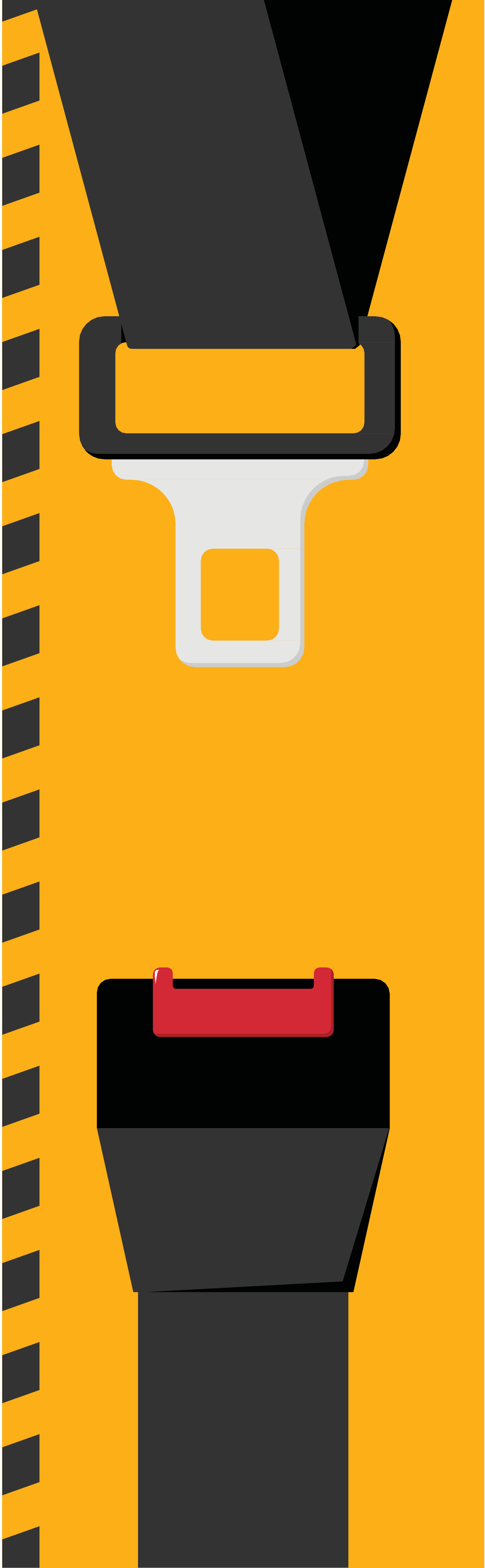
TRANSPORT AND COMMUNICATIONS BULLETIN FOR ASIA AND THE PACIFIC

#94

ROAD SAFETY



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EDITORIAL STATEMENT

The Transport and Communications Bulletin for Asia and the Pacific is published once a year by the Transport Division of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). The aim of the Bulletin is to share knowledge, experiences, ideas, and information on policies and practices pertaining to the development of transport infrastructure and services in the Asia-Pacific region. The 94th issue presents articles on the theme of “Road Safety in Asia and the Pacific”.

According to the WHO, approximately 1.19 million fatalities were due to road traffic accidents in 2021, with a mortality rate of 15 per 100,000 people.[1] Many of these accidents occurred in the Asia and Pacific region, which is estimated to have contributed to about 59 per cent of total fatalities in the world.[2] While many countries in the region have successfully strengthened their road safety policies and regulations, most still fall behind Target 3.6 of the Sustainable Development Goals (SDG), which explicitly calls for the number of global deaths and injuries from road traffic crashes to be halved by 2030. This target was also reaffirmed through Resolution 74/299 adopted by the General Assembly in 2020, which proclaimed the period 2021–2030 as the Second Decade of Action for Road Safety.[3]

In recent years, it has become more apparent that while international road safety standards are an effective way of setting road safety benchmarks, the policy measures designed to implement them will only be effective if they match the cultural context of the country. However, the majority of road safety research studies are still produced by researchers in Europe, North America and Australia. While the number of research papers from countries in East Asia has increased, there are still relatively few studies from other countries in Asia and the Pacific. In this regard, the current issue of the Bulletin offers an interesting range of academic papers which reflect the rich diversity of the road safety issues facing countries in the region.

The volume begins with an Op-Ed by the Global Alliance of NGOs for Road Safety. The Global Alliance represents a network of more than 300 NGOs working for road safety, the rights of road traffic victims and safe mobility in over 100 countries. Their proximity to what’s happening on the ground is helping to draw policy-makers’ attention to the realities of road safety, including what is and isn’t working. In particular, they have been vocal in highlighting the safety of motorcycle users, who are at greatest risk of injury in the region. The Op-Ed also introduces the Alliance Accountability Toolkit, developed by the Global Alliance, which helps NGOs to work with governments on road safety.

The first peer reviewed article, “Youth-Led Road Safety Initiatives: Harnessing Technology for Change in Viet Nam” by Bui, Lucchesi, Truong, Nguyen and Sidik, presents a study on the “AI&Me: Empowering Youth for Safer Roads” project, which aims to engage the youth in designing government policies on road safety. Using quantitative and qualitative approaches to survey about 2,000 youth, teachers, and government stakeholders in Viet Nam, the study assessed the effectiveness of the project’s Youth Engagement App (YEA), which allows students to map locations where they feel “safe” or “unsafe” on their journey to school. Following YEA’s pilot project, significant improvements were observed in students’ knowledge, awareness, and behavior regarding road safety. The data was shared with government stakeholders and led to road upgrades at high-risk schools, demonstrating that digital apps can not only contribute to the evidence-base of policy design and assessment, but also that youth could be meaningfully engaged in these processes.

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[1] WHO (2023a)
[2] Ibid.
[3] A/RES/74/299

The second article, “Consumer Awareness of Vehicle Safety Features and ASEAN NCAP in Malaysia” by Mustaffa, Ahmad, Wahi, Nursyuhada, Muhaimin and Johari, presents a study on factors influencing consumers’ decisions to purchase new passenger vehicles in Malaysia, and the level of influence that the safety standards developed by the New Car Assessment Program for Southeast Asian Countries, or ASEAN NCAP, had on these decisions. An online survey of 350 Malaysian consumers in 2021 revealed that most respondents opted to purchase new cars instead of used or imported refurbished units, and that car safety was the most important factor when making the purchase, followed by affordability. However, the study also revealed that most respondents did not refer to the ratings provided by ASEAN NCAP before making their purchase, suggesting that more effort was needed to raise awareness about the ASEAN NCAP ratings.

Sometimes, the introduction of new traffic safety regulations can cause confusion among drivers, thereby increasing the risk of accidents. In the third article, “Artificial intelligence-based traffic information and enforcement system to enhance the safety of right turns at intersections”, Sung, Kim, N. Park, G. Park, J. Park, and Choi assess the impact of a revision of the Korean Road Traffic Act which requires drivers to stop when they see a person turning right at an intersection, and to pause not only when pedestrians are “passing,” but also when they are “about to pass.” A detection system was developed 1) to determine whether a driver can make a right turn, and 2) to identify illegal right turns. Based on this system, a device was designed to provide right-turn information, and its effectiveness was evaluated through microscopic traffic simulation. Providing information about right turns led drivers to slow down, improving the safety of right-turn intersections.

The last peer-reviewed article addresses the effectiveness of speed cameras. In “Beyond the Lens: A Critical Review of Speed Camera Performance in the Islamic Republic of Iran”, Zavareh and Zakeri examined three months of traffic data and speed violation records in two provinces of the Islamic Republic of Iran and find that while speed cameras deter speeding, low activation rates and inconsistent performance of speed cameras lower the perceived risk of being caught. Furthermore, delays in penalizing violators reduces the certainty of punishment and further lowers the deterrent effect. These factors together undermine the overall effectiveness of speed cameras.

Finally, this 94th edition also features an interview with David Shelton, former Senior Transport Specialist (Road Safety) of the Asian Development Bank (ADB).[4] Hosted by the ADB and funded by the Government of Japan, the Asia Pacific Road Safety Observatory (APRSO) was established in 2020 and is widely considered to be among the best performing of regional observatories. Shelton notes that regional observatories provide members the opportunity to compare their road safety levels with other countries in the region, while also promoting communities of interest and transfer of knowledge between countries. For example, the APRSO supports members to conduct road crash data reviews, general data reviews, as well as reviews of data management practices. Growing membership in the APRSO reflects increasing government interest in improving road safety data, and there is growing scope for using big data to improve data collection and analysis.

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[4] David Shelton left ADB in July 2024. This interview was conducted prior to his departure.

TABLE OF CONTENTS

Op-Ed

Enhancing the Role of NGOs in Improving Road Safety in the Asia-Pacific Region

Global Alliance of NGOs for Road Safety

ABSTRACT

Recognizing the vital roles that non-governmental organizations (NGOs) play in promoting road safety worldwide, the Global Alliance of NGOs for Road Safety was founded by road safety NGOs and the WHO in 2011. The Alliance has grown to a network of more than 300 NGOs working for road safety, rights of road traffic victims and safe mobility in over 100 countries. Alliance member NGOs in the Asia Pacific have expressed their commitment to play their part in advocating for people's rights to safe mobility. Examples of NGO advocacy influencing government actions from countries in the Asia Pacific are presented, including an urgent focus on motorcycle users who are at greatest risk of injury in the region. The Alliance Accountability Toolkit, developed by the Global Alliance of NGOs for Road Safety, is helping NGOs to work with governments to achieve the SDG target of a 50% reduction in road deaths and injuries by 2030.

INTRODUCTION

According to the World Health Organization's (WHO) Global Status Report on Road Safety (2023), the world suffers 1.19 million preventable deaths from road crashes, causing enormous health, social and economic harm throughout societies. Tragically, road crashes are the leading killer of individuals aged 5-29 years (WHO, 2023). During the first Decade of Action for Road Safety (2011-2020), an extensive body of literature on effective interventions to reduce road deaths and injuries was developed. We therefore already know what works to achieve the 2030 Agenda for Sustainable Development target 3.6 to reduce road deaths and injuries by 50% by 2030 (United Nations Department of Economic and Social Affairs, 2015).
The Global Plan for the Decade of Action for Road Safety 2021–2030 contains many recommendations on evidence-based interventions (WHO & UN Regional Commissions, 2021). Aligned with the Global Plan, the Asia Pacific Road Safety Decade of Action 2021-2030 has also been developed as a regional initiative to reduce road traffic deaths and injuries in Asia by 50% by 2030 (ESCAP, 2023). NGOs must build pressure on decision makers to implement these interventions.

Global Alliance of NGOs for Road Safety

Recognizing the vital role played by non-governmental organizations (NGOs) in promoting road safety, the Global Alliance of NGOs for Road Safety (hereafter, the Alliance) was founded by road safety NGOs and the WHO in 2011 (Figure 1). The Alliance has grown to a network of more than 300 NGOs working for road safety, rights of road traffic victims, and safe mobility in over 100 countries. Through globally coordinated advocacy, information sharing and capacity building, the Alliance has successfully strengthened the voice of civil society and built the capacities of member NGOs to contribute to global road safety targets.

Global Alliance of NGOs for Road Safety

The Alliance's work is guided by the SDGs 3.6 and 11.2, and the Alliance Strategic Plan 2024-2030 sets out how we will achieve our vision of *a world where everyone has access to safe, affordable, accessible, and sustainable mobility, using the road system, where no one dies or is seriously injured as a result of a road crash* and mission to *advocate for effective actions and strengthen accountability for safe mobility, using the road system, and support NGOs for the same, thus accelerating implementation that results in the reduction of road crash victims*, in the remaining years of the Decade of Action 2021-2030.

Figure 1. For more information, see Alliance Strategic Plan 2024-2030
https://www.roadsafetyngos.org/about/about-us/strategic-plan/

NGO contributions in the Asia Pacific

WHO's South East Asia and Western Pacific regions combined account for 53% of the world's road deaths, with a rate of 16.1 and 15.4 per 100,000 population in 2020 (WHO, 2023). Within these regions, fatalities are concentrated among riders of motorized two- and three-wheelers, pedestrians and cyclists, accounting for 67% of all fatalities in each region (WHO, 2023). Road crashes also have a significant economic impact, costing billions of dollars each year (WHO, 2023). The most pressing road safety issues in the region as highlighted by Alliance member NGOs are: increasing motorcycle usage, helmet use law enforcement, pedestrian safety, promoting the use of public transport, and capacity building of government agencies to formulate and implement effective road safety policies and regulations. Many Asian cities also grapple with inadequate road infrastructure, including a lack of safe pedestrian lanes and bicycle paths (Asian Development Bank, 2017).

Alliance member NGOs are committed to advocating for people's rights to safe mobility (Global Alliance of NGOs for Road Safety, 2022). NGOs have stood up for people's right to be safe on the roads and spoken up on decisions that affect road safety. NGOs amplify best practices from around the world, while also collecting ground-level evidence that show the impact of safe and unsafe roads on people and communities. NGOs keep road safety on the agenda, monitoring progress and putting a spotlight on action and inaction, as demonstrated by the examples below.

AIP Foundation, Vietnam

The AIP Foundation, an NGO in Viet Nam, has been advocating for 30 km/h zones targeting schools. In August 2020, the authorities in Gia Lai Province announced new speed limits of 30 km/h and 40 km/h during drop-off and pick-up times across Pleiku city. In collaboration with the local government and with support from the Fondation Botnar and FIA, more than 30 primary schools underwent safety infrastructure modifications. The AIP Foundation has also advocated for safe helmets, which has led to a national commitment to child helmet safety by the Government of Viet Nam. Following a “Round the World Roundtable” in Hanoi on 19 March 2019, the Deputy Prime Minister gave a speech, noting that helmet usage among 6- to 15-year-olds increased from 35% in 2017 to 70% by the end of 2019, which was widely reported in online news channels and on some government websites.

Avoid Accident, People’s Trust Jaipur, and Patiala Foundation, India

Three NGOs in India, Avoid Accident, People’s Trust Jaipur, and Patiala Foundation have been advocating for a 25 km/h law around all schools in the state of Punjab, Rajasthan and Jharkhand. The governments of Punjab in 2022, Rajasthan in 2021, and Jharkhand in 2023, issued a notification that the 25 km/h mandate should be implemented across the states. A budget of more than 1 billion rupees (around US$16 million) was approved by the Mandi Board in October 2022 for rumble strips and mandatory, cautionary signage around all school zones on link roads in Punjab. The governments of Rajasthan and Jharkhand also invested in speed management initiatives, including infrastructure improvements and enforcement devices such as speed cameras and speed radar guns. Advocacy by the Patiala Foundation in Patiala led to reconstruction of footpaths with tenders for new roads including provision for footpaths. Similarly, advocacy by ArriveSAFE to reclaim pedestrian spaces in Chandigarh have influenced the city authorities to restore walking areas that had been turned into parking in one of two areas identified by ArriveSAFE. Surveys are being conducted in five further sectors. They have also implemented pedestrian crossings and traffic calming around hospitals and schools.

Swatantra Abiyan Nepal (SAN) and NASA, Nepal

Advocacy by two members NGOs in Nepal, Swatantra Abiyan Nepal (SAN) and NASA Nepal, who are part of the National Alliance for Safe and Sustainable Mobility, helped lead to a strong commitment to road safety leadership and the safety of citizens in the Government of Nepal’s Annual Policy and Program Statement 2077/78 (2020-2021). Continued advocacy saw all major political parties committing to improving road safety in their manifesto in November 2022, for the first time in history of Nepal’s elections. The Ministry of Physical Infrastructure and Transport has since prepared a draft of the National Road Safety Act, which is now in the process of endorsement from the House of Representatives, and have approved the Strategic Plan for Helmet Usage in Nepal, leading to budget allocation to road safety announced in May 2024.

NGO Calls to Action in the Asia Pacific

Alliance member NGOs in the Asia Pacific have made an urgent call on their governments to act for people’s right to safe mobility and a 50% reduction in road deaths and injuries by 2030, with an urgent focus on motorcycle users who are at greatest risk of injury in the region (Figure 2). Governments in the Asia Pacific have the opportunity to leverage these calls to action to introduce and implement evidence-based interventions.

NGO Calls to Action in the Asia Pacific

1

Align national and local road safety plans

Ensure that national and local road safety plans are aligned to the Global Plan for the Decade of Action 2021-2030 and address the 12 global voluntary performance targets and their indicators.

2

Protecting all users on the road by:

- Implementing laws at national, state, and local levels, that limit speed to 30 km/h or lower in school zones and where people live, walk, and play, through speed limits and traffic calming measures;
- Adopting and ratifying relevant UN conventions, strengthening national road safety regulation to meet international safety standards, including seat belts, child restraints, and helmets, and setting and enforcing appropriate driver competency standards;
- Strengthening laws and enforcement on drink and drug driving;
- Adopt and implement national action plans;
- Ensuring that national legislation and regulation is implemented at state and city levels, including speed limits, and that it is enforced effectively, by enforcement agencies that have both capacity and resources to deliver effectively;
- Guaranteeing the safety and quality of road infrastructure, through good design, build, and maintenance of roads and safety audits;
- Improving public transportation in urban, semi-urban, and rural areas, including last-mile connectivity to get people to their destinations safely, with particular focus on the safety of women, who face additional risks when using public transportation;
- Underpinning interventions with data and evidence, including data collection, scientific crash investigation, road safety audits and assessments, and measurement and monitoring of road safety actions with KPIs, building technical capacity to achieve a strong body of data and evidence.

Figure 2.1 NGO Calls to Action in the Asia Pacific

3 Protect riders and passengers of motorized two-wheelers, which are commonly used as a primary means of transport across the region, by:

Addressing the vulnerability of riders and their passengers through all aspects of the road system, including road design and infrastructure, legislation, with a particular focus on quality helmets and protective gear, vehicle standards, and enforcement.

4 Provide comprehensive support systems for victims and their families by:

Equipping and enabling first responders to treat crash victims quickly and efficiently and guaranteeing the rights of bystanders who provide assistance;

Guaranteeing crash victims' and families' rights and support, including psychological, social, rehabilitation, and judicial support, for as long as is needed, and, where appropriate, enabling and simplifying claims procedures.

5 Funding and reporting strategies for road safety interventions

- Allocate budgets for the full implementation of the above-mentioned actions.
- Report annually on the budget.
- Create and report on innovative schemes to finance road safety interventions, including corporate sector involvement.

6 Enabling environment for NGOs

Establish clear mechanisms for an enabling environment for NGOs to share their knowledge and expertise, in order to complement and facilitate government's work, for example through multi-sectoral road safety commissions or cell or as members of national committees, fora, or platforms.

7 NGO engagement mechanisms

Facilitate specific protocols for engagement between civil society and international road safety platforms, such as the Asia-Pacific Road Safety Observatory, ASEAN Road Safety Center, and South Asia Association for Regional Cooperation (SAARC).

Figure 2.2 NGO Calls to Action in the Asia Pacific

NGOs and government working together

In pursuit of SDG targets 3.6 and 11.2, NGOs play a pivotal role in influencing governments' decision-making in road safety (Brondum et al., 2020), but they are not always able to meaningfully participate in this process (Global Alliance of NGOs for Road Safety, 2021).

	Target 3.6: Reduce road injuries and deaths. By 2020, halve the number of global deaths and injuries from road traffic accidents.
	Target 11.2: By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.

In order for NGOs to positively influence road safety decision-making, they need an environment that enables them to exist and operate effectively. In partnership with local universities in Ethiopia, Uganda, and Zambia (Addis Ababa University School of Public Health, Makerere University School of Public Health, and Harvest University) and the Milken Institute School of Public Health at George Washington University, the Alliance developed a framework to initiate discussions between government and NGOs to identify and analyze barriers to road safety and enablers for both parties to address together (Sakashita et al., 2023). The research suggests that building and continually improving a meaningful relationship between government and NGOs involves a two-way regular and candid conversation.

As noted in the Global Plan, an important role for NGOs is to hold their governments to account and advocate for actions that will lead to a reduction of fatalities and serious injuries. Tasked with this immense role, the Alliance developed the Alliance Accountability Toolkit (Toolkit), a set of practical, customizable, web-based tools to support NGOs fulfilling their vital roles (Figure 3). The Toolkit takes NGOs through practical steps and milestones to advocate for evidence-based interventions and to hold their governments accountable for reducing road deaths and injuries by 50% by 2030. Each step is accompanied with a specific tool.

STEP 1:
Assess what your government is doing or not doing using the ACCOUNTABILITY CHECKLIST

STEP 2:
Prioritize specific interventions using the PRIORITY INTERVENTIONS

STEP 3:
Define what you want your government to do using the GOVERNMENT TO DO LIST

STEP 4:
Build your case using the NGO TALKING POINTS to meet and influence decision makers

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STEP 5:
Track your government's progress in response to your asks using the ACCOUNTABILITY TRACKER

Figure 3. Alliance Accountability Toolkit **(https://www.roadsafetyngos.org/toolkit/).**
As noted in the Global Plan, an important role for NGOs is to hold their governments to account and advocate for actions that will lead to a reduction of fatalities and serious injuries.

The Toolkit prioritizes a set of Priority Interventions that have been proven to be among the most effective in reducing road deaths and injuries (Global Alliance of NGOs for Road Safety) (Figure 4).

Figure 4. Alliance Priority Interventions
https://www.roadsafetyngos.org/toolkit/priority-interventions/

In particular, they focus on protecting pedestrians, cyclists, and motorcyclists, and addressing speed, which research has found reduces the most number of road deaths (Vecino-Ortiz et al., 2022). The Toolkit promotes targeted advocacy for a specific intervention, rather than a more general call for action. It makes budget needs more transparent and allows more concrete planning by government. It also makes it easier to monitor implementation, demonstrate results, and build community buy-in and demand for the intervention. The Toolkit facilitates NGOs and government working together and supports governments in achieving commitments in key global documents:

- Global Plan for the Decade of Action for Road Safety 2021-2030 (WHO & UN Regional Commissions, 2021).
- Global Road Safety Performance Targets (Global Road Safety Performance Targets)
- Stockholm Declaration (Government Offices of Sweden and WHO, 2020)
- Recommendations of the Academic Expert Group of the 3rd Ministerial Conference on Road Safety (Swedish Transport Administration, 2019)
- Save LIVES package (WHO, 2017)
- A/RES/76/294 on the Political Declaration of the High-Level Meeting on Improving Global Road Safety (United Nations, 2022)

For example, with the support of the Alliance and FIA Foundation, Swatantrata Abhiyan Nepal (SAN) are currently implementing the Toolkit to push for implementation of 30 km/h zones in Nepal. During our 2024 #CommitToAct campaign using Mobility Snapshots, Parisar, another NGO in India, highlighted a major intersection that is missing Priority Interventions (Figure 4) and endangering people's daily journeys in the Chhatrapati Shivaji Terminus (CST) Area, Fort, Mumbai, Maharashtra (Global Alliance of NGOs for Road Safety, n.d., a). This is a bustling urban environment surrounded by shops, offices, residential buildings, parks, hospitals, and other popular venues, with over 1,460 pedestrians and a mix of motorized vehicles using the intersection during peak hours, due to its proximity to the CST railway station. This is one example of NGOs in the Asia Pacific generating data to help understand the local context and realities on the ground, and to identify key priority areas for the government. In the coming months, NGOs will use such data in combination with the Alliance Accountability Toolkit to influence their governments to implement evidence-based interventions.

CONCLUSIONS

The Global Plan for the Decade of Action for Road Safety 2021–2030 presents an exciting and important opportunity for NGOs and governments to closely work together to implement life-saving interventions across the Asia Pacific region. NGOs in the Asia Pacific region have expressed their commitment to advocate for people's rights to safe mobility and to achieve a 50% reduction in road deaths and injuries by 2030. They are urgently calling on their governments to act for people's right to safe mobility and a 50% reduction in road deaths and injuries by 2030, with an urgent focus on motorcycle users who are at greatest risk of injury in the region. Governments have the opportunity to leverage these calls to action to implement evidence-based interventions. Building a working relationship between NGOs and government to implement effective interventions in a collaborative fashion requires a two-way conversation. The Alliance Accountability Toolkit helps NGOs and governments to work together to implement evidence-based interventions to help reduce road deaths and injuries by 50% by 2030.

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Peer-reviewed Articles

Youth-Led Road Safety Initiatives: Harnessing Technology for Change in Viet Nam

Quyen Bui,[a] Shanna Lucchesi,[b] Trang Truong,[a] Le Nguyen,[a] Mirjam Sidik[a]
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ABSTRACT

In Viet Nam, road crashes are the leading cause of death for youth aged 10-24, posing enormous economic and social implications. It is necessary to involve youths in the decision-making process by listening to their ideas and empowering them (Thapa, 2021). The "AI&Me: Empowering Youth for Safer Roads" project harnessed and developed multiple technology initiatives, including a digital perception tool called the Youth Engagement App (YEA). Built on the basis of feedback from youths, the app enables students to map locations where they feel "safe" or "unsafe" on their journey to school. To evaluate YEA's effectiveness and community acceptance, quantitative and qualitative surveys were conducted among approximately 2,000 youth, teachers, and government stakeholders across three target provinces in Viet Nam. Following YEA's pilot project, significant improvements were observed in students' knowledge, awareness, and behavior regarding road safety, and a remarkable number of government stakeholders demonstrated their support for the app. With 18,617 pins via YEA, the project identified high-risk locations for in-depth evaluation at 30 schools. Subsequently, the results were shared with the government, leading to successful advocacy for road upgrades at high-risk schools. These outcomes demonstrate that YEA was able to engage youth and provide evidence-based insights for life-saving decision-making on road safety.

INTRODUCTION

Road crashes are the leading cause of death among young people aged 5-29 worldwide (WHO, 2024). Facing such a crisis, the United Nations Sustainable Development Goal (UN SDG) 3.6 aims to halve road deaths and injuries by 2030. Nevertheless, policies, programs, and strategies designed to reduce youth injuries rarely involve young people in their development, despite strong evidence that youth engagement improves outcomes (Morris, 2012).

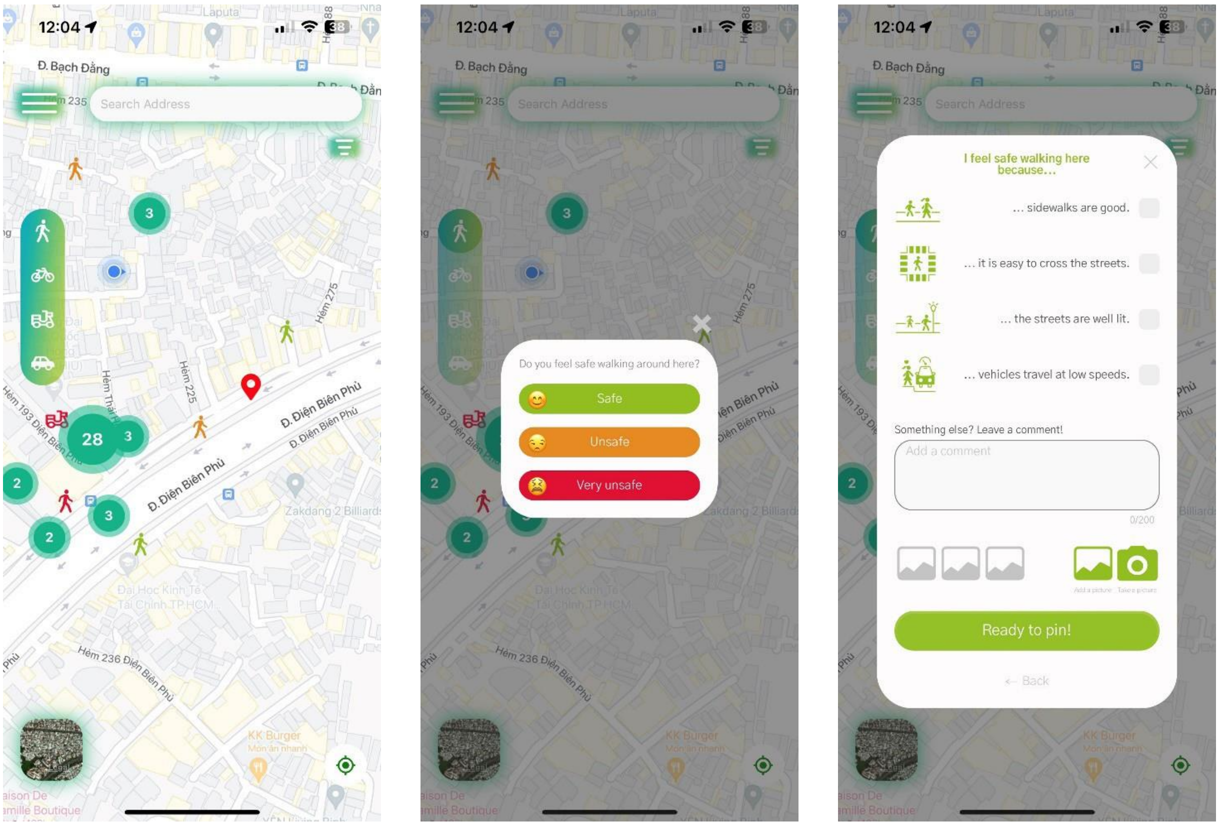
Despite rapid economic growth, Viet Nam suffers significant losses each year due to road crashes, with 3,389 people aged 10-24 dying on the roads, accounting for 15% of all road fatalities (IHME, 2019). While others have argued that it is critical to involve youths in the decision-making process, listen and take their ideas and thoughts seriously, and empower youth to be more confident to speak up regarding societal matters (e.g., Women Deliver, 2016, Lansdown, 2001). Youth are frequently underrepresented in policy-making processes across various societal issues (DiploFoundation, 2022, UN DESA, 2023). Vietnamese youth, who comprise one-fifth of the population, have few opportunities to engage in road safety (RS) decision-making.

Another problem in many Low- and Middle-Income Countries (LMICs) like Viet Nam is the lack of accurately recorded data associated with road infrastructure, leading RS analysts and asset managers to make decisions with partial or uncertain data (Eskandari Torbaghan et al., 2022). Despite the government's efforts to promote the use of information technology and digital transformation in RS management, the current data system remains fragmented and inconsistent (Tran et al., 2021). Some provinces and cities face limitations in their capacity and resources for data collection and management, making it difficult to identify locations needing road upgrades.

On the other hand, with digitalization on the rise, well-designed mobile applications offer youth not only access to personalized, interactive learning but also tools for building confidence, connecting with peers, and gaining knowledge relevant to their daily lives (Demir and Akpinar, 2018, Thackeray and Hunter, 2010). In past decades, Vietnam has witnessed a remarkable surge in digital adoption, particularly among young generation. A study found that most young Vietnamese use the internet (89%), and spend 5-7 hours daily online (ECPAT, INTERPOL, and UNICEF, 2022). While government-sourced traffic data is essential, integrating data contributed by community, especially youth, can help address data gaps and highlight hazardous locations, complementing the deficiency in official accident statistics (gTKP, n.d).

Understanding these challenges and opportunities, AIP Foundation and International Road Assessment Programme (iRAP) piloted a three-year project named 'AI&Me: Empowering Youth for Safer Roads' across three cities in Viet Nam - Ho Chi Minh (HCM) City, Yen Bai City, and Pleiku City - with support from Fondation Botnar and FIA Foundation. The project aims to leverage emerging technology to empower youth to inform high-risk locations and raise their voice with authorities on life-saving road upgrades, helping government stakeholders identify the "black spots" that require safer solutions in Viet Nam.

Figure 1. Interface of Youth Engagement App



Bearing that objective in mind, a mobile digital risk-perception tool called "Youth Engagement App" (YEA) was developed, which enables students to map locations that they perceive as "safe" or "unsafe" on their journey to school. Students upload photos of the location, select descriptive options and provide traffic and infrastructure details in the comments. All pedestrian assessment pins recorded on YEA are immediately incorporated into the Star Rating for School (SR4S) platform, which is an evidence-based tool developed by iRAP to quantify and communicate the risks that children are exposed to on their journey to school. SR4S utilizes the pedestrian component of Star Ratings to generate the results, with ratings ranging from one star (least safe) to five stars (safest), and provides a measure of the contribution of road design to the risk for each pedestrian (iRAP, 2023). Areas with high densities of YEA pins displayed on SR4S system will assist SR4S assessors in identifying prioritized locations for in-depth evaluation. Functioning as a versatile data collection tool and more, YEA serves as a guiding platform for users to share valuable insights regarding their perceptions of the road environment.

Youths aged 13-22 were invited to engage in the YEA development process from ideation and testing to the piloting stage. Their feedback was systematically gathered through several focus group discussions (FGDs) to evaluate YEA's usability and performance across different devices. The objective was to create an informative, user-friendly, and inspiring RS app for youth, as well as a valuable data resource for decision-makers.

With this project, the study aims to explore YEA's impact of youth engagement through four hypotheses: (i) YEA will significantly improve youth knowledge, attitudes, and behaviors (KAB) regarding road RS, (ii) the decision-makers and community will perceive YEA positively, (iii) YEA data will correlate strongly with results from an international technical assessment tool and (iv) YEA will contribute to sustainable change by driving decision-makers to take action on RS.

METHODS

Study design

The AI&Me project was designed with multiple cross-sectional surveys, including three primary assessment stages: [1] before experiencing YEA, [2] after training and experiencing YEA, and [3] after implementing the communication campaign in target schools. These 3 stages are labeled accordingly as Pre, Post1, and Post2, with mixed methods, including both quantitative and qualitative assessment, employed in each stage to investigate the impact of YEA on the target groups. Table 1 shows the surveys and evaluations that were conducted within this project.

Setting and participants

YEA app was piloted in 17 different schools, including 7 secondary schools, 7 high schools, and 3 universities/colleges across 3 cities over 12 months, from November 2022 to October 2023. Fourteen of the 17 schools were selected from 106 high-risk schools through the Big Data Screening (BDS) methodology, an initiative that screens high-risk schools for RS by utilizing Big Data from varying sources (AIP Foundation and iRAP, 2024). Since the BDS methodology didn't include the universities/colleges in the analysis, another 1 university and 2 colleges from target provinces were invited to participate in testing YEA. There were 3 target groups identified as the study's participants under this project, including youth, teachers, and local government stakeholders, with different surveys tailored for each group (Table 1).

- Youth of 17 selected schools

A cohort of 1,700 students, aged 13-22, from 17 target schools were invited to participate in the pilot program. Each youth was required to have their own smartphone that uses the Android or iOS operating system to install YEA and record their perceptions of RS at various locations on the app's map. Upon selection, students received training on using YEA. They were educated on how their voices could be amplified and acknowledged via the app and how this could contribute to reducing road injuries and fatalities. The RS knowledge page integrated within YEA, along with the additional lessons during the training, provided students with knowledge of safe infrastructure around school zones, pedestrians' safe behavior, and appropriate speed when passing school zones. To strengthen the knowledge and remind them of the previous trained lessons, a public awareness campaign (PAC) promoting YEA through a catchy music video along with school-based extracurricular activities targeted at young people was organized several months after the YEA launch. However, due to budget limitations, the reinforcement activities were deployed on a smaller scale at 10 schools compared to the initial app launch events.

To measure the changes in students' awareness before and after the intervention, Pre and Post1 of the KAB assessment were conducted on all 1,700 students, and Post2 of the KAB was executed with only students who engaged in more intensive educational activities at 10 schools. This was to ensure a more precise assessment of changes in KAB among the target population. Alongside the KAB evaluation, several FGDs were implemented to collect detailed feedback regarding YEA's usefulness and practicality in addressing RS concerns. The subjects for group discussions at 17 schools were selected through a convenient and purposive sampling method. Each school held one group discussion session, with each group consisting of at least 8 individuals who had experienced the app for at least one month.

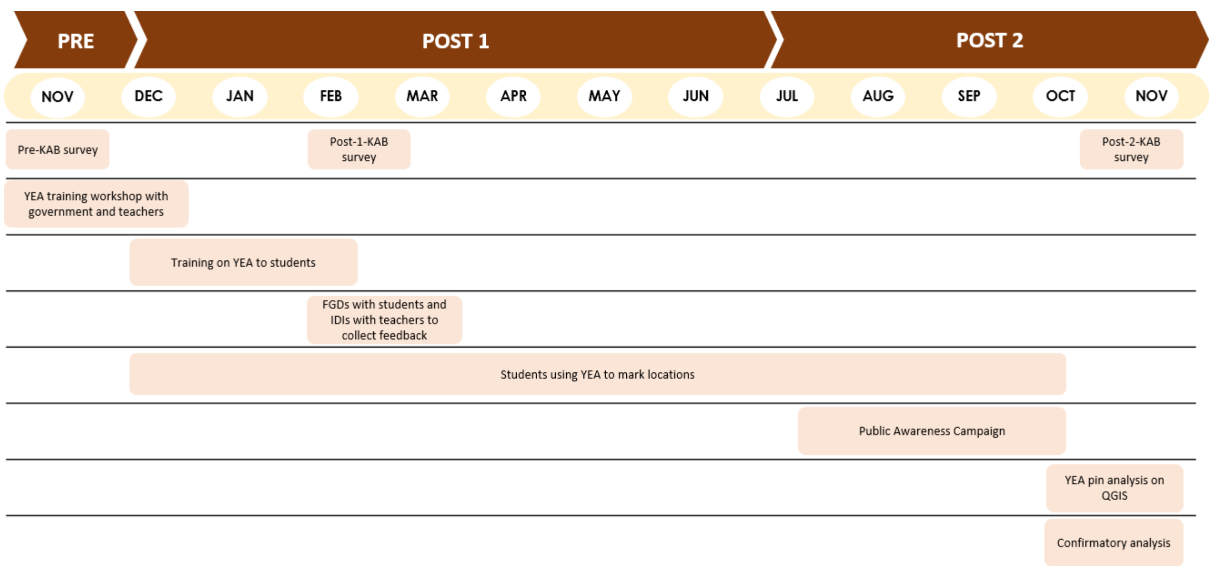
- Teachers and government stakeholders

Prior to implementing YEA among youth, the app was first introduced to teachers and local authorities from different government departments during the YEA training workshops. In the workshops, participants, especially teachers from pilot schools, were trained on how to use YEA and encourage youth to be more involved in addressing RS challenges. Government stakeholders participating in the workshops also gained a better understanding of how the app and feedback from the youth can benefit the decision-making process to identify the black spots and improve the road environment. The workshop participants answered the stakeholders' opinion survey to rate their level of support for this initiative.

Similar to the FGDs with students, teachers who participated in YEA training and piloting process were selected to join In-depth Interviews (IDIs) to provide their insight of the app after experiencing and observing its influence on their students a few months after the YEA launch.

Table 1. Type of surveys and analysis conducted in AI&Me project				
Type of survey/ assessment	Objective	Target respondent/Data source		
		Pre	Post1	Post2
KAB survey	Measure changes in target youth before and after exposure to YEA, RS training and public awareness campaign (PAC).	Students participating in YEA pilot at 17 target schools	Students participating in YEA pilot at 17 target schools	Students from 10 schools that received additional intensive road-safety-related activities
Stakeholders' opinion survey	Measure local stakeholders' level of support for YEA.	-	Participants of YEA teacher training workshop	-
Focus group discussion with students	Collect youth's insights regarding YEA's usefulness and sustainability	-	Students participating in YEA pilot at target schools	-
In-depth Interview with teachers	Collect teachers' insights regarding YEA's usefulness and sustainability	-	Teachers who participate in YEA teacher training workshop	-
YEA pin analysis on QGIS	Assessment of the concentration predisposition of YEA pins in the pilot phase	-	-	Pins synthesized from YEA system
Confirmatory analysis	Analyze the correlation between qualitative data gathered from students and road-related attributes in the assessments around schools	-	-	YEA pins and road-related SR4S attributes

Figure 2. Timeline of YEA-piloted activities



Questionnaire development and data collection

KAB survey

The KAB questionnaire was primarily developed using content from YEA's RS Knowledge Page and associated training sessions. The questionnaire was structured into three sections - knowledge, attitude, and behavior - covering three core topics: safe school zones, pedestrian safety, and speed. The survey evaluated the following key variables:

- Knowledge regarding road infrastructure around school zones, pedestrian safety, and safe speed.
- Attitude towards safe school zones, pedestrian safety, and speed.
- Self-report behavior regarding pedestrian behavior and speed.

Due to variations in age and awareness resulting from varying academic levels, the knowledge section was classified into two distinct groups: (1) middle school level and (2) high school level and above. Questions in the attitude and behavior sections were the same for both groups. The behavioral questions about speed were only answered by students who drove motorized vehicles to school.

The questionnaire underwent pretesting with a sample of five young individuals to identify any potential difficulties in understanding the survey items, including ambiguous or unclear phrasing. After finalizing the tool, the project team coordinated with schools to distribute the online survey link via KoboToolbox to students participating in the YEA pilot, constantly monitoring the completion rates and urging schools to remind students who had not yet completed it. The number of participants completing the Pre, Post 1, and Post 2 KAB survey were 1,393, 1,468 and 133, respectively.

Stakeholders' opinion survey

Questions asking local stakeholders to rate their level of support for YEA were combined with other questions to evaluate the organizational quality of the training session, and distributed via a printed survey at the end of the training. The stakeholder opinion survey was conducted in three workshops, resulting in 42 respondents.

FGDs with students and IDIs with teachers

The questionnaire for FGDs and IDIs was designed to gather insights on the app's impact on youth, along with the advantages and disadvantages of YEA in terms of its effectiveness in raising RS awareness and addressing community road issues. The interview and discussion questions were open-ended to prevent the research team's prejudices towards the research issues from dominating participants' viewpoints.

With the qualitative survey, interviewers directly coordinated student discussions and interviewed teachers in person. Each FGD usually lasted 60-75 minutes, while the IDI with teachers lasted 45-60 minutes on average. During FGDs, students were given sticky notes to write down their summary about YEA and encouraged to share their thoughts with the interviewers confidently. Besides following the questionnaire, interviewers also explored various aspects of the participants' opinions by delving into specific points raised during discussions. There were 161 students participating in group discussions and 33 teachers participating in the interviews.

Data Analysis

KAB survey and stakeholders' opinions survey

Quantitative data from the KAB survey and stakeholder opinion survey were imported and managed directly in the KoboToolbox system. Subsequently, the data were cleaned and analyzed using Excel. For the group of questions evaluating student knowledge, each correct answer was worth one point, with a total of nine correct answers for the middle school group and fifteen answers for the high school and college-university groups. Each student's knowledge score was calculated from the total number of correct answers from the students, divided by the maximum number of correct answers in each group and multiplied by 10 (corresponding to the 10-point scale). Knowledge scores were classified into four groups (Table 2). To gauge students' attitudes toward RS, all students were asked to rate their agreement or disagreement for 10 RS statements using a Likert scale (Likert, 1932), with options ranging from Strongly Disagree to Strongly Agree on a scale of 1-5. The total attitude assessment score was classified based on the criteria in Table 2. Similarly, the behavior section had five levels to assess the frequency of students' adherence to RS practices: Never, Rarely, Sometimes, Usually, and Always, with a scale of 1-5 for 10 statements.

Table 2. Classification of knowledge, attitudes and behaviors based on scores

	Score interval (points)	Categories
Knowledge classification	8 – 10	Excellent
	6.5 - 7.9	Good
	5 – 6.4	Fair
	0 – 4.9	Poor
Attitude classification	40 – 50	Positive
	21 – 39	Neutral
	10 – 20	Negative
Behavior classification	36 – 45	Usually and Always
	27 – 35	Sometimes
	18 - 26	Rarely
	9 - 17	Never

Likewise, respondents to the stakeholders' opinions survey were asked to rate YEA's usefulness based on 5 levels, which corresponds to Not Useful At All, Not Useful, Neutral, Useful, and Very Useful.

YEA pin analysis

The YEA pin data was analyzed using qualitative spatial techniques. We utilized QGIS (QGIS, 2020), a free and open-source geographic information system, to geolocate the pins and conduct quality checks on the data. QGIS was also employed to perform spatial matches between different spatial databases. Specifically, the YEA pins were combined with OpenStreetMap data to analyze their attachment to the road network and to integrate both the YEA pins and the results of the SR4S assessments around schools into a single database, which was used in the confirmatory analysis.

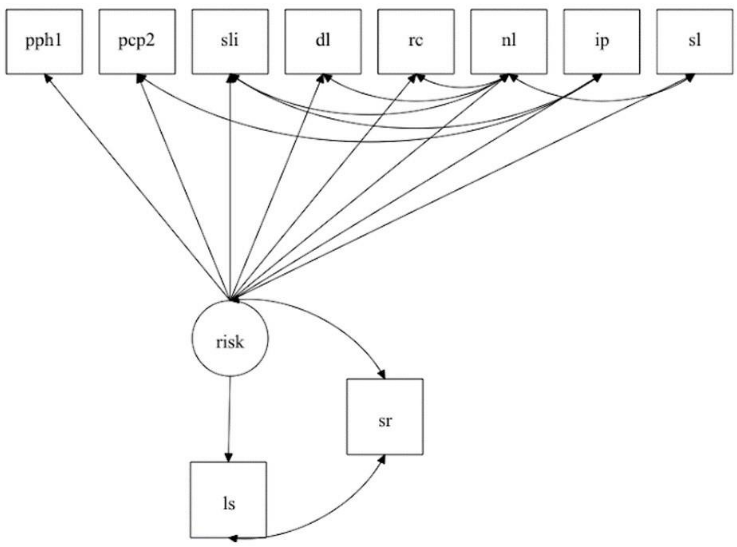
Confirmatory analysis

To explore the correlation of data gathered by students and road-related attributes around schools identified through the iRAP SR4S tool, we utilized a confirmatory model using structural equation modeling. This analysis aims to identify which characteristics of the built environment most significantly influence risk perception. Understanding the gaps among actual built environment parameters and how road users perceive them can guide road interventions that most effectively impact risk perception and potentially influence more students to walk to school.

The first step in this process is to correlate the locations evaluated by the SR4S assessor with the pins reported by the students to create the analysis database. Pins within a 15-meter buffer of the assessed spot were considered close enough to refer to the same locations assessed. Exploratory analysis of the data using correlation and dimension reduction techniques supported the definition of the theory tested, as presented in Figure 3. The SR4S attributes were used as factor variables for a latent construct called "Perception of Risk." The model was conceived as reflexive for simplicity. We then model the effect of this latent construct on the perception of safety reported by the students to establish the causal effect between the SR4S factors and the YEA reports.

Additionally, the model considers the relationship between the Star Ratings bands (ranging from 1 to 5 stars) and the perception of safety. The star ratings are effective measures of safety, with score calculations based on crash modification factors from available RS literature (iRAP, 2014). By modeling the relationship as a covariance, we do not aim to assert causal effect relationships but to demonstrate a relationship between objective and subjective safety.

Figure 3. Variables used to analyze the relationship between SR4S and YEA



Variable	Description (categories available for the analysis)
pph1	Pedestrian peak hour flows (1,2,3,4,5,6,7,9,10)
pcp2	Presence of pedestrian crossing (0 = Not present, 1 = Present)
sli	Presence of street lighting (0 = Not present, 1 = Present)
dl	Delineation representing the adequacy of lines and markings (1 = Adequate, 2 = Poor)
rc	Road condition (1 = Good, 2 = Medium, 3 = Poor)
nl	Number of lanes (1 = One, 2 = Two, 3 = Three)
ip	Presence of intersections (0 = Not present, 1 = Present)
sl	Speed limit (1 = <30 km/h, 3 = 40km/h, 5 = 50km/h, 7 = 60 km/h)
ls	Level of safety (1 = Safe, 2 = Unsafe, 3 = Very unsafe)
sr	Star Rating bands (1 = 1 Star, 2 = 2 Stars, 3 = 3 Stars)

FGDs and IDIs analysis

For qualitative data, FGDs and IDIs with targeted groups were recorded, transcribed and thematically analyzed.

Ethics approval

Prior to project implementation, the Ethical Committee of Hanoi University of Public Health issued decision No. 393/2022/YTCC-HD3 on Ethical Approval for Research Involving Human Subject Participation. Individuals aged 18 and older were required to sign a consent form outlining the project details and the participants' roles and responsibilities before participating in any surveys or data collection activities related to the research. For project participants under 18, a consent form was sent to their parents or legal guardians, who had to sign it to confirm their child's participation before any surveys, FGDs, or interviews with students were conducted. Participants were informed of their right to withdraw from the study at any time. To ensure anonymity, questionnaires did not include participant names, and all collected data were securely stored. Reports generated from the study does not contain any identifying information about the participants, and the confidentiality of the data has been maintained throughout the research.

RESULTS

KAB survey results

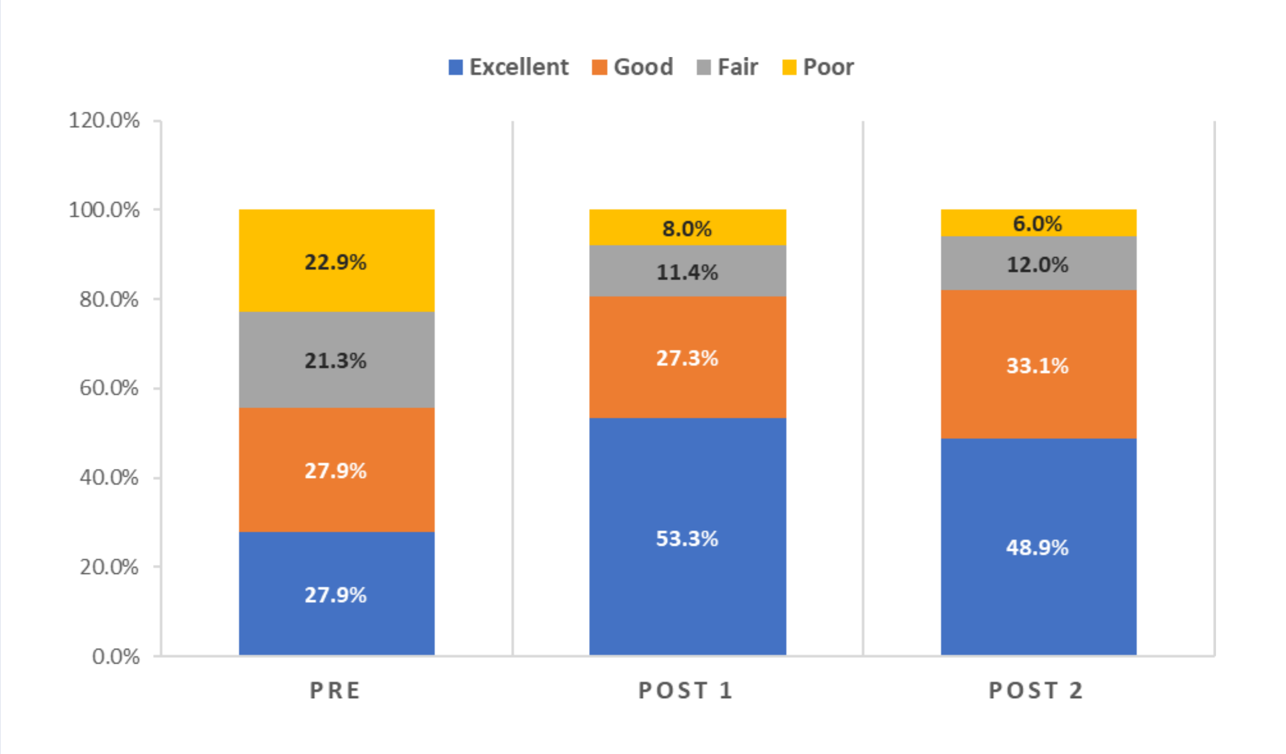
Among the participants of the survey conducted at Pre, Post1, and Post2 in 17 project schools, approximately 55% were female and 45% were male. The middle school student cohort constituted 40% of the survey sample in each phase, while the high school cohort constituted 40%, and the college-university student cohort constituted 17% (Table 3).

Table 3. General information of participants

		Frequency			Percentage		
		Pre	Post1	Post2	Pre	Post1	Post2
Gender	Male	636	667	60	45.7%	45.4%	45.1%
	Female	757	801	73	54.3%	54.6%	54.9%
Academic level	Secondary school (age 10-15)	544	615	56	39.1%	41.9%	42.1%
	High school (age 15-18)	610	594	54	43.8%	40.5%	40.6%
	College/ University (above 18)	239	259	23	17.2%	17.6%	17.3%
TOTAL		1,393	1,468	133			

In the assessment of RS knowledge, the project recorded a significant improvement before and after students were exposed to the YEA application and the project's media education activities. Specifically, the proportion of students with excellent and good knowledge in all three provinces increased from 55.8% (n=777) in Pre to 80.6% (n=1,183) in Post1 and 82% (n=109) in Post2 (Figure 4).

Figure 4. Results of the knowledge test among target students



The rate of good and excellent knowledge from Pre to Post1 at all three academic groups, including secondary schools, high schools, and universities/colleges, increased at least by 19.9%. The knowledge result in the Post2 assessment with a smaller group of students continued to demonstrate good results after the communication campaign, while the rate of Post2 compared to Post1 only increased or decreased slightly below 4% (Figure 5).

Following the knowledge session, all the surveyed students were asked to determine their levels of agreement or disagreement with statements regarding their attitudes toward safe school zones, pedestrian safety, and speed-related issues (Figure 6). The results reveal that the rate of respondents expressing positive attitudes slightly grew from 42.1% (n=586) in Pre to 44.1% (n=647) in Post1, then jumped remarkably to 58.6% (n=78) in Post2.

Figure 5. The rate of students with good and excellent categorized by academic level

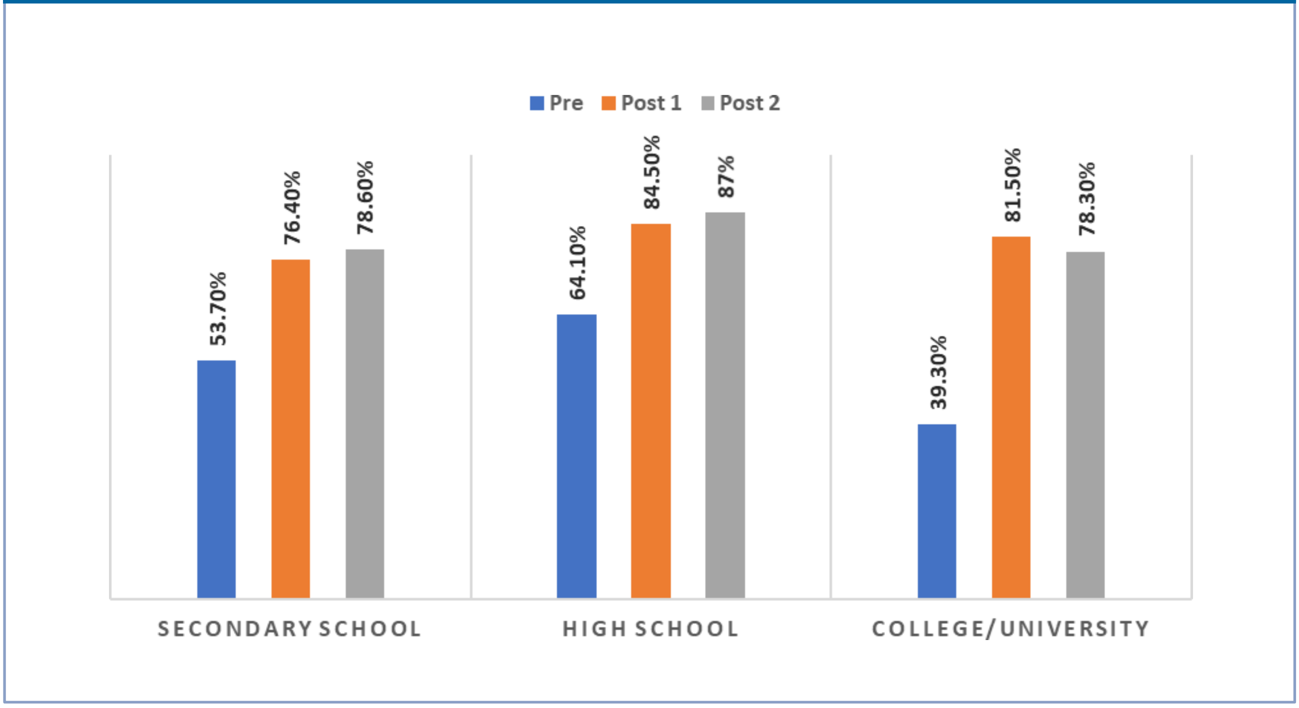
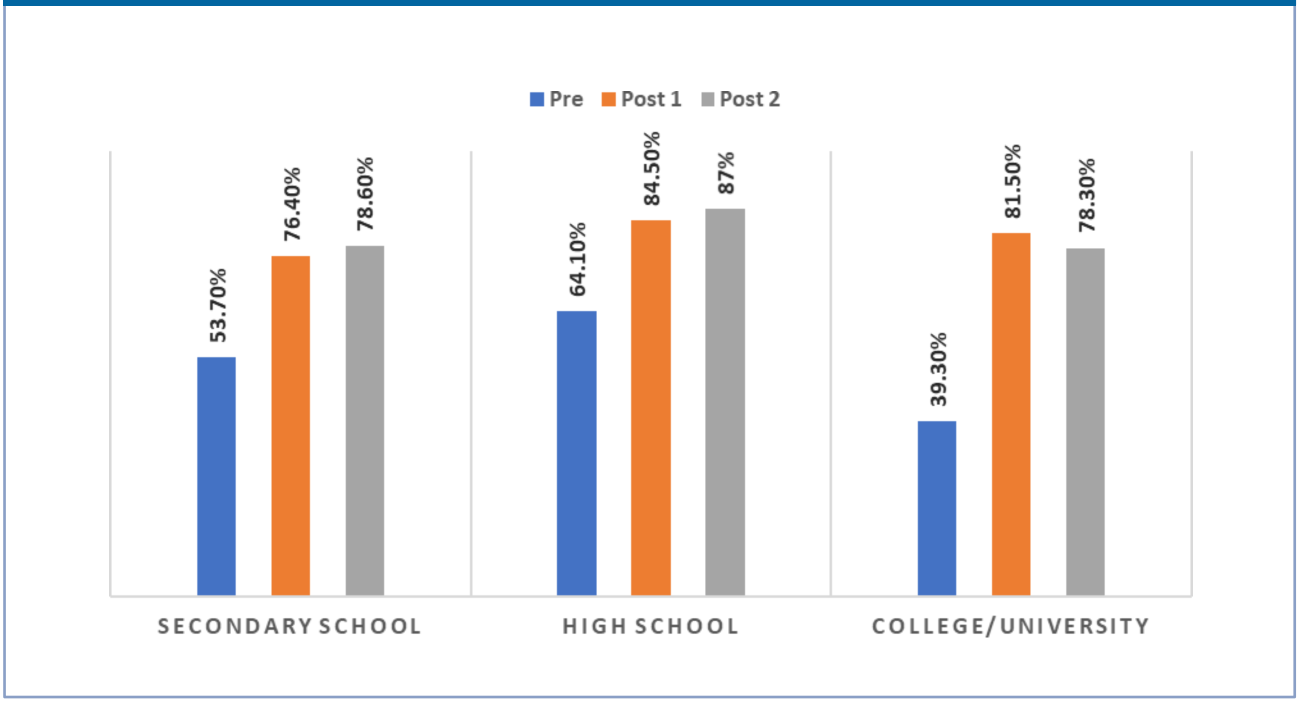


Figure 6. The rate of students who demonstrated positive towards road safety statements



When asked about their level of agreement with RS behaviors, all three subject groups recorded substantial growth from Pre to Post2. Particularly, the rate of respondents showing positive attitudes regarding safe infrastructure around the school zone rose gradually from 34.2% (n=477) at Pre to 42.7% (n=627) at Post1 and to 54.9% (n=73) at Post2. Likewise, positive attitudes towards pedestrian safety grew considerably from 47.1% (n=656) at Pre to 50.3% (n=738) at Post1, then to 66.9% (n=89) at Post2. Meanwhile, the topic related to speed reduction around school zone dropped a little from 63.4% (n=883) at Pre to 57.8% (n=849) at Post1, but after exposure to the media campaign to strengthen youth awareness, the rate grew back considerably to 72.9% (n=97) at Post2.

For three topic groups about safe behavior, one topic group showed a gradual growth: walking across the street, which increased from 37% (n=516) in Pre to 40.3% (n=592) in Post1, and then 69.2% (n=92) in Post2. Another group of topics that demonstrated positive stability was the percentage of students driving 30 km/h when passing school zones, which ranged from 78.6% to 78.7% in Post1 and increased to 79.8% in Post2. However, the percentage of behaviors related to walking on the sidewalk decreased from 58.6% (n=816) in Pre to 54.4% (n=799) in Post1 and 42.3% (n=74) in Post2. In general, the percentage of students who followed safe behavior decreased slightly in Post1 from 39.6% (n=552) to 31.1% (n=456) before rising remarkably to 57.1% (n=76) in Post2 (Figure 7).

Local stakeholder's perceptions of YEA:

Among 42 respondents of the stakeholders' opinion survey, 16.7% (n=7) are representatives from local government departments and 83.3% (n=35) are teachers from the 17 target schools. After being trained on how to use the new app and using it, 93% (n=39) of the surveyed participants found the youth's opinions collected from YEA useful/very useful for authorities to identify high-risk locations (Table 4). Moreover, 90% (n=37) of the participants agreed that YEA was helpful/very helpful in enhancing students' knowledge regarding RS.

During the survey, some respondents shared that they believed the app has the potential for enhancement and expansion to improve its efficiency, pin coverage and app usage among the community.

Figure 7. The rate of compliance to safe behaviors self-reported by students

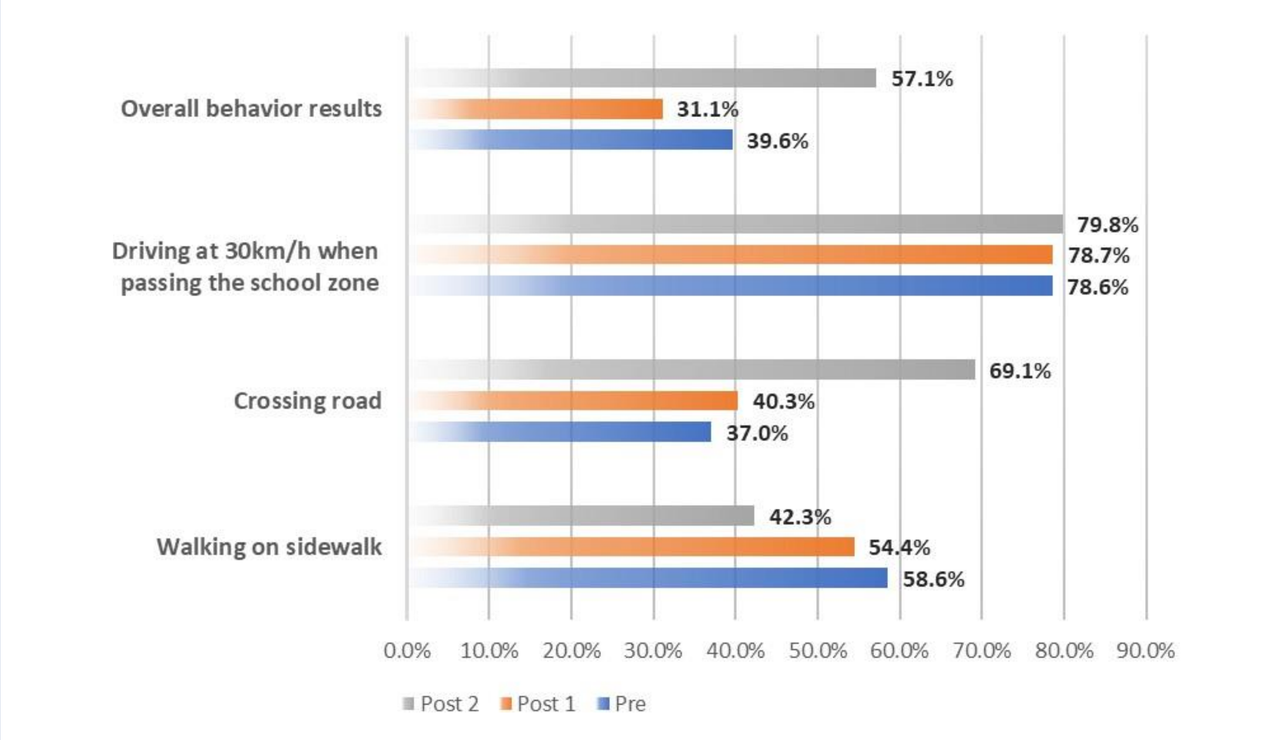
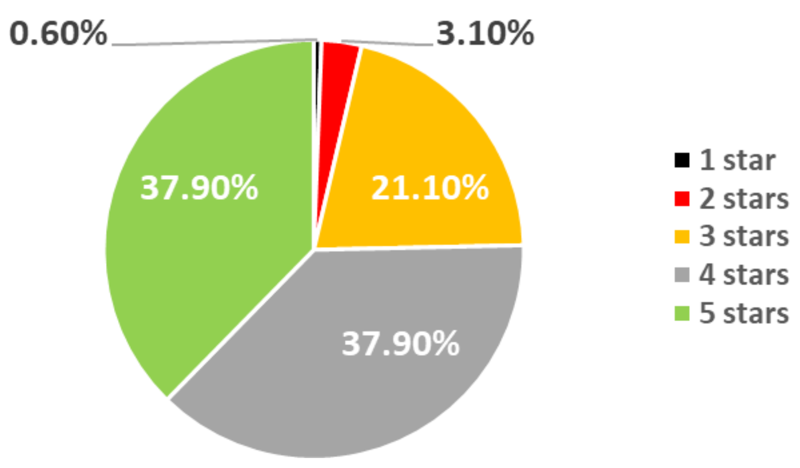


Table 4. The local stakeholders' assessment for YEA					
	Not useful at all	Not useful	Neutral	Useful	Very useful
Are the opinions collected from youth via YEA useful for the government stakeholders to identify the high-risk locations?	0%	0%	6.7%	63.3%	30%
Is YEA helpful in enhancing the students' knowledge regarding RS	0%	0%	10%	63.3%	26.7%

Figure 8. Students' scores on YEA's usefulness and practicality



Youth and teachers' perception on YEA:

- Findings from FGDs with students:

  When 161 students from FGDS were asked to rate the app's usefulness on a scale of 1 to 5, with 1 being very dissatisfied and 5 being very satisfied, more than three-quarters (n=121) of students gave the application 4 points and above. 21% of students (n=34) gave the app a three-star rating. Less than 5% of surveyed students (n=6) gave the app 1-2 points (Figure 8). In addition to their detailed feedback above, the rating score also demonstrated the youth's appreciation of YEA's usefulness to the community and indicated additional areas for improvement in the app.

  The students' feedback for YEA during the discussion is predominantly positive, echoing their score for the app. The majority agreed that developing a digital risk perception app was both innovative and meaningful. Several students shared that they often encountered road infrastructure issues such as potholes or the absence of zebra crossings and sidewalks on their daily journey to school, which could lead to road crashes, but didn't know whom to share their views with and thought that their concerns wouldn't be addressed. Some said facing these road issues every day normalized these concerns for them.

Hence, the advent of YEA can significantly benefit numerous users, particularly students, by facilitating the acquisition of new RS knowledge, exposing them to an international standard school zone model, deepening their understanding of the local situation and enables them to share their RS concerns with family, friends, and local authorities. With the youth's voices raised and acknowledged, the students will be more confident and empowered to engage in more decision-making processes, while the local authorities will be equipped to identify hazardous locations and allocate resources to address RS issues.

"Nowadays, if you want to report potholes, no one will listen, but with this application, I can report these spots easily because everyone owns a phone. When a location receives many unsafe pins due to poor infrastructure, the local authority can upgrade that road section." – College student from Pleiku city.

"If the app can fix all the errors, I will share it because of its high applicability potential. The app also provides knowledge sections, and YEA pins help people be aware and avoid unsafe places." - High school student in HCM City.

Despite the positive feedback about YEA's usefulness and pioneering nature, only a minority of interviewed students agreed that aggregated data from student-reported pins was sufficient to reflect the current situation of local road situations. The others remarked that the app needs to attract more users nationwide, so the database would be more diverse, comprehensive, and valuable. Some indicated that the sufficient level of data also depends on the user's awareness of whether they are using it correctly, and that a technical team is required to manage and verify the information uploaded to the system.

"The app will only be practical and the pins will be more meaningful when more people learn to use the app properly. The location's credibility on YEA will increase, the authorities will pay more attention to improve the safety" - High school student in Yen Bai.

"To limit the false pins, there should be someone verifying the authenticity of pins" - Secondary school student in Yen Bai.

- Findings from IDIs with teachers:

Most of the teachers' opinions regarding the app's performance were similar to that of students. They agreed that this app would broaden students' knowledge of RS, create a greater sense of accountability for their actions, and motivate them to speak up to local stakeholders. Given the increasing number of students riding motorcycles and electric bikes to schools recently, many teachers believed that YEA would heighten awareness of maintaining a safe speed of 30 km/h in school zones, gradually promoting this new norm within their local community.

"After being trained of the application, I and the students have the belief that there will be changes to secure the safest environment. The first change is the students' awareness of RS […] Another change needed is from the infrastructure side" (Teacher in Pleiku city)

However, beyond the aforementioned benefits, what the interviewed students and teachers were most eager to see was the tangible efforts made by local authorities to improve road infrastructure in their community and promote safer behavior among road users. Most of them concurred that only when these changes happen will users progressively trust and use YEA more frequently. Otherwise, the interaction on YEA will be one-sided, making the intervention unsustainable.

"The real question is whether the government pays attention to, monitors, and processes road upgrades at the locations recorded by people using the app." - Teacher in Yen Bai city

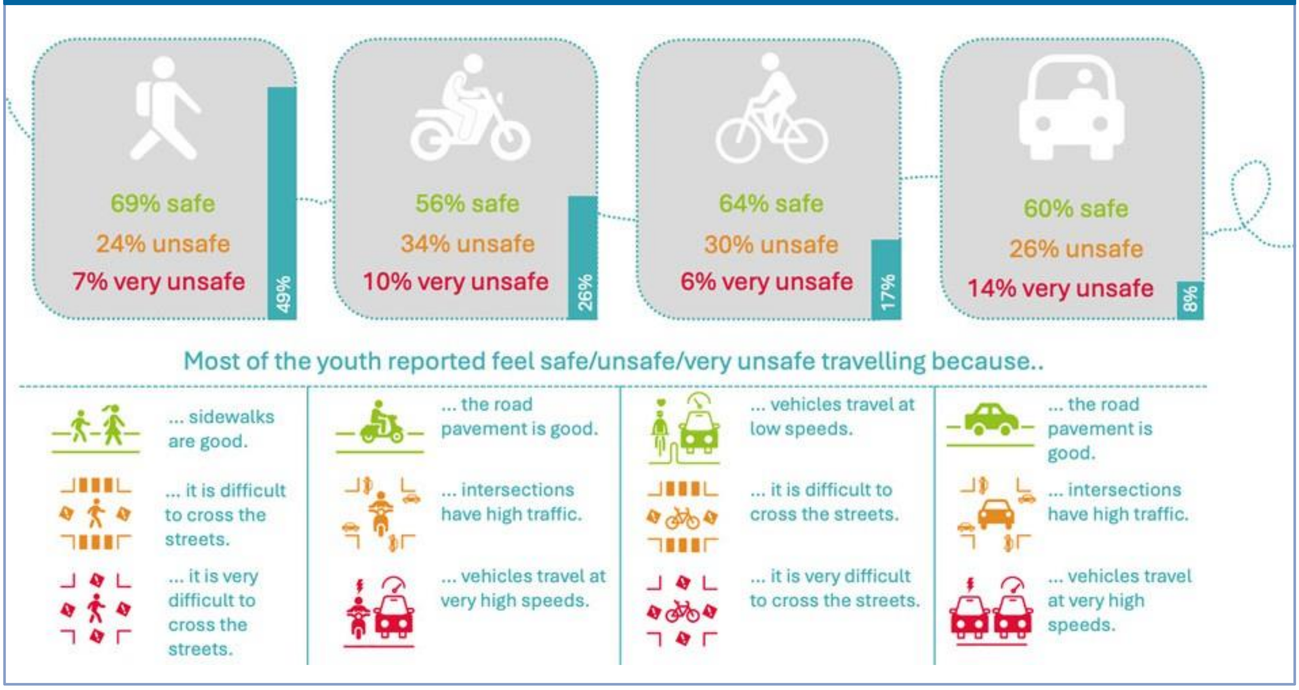
"The interaction must be two-way in order to be effective, because if the reflection remains the same after 1-2 years, people will believe that the project is just a project that costs money and has no meaning." - Teacher in Pleiku city

YEA results and their correlation with SR4S

A few months after YEA was introduced at 17 schools, the project recorded more than 19,000 pins on YEA, which represent over 19,000 locations where the students felt safe, unsafe, or very unsafe from the perspectives of pedestrians, cyclists, motorcyclists, and car occupants. Consequently, each of the participating students recorded over 10 pins.

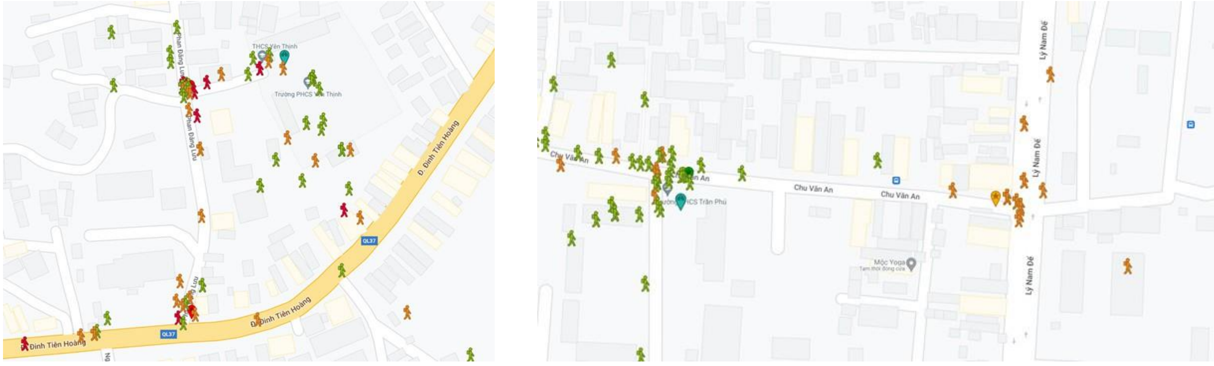
Figure 9 depicts the statistics of the pins received during the pilot. Over 50% of the recorded pins indicated locations where students feel safe. The high traffic volume and speed of operating vehicles were the primary reasons youth reported feeling unsafe or extremely unsafe while traveling. To understand the youth's perceptions and to ascertain whether their feedback was reliable, it is necessary to examine the concentration of pins, SR4S results at reported locations, and the correlation between the qualitative attributes recorded from YEA and the road-related attributes from SR4S.

Figure 9. Statistic of the reported pins from the pilot



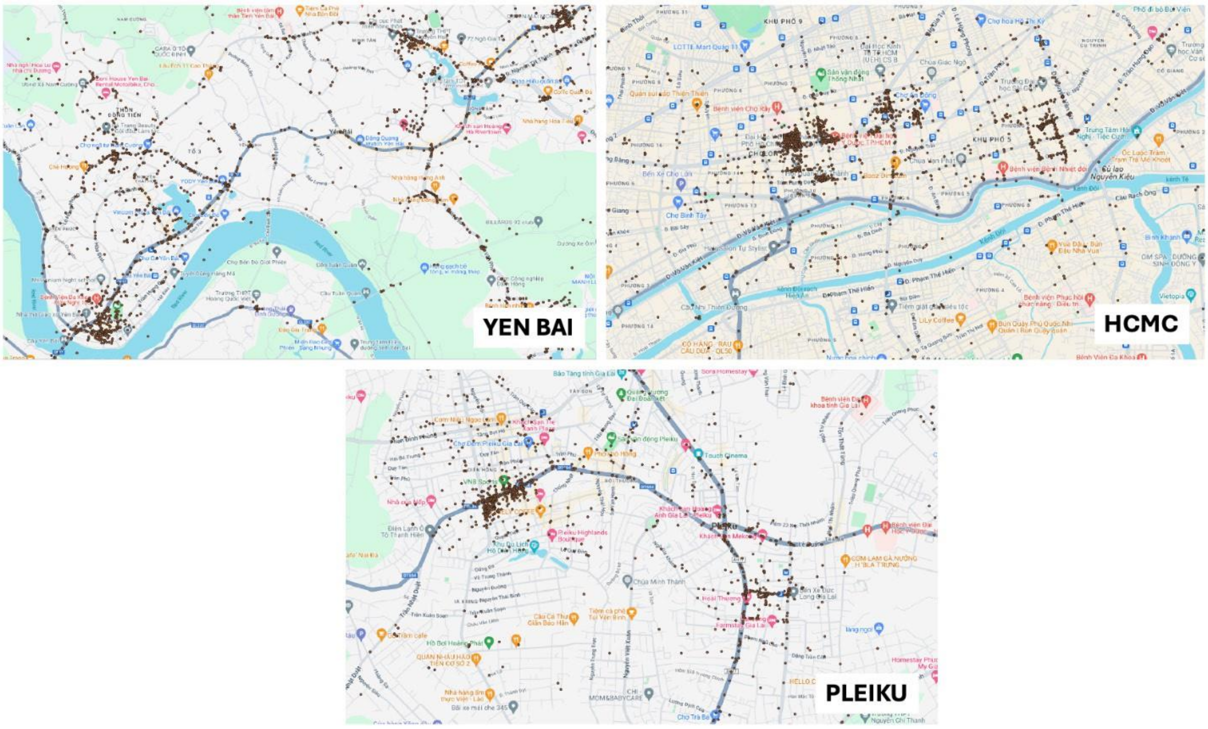
Preliminary analysis of the concentration predisposition of YEA pins revealed that most recorded locations were concentrated near the school gate or along the city's road network (Figure 10). Specifically, Pleiku city possessed over 3,800 pins, with 3,237 points representing 83% of the total pins recorded along the roads. In HCM city, 78.7% of total pins were located along the road, while in Yen Bai, this rate was 76%. The high concentration of pins at the school entrance and along the roads attested that students were reporting real locations.

Figure 10. YEA pins located along the road network in Pleiku city



YEA is a perception application designed to assist in identifying areas necessitating comprehensive road assessment, rather than serving as a replacement for an inspection tool. The app places greater importance on analyzing pin clusters or collective opinions rather than individual feedback. Given that the SR4S tool specifically harnesses the Star Rating component for pedestrians, YEA pins associated with pedestrians were directly utilized and embedded on the SR4S web-based tool, enabling SR4S assessors to select locations with a high density of pins for road infrastructure evaluation and further propose countermeasures to improve safety. The pin colors corresponded to the reported safety level, with green indicating safe, orange indicating unsafe, and red indicating very unsafe (Figure 11).

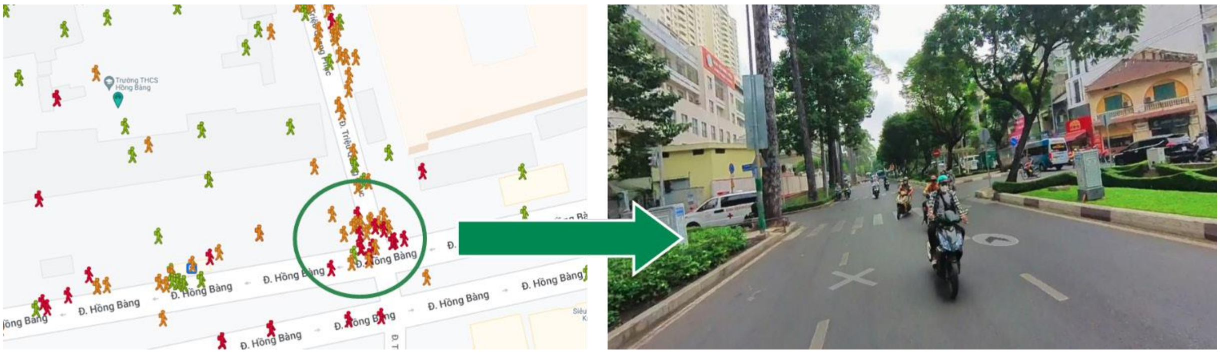
Figure 11. YEA's pedestrian pins displayed on SR4S web-based tool



During the YEA pilot, 30 locations populated with pin clusters were identified around 14 high-risk schools listed in the BDS methodology. These locations then underwent the assessment process and received the Star Rating results by SR4S (Table 5). Notably, all 30 locations were rated 1 or 2 stars, signifying the road risks present at the assessed locations.

Figure 12 shows an example of an intersection near Hong Bang Secondary School in HCM city which was rated with 1 star and received many unsafe and very unsafe pins from pedestrians, most of which were due to difficulties when crossing the street. When the location was surveyed, a high volume of traffic and the lack of pedestrian signals were noted, factors that may be causing students to feel unsafe when crossing the street.

Figure 12. YEA pins located at an intersection near a target school



It is worth noting that even though many safe pins were reported around the target schools by students, as shown in Figure 9, the star rating results at these locations remain very low, with 1 or 2 stars (Table 5). These unexpected findings could be attributed to the participants' lack of understanding of RS risks. They may struggle to understand how roads can be made safer because they are accustomed to their surroundings and have never experienced a different setting.

Table 5. SR4S results of locations identified by YEA				
No.	**School Name**	**City**	**Assessed Location**	**SR4S result**
1	Ly Thuong Kiet high school	Yen Bai city	School Gate	1
			Intersection near school	1
2	Nguyen Hue high school	Yen Bai city	School Gate	1
			Intersection	1
3	Le Hong Phong secondary school	Yen Bai city	School Gate	1
			Intersection	1
4	Yen Thinh secondary school	Yen Bai city	School Gate	1
			Intersection	1
5	Phan Boi Chau high school	Pleiku city	School Gate	1
6	Nguyen Du secondary school	Pleiku city	School Gate	2
7	Hoang Hoa Tham high school	Pleiku city	School Gate	1
			Intersection	2
8	Tran Phu secondary school	Pleiku city	School Gate	2
			Intersection	1
9	Tran Huu Trang high school	HCM city	School Gate	1
			Intersection	1
10	Ba Dinh secondary school	HCM city	Intersection near school	1
			Intersection Tran Hung Dao Street	1
11	Ly Phong secondary school	HCM city	School Gate	1
			First Int. (with An Duong Vuong Street)	1
			Second Int. (with Hung Vuong Street)	1
12	Hong Bang secondary school	HCM city	Main Gate on Hong Bang Street	1
			Side Gate on Trieu Quang Phuc Street	1
			Int. between Trieu Quang Phuc & Hong Bang St.	1
13	Tran Khai Nguyen high school	HCM city	School Gate on Nguyen Tri Phuong Street	1
			First intersection at roundabout	1
			Second intersection (with Hung Vuong Street)	1
14	Hung Vuong high school	HCM city	Main gate on Hong Bang Street	1
			Side gate on Nguyen Kim Street	1
			Inter. between Nguyen Kim and Hong Bang	1

To statistically measure the influence of road-related attributes on perceptions of safety, the structural model was performed and estimated, as shown in Table 6. All the estimations are statistically significant and consistent with the theoretical framework tested. The model demonstrates a high goodness of fit, as indicated by traditional fit indices: Comparative Fit Index (CFI) = 0.94 and Tucker-Lewis Index (TLI) = 0.92, both within best practice values. However, the Root Mean Square Error of Approximation (RMSEA) = 0.128, a widely used index, falls outside of optimal parameters, which may be attributed to the non-normal nature of categorical variables.

Table 6. Structural model results				
Endogenous relationships (standardised results)		**Estimates**	**Standard Error**	**P-value**
Perception of Risk	Speed Limit (SL)	0.707	0.000	0.000
	Intersection Present (IP)	-0.304	0.061	0.000
	Number of Lanes (NL)	-0.636	0.046	0.000
	Road Condition (RC)	0.483	0.051	0.000
	Delineation (DL)	0.706	0.036	0.000
	Street Lighting (SLI)	-0.490	0.055	0.000
	Pedestrian Crossing present (PCP2)	-0.618	0.038	0.000
	Pedestrian crossing the road (PPH1)	-0.721	0.035	0.000
Endogenous relationships (standardised results)		**Estimates**	**Standard Error**	**P-value**
Perception of Risk (RISK)	Reported level of Safety (LS)	0.659	0.038	0.000
Covariances (standardized results)		**Estimates**	**Standard Error**	**P-value**
Star Rating Bands (SR)	Perception of Risk (RISK)	-0.204	0.035	0.000
	Reported level of Safety (LS)	-0.157	0.071	0.026

Eight different indicators were used to model the latent variable "Perception of Risk." Among these, the number of pedestrians crossing the road and the speed limit were the most significant variables, negatively and positively affecting the risk perception, respectively. Other variables like the presence of pedestrian crossings, number of lanes and delineation also have a strong impact on the risk perception. The perception of risk also positively influenced the reported level of risk, indicating that individuals' subjective perceptions significantly impact their responses when asked to rank their feelings about traveling in the assessed locations.

Moreover, the statistically significant covariances demonstrate that objective measures can effectively capture how pedestrians perceive their environment. These results provide strong evidence for decision-makers to implement changes in the road environment, ensuring that users perceive their efforts to make roads safer.

Actions taken by the government

If youth are the driving force behind future changes, it is the government and policymakers who actualize these. Engaging government stakeholders in all project stages not only serves the dual purpose of coordinating and promoting local efforts, but also provides them with a deeper understanding of how community input can address the deficiencies caused by insufficient and poor-quality RS data. After witnessing the significant number of recorded pins, the app's impact on youth, and the verified results from SR4S, the municipal authorities demonstrated their strong commitment to improving safety around school zones by officially approving the modification plans to execute the infrastructure upgrades across 3 target cities. The road environment, particularly speed-calming measures and pedestrian facilities, surrounding 20 high-risk schools was improved using budgets of the provincial government, funders, and private partners to deliver safer outcomes for youth and local communities.

DISCUSSION

The YEA pilot, complemented by training and communication activities, has demonstrated the potential to improve youth awareness of RS. The KAB results exhibited significant increases in student knowledge (from 55.8% to 82%), positive attitudes (from 42.1% to 58.6%), and compliance with RS behaviors (from 39.6% to 57.1%) after the intervention. Not only are there significant changes in students' KAB, but YEA also recognizes and promotes youth perspectives on RS issues. For example, the significant number of pins collected through the app during the pilot exemplified the positive contribution of students when given the opportunity to share. True to the spirit of an inspirational application aimed at youth and developed based on youth feedback, YEA has attested how reinforcing community feedback can yield reliable evidence and how its implementation will benefit government agencies.

In VietNam, theconceptofgathering communityfeedbacktoaddress collective concernsisrelatively new. However, YEA-like perception tools have been successfully developed and applied in diverse contexts globally. Examples include Safe2School, Walkability, WalkRollMap, and BikeMap. These initiatives extend beyond applications, also functioning as websites and community groups. The primary objectives of these tools and platforms are to: [1] address the data deficiencies in traditional reporting methods and supplement the government-operated data system, thereby identifying priority areas, assessing accessibility, and monitoring changes; and [2] facilitate engagement and provide input via application devices like YEA, enabling improved collaboration and greater impact. Despite having different target groups, these applications and tools share common goals, which are empowering and motivating the target population (Holzinger et al., 2010). Beyond improving RS, they are designed to foster collective engagement to enhance infrastructure quality, pedestrian experiences, public transportation services, and cycling, while also reducing the use of personal motorized vehicles. All these efforts contribute to a more environmentally friendly and sustainable transportation model. While there is limited research on the effects of these app models, many valuable lessons can be drawn from the pilot of YEA:

- The app is a supporting tool to collect users' perceptions without validation needed. People's experiences vary depending on their backgrounds, social and psychological characteristics, making RS perception a subjective matter. However, findings from YEA pins indicated that youth might have a limited comprehension of what safety entails. Consequently, it is crucial to engage and educate young people about road RS, empowering them to advocate for better roads. Meaningful engagement with youth can help foster greater ownership of RS issues as well as develop a new cohort of RS advocates with a fresh perspective on the future of mobility (WHO, 2021).

- The focus should be on the collective perception of the road environment rather than individual perceptions. It is advisable to combine cognitive analytics tools, such as YEA, with other in-depth road assessment tools to enhance credibility, aid decision makers in identifying problematic areas and allocate adequate resources for safety enhancements.

- Youth deserve a vote of confidence. During IDIs with teachers, a common question was raised about why the emphasis was on young people and not on developing an application for the entire community. Youth, as the future generation of transportation, should have a significant impact on the design and structure of society's transportation system. Incorporating the youth's perspectives will lead to the modernization of road infrastructure management and the reduction of accidents. (Bohdidi et al., 2024). If we ask them to participate in RS decisions, we must trust and listen to their feedback.

- Youth desire recognition and will disengage if they don't feel acknowledged or see tangible changes. What they want for the future is what the future could become; or, if these ideas can be worked on and reshaped, then an alternative future could be brought into existence (Simpson and Collard, 2019). If students report feeling unsafe without receiving any response or action, their motivation to use the app will decline, threatening the intervention's sustainability. It is decision-makers' duty to address RS concerns and secure safer pathways for students commuting to school.

Besides its effects on youth, YEA has also influenced government actions, as evidenced by the proactive execution of road modification plans at several high-risk schools. However, to translate stakeholders' support for YEA into tangible actions, it is essential to demonstrate results with robust evidence from the app pilot process and ensure that government and decision-makers at all levels are constantly engaged in the project. The pilot results have demonstrated how the substantial data collected as pedestrian pins allows SR4S assessors - including engineers, experts, and government sectors involved in RS - to swiftly identify areas needing detailed assessment, determine safer countermeasures, and validate YEA as a credible data source contributed by young people. Additionally, another crucial factor contributing to the success and scalability of YEA implementation is the ongoing engagement with local government stakeholders at national and provincial levels throughout every stage.

From the outset, the notion that the role of YEA is to serve not as an immediate RS solution but as a versatile tool to capture community feedback, bridge gaps in existing traffic data, and a way to enhance evidence-based decision-making, was consistently communicated to government stakeholders. To support this vision, a strategic framework was established to engage key stakeholders, define the roles of each government agency, plan activities for implementation, and augment the capabilities of all involved. This approach ensures that stakeholders comprehend YEA's goals within the intervention chain, while also fostering consensus, securing government support for the data collected by YEA, and underscoring the importance of youth involvement in addressing local RS concerns. Such comprehensive engagement is vital for the successful implementation and scalability of YEA, ultimately contributing to safer school zones and improved RS outcomes.

LIMITATIONS

Despite the positive achievements, the project also faced several drawbacks:

- Firstly, although we piloted YEA at 18 schools in practice, the findings in the study were derived from 17 schools. The exclusion of this secondary school from the study resulted from its late selection and the absence of certain assessments conducted there.

- Secondly, it is worth noting that the accuracy of the reported coordinates can be influenced by the GPS connection, which is impacted by both the user's environment and the device in use. GPS signals are frequently obstructed in urban environments due to the influence of high-rise buildings and their density, whereas GPS signals are easier to identify in suburban or rural areas due to the minimal interference from other wireless connections which reduces pins misplaces. However, further analyses are recommended to correct coordinates or clean databases with outliers.

- As digital natives who grew up with advanced technology, the youth naturally have higher expectations and more specific requirements for the application. Since YEA was a newly piloted app and still under development, the app's malfunction was inevitable, considerably affecting young people's experience. Hence, the app requires further improvements to sustain interest and address RS challenges effectively.

- Fourthly, merely asking students to download the app without offering training, explaining the significance of YEA, and clarifying their role and influence in the decision-making process, may prove ineffective since some younger adolescents may not fully comprehend their critical role in shaping the app's impact. Consequently, schools should implement structured workshops featuring teacher mentorship to instruct students on app utilization and underscore the importance of their contributions to RS.

- Finally, while the findings of this study demonstrate remarkable improvements in youth's KAB of RS, potential confounding factors may exist. Specifically, the smaller sample size in Post2 compared to Pre and Post1 may have affected the robustness of the results. Due to budgetary constraints to implement reinforcement activities, the Post2 KAB assessment were only conducted with only 133 participants, which partially limited the generalizability of the findings from Post2 and introduced biases, as only students who thoroughly engaged in additional RS activities were assessed. Students who participated in more intensive educational activities may have exhibited greater improvement. Thus, Post2 findings only reflect the changes among the smaller group receiving the intense, engaging educational and communication activities, not the cohort of 1,700 students, highlighting the need for more comprehensive initiatives across all target groups to reinforce desired behaviors.

CONCLUSIONS

Including youth feedback in decision-making can be a game-changing factor in tackling many global challenges. By actively involving young people in the identification and reporting of road hazards, the AI&Me project has proved that YEA is an effective platform to empower youth to become vital contributors to their communities' safety and to serve as a vital connection between youth and government authorities. By allowing students to map unsafe locations and provide detailed feedback, YEA facilitated direct communication with authorities, enabling more informed decision-making for road improvements. This engagement amplified youth voices in the decision-making process, which has traditionally been dominated by adults, and ensured that young people's perspectives are considered in safety measures. The success of YEA has also broadened government stakeholders' perspectives on the valuable contributions of youth to RS, prompting decision-makers to take potent actions and upgrade infrastructure based on youth feedback.

In conclusion, the YEA initiative has proven to be a handful tool in promoting RS education and empowering youth in Viet Nam. Leveraging insights acquired from Phase I, the next phase of AI&Me project is expected to commence in 2025, with the objective of tackling the identified challenges, further refining YEA and integrating app deployment with various engagement and capacity building initiatives for youth. This opportunity holds promise for broader implementation and scalability, ultimately contributing to the creation of safer road environments not just in Viet Nam but also to other countries. The active participation of youth, supported by technology and community engagement, can result in substantial progress towards the UN Sustainable Development Goal target of halving road deaths and injuries by 2030.

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Consumer Awareness of Vehicle Safety Features and ASEAN NCAP in Malaysia

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ABSTRACT

The New Car Assessment Program for Southeast Asian Countries, or ASEAN NCAP, was established in 2011 with MIROS as its Secretariat. Since its establishment, ASEAN NCAP has published 157 ratings for various models and variants available in ASEAN countries. The NCAP ratings are significant as they are a means to ensure the availability of consumer information and enhance awareness about the safety performance of motor vehicles currently sold in the regional market. As ASEAN NCAP is based in Malaysia, this study aims to determine the factors influencing Malaysian consumers' decisions to purchase new passenger vehicles, including the safety features that consumers prioritize when selecting their cars, and most importantly, whether they purchased the vehicles based on ASEAN NCAP ratings. The study was conducted through an online survey in 2021 involving 350 Malaysian consumers as the respondents. Based on the findings, the study revealed that most of the respondents opted to purchase brand new cars instead of used or imported refurbished units, whereby the car safety aspects became the most important factor to be considered before making the purchase, followed by affordability. The majority of respondents also agreed that vehicle stability control (VSC) was the most important device to be fitted in their car aside from autonomous emergency braking, blind spot warning detection, and child restraint system. However, the study revealed that most respondents did not refer to the ratings provided by ASEAN NCAP before making their purchase. The results indicate that ASEAN NCAP must put in more effort to raise awareness about ASEAN NCAP ratings, for example by having more engagements with South-East Asia car buyers to convince the latter to use ASEAN NCAP ratings in the future.

INTRODUCTION

The pioneering Global Plan for the Decade of Action for Road Safety 2011-2020 emphasized the need to implement a new car assessment program in every region of the world. Based on this recommendation, the Global New Car Assessment Program (Global NCAP) was set up in the United Kingdom, with one of its missions being to support New Car Assessment Programs (NCAPs) in emerging markets by offering technical expertise guidance and quality assurance (Global NCAP, 2024).

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The New Car Assessment Program for Southeast Asian Countries, or ASEAN NCAP, is a non-affiliated vehicle assessment program that was founded in 2011 based on a Memorandum of Understanding (MoU) ratified by the Malaysian Institute of Road Safety Research (MIROS) and Global NCAP (Abu Kassim, 2018). It aims to increase awareness among consumers and provide information regarding the safety performance level of new cars (ASEAN NCAP, 2023). As of June 2024, ASEAN NCAP has conducted 126 crash tests and published 157 ratings of various models and variants that are sold in the South-East Asia region. From these numbers, it is estimated that almost 90% of the passenger cars assessed by ASEAN NCAP had been awarded 4-star and 5-star ratings (Abu Kassim et al., n.d.).

To date, ASEAN NCAP has developed three roadmaps: the 2012-2016 Roadmap, 2017-2020 Roadmap, and the current 2021-2025 Roadmap. The first roadmap in 2012-2016 focused on the passive safety protection of occupants in the passenger vehicle where there were two types of rating: Adult Occupant Protection (AOP) and Child Occupant Protection (COP) (ASEAN NCAP, 2012; ASEAN NCAP, 2015; Abu Kassim et al., n.d.). In the second roadmap (2017-2020), ASEAN NCAP created another assessment pillar, Safety Assist (SA), in addition to the existing ones. The new pillar covered not only Effective and Braking Avoidance technologies such as Electronic Stability Control (ESC) and Anti-lock Braking System (ABS), but also incentives for the Seatbelt Reminder System (SBR) for rear seat occupants (in addition to the frontal seat passenger). The SA pillar also covered advanced safety assist technologies such as Autonomous Emergency Braking (AEB), Forward Collision Warning System (FCW), and Lane Departure Warning System (LDW), that help to prevent collisions with other vehicles. Additionally, through this new assessment pillar on Safety Assist, ASEAN NCAP began to embark on new initiatives to evaluate the vehicles' effectiveness in avoiding collisions with motorcycles during lane change manoeuvres by placing scores for fitment of Blind Spot Technology (BST).

With motorcycle fatalities making up 43% and 48% of the total number of deaths in 2018 and 2023 respectively (WHO 2018, WHO 2023), ASEAN NCAP took another step forward in the 2021-2025 Roadmap by including a new assessment pillar named Motorcyclist Safety (MS), which is fitment scoring of safety assist technologies that are able to avoid collision with motorcycles. Under the MS assessment pillar, ASEAN NCAP identified several technologies that have been proven effective in meeting the objective, namely Blind Spot Detection (BSD), Blind Spot Visualization (BSV), Advanced Rear View Mirror, Auto High Beam (AHB) and Pedestrian Protection technology. In addition to the new assessment pillar, ASEAN NCAP also included additional improvements for each assessed item of the other assessment pillars (Abu Kassim et al., 2018).

To date, several studies have been conducted to find out the level of consumer awareness of ASEAN NCAP in Malaysia, but respondents were mainly residents of Klang Valley, an urban area centred in the federal territories of Kuala Lumpur, Putrajaya, and Selangor. Hence, there was little information to determine the awareness level of consumers living outside the Klang Valley about the ASEAN NCAP rating and the availability of vehicle safety technologies in the market. Because of this, MIROS decided to assess the awareness of Malaysian consumers of the car safety rating and also ASEAN NCAP's role in the automotive ecosystem. A study was therefore carried out:

1. To determine the level of Malaysian consumer awareness about the safety ratings produced by ASEAN NCAP on new cars sold in the regional market.
2. To evaluate the effectiveness of ASEAN NCAP social media communication channels in promoting ASEAN NCAP results and new car safety tests.
3. To find out whether Malaysian consumers know about the availability of the current safety technologies in the automotive market.

METHODOLOGY

Previous studies had used face-to-face methods to collect data, including handing out survey forms (Md Isa et al., 2016; Abu Kassim et al., 2016). However, the current study, which began in the first quarter of 2020, was interrupted by the nationwide lockdown by the Government of Malaysia due to COVID-19. To overcome the restrictions on commuting and face-to-face meetings, an online survey was developed and respondents were invited through ASEAN NCAP social media platforms, including Facebook and X (formerly Twitter), and also through WhatsApp group messages.

The target respondents for this study were Malaysian car buyers with valid driving licenses. The survey questions were divided into three parts: Part A was on respondents' demographic profiles, Part B used a Likert Scale method to assess what factors respondents placed importance on when choosing a car, and Part C asked about their awareness of ASEAN NCAP car safety ratings.

RESULTS

Gender and Location of Respondents

Respondents consisted of 254 male and 96 female respondents. They hailed from various states in Peninsular Malaysia, the Federal Territory of Labuan, and also Sabah and Sarawak. Although the number of respondents from the Federal Territory of Labuan and also Sabah and Sarawak were quite small, it was still considered an accomplishment as this study was able to reach out to them to get their views on vehicle safety and the role of ASEAN NCAP.

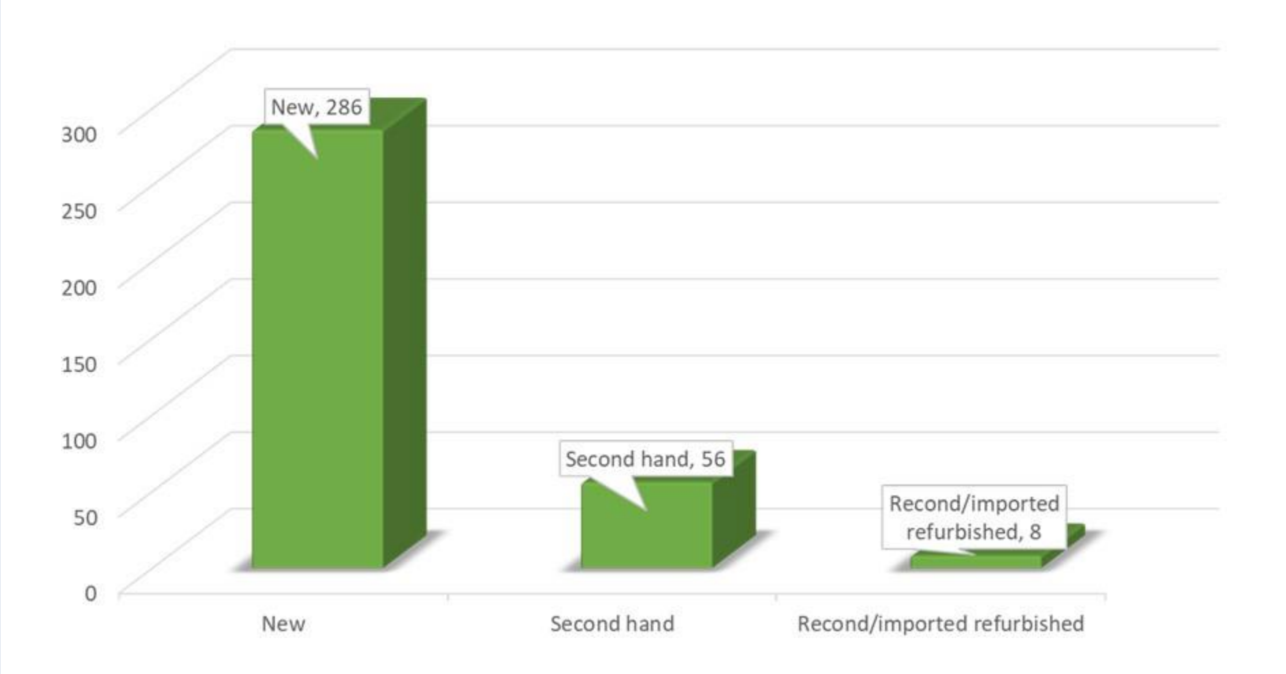
Condition of Purchased Cars

Generally, passenger cars entering the South-East Asian automotive market could be differentiated into three categories, namely brand new, used, and reconditioned or imported refurbished. According to the Malaysian Automotive Association (2022), the Total Industry Volume (TIV) for passenger vehicles in 2021 was 452,663 units. Although this study was unable to confirm the number of used and reconditioned passenger vehicles sold in Malaysia that year, cars in the brand new category exceeded the other two categories. The survey found that more than half of the respondents (286) purchased brand new cars, while 56 respondents purchased second-hand cars and only 8 respondents purchased reconditioned or imported units that were refurbished (Figure 1).

Contributing Factors Toward Buying Decision

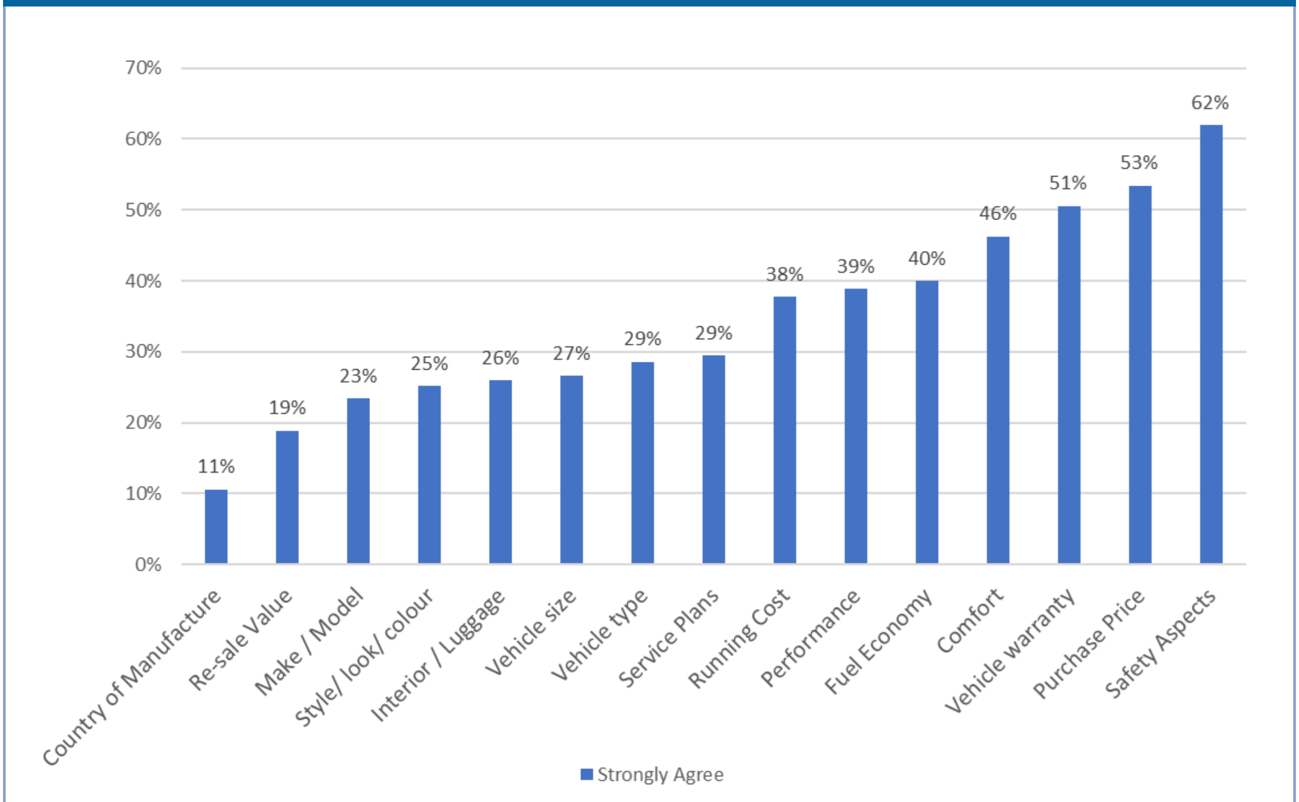
There are a lot of reasons as to why a potential buyer will select a particular passenger car. Among the factors that might attract a car buyer include the car safety aspects, aesthetic features, and purchase price. Earlier studies (Md Isa et al., 2014; Abu Kassim et al., 2016; Md Isa et al., 2016) noted that most car buyers in Malaysia were likely to focus on the car price. The current study asked respondents about 15 factors that affected their purchase decisions. Figure 2 below shows all of the factors: Comfort, Country of manufacturer, Fuel economy, Interior/luggage space, Make/model, Performance, Purchase price, Resale value, Running cost, Safety aspect, Service packages, Style/look/color, Vehicle size, Vehicle type, and Vehicle warranty.

Figure 1. Respondents' preference of purchased car condition



As can be seen, the three most preferred factors were the safety aspects, which made up about 62% of the respondents' preference, price of the vehicle (53%) and warranty of the vehicle (51%). However, "price of the vehicle" also occupied the second spot according to the respondents. On the contrary, the least important factors were "country of manufacture" and "resale value" at 11% and 19%, respectively.

Figure 2. Contributing factors in purchasing cars



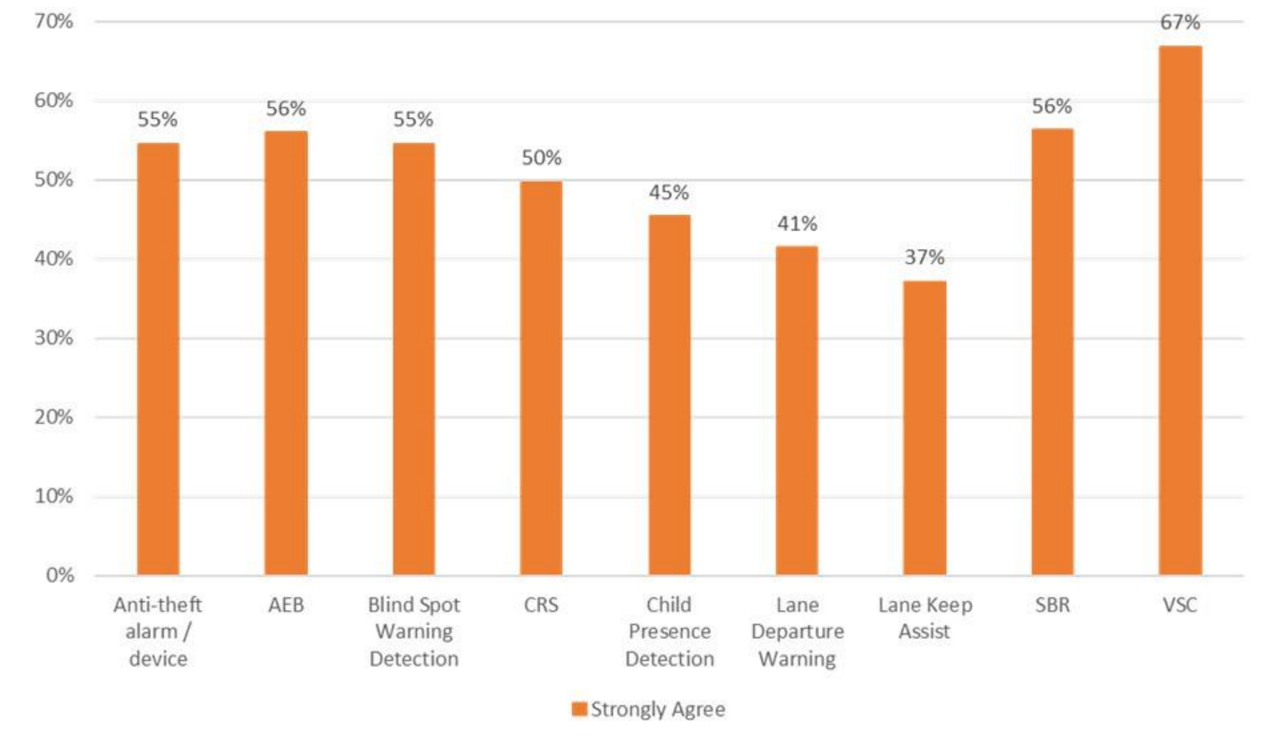
Prioritised Safety Features When Choosing Cars

Today, a new passenger car would normally be installed by the manufacturer with various safety features to protect the driver and passengers alike. Such features include the anti-theft alarm, autonomous emergency braking, blind spot warning detection, and child restraint system. The crash tests conducted by ASEAN NCAP at different crash labs placed the greatest importance on car safety technologies in order for a model or variant to reach a 4- or 5-star rating (Khairil Anwar, 2018). This study also looked at whether the respondents preferred car safety devices that had been fitted by the manufacturer as recommended and appraised by ASEAN NCAP.

As shown in Figure 3 below, there was a high consensus among the respondents towards prioritizing safety features when choosing a car. The majority of respondents (87%) strongly agreed that the vehicle stability control (VSC) was the most important technology to be installed. More than 50% of the respondents also identified the anti-theft device, autonomous emergency braking, blind spot warning detection, and child restraint system as the most necessary safety features on their car. It was interesting to note that only 37% of respondents identified the lane keep assist technology as important. The lane keep assist is a feature to prevent the car from crossing lane lines inadvertently due to driver fatigue and dozing off (National Safety Council, 2024).

Another safety feature was child presence detection. This has become more important due to the rising number of fatalities involving a child trapped inside the car for a long period, normally due to forgetfulness of the caregiver. Such cases have been called “hot car tragedies” (The Malaysian Reserve, 2024) and have prompted MIROS to launch the MyCinta system to track the presence of a child in a vehicle once the engine is turned off (MIROS, 2023). Other safety features which were ranked by study respondents included the Lane Departure Warning and the Seat Belt Reminder System (SBR).

Figure 3. Safety features prioritised when choosing a car

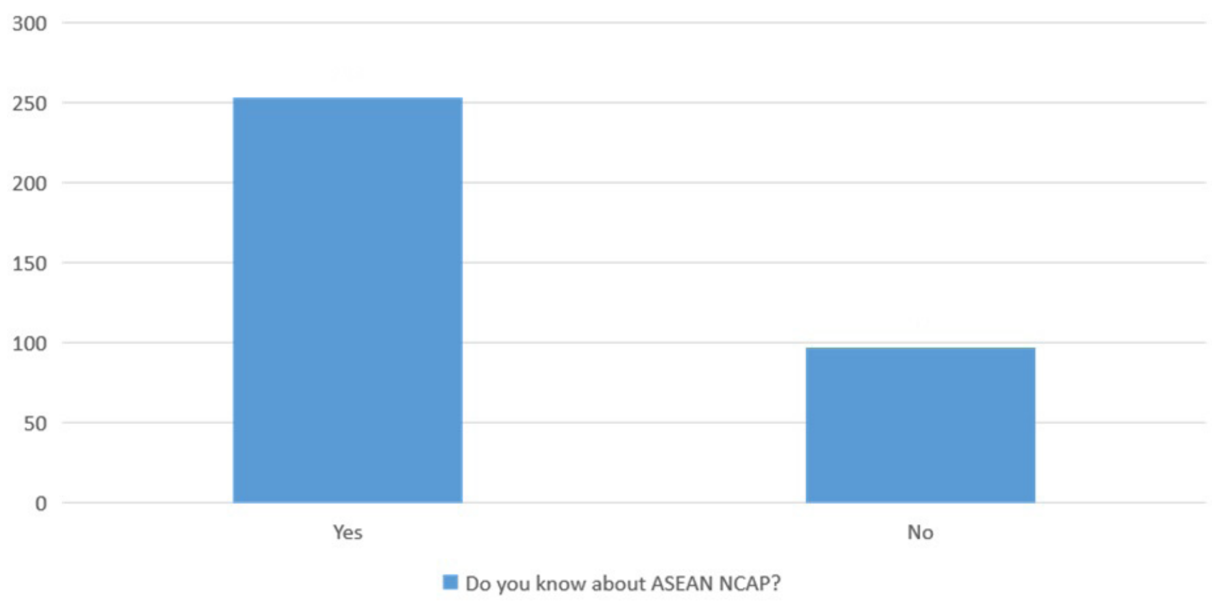


Consumer Awareness of ASEAN NCAP

At the time this study was conducted in 2021, ASEAN NCAP had just celebrated its tenth anniversary. Over the years, ASEAN NCAP has conducted more than 100 crash tests besides producing 157 ratings for new passenger cars entering the automotive marketin South-East Asia. ASEAN NCAP has also organized numerous programs including the Grand Prix Award as well as roundtable discussions with the main stakeholders in the automotive industry. The presence of ASEAN NCAP has changed the motoring landscape in the region (Abu Kassim et al., 2019). A clear example was the fitment of various safety features that had become a standard for manufacturers to attain a 4- or 5-star rating for the car models offered to consumers.

However, when asked about ASEAN NCAP's influence on consumer behavior, 250 respondents (71%) were aware of the role of ASEAN NCAP compared to 100 (29%) who had never heard of it (Figure 4). As it was originally meant to be a consumer-driven program, this suggests that ASEAN NCAP must double its efforts to gain more recognition from car buyers in the region.

Figure 4. Knowledge/awareness of ASEAN NCAP

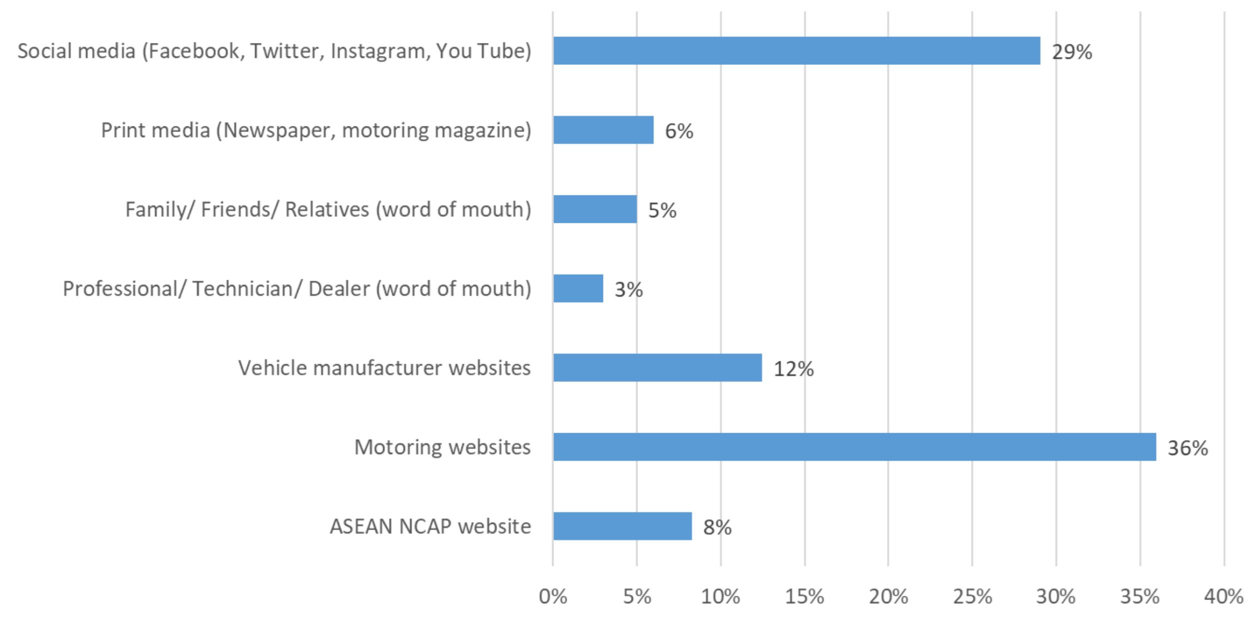


Channel/Media Platform on ASEAN NCAP

As the car models are sold across the South-East Asia region, ASEAN NCAP must disseminate the assessment results of a particular car model and information about its activities widely across countries. The assessment results are extremely important as they provide the necessary knowledge to the consumers in their decision-making process when purchasing a vehicle. As Figure 5 shows, the study results indicated that most respondents knew about ASEAN NCAP through social media (Facebook, X formerly known as Twitter, Instagram, and YouTube) as well as local automotive websites and blogs, at 29% and 36%, respectively. The ASEAN NCAP official website offers various information about the crash tests conducted and the ratings produced for the passenger cars currently on the market, as well as short videos of the crash tested models. However, the ASEAN NCAP website was a reference point for only 8% of the respondents, while the vehicle manufacturer's official web pages were the main source of consumer awareness for 12% of the respondents.

Collaboration with social media influencers such as Abang Gan (Pandu Laju) and Paul Tan (paultan.org) is also important, as these figures are important sources of information among car enthusiasts, especially in Malaysia. It was also interesting to notice that only 3% of the respondents got to know about ASEAN NCAP from professionals, technicians, and car dealers.

Figure 5. Source of information about ASEAN NCAP

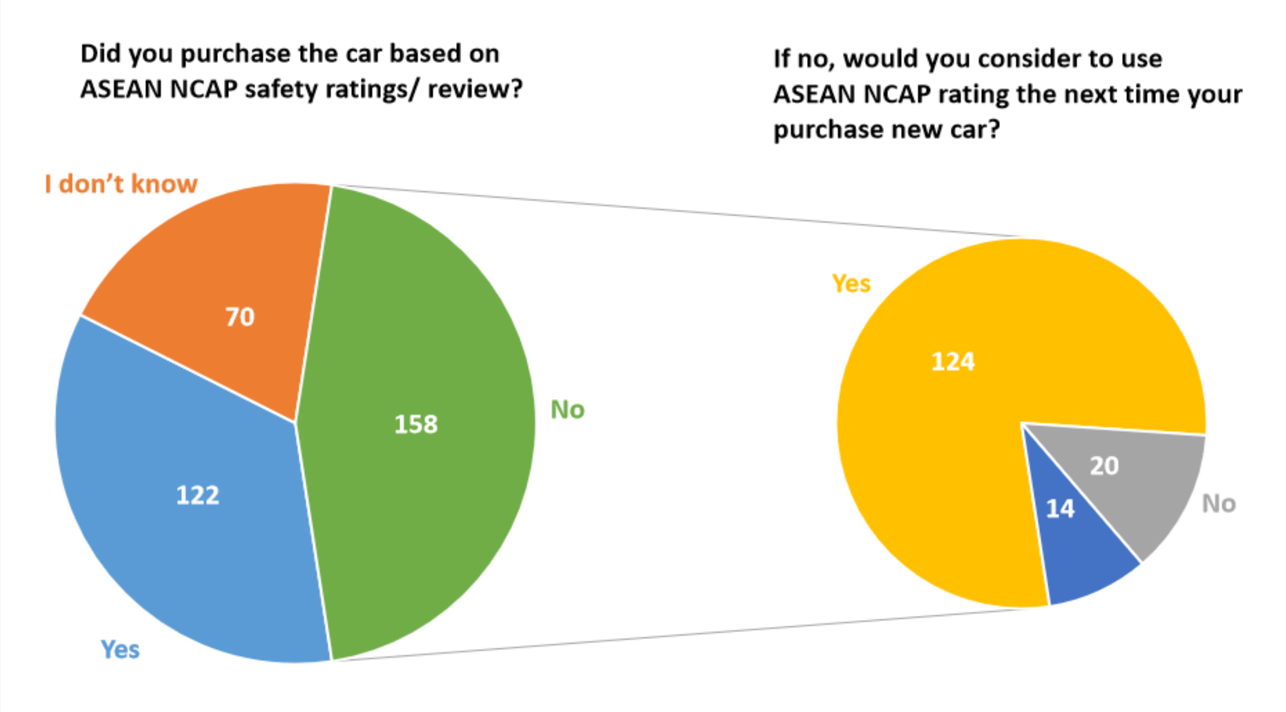


Consumer Purchasing Behavior Based on ASEAN NCAP Safety Ratings/Reviews

With the emergence of ASEAN NCAP, new passenger cars sold on the South-East Asian market today are normally fitted with the latest safety technologies such as Blind Spot Detection, Seat Belt Reminder, Autonomous Emergency Braking (AEB), and Anti-lock Braking System (ABS), to name a few. This trend will eventually lead to the having "Safe Vehicles driven by Safe Drivers on Safe Roads," as envisioned by the various stakeholders. To this end, the current study also looked at how far ASEAN NCAP ratings were utilized by the respondents who were also car buyers.

The results revealed that the majority of respondents (n: 158) did not make use of the information offered by ASEAN NCAP before making their car purchase. Only 122 respondents referred to the ASEAN NCAP ratings when purchasing their new car, whereas another 70 were not sure whether they referred to ASEAN NCAP rating or otherwise. The respondents who answered "No" were also prompted as to whether they would consider using the ASEAN NCAP rating the next time they bought a car. Most mainly agreed to refer to the ASEAN NCAP rating (n: 124), as opposed to those who answered in the negative (n: 20) and "not sure" (n: 14). This indicated that ASEAN NCAP could become the main reference point to obtain information as regards new passenger car safety on the regional market. To this end, ASEAN NCAP must try to have more engagements with potential car buyers in South-East Asia to convince them to use ASEAN NCAP ratings.

Figure 6. Consumers purchasing behaviour based on ASEAN NCAP ratings



CONCLUSIONS

This study surveyed Malaysian consumers to assess the factors influencing their decisions to purchase new passenger vehicles, including whether they purchased the vehicles based on ASEAN NCAP ratings. After ten years of ASEAN NCAP's existence and over 150 ratings published, it was also deemed important to ascertain the Malaysian consumers' level of awareness of the ASEAN NCAP ratings.

Most of the 350 study respondents chose to buy a brand new car compared to a used or recon unit. Sixty-two percent (62%) of the respondents placed importance on the safety aspect of the vehicle in addition to the vehicle price (53%). In addition, the study also found that the majority of respondents (87%) strongly agreed that vehicle stability control (VSC) was a safety feature that needed to be installed by manufacturers on their vehicle in addition to anti-theft devices, autonomous emergency braking, blind spot warning detection and child restraint system.

The study found that the 71% of respondents were aware of the role of ASEAN NCAP in the regional automotive ecosystem, compared to 29% who were not aware of the role of the new car assessment program. Most respondents were acquainted with the role of ASEAN NCAP through social media (Facebook, X formerly known as Twitter, Instagram, and Youtube) and local automotive websites. However, the majority of respondents did not refer to the safety rating supplied by ASEAN NCAP before making their car purchase.

Those who answered "No" were asked whether they would consider using ASEAN NCAP's rating the next time they bought a car. The finding showed that about 78% of these respondents agreed to refer to the ASEAN NCAP rating, compared to about 13% who said they would not. ASEAN NCAP must therefore step up its efforts to raise awareness about their ratings system.

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Artificial intelligence-based traffic information and enforcement system to enhance the safety of right turns at intersections

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ABSTRACT

A recent revision of the Korean Road Traffic Act has complicated the right turn procedure, resulting in some confusion. There is therefore a need to reduce confusion and promote safety at intersections by guiding drivers to make proper right turns. In this study, a detection system was developed that can 1) determine whether a driver can make a right turn, and 2) identify illegal right turns. Based on this system, a device was designed to provide right-turn information, and its effectiveness was evaluated through microscopic traffic simulation. An algorithm was developed using CCTV videos based on YOLOv8, and the resulting data was analyzed using various driving safety indicators through traffic simulation. It was found that through the provision of right turn availability information, drivers slowed down and their safety was significantly improved. The findings have important implications for traffic safety policymaking and highlight the critical role of automated enforcement systems in mitigating vehicle-pedestrian crashes and creating safer urban environments.

INTRODUCTION

Article 27 of the Korean Road Traffic Act (Protection of Pedestrians) was recently amended to change the procedure for right turns at intersections. Under the new rules, drivers are required to stop when they see a person turning right at an intersection, and to pause not only when pedestrians are “passing,” but also when they are “about to pass.” These changes have complicated the right-turn procedure at intersections, causing confusion among drivers. In addition, due to the geometry of intersections, crashes between vehicles and pedestrians are frequent, especially at the crosswalks in the right-turn section of the intersection. According to data on traffic crashes for the last five years, the number of crashes at intersections has been gradually decreasing, but the proportion of crosswalk crashes among intersection crashes has been gradually increasing and was the highest in 2023 (Traffic Analysis System TAAS, 2024). In addition, the proportion of fatal crashes has also been steadily increasing and was the highest at about 28%. It is important to strengthen traffic safety measures to prevent pedestrian crashes at intersections, especially vehicle-pedestrian crashes which have a higher severity compared to other crash types.

In order to prevent crashes in the right-turn section of these intersections, each local government has individually developed right-turn notification devices with different features, or installed right-turn signals. However, while this has a temporary positive effect, it is difficult to guarantee the sustainability of the policy in the future due to various policy issues. For example, although traffic police conduct visual checks to control illegal drivers, such enforcement is inefficient because of workforce limitations that restrict the areas they can cover. In addition, drivers are not fully and/or accurately aware of whether they can make a right turn due to their lack of familiarity with the new law, which is another source of confusion at intersections. To overcome these limitations, it is necessary to develop a system that can recognize, identify, and sanction illegal right-turning vehicles, as well as develop a device that can prevent crashes by providing drivers with information on whether they can make a right turn.

The purpose of this study is to design a system for judging right-turn availability and enforcing illegal right turns, ultimately reducing the frequency and severity of vehicle-pedestrian crashes at intersections and improving traffic safety in urban areas. Accordingly, an algorithm for determining whether a right turn is possible and for enforcing illegal right turns was developed using multi-angle intersection CCTV images and YOLO (You Only Look Once), a widely used object detection algorithm, and then the effectiveness of the device in providing right-turn information to drivers was analyzed using traffic simulation. While there have been many previous studies in the field of transportation using various object recognition algorithms such as YOLO, Faster R-CNN, and BP neural networks, this study is significant because there is a lack of research based on the revised law described above. In addition, since the law has not been in effect for a long time, many drivers are currently unfamiliar with the new right-turn method, resulting in unnecessary stops and reduced operability at intersections during right turns. The development of this system is therefore expected to guide drivers to make proper right turns and improve operability.

The paper is structured as follows. In the second section, previous studies on object detection using video detection algorithms in transportation are reviewed, as well as past research on microscopic traffic simulation and analysis of vehicle driving behavior using driving simulators. The third section describes data collection and methodology. The fourth section presents the system developed in this study and the results of the analysis using simulations. The final section presents the conclusions.

LITERATURE REVIEW

1. Research on AI-based object detection in transportation

As object recognition technology using video data has been developed in recent years, research on vehicle and object detection using algorithms has also increased, particularly using the YOLO algorithm. Jeon et al. (2020) studied the design and implementation of a YOLO-based lane detection system by preprocessing video data collected directly using a CSI-camera, and Lee et al. (2021) used video data collected from traffic surveillance cameras at real intersections to investigate how much the YOLOv3 model improves the detection performance of small-sized vehicles at a distance compared to the YOLOv2 model. As a result, a vehicle detection system was designed that can be located at the roadside with video that can be analyzed in real time to calculate information on objects located on the road. In addition, YOLOv4 was used to detect the license plate in car images, showing the unique number of the vehicle (Kim & Kim, 2021).

Meanwhile, Jeong et al. (2023) proposed a method to detect a stopped vehicle from the dashcam video of a moving vehicle. YOLOv5 and Deep SORT tracking algorithms were used to identify the object region, and the flow in and around the object region was compared to determine whether the vehicle was stationary or not. Manongga & Chen (2024) proposed an algorithm to detect traffic signs with a YOLO (v5, v8) model using a traffic sign dataset containing seven types of traffic signs in Taiwan Province of China and an intersection dataset consisting of images captured by a vehicle dashboard camera, and to predict the location of intersections based on this information. The YOLO model detected seven types of traffic signs when the image from the front camera was input into the YOLO model, and a model was developed that generated an intersection detection area based on the location and size of the detected signs, showing high accuracy and fast processing time. Dewantoro et al. (2020) and Azimjonov & Özmen (2021) analyzed the effectiveness of the algorithm in detecting the number of vehicles using a dataset consisting of images of vehicles taken from the road and the YOLO algorithm, and Wang et al. (2020) developed an algorithm to automatically detect illegal turns and record vehicle license plates. The proposed algorithm, which worked effectively, consisted of setting the ROI, using the location of the vehicle in the area to determine whether it was an illegal turn, and recognizing the license plate.

There have been many other studies that utilize YOLO algorithms to detect vehicle-specific objects or pedestrians in photo and video data, which have shown that YOLO algorithms perform well in terms of accuracy and processing time (Kejriwal et al., 2022, Putra et al., 2018, Sang et al., 2018, Ibriaeva et al., 2020, Jo et al., 2022).

2. Research on driving behavior following the installation of safety signs

This study designed a right-turn information device to analyze its effectiveness when installed at actual intersections. To overcome the limitations of actual installation, a network was built and analyzed in VISSIM, a microscopic traffic simulation. This section reviews studies using VISSIM and research related to the installation of safety signs using driving simulators.

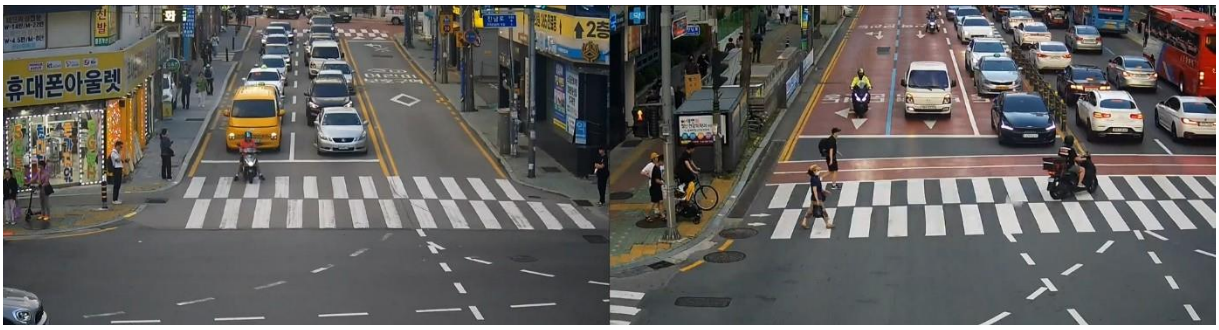
Yun & Ji (2013) used VISSIM simulation software to evaluate the delay and latency of installing yield sign intersections, two-way stop sign intersections, and all-way stop sign intersections. Wei et al. (2021) used a driving simulator to analyze the change in readability time and driver behavior as a function of signage, and concluded that as the amount of information increases, the average speed decreases. El-Shawarby et al. (2007) used GPS data to extract driving data from vehicles approaching a signalized intersection at a yellow light to determine the intersection approach speed, deceleration distance, and deceleration time of a stopped vehicle, and found that the average deceleration of the vehicle was approximately 3.2 m/s^2. A similar study using GPS data from a vehicle to analyze the deceleration of a vehicle within a signalized intersection found an average maximum deceleration of 2.65 m/s^2 (Wang et al., 2005). Wortman & Matthias (1983) and Mondal & Gupta (2023) also analyzed vehicle driving behavior at signalized intersections using time-lapse data and vehicle trajectory data, respectively, and found average decelerations of 3.5 m/s^2 and 2.2~3.01 m/s^2, respectively. In addition to research papers, ‘A Policy on Geometric Design of Highways and Streets (2018)’ by the American Association of State Highway and Transportation Officials (AASHTO) recommends 3.4 m/s^2 as a comfortable deceleration rate for drivers, while Traffic Engineering Handbooks (1999), published by the Institute of Transportation Engineers, suggests a comfortable deceleration rate for vehicles of about 3.0 m/s^2.

Through the review of previous papers and manuals, it was found that the driver’s deceleration speed when recognizing traffic signs or signals on the road is about 2.5 to 3.5 m/s^2. In this study, the behavior of vehicles driving in the simulation network reflects the deceleration values based on these existing literature reviews. When setting the range of deceleration values for the vehicle driver after receiving the right-turn information, the minimum and maximum values were set to 2.5 m/s^2 and 3.5 m/s^2, respectively, to run the simulation.

DATA and RESEARCH TOOLS

The video data utilized in this study was collected from real-time CCTV images provided by the Busan Smart Intersection Traffic Management System site (https://its.busan.go.kr/sint.do) in Busan, Republic of Korea. The data was collected at the Daeyeon intersection in Nam-gu. In addition, the video data was collected from two directions of the four directions of the intersection at the same time, not just one section of the intersection, but the connected roads, in order to consider all the factors (crosswalks, sidewalks, driveways) that can affect a single right-turn section (Figure 1). The signal cycle in the video was reflected by collecting and comparing the actual data by checking the real-time video data with the current data of the National Police Agency.

Figure 1. Video Data Screen (Daeyeon Intersection)



1. YOLO (You Only Look Once)

YOLO stands for "You Only Look Once" and is an object detection algorithm and framework that stands out among various object detection algorithms for its ability to quickly and reliably identify objects in images with an excellent balance of speed and accuracy. It was first published by Joseph Redmon et al. (2016) and has gone through several version updates. It is characterized by its ability to complete the detection task in a single pass through the network, as opposed to previous approaches that split the task into two phases, either using a sliding window with a classifier that requires hundreds or thousands of runs per image, or using an advanced method that detects the region where the object or region is located in the first phase and runs the classifier in the second phase.

YOLOv8 is the most recent YOLO model released by Ultralytics, the company that developed YOLOv5, and supports multiple vision tasks such as object detection, segmentation, pose estimation, tracking, and classification. Its design of handling objectivity, classification, and regression tasks independently allows it to focus on each of these tasks and improves the overall accuracy of the model.

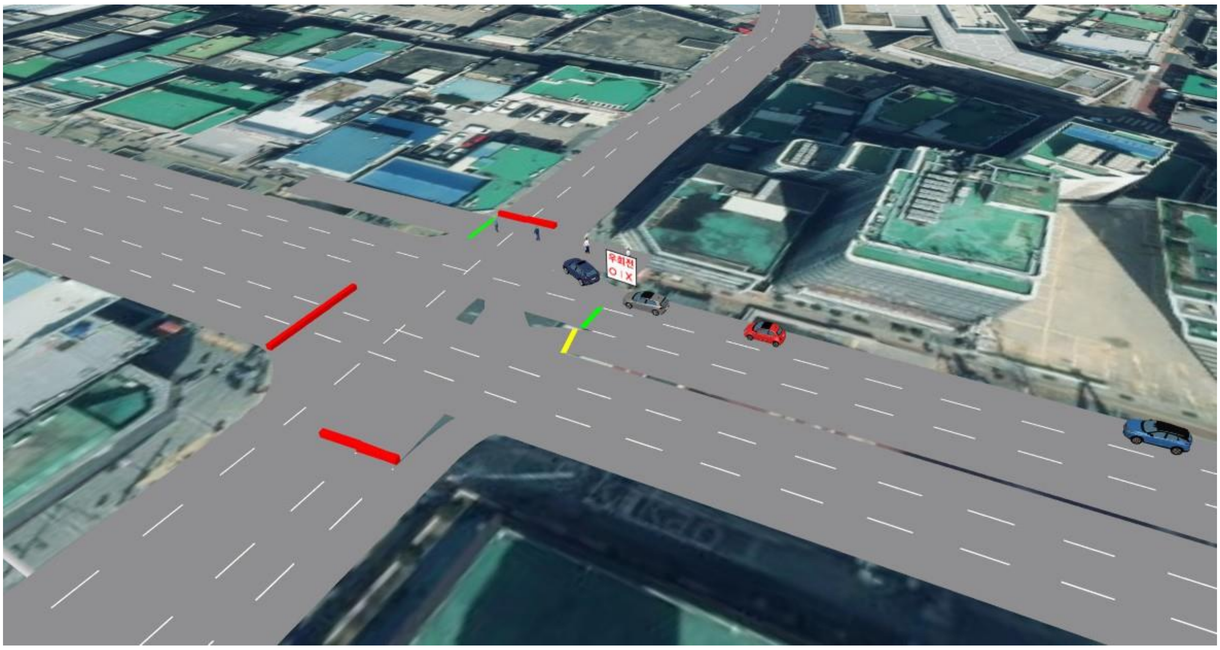
For the collected video data in this study, the video was divided into 30 frames per second, and autolabeling was performed using Ultralytics' autodistill. From the various detection models, YOLOv8 was selected because it performed well in terms of map and latency. YOLOv8's detector and BOT SORT Tracker were used to track the ID to understand the subsequent behavior of the object.

2. VISSIM

VISSIM is a microscopic traffic simulation software developed by the PTV Group in Germany that is used to analyze and evaluate traffic flow by simulating the movement of individual vehicles to set up various traffic scenarios. It is characterized by precise traffic modeling by monitoring the position, speed, and acceleration of each vehicle on an hourly basis. Users can also set up a detailed traffic environment, including intersections, traffic lights, road signs, lane change rules, and more, which allows them to create conditions similar to real-world traffic situations, increasing the realism of the simulation. In this way, VISSIM allows you to more realistically reproduce complex urban traffic environments, simulating different traffic situations and statistically analyzing the results to evaluate traffic efficiency. Ultimately, VISSIM is an important tool for solving transportation problems and designing efficient transportation systems in various fields such as urban planning, traffic operations, engineering design, and policy evaluation.

In this study, VISSIM was used to build a realistic Daeyeon intersection network identical to the one in the video, and the signals were input by identifying the current signals, also as in the video. The built network is shown in Figure 2 below. The traffic volume was collected using the View T program provided by the Korea Transportation Research Institute. View T is a platform that provides basic traffic database and analysis functions in Korea, and traffic data was collected and reflected using this platform. Due to the limitations of the detector, data on the observed traffic volume for all links was not available. Therefore, the estimated traffic volume calculated within the platform was used. To reflect the established network, vehicles were set to slow down when they recognized the right-turn information device, with the range of slowing down set as 3.0 m/s^2~ 3.5 m/s^2 based on the literature reviewed above. A crosswalk was implemented to specify the yield ranking between pedestrians and right-turning vehicles, and the simulation experiment time was set to 3600 seconds.

Figure 2. VISSIM network



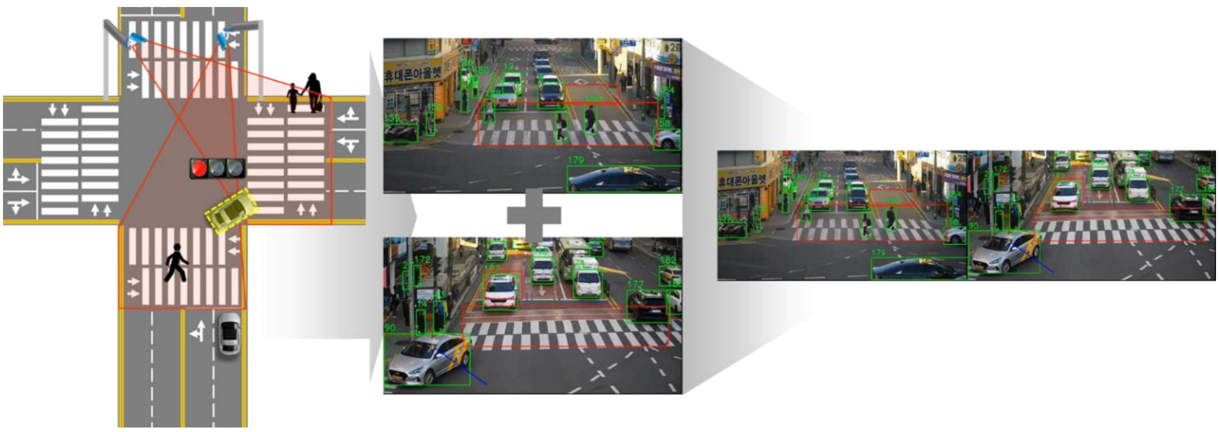
RESULTS

1. Development of right-turn information and enforcement system algorithms

The algorithm was developed to detect vehicles traveling in the straight lane and entering the intersection area to check whether the vehicle was making an illegal right turn. It consisted of three parts: (1) vehicle and pedestrian detection, (2) illegal right-turning vehicle detection, and (3) vehicle information collection for illegal right-turning vehicle enforcement. Before developing the algorithm, the right-turn cases were defined according to the aforementioned revised law. There are two main types of right-turn cases, as follows: (1) when the traffic signal is red, the driver stops and turns right when there is no pedestrian traffic and no pedestrian is attempting to pass; (2) when the traffic signal is green, the driver stops and turns right when there is no pedestrian traffic and no pedestrian is attempting to pass. The algorithm was designed based on these cases, defined in conjunction with the traffic signal.

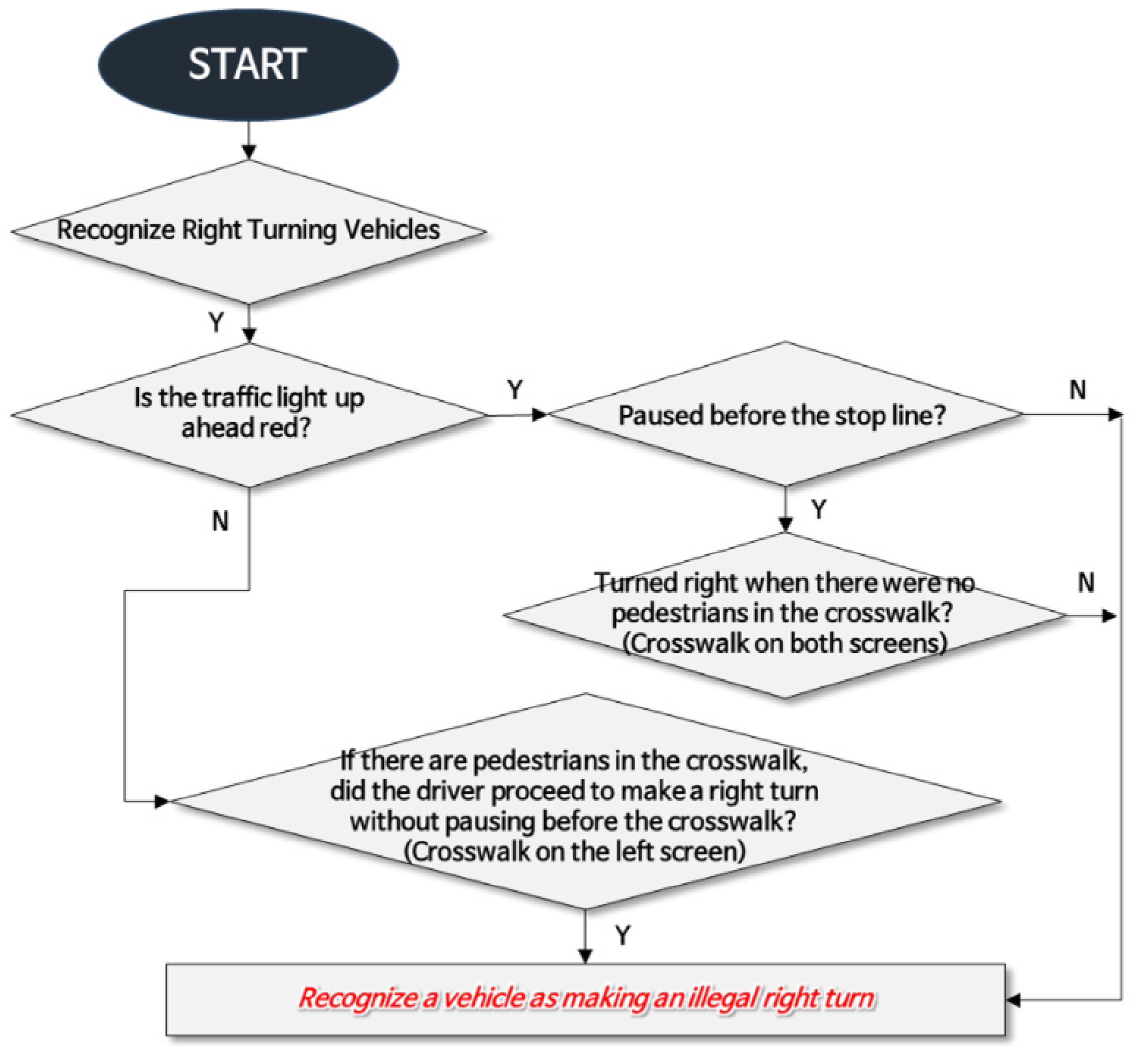
First, the vertical road of the intersection is the road currently traveling before the expected right-turning vehicle turns right. The horizontal road is the road the expected right-turning vehicle will travel after turning right, perpendicular to the longitudinal road, and is marked with a crosswalk and a stop line. The stop line is a line that indicates where the vehicle traveling on the road should stop in front of the crosswalk, according to the stop sign. As shown in Figure 3, CCTV images in vertical and horizontal directions were collected, respectively, and the vertical image was set in a single frame by placing the vertical image on the right and the horizontal image on the left in a row. Accordingly, when the front vehicle signal of the driving lane (right turn) on the right screen was red, the video information first determined whether the vehicle paused at the stop line of the crosswalk marked on the driving lane, and then determined whether the vehicle turned right into the right-turn lane when no pedestrians were crossing the crosswalk. When the traffic signal ahead of the vehicle in the driving lane was not red, the video information on the left screen recognized the pedestrian crossing the marked crosswalk and determined whether the vehicle paused until there were no pedestrians crossing the crosswalk, and proceeded to make a right turn.

Figure 3. CCTV video frames from multiple angles within an intersection



The algorithm's detection of vehicles or pedestrians within a certain area utilizes the concept of a bounding box, which represents an object as a rectangle using the x- and y-axes. The enforcement method for pausing according to the red signal of the vehicle ahead calculates the center point of the bounding box of the right-turning vehicle in the right-turn lane, and determines whether the point crosses the stop line to detect whether the vehicle has paused. In addition, the detection of illegal right turns first sets a right-turn baseline in the section where the vehicle makes a right turn between the crosswalk on the right screen and the crosswalk on the left screen. Then, it checks whether there are pedestrians at all crosswalks, and if the center point of the vehicle moves above a certain threshold in the presence of pedestrians, it is considered an illegal right turn and detected. In addition, GO and STOP are displayed on the top left of the screen to indicate whether a right-turning vehicle can make a right turn, depending on traffic conditions. If the system determines that the vehicle can turn right, it displays GO. If there are pedestrians in the crosswalk or the traffic light is red, it displays STOP. The logic of the described algorithm is shown in Figure 4 below.

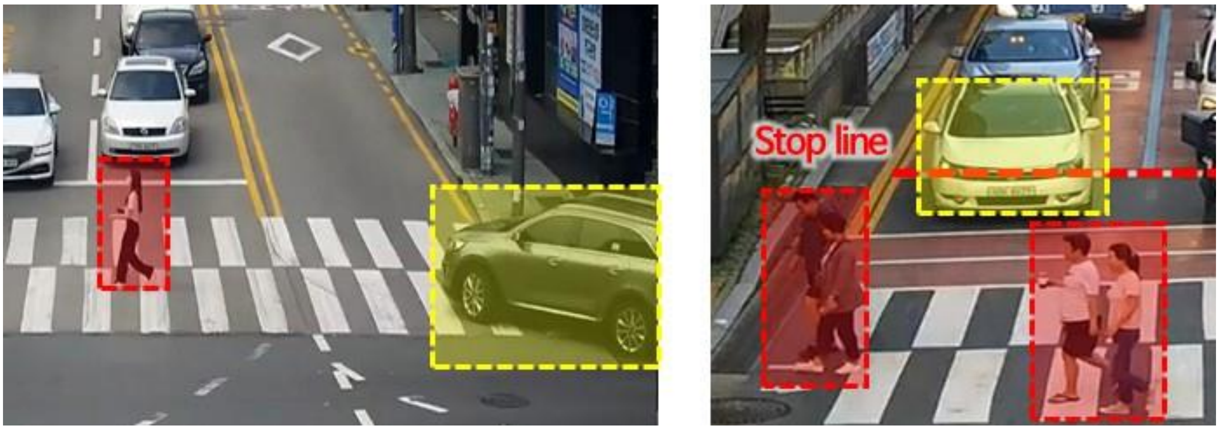
Figure 4. Logic of Illegal Right-Turn Detection Algorithm



In this research, each crosswalk and right-turn lane ROI (Region of Interest) in the algorithm is created by clicking the desired point on the screen (top left, bottom right) for the X, Y coordinates directly when the system is executed. The right-turn reference line is also designed by the executor directly by clicking both endpoints. This has the advantage of being universal in that it can be utilized in the CCTV screens of other intersections rather than being limited to the intersection where the algorithm was developed in this study. In addition, the bounding box frames of the vehicles that were finally detected as violating the stop line and making illegal right turns were transferred to a folder in the system to save the vehicle's information.

As a result of the algorithm development, the algorithm detected illegal right-turning vehicles in the collected video with high accuracy. Figure 5 below shows an example of detected illegal vehicles. In the case of the left image, the vehicle made an illegal right turn despite pedestrians remaining in the crosswalk, and in the case of the right image, the signal in front of the vehicle is red, and the vehicle crossed the stop line even though pedestrians were walking in the crosswalk. The algorithm developed to detect illegal right turns using real-time video showed high performance.

Figure 5. Examples of Illegal Right-Turn Detection



Illegally Driving Vehicle Example (1) **Illegally Driving Vehicle Example (2)**

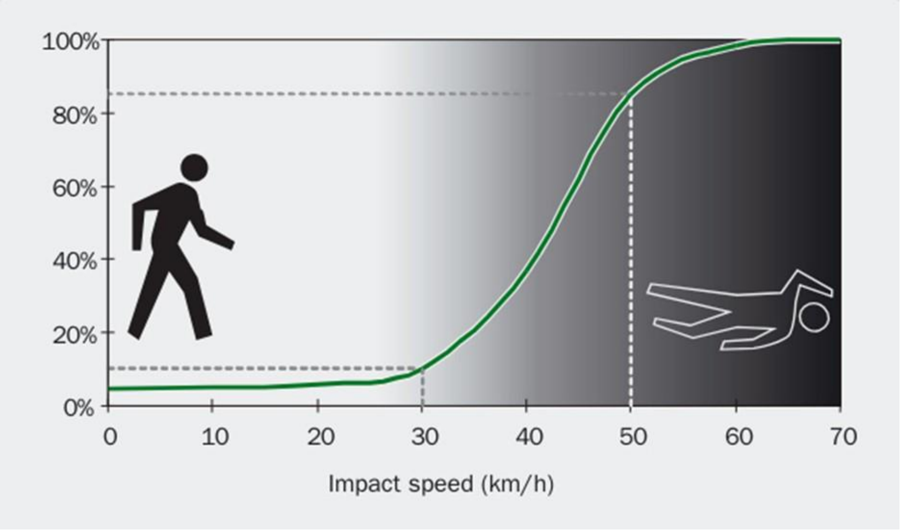
2. Analysis of safety and mobility with VISSIM

VISSIM can perform simulations with the built network and scenarios, and calculate various mobility-related metrics from the results. In this study, the average driving speed (km/h) and average deceleration (m/s^2) were selected as mobility-related indicators.

SSAM (Surrogate Safety Assessment Model) is a conflict analysis program developed by FHWA in the U.S. It analyzes the occurrence of conflicts between vehicles using road geometry and vehicle path data produced by simulation models such as VISSIM. The *.trj file for SSAM analysis is created through the export command in the evaluation menu of the VISSIM program, and the *.inp file is used to create the road geometry. The indicators used by the SSAM program to determine whether a collision between vehicles occurs through the road geometry and each vehicle's path data are called surrogate measures.

According to the World Health Organization's Speed Management Manual (2008), the higher the speed, the greater the risk of an impact, and the more serious the crash. In a collision between a vehicle traveling at 50 km/h and a pedestrian, 5 out of 10 pedestrians are killed, but at 30 km/h, only 1 out of 10 pedestrians are killed (The Love 30 Campaign, 2023). As Figure 6 below shows, the probability of a pedestrian being injured is significantly lower at 30 km/h than at 50 km/h. It was therefore decided to select and analyze TTC (Time to collision), PET (Post Encroachment Time), and DeltaS as safety evaluation indicators, each of which measure a dimension of speed. In addition, many studies using VISSIM have utilized TTC, PET, and DeltaS as evaluation measures (Gettman and Head, 2003, Jung et al. 2015, Yun et al. 2011). Each measure is explained below.

Figure 6. Probability of fatal injury for a pedestrian colliding with a vehicle (WHO, 2008)



1) Time to Collision (TTC)

TTC is the time before a collision occurs if the current speed and path are maintained, and is derived by the gap and speed difference between the lead vehicle and the target vehicle at a specific point in time. The lower the TTC value, the higher the probability of a collision. The formula is as follows:

$$TTC= \frac{(x\_s\ (t)-\ x\_f\ (t)-\ l\_s)}{(v\_s\ (t)-\ v\_f\ (t))} \qquad (1)$$

x_s : Position of the lead vehicle
x_f : Position of the target vehicle
v_s : Speed of the lead vehicle
v_f : Speed of the target vehicle
l_s : Vehicle length

2) PET (Post Encroachment Time)

PET is the difference between the time when the first vehicle occupies a point on the road and the time when the second vehicle arrives at the same point in succession. Accordingly, if the value of PET is zero, a collision between vehicles has occurred. A higher PET value indicates a lower probability of a collision.

3) DeltaS

DeltaS is the amount of speed difference between the two vehicles at the simulation time when the minimum value of TTC is observed in a conflict situation, where TTC is below the threshold value. For example, if two vehicles traveling in the same direction have the same speed, the value of DeltaS is 0. If the two vehicles are traveling at right angles, DeltaS =√2v. This means that the higher the DeltaS value, the more severe the collision. The detailed formula is as follows:

$$Delta\ S= \ \| v\_s\text{-}v\_f \| \qquad (2)$$

v_s : Speed of the target vehicle
v_f : Speed of the lead vehicle

Using these indicators, a network was built and the effect of installing right turn information devices on mobility and safety was analyzed. The detailed results are shown in Table 1. First, the average driving speed in the right-turn lane was checked for mobility, and the average driving speed in the right-turn entry lane was about 41.68 km/h without the guidance device, but 33.22 km/h with the device, showing that the vehicle's driving speed decreased when the information was provided through the device. In addition, the average deceleration was larger (-1.23 m/s^2) when the information was provided at the stop line in front of a pedestrian crosswalk in the turning section than when it was not provided. The safety analysis using SSAM also showed that the TTC value increased from 2.41 to 3.17, and the PET value increased from 2.6 to 3.17. Similarly, DeltaS values decreased with right-turn information.

Table 1. Results of evaluating the effectiveness of installing right turn information devices

	Evaluation indicator	No right-turn information	With right-turn information
	Average travel speed (main road) (km/h)	41.68	33.22
Mobility	Average deceleration (intersection approach) (m/s^2)	-0.83	-1.23
	TTC (s)	2.41	3.17
Safety	PET (s)	2.62	2.92
	DeltaS (km/h)	9.9	5.34

CONCLUSIONS

The purpose of this study was to design a system to detect illegal right turns of vehicles based on the revised right-turn law, and to reduce the frequency and severity of pedestrian crashes at intersections by guiding proper right turns. For this purpose, a system algorithm was developed to determine whether a right turn was possible and to detect illegal right-turning vehicles using multi-angle intersection CCTV images and a YOLO (You Only Look Once) algorithm. In addition, VISSIM, a microscopic traffic simulation, was used to analyze the effect of installing a right-turn information device from the perspective of the overall traffic flow.

The before-and-after comparison showed that vehicle speeds at the intersection decreased by nearly 10 km/h (from approximately 42 km/h to 33 km/h) when the right-turn information device was installed. In addition, pedestrians in the intersection slowed down more when the device was detected than when it was not. The results of this study also suggest that the installation of right-turn notification devices reduced vehicle travel speeds by approximately 10 km/h, which contributed to a reduction in the risk of collisions at intersections and improved safety.

In addition, the TTC value, which is the time before a collision occurs, increased from 2.41 seconds to 3.17 seconds after the device was installed, indicating a decrease in the probability of a collision. The PET value also increased from 2.6 to 3.17, indicating that the likelihood of a collision between vehicles was reduced. In addition, the DeltaS value decreased, indicating that the speed difference at the time of the collision decreased, and thus the severity of the collision decreased. In conclusion, it appears that the installation of the right-turn information device was effective in reducing the likelihood and severity of collisions by changing the driving patterns of vehicle drivers in the intersection. These results suggest that the system can improve the operability of the intersection by providing drivers with appropriate right-turn information, and ultimately contribute to improving traffic safety at urban intersections.

This research shows that traffic crashes can be reduced, and pedestrian safety enhanced, by detecting illegal right-turning vehicles at intersections in real time and providing appropriate driving information accordingly. In future research, it is necessary to validate the system through empirical experiments in various environments and use the results to build a more sophisticated and efficient traffic management system.

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Beyond the Lens: A Critical Review of Speed Camera Performance in the Islamic Republic of Iran

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ABSTRACT

Speeding is a significant risk factor in road safety, and speed cameras are proven deterrents. However, in Iran, officials focus on increasing the number of speed cameras rather than evaluating their deterrence effects. This study examines the detection and ticketing efficiency of speed cameras in Iran using three months of traffic data and speed violation records from three principal arterials across two provinces. Key findings include: the likelihood of being caught is crucial for deterring speeding, but low activation rates and inconsistent performance of speed cameras reduce this perception. Speed cameras often fail to accurately record traffic volumes and violations, lowering the perceived risk of being caught. Drivers exhibit the “kangaroo effect,” slowing near cameras and speeding afterward, indicating fixed cameras may not deter speeding over longer distances. Delays in penalizing detected violations further reduce the certainty of punishment and consequently the deterrent effect, with many violations not resulting in fines. The rate of penalization based on average speed is even lower, diminishing the overall effectiveness of speed cameras. Recommendations are proposed to enhance speed enforcement efficiency, potentially benefiting other nations as well.

INTRODUCTION

The World Health Organization (WHO) has identified speeding as a major risk factor in road safety (WHO, 2013). The speed of a vehicle not only affects the probability of a crash occurring but also significantly impacts the severity of injuries and the likelihood of fatalities resulting from such incidents (WHO, 2023). Higher speeds result in a significant increase in the kinetic energy released during a collision, which escalates with the square of the speed. This means that both the impact force and the changes in speed experienced by those involved in the crash are greater at higher speeds (ITF, 2018). Additionally, the risk of a crash increases with speed because drivers have less time to react to changes in their environment and reduced maneuverability. At higher speeds, the distance covered during the reaction time is longer, which diminishes the chances of avoiding a crash (ITF, 2018).

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The relationship between speed and crash risk, as well as the severity of crash outcomes, has traditionally been empirically validated using the power model (Nilsson, 2004). Recent empirical research indicates that despite many advances in the industry (e.g., automobile technologies), speed still continues to be a significant risk factor for both accident occurrence and injury severity. In fact, it seems to have become even more critical than before, with no evidence suggesting that the relationship between speed and road safety is weakening (Elvik et al., 2019).

Empirical estimates suggest that speed reductions most significantly impact road fatalities, with a slightly smaller effect on serious injuries and an even lesser effect on minor injuries (SWOV, 2021). Reducing the number of speeding violations can save many lives and prevent numerous severe injuries. However, managing excessive and inappropriate speed does not have any single solution, requiring a multifaceted approach, including police enforcement to enhance the effectiveness of each measure (European Commission, 2018). Police enforcement is typically the final step, targeting drivers who still exceed speed limits intentionally after all other measures have been taken (Wegman and Aarts, 2006).

Traditional speed enforcement methods, like physical policing, involve stopping drivers at the roadside. These methods are often criticized for being selective, inconsistent, costly, ineffective, and labor-intensive, making it difficult to achieve the same level of enforcement as speed cameras. Consequently, the actual risk of being caught is much lower than the perceived risk (European Commission 2018). Automatic speed cameras, on the other hand, detect speed offenders continuously and send fines or notifications by mail. They can be used full-time at fixed locations or rotated among different locations, sometimes swapped with dummy cameras. Evidence indicates that automatic speed enforcement is effective and cost-efficient in reducing traffic-related injuries (Morain, Gielen, and Bhalla, 2016). This approach is favored by road safety policymakers and practitioners as a promising strategy to overcome the limitations of traditional methods.

Effectiveness of speed cameras

Despite numerous systematic reviews evaluating the effectiveness of speed cameras in reducing road traffic crashes, casualties, and speeding, the task is challenging due to methodological issues (Wilson et al. 2010), such as the difficulty in conducting randomized controlled trials (RCTs), not accounting for regression to the mean in many studies, control for long-term trends in crash rates and changes in traffic volumes in few studies, and overlooking important factors like traffic or crash migration to non-enforced routes.

Despite these challenges, systematic reviews, which consider the safety benefits of both mobile and fixed speed camera enforcement, have consistently found that speed cameras effectively reduce road traffic collisions and related casualties (Fisa et al. 2022). For instance, Pilkington and Kinra's review of 14 observational studies (2005) revealed that all but one study demonstrated the effectiveness of speed cameras within three years of their introduction, with one study showing sustained effects for up to 4.6 years. The reductions in collisions ranged from 5% to 69%, injuries from 12% to 65%, and deaths from 17% to 71% near camera sites. Similar reductions were observed over broader geographical areas, although the authors noted the relatively poor level of evidence, as most studies lacked satisfactory comparison groups or adequate control for potential confounders.

Wilson et al. (2010) reviewed more recent studies than Pilkington and Kinra's, conducted with greater methodological rigor, showing that speed cameras consistently reduce speed and crashes, making them effective for reducing road traffic injuries and deaths. They reviewed 35 studies meeting pre-set criteria. All studies reported reductions in average speeds after intervention with speed cameras. Speed reductions were reported as decreases in the percentage of speeding vehicles, reductions over various speed limits, or reductions in top-end speeders. The reduction in speeding vehicles ranged from 8% to 70%, with most countries reporting 10% to 35%. Twenty-eight studies measured crash effects, all finding fewer crashes in speed camera areas post-implementation. Reductions ranged from 8% to 49% for all crashes, with most studies reporting 14% to 25%. For injury crashes, decreases ranged from 8% to 50%, and for fatal or serious injury crashes, reductions were 11% to 44%. Wider area effects showed crash reductions from 9% to 35%, with most studies reporting 11% to 27%. For fatal or serious injury crashes, reductions ranged from 17% to 58%, with most studies reporting 30% to 40%. Longer-duration studies showed these positive trends were maintained or improved over time.

Recent studies align with literature reviews from 2005 to 2010, confirming that speed cameras effectively reduce speeds, crash frequency, and crash severity. For instance, (Moore-Ritchie et al., 2023) reviewed 13 rigorous Safe Speed Camera (SSC) studies and four literature reviews, all of which reported reductions in mean, threshold, and/or 85th percentile speeds. Among the eight SSC studies and six literature reviews that analyzed multi-year crash data before and after SSC implementation, all observed decreases in fatal and severe crashes. No studies reported an increase in crash rates or other negative safety impacts.

Point-to-point speed cameras are increasingly popular in highly motorized countries, especially in the UK and Europe. These systems use multiple camera sites along a road to capture vehicle images and registration data, calculating average speeds with automatic number plate recognition (ANPR) technology. If a vehicle's average speed exceeds the legal limit, offence data is sent for human verification. This approach promotes speed reductions over larger road sections compared to instantaneous speed cameras, which have localized effects. Point-to-point systems make it difficult to avoid punishment and focus on persistent speeding. Research suggests these systems effectively reduce vehicle speeds, particularly high-range speeding, and decrease speed variability. They also positively impact fatal and serious injury crash rates, and offer benefits like homogenized traffic flows and reduced fuel consumption and emissions (Soole, Fleiter, and Watson, 2013).

Deterrence effects of automated speed enforcement

Using speed cameras for automated speed enforcement involves actively deterring or detecting traffic law violations, apprehending offenders, and securing evidence for prosecution. While speed cameras are effective in ensuring compliance with road safety rules, they are not sufficient on their own. Effective enforcement requires a broader context, including a supportive framework of laws, regulations, and a responsive penal system (European Commission, 2018). Therefore, speed cameras should not be viewed in isolation but should encompass the entire process, including the critical steps of detection of violations, apprehension of offenders, evidence collection, notification of offenders, imposition of penalties, and follow-up and enforcement.

Penalties and their enforcement in traffic law are grounded in the principles of deterrence theory (Gibbs 1979). This theory suggests that people are less likely to commit offenses if they believe there is a high likelihood of being caught and if they fear the consequences of their actions. The effectiveness of this deterrence is influenced by how certain, severe, and swift the punishment is perceived to be. In other words, higher overall preventative effects of police surveillance are generally linked to a higher perceived risk of offenders being caught, more severe penalties, increased certainty of punishment, and quicker imposition of penalties, with each of these elements forming a crucial link in the enforcement chain (Wegman, 2001; Sakashita et al., 2021).

The key factor in the enforcement chain is the perceived likelihood of being caught. If road users believe their chances of being caught are low, the severity, certainty, and speed of punishment will have little impact on preventing traffic violations (Wegman, 2001). The perceived likelihood of being caught can be assumed to be closely related to several factors associated with the operation of fixed speed cameras, which interact as follows:

- Camera Activation Rate: If speed cameras are operational most of the time (high activation rate), drivers are more likely to believe they will be caught if they speed.
- Precision of Detecting Vehicles and Recording Speed Violations: High precision in vehicle detection and recording speed violations increase the perceived risk of being caught and their chance of adhering to speed limits.
- Threshold Speeds for Enforcement: Higher threshold speeds (e.g., allowing a tolerance over the limit) can reduce the perceived risk of being caught for minor speeding.

In addition to the perceived risk of being caught, the deterrent effect of speed cameras is also influenced by the certainty, severity, and swiftness of punishment. If the ticketing rate is low (few tickets issued relative to violations detected), drivers might perceive a lower certainty of being penalized, even if they are caught speeding. High ticketing performance, where most detected violations result in tickets, reinforces the deterrent effect. Punishment severity and swiftness can also enhance the deterrence effects by increasing the perceived consequences of violations. Severe penalties can act as a strong deterrent by making the cost of violations high, while swift punishment ensures that the consequences are immediate, reinforcing the connection between the violation and the penalty.

Research aims and contribution

In the Islamic Republic of Iran, road safety officials are keen to increase the number of fixed speed camera installations without adequately assessing the efficiency of the existing systems. For instance, fixed speed camera installations have increased by 62% since 2018. Additionally, they have ambitious plans to further expand the number of fixed speed cameras across the road network by 2,000 additional units in the near future, which will require substantial budget allocations. Traffic police officials generally believe that fixed speed cameras should replace manned personnel on rural highways due to the significant workload on police officers and the variety of traffic violations that need enforcement. Consequently, the traffic police have been actively lobbying the National Road Safety Commission (the national road safety lead agency) to increase the number of fixed speed cameras.

However, there has been widespread criticism regarding the efficiency of the current fixed speed cameras, with operations often conducted without considering the entire traffic law enforcement chain. This has led to concerns that the performance efficiency of speed cameras is far from optimal, resulting in low levels of perceived likelihood of being caught and consequently a weak deterrent effect. The present study is among the first that examines the factors influencing the general deterrence of speed cameras by evaluating their activation rate, precision in detecting vehicles, accuracy in recording speed violations, public disclosure of threshold speeds, and police ticketing performance.

DATA

The analysis conducted in this study is part of a speed management project (2019 - 2022). The aim of the project was to explore how Iran was addressing speed-related road trauma and to provide recommendations for improving these practices, aligning with the Safe System Approach to enhance road safety strategy, speed limit guidelines, and educational and enforcement frameworks (Mooren et al., 2021). Six principal arterials across three provinces were selected as the pilot corridors (Ranjbar et al., 2022)[1]. This study presents the results of the speed camera analysis for three of these arterials including a freeway segment.

Traffic volume and speed data were obtained from the National Road Information and Traffic Management Center (RITMC), which serves as a focal point for exchanging road information with stakeholders, travelers, mass media, and other parties (Torfehnejad, 2010). The traffic data in this study were analyzed for the months of December 2021, January 2022, and February 2022. It is important to note that, according to the Iranian calendar, the year starts in March. Hence, the months of December, January, and February are considered normal months during which traffic patterns are typically consistent and not influenced by the fluctuations that occur at the end or beginning of the year.

Part of the data in this study comes from the fixed speed cameras used for enforcing speeding violations across the rural road network, and partly from the inductive loop sensors (ILS) that have been in place across the rural road network for traffic counting (Figure 1). Both systems are managed and maintained by the RITMC.

Figure 1. Photos of typical fixed speed cameras (left) and traffic counting indultive loop sensors (right) in Iran

The procedure for automated speed violation enforcement involves fixed speed cameras capturing information on all vehicles, including their speed and license plate numbers, regardless of whether they are violating the speed limits. Hence, the traffic volume data are also captured by the fixed speed cameras. Additionally, high-resolution images of the vehicles are captured. This information is automatically shared with the police server for control and enforcement. High-resolution images are reviewed by human officers to confirm the violation. This is usually done by comparing the vehicle's details, including brand, model, and color, to the registration database of the traffic police. The traffic police typically apply a tolerance of 10 km/h over the speed limit, mainly to account for minor speedometer inaccuracies, variations in road conditions, and other factors.

Besides the speed cameras, information on individual vehicles registered by the ILS sensors is also preserved by the RITMC. This includes the category of the vehicle, speed, and time of each vehicle passing over the sensor. This provides a valuable source of information for measuring the traffic volume and speeding rate over a period of time, although, unlike the speed cameras, the sensors are not capable of obtaining the identity (license plate number) of the vehicles. We also obtained the number of monthly citations issued by each speed camera from the traffic police.

[1] The ARA (Iranian Highway Geometric Design Code) is based on the AASHTO Green Book (2018). The Green Book classifies rural roads as principal arterials, minor arterials, major and minor collectors, and local roads. Freeways, designed for high-speed, high-volume traffic with full access control, are not a separate functional class but are typically classified as principal arterials with unique geometric criteria. According to the Iranian code, principal arterials are part of the national road network, connecting provincial centers and major cities. They are similar to freeways but allow for at-grade intersections with partial access control. Freeways, considered a type of principal arterial, have at least two lanes in each direction and full access control, prohibiting at-grade access to ensure uninterrupted flow.

METHODS

To assess the operational activity levels of speed cameras, we measured the monthly operational activity rate for each camera for the months of December 2021, January 2022, and February 2022. This was calculated by dividing the total number of days each camera was active, by the total number of days in the month.

To analyze the precision of speed cameras, we collected average daily traffic volume data from various cameras for each month. We assessed the consistency of these recordings by examining the range of daily traffic volumes captured by each camera within the same month. The standard deviation of daily volumes was calculated to measure the precision of traffic counting. Additionally, we computed the coefficient of variation (the ratio of standard deviation to the average) for each camera over different months to evaluate the stability of the cameras' performance.

To verify the accuracy of speed cameras in traffic counting, their performance was compared with real or near-real traffic volumes using data from ILS traffic counters. The positions of the speed cameras were matched with those of the ILS sensors, and traffic data from ILS sensors located between the speed cameras were extracted. The number of unique license plates detected by consecutive cameras was used to calculate the matching percentage between the traffic volumes recorded by the cameras and the ILS sensors. Although the ILS method does not capture license plates, significant discrepancies between the volumes recorded by the two methods can indicate the accuracy and reliability of the speed cameras in traffic counting.

Additionally, because the cameras can read vehicle license plates, the average speed of each vehicle can be calculated by matching the license plates captured by two successive fixed speed cameras and dividing the distance between the cameras by the travel time of each vehicle. This method allows the average speed violations for individual vehicles to be determined. It also enables the measurement of the monthly percentage of average speed violations in the area between consecutive cameras and a comparison of the speeding violation rate at the camera sites.

To evaluate drivers' awareness of the 10 km/h tolerance levels, we analyzed speeding violation rates at different speed limits. The main idea was to determine how the violation rate would change if the speed limit were hypothetically set 10 km/h higher than the speed limit, at the speed limit, and 10 km/h lower than the speed limit. Additionally, we measured the average speed violation rates assuming 10 km/h above and below the speed limit, as well as at the speed limit, in the span between successive cameras.

To analyze the ticketing performance of speed cameras, we collected data on the number of speeding violations detected and the number of tickets issued by specific cameras. We calculated the monthly ticketing rate by dividing the number of tickets issued by traffic police by the number of detected violations (considering the threshold speed). Additionally, we considered average speed violations, where the camera enforced speed limits based on the span between consecutive cameras, to provide a comprehensive view of the ticketing performance.

RESULTS

Speed Camera Operational Activity Levels

Investigations show that some speed cameras have remained out of service for long periods. For example, Table 1 shows that the activity level of successive speed cameras on the Isfahan-Dilijan Highway was low during the three months of December 2021, January 2022, and February 2022.

Table 1. Operational activity rate for the speed cameras on Isfahan-Dilijan Highway

Month	Camera ID	ACTIVITY	
		Active days	Operational activity rate %
Dec 2021	25213121	21	70.0
Jan 2022		8	26.7
Feb 2022		19	63.3
Dec 2021	25213122	30	100.0
Jan 2022		22	73.3
Feb 2022		29	96.7
Dec 2021	15213159	0	0.0
Jan 2022		0	0.0
Feb 2022		0	0.0
Dec 2021	15213110	0	0.0
Jan 2022		0	0.0
Feb 2022		0	0.0
Dec 2021	25213123	30	100.0
Jan 2022		10	33.3
Feb 2022		0	0.0
Dec 2021	15213111	0	0.0
Jan 2022		0	0.0
Feb 2022		0	0.0
Dec 2021	25513557	30	100.0
Jan 2022		22	73.3
Feb 2022		30	100.0

Precision of Recording Traffic Volume by Speed Cameras

Table 2 presents monthly average daily traffic volume and the statistical precision of recordings through speed cameras on the Saveh-Tehran freeway. According to this table, the average daily traffic volume varies significantly across different segments of the freeway (captured by different cameras), ranging from approximately 5,200 vehicles per day captured by camera #25513669 in December 2021 to about 14,500 vehicles per day by camera #25513616 in February 2022.

However, observations indicate that the daily traffic volumes in the same location (the same camera) are not recorded with consistent precision. There is a considerable difference between the lowest and highest daily traffic volumes recorded within the same month and location. For instance, in December 2021, the daily traffic volume of camera #25513669 ranged from 920 vehicles (similar to the daily traffic volume on a rural minor road) to a maximum of 8,250 vehicles (it should be noted that verifying the volume values registered by the cameras is not the focus of this section; such analyses will be presented later). This large range suggests low precision in volume registration. Despite using the same tool to count traffic, the daily volume values vary so much that these differences cannot be attributed to typical weekly or monthly variations in daily traffic volume.

The standard deviation of daily volumes observed within a month indicates the precision of the tool in counting daily volumes. This measure varies for different cameras, ranging from about 15% of the daily average traffic (for camera #25513669 in February 2022) to more than 50% of the daily average traffic (for camera #25513665 in February 2022). Further investigations reveal that the coefficient of variation (the ratio of standard deviation to the average) for a specific camera also fluctuates over time, indicating the instability in the camera's performance in capturing consistent traffic data. For example, the coefficient of variation for camera #25513669 in December 2021, January 2022, and February 2022 is 33.6%, 16.9%, and 15.4%, respectively.

Verification of Traffic Volumes Observed by Speed Cameras

Table 3 compares the performance of vehicle traffic counted by speed cameras and ILS sensors on the Saveh-Tehran freeway. The table reveals a significant lack of agreement between the traffic counts from the cameras and the inductive loops, with matching percentages ranging from about 10% between cameras #25513616 and #25513665 in December 2021, to a maximum of only 31% between cameras #25513669 and 25513668 in February 2022. These results highlight the underreporting of traffic data by speed cameras compared to ILS sensors, suggesting that a significant volume of traffic, including vehicles driven by speed offenders, may not be recorded by the speed cameras, allowing these drivers to evade enforcement.

There might be a notion that the lower traffic volumes captured by the cameras compared to the ILS sensors are due to the presence of exit ramps between the cameras, where some vehicles might leave the main road. However, the large discrepancy between the volumes recorded by the two methods makes this explanation unlikely, as it is implausible that about 80% of the traffic would exit the freeway.

Nonetheless, it is also possible to compare the volumes in cases where ILS sensors are located very close to the speed cameras to further verify the traffic volumes observed by the speed cameras. Investigations revealed that inductive loop traffic counters are located very close to camera #25513163 on the Salafchagan-Arak Highway. Table 4 compares the counting performance of the speed camera and the ILS sensors. Similar to the Saveh-Tehran Freeway, there is a significant difference between the two methods in vehicle counting. The agreement between the methods varies from 21% in December 2021 to 67% in January 2022, despite the proximity of the speed control camera to the ILS sensor. This confirms the hypothesis of underreporting traffic volume by the speed cameras.

Table 2. Daily Traffic Volume and Recording Precision by Speed Cameras on the Saveh-Tehran Freeway

	Camera ID	#25513669	#25513668	#25513616	#25513665	#25513614
DECEMBER 2021	Operational days in a month	30	30	30	30	30
	Average daily volume	5,182.47	6,447.87	10,057.32	5,478.57	8,406.35
	Minimum daily volume	923	3,356	4,711	378	2,674
	Maximum daily volume	8,256	9,624	15,212	9,144	13,126
	Standard deviation (SD)	1,742.53	1,771.43	3,332.33	2,212.13	3,181.40
	Standard error (SE)	318.14	323.42	608.40	403.88	580.84
	Coefficient of variation (CV)	0.336	0.275	0.331	0.404	0.378
JANUARY 2022	Operational days in a month	30	30	30	30	30
	Average daily volume	8,485.96	8,127.10	11,473.77	5,402.46	10,716.86
	Minimum daily volume	4,672	3,768	6,061	1,655	5,059
	Maximum daily volume	11,097	11,589	19,641	8,959	18,059
	Standard deviation (SD)	1,434.01	2,037.52	3,584.81	1,587.40	3,228.08
	Standard error (SE)	261.81	372.00	654.50	289.82	589.36
	Coefficient of variation (CV)	0.169	0.251	0.312	0.294	0.301
FEBRUARY 2022	Operational days in a month	30	30	30	30	30
	Average daily volume	8,896.47	8,609.60	14,454.75	7,641.63	14,077.33
	Minimum daily volume	6,144	5,522	1280	1,616	7,860
	Maximum daily volume	11,763	13,204	21,277	15,988	19,776
	Standard deviation (SD)	1,367.74	1,577.09	4,324.33	3,853.04	3,144.46
	Standard error (SE)	249.71	287.94	789.51	703.47	574.10
	Coefficient of variation (CV)	0.154	0.183	0.299	0.504	0.223

Table 3. Comparison of the performance of vehicle traffic counting by speed cameras and ILS sensors on the Saveh-Tehran freeway

Months	Camera ID	Monthly average daily volume		Volume Matching %
		Camera counted	ILS counted	
DECEMBER 2021	#25513669	5,182.47		
	Span	2,098.20	19,435	10.80
	#25513668	6,447.87		
	Span	2,052.21	16,358	12.55
	#25513616	1,0057.32		
	Span	2,346.89	22,738	10.32
	#25513665	5,478.57		
	Span	2,121.10	N/A	N/A
	#25513614	8,406.35		
JANUARY 2022	#25513669	8,485.95		
	Span	4,832.36	18302	26.40
	#25513668	8,127.09		
	Span	3,239.59	15297	21.18
	#25513616	1,1473.77		
	Span	2,799.14	20070	13.95
	#25513665	5,402.45		
	Span	2,640.57	N/A	N/A
	#25513614	10,716.86		
FEBRUARY 2022	#25513669	8,896.47		
	Span	5,728.87	18,566	30.86
	#25513668	8,609.60		
	Span	3,779.75	15,614	24.21
	#25513616	14,454.75		
	Span	5,089.54	21,770	23.38
	#25513665	7,641.63		
	Span	5,109.73	N/A	N/A
	#25513614	14,077.33		

Discrepancies in Speed Violation Rates Detected by Fixed Speed Cameras and the ILS Sensors

As Table 4 suggests, the monthly percentage of speeding detected by the speed camera #25513163 on the Salafchagan-Arak Highway in December 2021, January 2022, and February 2022 was 0.46%, 0.59%, and 0.87%, respectively. In contrast, the percentages of speed violations detected by the adjacent ILS sensor in the same periods were 34.82% (76 times higher), 35.45% (61 times higher), and 34.28% (40 times higher), respectively. This observation suggests that drivers deliberately reduce their speed near the speed cameras but continue speeding in the areas between them.

Table 4. Comparison of counting and speeding detection performance by speed camera and its adjacent ILS sensor on the Salafchagan-Arak Highway

Month	Camera ID	SPEED CAMERA				INDUCTIVE LOOP SENSOR (ILS)			
		Monthly average daily volume	Daily Average Speeding Offences	Monthly percentage of speeding	Monthly Speeding Offences	Monthly average daily volume	Monthly percentage of speeding	Monthly Speeding Offences	Volume Matching percentage
Dec. 2021	#25513163	18,293.0	80.93	0.46	2428	27,474	34.82	285,471	66.58
Jan. 2022		5,521.5	30.31	0.59	394	26,099	35.45	271,468	21.16
Feb. 2022		7,555.5	41.77	0.87	1253	25,234	34.28	257,113	29.94

To further investigate this phenomenon, Table 5 compares the percentage of speed violations at the camera locations and in the areas between the cameras (the monthly percentage of average speed violations in the area between consecutive cameras) on the Saveh-Tehran Freeway.

Comparing the percentage of speed violations near the cameras sites with the violations detected by the ILS sensors in the area between the cameras indicates that the level of speed violations in the vicinity of the speed cameras is low, while the violations recorded by the ILS are significantly higher. For example, although the monthly speed violation rate near cameras #25513616 and #25513665 is less than one percent, the monthly percentage of average speed violation in the area between these cameras, as reported by ILS sensors, reaches about 50%. The results strongly confirm the hypothesis that drivers reduce their speed near speed control cameras to avoid fines but continue speeding between the cameras.

Accordingly, while the percentage of speed violations detected by the speed camera #25513616 in December 2021, January 2022, and February 2022 was 0.58%, 0.78%, and 0.80%, respectively, the monthly percentage of average speed violations in the area between cameras #25513616 and #25513665 was 4.21% (7.3 times higher), 4.63% (5.9 times higher), and 5.99% (7.5 times higher), respectively. Similarly, while the percentage of speed violations detected by camera 25513665 in December 2021, January 2022, and February 2022 was 0.32%, 0.35%, and 0.40%, respectively, the monthly percentage of average speed violations between cameras #25513665 and #25513614 was 53.5% (17.3 times higher), 3.84% (11.0 times higher), and 4.61% (11.5 times higher), respectively.

Table 5. Comparison of the percentage of speed violations at camera locations and in the areas between cameras on the Saveh-Tehran Freeway

		Camera		ILS Sensor
Month	Camera ID	Monthly percentage of speeding	Total no. of speeding violations	Monthly percentage of speeding
Dec 2021	#25513616	0.58	1,202	N/A
Jan 2022		0.78	1,921	
Feb 2022		0.80	3,384	
Dec 2021	Span	4.21	2,237	48.1
Jan 2022		4.63	3,151	46.66
Feb 2022		5.99	10,724	49
Dec 2021	#25513665	0.32	590	N/A
Jan 2022		0.35	417	
Feb 2022		0.40	1,089	
Dec 2021	Span	5.53	2,759	N/A
Jan 2022		3.83	2,234	
Feb 2022		4.61	8,700	
Dec 2021	#25513614	0.36	653	N/A
Jan 2022		0.43	984	
Feb 2022		0.46	1,939	

Threshold Speeds in Fixed Speed Cameras

Table 6 shows the speeding rates at different speed limits—100, 110, and 120 km/h—on the Salafchegan-Arak Highway, which has a speed limit of 110 km/h. When the speed limit is set 10 km/h below the actual limit (100 km/h), the percentage of violations is relatively high both at camera sites and between cameras. At the actual speed limit (110 km/h), the percentage of speed violations at speed control camera locations decreases significantly but remains relatively high at about three to four percent. The percentage of violations between cameras is still high, though lower than at 100 km/h. When the speed limit is set at 120 km/h (including a 10 km/h tolerance), a significant drop in violations is observed.

This may be due to two main reasons: first, achieving 120 km/h is beyond the performance of some vehicles, which is unlikely because traffic data shows that many vehicles exceed 120 km/h on freeway segments. The second, more plausible reason is that drivers are aware of the 10 km/h tolerance. This suggests that most drivers violating speed limits are aware of the tolerance applied by speed cameras and consider it when choosing their speed. Similar patterns are observed between camera sites, where a larger share of drivers obeys the threshold speed rather than the actual speed limit.

Table 6. Monthly percentage of speeding with different hypothetical speed limits on the Salafchegan-Arak Highway

Month	Camera ID	Monthly percentage of speeding		
		Speed Limit 100 Km/h	Speed Limit 110 Km/h	Speed Limit 120 Km/h
Dec 2021	#25513205	21.59	3.13	0.60
Jan 2022		17.48	2.55	0.53
Feb 2022		19.15	2.84	0.58
Dec 2021	Span	36.62	15.08	0.92
Jan 2022		26.02	9.94	0.89
Feb 2022		29.94	12.06	0.89
Dec 2021	#25513207	25.74	4.95	1.31
Jan 2022			4.69	1.50
Feb 2022		25.29	4.72	1.08
Dec 2021	Span	20.86	2.49	0.26
Jan 2022		20.44	3.02	0.28
Feb 2022		16.23	3.46	0.59
Dec 2021	#25513163	6.57	0.46	0.04
Jan 2022		6.63	0.59	0.09
Feb 2022		6.19	0.87	0.46

Speed cameras ticketing performance

Table 7 shows that despite the many difficulties and high costs involved in identifying offending drivers, the percentage of violations fined by the police is very low. For example, the total number of tickets issued for speeding by camera #25513668 on the Saveh-Tehran freeway was 23 in December 2021, 19 in January 2022, and 6 in February 2022. This was considerably lower than the number of drivers detected for speeding in the same period, which were 73, 109, and 168, respectively (excluding average speed violations and considering a threshold speed of 130 km/h, i.e. enforcement at 10 km/h above the speed limit). This corresponds to a monthly ticketing rate of 31.51%, 17.43%, and 3.57%, respectively.

When including the average speed violations, the monthly ticketing rate is even lower. This is because the camera enforces violations for drivers who exceeded the speed limit in the span between the same camera and the preceding camera, increasing the total number of speeding violations requiring tickets. For example, for the same camera #25513668, the monthly ticketing rate including average speed violations was 29.49% in December 2021, 15.97% in January 2022, and 3.39% in February 2022.

Table 7. Ticketing performance of cameras on the Saveh-Tehran freeway (Speed limit: 120 Km/h, Threshold speed: 130 Km/h)

Month	Camera ID	Total violations detected (threshold speed=130 Km/h)	Total no. of citations issued	Ticketing rate (excluding average speed violations)	Ticketing rate (including average speed violations)
Dec 2021 Jan 2022 Feb 2022	#25513669	36 121 235	15 33 17	41.67 27.27 7.23	
Dec 2021 Jan 2022 Feb 2022	Span	5 10 9			
Dec 2021 Jan 2022 Feb 2022	#25513668	73 109 168	23 19 6	31.51 17.43 3.57	29.49 15.97 3.39
Dec 2021 Jan 2022 Feb 2022	Span	4 13 25			
Dec 2021 Jan 2022 Feb 2022	#25513616	199 682 1033	70 185 92	35.18 27.13 8.91	34.48 26.62 8.70
Dec 2021 Jan 2022 Feb 2022	Span	137 289 1187			
Dec 2021 Jan 2022 Feb 2022	#25513665	96 163 502	50 96 57	52.08 58.90 11.35	21.46 21.24 3.37
Dec 2021 Jan 2022 Feb 2022	Span	170 142 656			
Dec 2021 Jan 2022 Feb 2022	#25513614	104 411 848	37 223 171	35.58 54.26 20.17	13.50 40.33 11.37

DISCUSSION

In Iran, road safety officials are eager to increase the number of fixed speed cameras, aiming to replace officers on rural highways due to their heavy workload and the variety of traffic violations. This expansion plan requires substantial budgets. However, there is a lack of thorough assessment of the current performance of existing cameras. This study is among the first to critically examine factors influencing the general deterrence of fixed speed cameras.

The deterrence effect of police surveillance in preventing offenses is higher when offenders perceive a greater risk of being caught, face severe penalties, and experience swift and certain punishment. However, the most crucial factor is the offender's perception of the likelihood of being caught; without this, other deterrents have little impact (Wegman, 2001). It is prudent to assume that the perceived likelihood of being caught is influenced by the camera activation rate, precision in detecting vehicles and recording speed violations, and threshold speeds for enforcement. High activation rates and precision increase the perceived risk of being caught, while lower threshold speeds for enforcement increases compliance by making drivers feel that even minor speeding will result in a ticket.

The evidence from this study indicates potential gaps in enforcement by fixed speed cameras, which could undermine the perceived risk ofbeing caught for speeding, and consequently reduce the overall effectiveness of speed cameras in deterring traffic violations:

- Successive speed cameras on a highway may be inactive for extended periods resulting in low activity levels.
- The precision of speed cameras in recording traffic volumes may be inconsistent. This variability in daily traffic counts, even at the same location, indicates that the cameras may not reliably capture all vehicles, including those exceeding speed limits.
- A significant discrepancy between traffic volumes recorded by speed cameras and ILS sensors was observed. This lack of agreement suggests that speed cameras may underreport traffic data, potentially allowing many vehicles, including those driven by speed offenders, to go undetected.
- A stark contrast was observed between the speed violations detected by the fixed speed camera and the adjacent ILS sensor, even if the ILS is located very close to the speed camera. This suggests that drivers tend to slow down near speed cameras to avoid fines but resume speeding once they pass the cameras. Such behavior, known as the "kangaroo effect," has been extensively noted in other reports on the impact of fixed speed cameras on speeding globally (Høye, 2014) and in the Islamic Republic of Iran (Tavolinejad et al. 2021). This indicates that fixed cameras may not be effectively deterring speeding over longer stretches of road, as drivers are aware of their locations and adjust their speed accordingly.
- Drivers are aware of the tolerance limits for speeding and adjust their speed accordingly. When the speed limit is set at the actual limit, the violation rate remains high, both at camera locations and between cameras. However, when the speed limit is set higher, with a 10 km/h tolerance included, the violation rate drops significantly. This behavior indicates that drivers are conscious of enforcement thresholds and modify their driving to avoid penalties.

Besides the perceived risk of being caught, the deterrent effect of speed cameras is influenced by the certainty, severity, and swiftness of punishment. The study assessed ticketing performance as a factor influencing the certainty of punishment. High ticketing performance, where most detected violations result in tickets, reinforces the deterrent effect by making the punishment seem more certain. However, evidence indicates that the percentage of violations resulting in fines is very low, and many detected speeding violations do not lead to penalties, significantly reducing the perceived certainty of punishment. When drivers believe there is a low likelihood of receiving a ticket even if caught speeding, the deterrent effect of speed cameras diminishes.

This study mainly focused on the risk of being apprehended by fixed speed cameras and the certainty of punishment by these cameras as factors affecting deterrence on selected highways. It is, however, noted that the severity of punishments is also a contentious issue, with extensive claims that the existing penalties are too lenient to provide any effective deterrence. For example, there is a claim that monetary fines may not be deterrent enough for more wealthy strata in the social hierarchy (Yarahmadi, Fallah Zavareh, and Zabihi Tari, 2020). In addition, the swiftness of punishment has been widely criticized, as the penalties are not imposed swiftly enough to serve as an effective deterrent. According to Article 5 of the Law on Handling Traffic Violations, approved by the Islamic Consultative Parliament, the offender is required to pay the fine within sixty days from the date specified in the fine receipt or the date notified in the fine receipt that is brought to their attention. If the offender does not pay the fine within the legal period, they are required to pay the fine at double the amount specified in the fine receipt.

Interestingly, however, drivers fined by speed cameras are not included in this rule. This exclusion may be due to the lack of effective communication informing the violating drivers of their infraction and the citation they have received. According to the practice, traffic police send two short messages to the violating drivers: one upon detection of the violation and another upon verification and issuance of the citation. However, there is a technical debate that the short messages are not reliably sent to the violating drivers, and this method does not legally ensure that the driver has seen the message and is informed of the violation, which is why they are not subject to the doubling of the fine. Because the fines for camera-detected violating drivers who do not pay within 60 days are not doubled, these drivers do not usually tend to pay the tickets promptly. The high rate of inflation encourages this practice; if they postpone the payment, the value of money will decrease, and the severity of the punishment will be felt less by the driver.

According to Article 4 of the Law on Handling Traffic Violations, police officers have the authority to impound vehicles of drivers who have committed violations and whose fines exceed the legal threshold. This measure is intended to ensure that drivers pay their traffic fines promptly. However, there are concerns that the traffic police do not enforce this rule effectively due to pressure from the general public. This lack of enforcement reduces the deterrent effect of penalties and the overall effectiveness of traffic law enforcement.

CONCLUSIONS AND RECOMMENDATIONS

This study examined the factors influencing the effectiveness of deterrence by the fixed speed cameras on highways in Iran. The findings highlight several key issues. The likelihood of being caught is crucial for deterring speeding, but low activation rates and inconsistent performance of speed cameras can reduce this perception. Additionally, speed cameras sometimes fail to accurately record traffic volumes and speed violations, leading to a lower perceived risk of being caught. Finally, drivers often slow down near speed cameras and speed up afterward, known as the “kangaroo effect,” indicating that fixed cameras may not deter speeding over longer distances.

Effective deterrence requires severe and swift penalties, but delays in the current system and lenient penalties, especially for wealthier drivers, may reduce the deterrent effect. In particular many detected violations do not result in fines, lowering the perceived certainty of punishment and diminishing the overall effectiveness of speed cameras.

Based on the findings, the following recommendations are proposed:

- Increase camera activation rates: Ensuring that speed cameras are active and operational at all times can enhance the perceived risk of apprehension. Regular maintenance and monitoring of cameras are essential to achieve this.
- Improve precision and reliability: Enhancing the precision and reliability of speed cameras in detecting violations and recording traffic volumes can increase the perceived risk of being caught. Implementing advanced technologies and regular calibration of cameras can help achieve this.
- Address behavioral adaptations: To counteract the "kangaroo effect," authorities could consider deploying mobile speed cameras and increasing the number of fixed cameras at random intervals. Enforcement of the average speed violations is also important. This approach can create a continuous deterrent effect along highways.
- Decrease tolerance in speed limits: Reducing the tolerance levels for speed limit enforcement can enhance compliance. Lowering the threshold speeds for enforcement makes drivers feel that even minor speeding will result in a ticket, thereby increasing adherence to speed limits. Additionally, the specific tolerance levels should not be disclosed to the public to prevent drivers from exploiting this information.
- Enhance penalty severity and swiftness: Revising the penalty structure to ensure that fines are substantial enough to deter all drivers, regardless of their economic status, is crucial. Additionally, reducing the time allowed for fine payment and ensuring swift imposition of penalties can enhance deterrence.
- Improve ticketing performance: Increasing the rate of ticket issuance for detected violations is essential. This can be achieved by streamlining the process of identifying offending drivers and ensuring that all detected violations result in penalties.
- Public awareness and communication: Effective communication about the presence and operation of speed cameras, including their activation and precision, can enhance the perceived likelihood of being caught. When drivers are well-informed about enforcement measures, they are more likely to comply with speed limits. Public awareness campaigns and clear signage can play a significant role in this regard.

The findings and recommendations of this study have broader implications for countries worldwide seeking to improve road safety through the use of speed cameras. Key takeaways include:

- Comprehensive assessment: Regular assessment of the performance of speed cameras is essential to identify gaps and areas for improvement.
- Technological advancements: Investing in advanced technologies for speed detection and traffic monitoring can enhance the precision and reliability of enforcement measures.
- Behavioral insights: Understanding driver behavior and adapting enforcement strategies accordingly can improve the overall effectiveness of speed cameras.
- Policy revisions: Revising penalty structures and enforcement policies to ensure they are effective for all socioeconomic groups is crucial for achieving deterrence.
- Global collaboration: Sharing best practices and lessons learned from different countries can help develop more effective traffic enforcement strategies globally.

By implementing these recommendations, countries can enhance the deterrent effect of speed cameras, improve traffic law enforcement, and ultimately reduce traffic violations and accidents.

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Interview

David Shelton, former Senior Transport Specialist (Road Safety) at the Asian Development Bank

Globally, regional road safety observatories are functioning at many different performance levels. The Asia Pacific Road Safety Observatory (APRSO) was established in 2020 and is widely considered to be among the best performing of regional observatories. It is hosted by the Asian Development Bank and funded by the Government of Japan through the Japan Fund for Prosperous and Resilient Asia. Here, we asked David Shelton, former Senior Transport Specialist (Road Safety) at the Asian Development Bank (ADB), for his insights into the observatory and its role in improving road safety in the region.

1. The Asia Pacific Road Safety Observatory was established in 2020. What was the rationale for creating a regional, as opposed to national, road safety observatory?

   Regional observatories provide the opportunity for multi-country comparisons which country observatories are not well equipped to perform. This benefit is well illustrated by the European Road safety Observatory. Comparing performance between countries allows observatory members to identify performance 'beacons' in other countries which may provide guidance for improving safety in their own country. In addition, the regional approach supports establishment of communities of interest and the transfer of knowledge between countries.

2. In the late 1990s to 2000s, ESCAP also developed a road safety database for the Asia and Pacific region. One of the biggest challenges was that road safety data was collected by different authorities in countries, without a central authority to consolidate the data. Is this still a challenge, and if so, how does the APRSO handle it?

   Across the countries of Asia and the Pacific there are several different approaches to the governance of road safety and the management of road safety data. The APRSO supports its member countries to implement best practice road safety data management regardless of which authority is charged with data collection. Most important are the quality of data being collected, the extent to which it is made available to all agencies, and how extensively it is being used for decision making. These functions remain paramount regardless of which agency is the designated central authority or has lead agency status.

3. Since the establishment of the APRSO, have you seen any changes in how member governments view the issue of road safety data?

   The APRSO was established in 2020 just as the 1st UN Decade of Action on Road Safety was coming to an end. The World Health Organization estimates that the 1st Decade of Action saw a 5% reduction in road traffic fatalities. While this reduction was well short of the 50% target, the Decade did mark a substantial increase in awareness among governments. This momentum has been picked up by the

APRSO and growing membership and engagement in the Observatory is a strong indicator of increasing government interest in improving road safety data. The Observatory has assisted this increased interest in road safety data by conducting reviews of road crash data in three countries and supporting data reviews in all Central Asia countries.

4. Do other stakeholders, such NGOs or academic researchers, contribute to or use the APRSO data?

   Since its commencement in 2020, the APRSO has completed its establishment phase. Data collection is commencing in 2024. The APRSO Governance Statute supports non-country membership and the Observatory has commenced building this cohort of partners. In future, it is expected that non-country members will not only use APRSO data but will also contribute to the datasets held by the Observatory.

5. Countries in the Asia and Pacific region face different situations regarding road crash and road safety performance data. How are you supporting developed countries in this area, including the use of big data? How are you supporting developing countries in making greater use of big data?

   The 54 countries that are eligible to join the APRSO span high-, middle- and low-income status. Observatory events bring together professionals from across this spectrum in recognition that the majority of road safety technical knowledge is relevant regardless of development status. The challenges of creating sustained positive change in road safety also have many similarities independent of a country's capacity to invest. The APRSO supports its members by enabling the transfer of good practice, much of which is universally relevant. For example, the APRSO is researching technology-based methods for efficient data collection to report against the 12 Global Voluntary Performance Indicators (SPI). Some of the methods being used make use of big data and all countries interested in reporting against these SPIs will benefit from the project.

6. Do you think there could be a risk of too much data in the future?

   The risks of there being too much data in the future are far outweighed by the current realities of there being too little quality data. Moreover, where data do exist, they are rarely being well utilised to support decision making. The greater promise that the future holds is through advances in artificial intelligence and the growing availability of big data which, when combined, offer the potential for modelling road safety trends in a timely and cost-effective manner in order to inform the planning and refining of road safety action. ADB and the APRSO have already commenced AI pilots aimed at enhancing road safety outcomes.

7. Based on the work done by APRSO so far, is there a specific policy area where you think data can make a tangible difference to road safety outcomes?

   Due to the current dearth in quality data, there are few areas of road safety that would not benefit tangibly from improved data availability and analysis. From this standpoint, the policy areas offering greatest benefit from improved data are those interventions known to have the greatest road safety benefits and those road safety functions most critical to obtaining results. Foremost among the latter is increased funding and resourcing for what works in road safety. Closing the gap in under-reporting of road crash casualties and quantifying the economic costs of these would be a substantial benefit for many countries and help make the case for increased investment. The APRSO is assisting member countries in this regard by reviewing current data management practices and recommending improvement actions.

8. Is there anything else in particular that you would like to convey to the readers of this ESCAP Bulletin?

Lessons learned to date in implementing the APRSO are that adequate and certain funding is essential, global and regional partners such as the World Health Organization must be actively supportive and there is benefit in attaching the observatory to an aligned and effective regional body, which in this case is the Asian Development Bank.

9. Thank you very much for your valuable time.

Readership Survey

ESCAP would appreciate your comments and suggestions on how to improve the quality of this publication. A link to a readership survey is accessible below. Please note that it will take approximately 3 minutes to complete.

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