offense and consequence, diminishing the intended deterrent effect. These findings are consistent with studies on

automated enforcement in other jurisdictions, which indicate that initial compliance gains often wane unless enforcement is continuously reinforced.

Another challenge affecting ETLE's long-term effectiveness is its uneven distribution across regions, leading to differential perceptions of enforcement risk. Areas with extensive ETLE coverage naturally report higher violation rates, not because compliance is lower, but because more infractions are being detected. In contrast, regions with minimal ETLE infrastructure experience enforcement gaps, allowing drivers to perceive a lower risk of detection. This disparity mirrors patterns observed in other countries, where automated enforcement fosters localized rather than habitual compliance, as individuals adjust their behaviors based on enforcement density rather than an intrinsic commitment to traffic laws.

The effectiveness of ETLE also varies depending on the type of violation, exposing fundamental limitations in automated enforcement. The system has proven highly effective in detecting administrative infractions such as helmet use, disobeying traffic signals, and missing vehicle documentation, as these offenses can be easily captured by cameras. However, ETLE is significantly less effective in addressing behavioral violations such as reckless driving, mobile phone use, and driving under the influence, which require real-time human judgment and discretionary enforcement. This suggests that automated surveillance alone cannot fully address all traffic infractions and must be complemented by manual enforcement strategies.

Public perception also plays a crucial role in determining ETLE's long-term impact. Research suggests that compliance is most sustainable when enforcement is perceived as just and aimed at improving road safety rather than as a revenue-generating mechanism. If drivers view ETLE as primarily a tool for increasing fines rather than reducing accidents, they may resist compliance. The increase in violations in 2024 could indicate a growing perception that ETLE is less about safety and more about financial penalties, leading to compliance only in camera-monitored areas while disregarding traffic laws elsewhere. This aligns with findings from studies on selective deterrence, which suggest that individuals comply when they perceive active enforcement but revert to old behaviors when surveillance is perceived as inconsistent or ineffective.

To sustain ETLE's deterrent effect, a multi-faceted approach is required. Expanding ETLE coverage would help close enforcement gaps, reducing opportunities for selective compliance. Integrating mobile enforcement units and AI-based behavioral analysis could enhance the detection of infractions that static cameras fail to capture, such as distracted driving. Strengthening penalty enforcement, particularly for repeat offenders, could reinforce the perception that violations carry meaningful consequences. Additionally, public awareness campaigns that emphasize ETLE's role in road safety rather than its punitive aspects may encourage voluntary compliance rather than rule-following driven purely by avoidance of fines.

The findings suggest that while ETLE has effectively increased the certainty of punishment, its long-term effectiveness in shaping compliance remains uncertain. The presence of deterrence fatigue highlights the need for continuous reinforcement through technological advancements, legal policy adjustments, and behavioral interventions. Without these reinforcements, ETLE risks becoming an initially effective but ultimately diminishing enforcement tool, rather than a sustainable deterrent mechanism capable of fostering lasting improvements in road safety.

5. Conclusion

This study evaluates the effectiveness of Electronic Traffic Law Enforcement (ETLE) in Indonesia by analyzing traffic violation trends from 2019 to 2024. The findings confirm that ETLE has significantly improved enforcement efficiency by increasing the certainty of punishment and reducing human discretion in traffic law enforcement. However, while ETLE enhances violation detection, its long-term impact on compliance remains inconsistent. Rising violation trends in 2024, suggests that deterrence fatigue may weaken its sustained effectiveness unless enforcement strategies are continuously reinforced.

The results indicate that ETLE should not function as a standalone solution but rather as part of a broader traffic law enforcement strategy. While it is effective in detecting administrative violations, its limited ability to address behavioral infractions highlights the need for manual policing, mobile enforcement units, and AI-based monitoring. Additionally, regional disparities in ETLE coverage create inconsistencies in perceived enforcement risk, which could diminish its deterrent effect over time. Expanding ETLE coverage, ensuring stricter penalties for repeat offenders, and integrating public awareness campaigns would help sustain compliance and mitigate deterrence fatigue.

This study contributes to the understanding of automated enforcement in the context of deterrence theory, emphasizing that certainty alone is insufficient for long-term deterrence. Future research should examine ETLE's impact on accident rates, long-term behavioral changes, and comparative enforcement strategies across different jurisdictions. By continuously adapting technological and legal approaches, ETLE has the potential to transition from a reactive violation detection tool to a proactive mechanism for sustained traffic law compliance. However, without ongoing reinforcement, ETLE risks losing its long-term effectiveness, limiting its role in shaping safer road behaviors.

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