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Utilization of the information sharing road safety measure in developing Countries: Case study of Suphanburi, Thailand

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ABSTRACT

Despite decades of road safety efforts, it is a big question why the number of road fatalities in developing countries has not been reduced. One of the reasons for the ineffectiveness of road safety measures is the lack of cooperation and information sharing between the concerned agencies. This study examined the utilization of the "information sharing road safety measure" based on a successful case in Kamagaya City, Japan. By cooperating with local authorities and the community, the current status and implementation issues of road safety measures under a local context were identified/extracted, especially by utilizing an engineering approach as the main part of the "information sharing road safety measure" study. Suphanburi Province, Thailand, was selected for a case study. The results showed that to successfully implement the "information sharing road safety measure," its continuation and consistency are essentially required. Furthermore, an engineering approach for identifying risk and black spots by the local community can help in clarifying the causes of accidents in the targeted areas. The cooperation and participation of stakeholders from government sectors, i.e., municipality, police, schools, residents/communities, academic sector, and the private sector, play a key role in disseminating and sharing information regarding road safety and selecting appropriate road safety measures to suit the local contexts.

1. Introduction

1.1. Background

The number of automobiles and motorcycles has rapidly increased in road fatalities for decades. According to the World Health Organization (WHO) (World Health Organization, 2018), road fatalities in Thailand are the second worst road traffic accident situations in the world. The number of road accidents and fatalities keeps increasing every year. For instance, in 2016, 21,745 people died in road crashes. Compared with other Southeast Asian countries, Thailand has the highest road traffic fatality rate of 36.2 per 100,000 individuals (World Health Organization, 2015). Hence, the Ministry of Transport (MOT), Thailand, has strongly requested the Japanese government for technical assistance on the capacity improvement of road safety countermeasures. The Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan, has actively responded to MOT's request and worked closely with MOT administrative to implement road safety measures. Based on successful experiences in Japan, MLIT introduced several effective countermeasures. For instance, an implementation of safety measures for road facilities, dissemination of traffic safety education, improvement of traffic safety awareness, an introduction of an operation management system, so-called transport safety manager for commercial vehicles, revision of the license system, collection of traffic accident data/information and sharing, and transfer of road safety technologies. For the successful implementation of these countermeasures, MLIT formulated a joint road safety working group to establish traffic safety initiatives and transfer technologies to Thailand. As part of this initiative, four model districts were selected over three years. Then, technology for road safety has been transferred based on Japan's experience regarding specific road traffic safety measures, thereby contributing to the considerable reduction in road traffic accidents in Thailand.

Hence, this study applies a method highly regarded as Japan's road traffic safety experience, namely the "information sharing road safety

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measure," which was implemented at Kamagaya City in Chiba Prefecture, Japan. This method is a process by which local governments and road administrators share information on the occurrence of traffic accidents with communities and link them to corresponding road traffic safety measures. The concerned agencies and/or stakeholders, such as road administrators, municipalities, communities, and academia, worked together by employing academic knowledge in Kamagaya City. An engineering approach was introduced to identify risk spots or near-miss (so-called Hiyari-Hatto in Japanese) spots and black spots. The causes of accidents were analyzed from an engineering viewpoint, and education and awareness workshops were conducted. The implementation of enforcement factors was discussed as a key part of the "information sharing road safety measure," to identify road safety situation and its existing problems, share information about the identified issues, propose new countermeasures, and implement them to reduce traffic accidents successfully through the concerned agencies and/or stakeholders' deliberation and decision though these overall processes.

Nevertheless, in Thailand, it is not always understood that the collaboration between local governments and road administrators with the community is essential for enhancing the effectiveness of road traffic safety measures. Therefore, in this study, we apply "information sharing road safety measures" in Suphanburi, Thailand, one of the four model districts of the road traffic safety working group, to verify its feasibility and effectiveness.

1.2. Information sharing road safety measure

According to Kobayakawa et al. (Kobayakawa et al., 2011), the "information sharing road safety measure" is a process by which the data of road traffic accidents and road traffic safety countermeasures are collected and shared among stakeholders, such as residents, administrations/municipalities, and road safety experts. The traffic safety measure support system, as described in Fig. 1, is used in the information sharing road safety measure. This system integrates the management data of road traffic accidents and Hiyari (near-miss) experience data collecting from citizens using the web geometric information system (GIS) technology. Then, it constructs a base for rationalizing and streamlining the planning and drafting of safety measures. As described in Fig. 1, this system has two subsystems: Hiyari Experience Input Sub System (HEISS) and Traffic Accident Analysis Sub System (TAASS). The HEISS allows the reporting of Hiyari experiences, i.e., when a road user experiences an actual road condition and creates a Hiyari map. Furthermore, the TAASS has the function of exchanging information with area residents, road traffic administrators, and experts to plan traffic safety countermeasures. They can then easily understand and improve traffic safety plans together, use the website to organize the data of traffic accident occurrences and Hiyari experiences, and then compare this data with the situation before the enforcement of the measures. In addition, an evaluation system converges the opinions of road users or district citizens onto traffic safety measures. The mapping system of Hiyari experiences is the zone citizens or road users using the website managed by the local government to report their Hiyari experiences and participate in the mapping process. The traffic safety information website can gather information from road users or zone citizens and distribute information on behalf of the local government. This system has been operated in Kamagaya City since 2001 and has been used in implementing road traffic safety measures in this area. As a result, the number of traffic accidents in Kamagaya decreased from 26 in 2001 to 6 in 2004. With this system, related parties can share Hiyari-Hatto and traffic accident data to find effective road traffic safety measures and provide feedback on the results. These are cyclical activities that constantly review traffic safety measures.

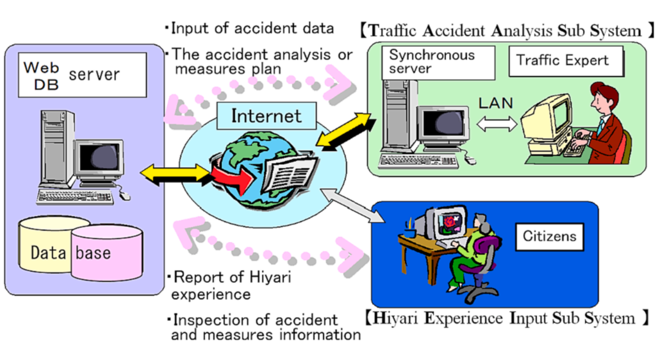


Fig. 1. Traffic Safety Measure Support System (Kobayakawa et al., 2011).

1.3. Hiyari-Hatto

Hiyari-Hatto is a Japanese term that describes the incidences, near-misses, or risks that have been used as safety precaution procedures by Japanese manufacturers for several decades. The word "Hiyari-Hatto" is widely spread in other fields, including road safety, to identify near-miss spots or the potential black spots that can cause injuries, death, or property damage (Suzuki et al., 2014; Kato and Fukumoto, 2017; Suzuki et al., 2017).

In a road safety study, Hiyari-Hatto was used as a psychological method to encourage road users to participate in or be involved with road traffic safety programs and to raise their safety awareness. This method was initially utilized to collect and share information about near-miss spots or potential blackspots by asking elderly people in identified communities to locate near-miss areas on provided cognitive maps based on their actual experiences. This helped increase the traffic safety awareness of many drivers (Fukuda et al., 2005; Fukuda et al., 2010; Suzuki, 2010). Thus, the Hiyari-Hatto method has been widely recognized for its effectiveness in raising traffic safety awareness among Japanese citizens. It has become widely adopted as a Hiyari map development workshop in many communities and as an inspection method of safe routes to use for school children nationwide.

In recent decades, technology has improved, and traffic accident data can be displayed on digital maps. For example, the Hiyari-Hatto information collected by the Honda Safety Map[2] reported and showed near-miss spots or potential black spots on a digital map together with the occurrence status of traffic accidents. This information has proven to help develop preventive countermeasures and raise road safety awareness among citizens. For instance, local traffic police officers or road managers can utilize Hiyari-Hatto information to locate near-miss spots or potential black spots so that traffic safety measures can be implemented before road accidents occur.

There was an argument that the Hiyari-Hatto method may seem intuitive. However, it has been introduced and utilized as an alternative method to collecting traffic accident data, near-miss spots, and potential black spot data in countries and regions where traffic accident data is not available or not properly collected. This is why the Hiyari-Hatto approach was used as the primary source of information sharing on road safety in the Kamagaya case.

1.4. Objectives

In this study, the application of the "information sharing road safety measure" was examined by the following: 1) extracting the current status and implementation issues of road safety measures under local contexts, 2) clarifying the challenges that must be addressed to implement traffic safety measures, and 3) considering whether the method of "information sharing road safety measure" that proved successful in Japan can solve the identified problems in Thailand. Finally, we examined how to implement traffic safety measures to solve specific issues at the community level based on the "information sharing road

[2] https://safetymap.jp/.

safety measure" by utilizing academic knowledge (i.e., identifying Hiyari-Hatto or near-miss spots or potential blackspots), providing education (i.e., workshops and training), considering new enforcement factors, and applying the case study in Suphanburi Province, Thailand.

2. Literature review

Various studies have investigated traffic accident countermeasures to identify the high potential areas with traffic accidents and implement road safety measures, quantitatively analyzing their impacts using traffic accident data is necessary. For example, Hughes et al. (Hughes et al., 2015) systematically reviewed to identify and summarize concise descriptions of road safety. They covered information from a wide variety of fields and contexts, including transport, occupational safety, food industry, education, construction, and health. Moreover, they clarified that the language of safety models and systems has been inconsistent and concluded that the models identified in their review are likely to be adaptable to road safety. Timmermans et al. (Timmermans et al., 2019) analyzed crash data for seven consecutive years, from 2010 to 2016, to evaluate the road traffic crash (RTC) rate over time and understand the influencing factors related to the frequency of RTCs. As analyzed by time series, the results showed an increasing trend of the RTCs leading to severe injuries and a slightly decreasing trend of fatal RTCs. The study clarified that the crashes that cause severe injuries or result in fatalities for drivers and pedestrians are significantly affected by seasonal weather variations, particularly in winter and autumn. Kumar and Toshniwal (Kumar and Toshniwal, 2016) proposed a framework for analyzing road accident time series data that took time series data from 39 districts of India and developed a time series merging algorithm to find the representative time series for each cluster. Moreover, they clarified that the road accident trend is going to increase in certain clusters. Chang et al. (Chang et al., 2020) employed the data envelopment analysis approach for benchmark analyses and revealed the nature of returns to scale the under investments in road safety in Korea.

In addition, there are some studies regarding the conceptual frameworks of road safety measures. Vingilis (Vingilis, 2016) mentioned a detailed description of the constructs of the causal chain, program logic models, and process evaluation, and they indicated an example of how these standard methods of theory-driven evaluation can improve the interpretation of outcomes and enhance the causal attribution of road safety countermeasures. Guttman (Guttman, 2016) developed a detailed categorization of persuasive appeals used in road safety communication campaigns that differentiate between the appeals that appear to be similar but differ conceptually with the aim of indicating the advantages, limitations, and ethical issues associated with each type, drawing on behavior change theories. This study indicates the advantages, limitations, ethical issues, and challenges of using different types of appeals. Howat et al. (Howat et al., 2001) discussed a road safety measure framework based on community participation, identified the barriers to community participation in road safety activities, and recommended strategies to reduce these barriers. They also revealed that the barriers to community involvement in road safety initiatives are similar in many parts of Australia and overseas and that they can be applied to a wide range of health promotion interventions besides road safety.

There are many existing studies regarding road safety assessments, especially focused on the Association of Southeast Asian Nations (ASEAN) countries. Sigua and Palmiano (Sigua and Palmiano, 2005) summarized the issues and concerns of the 10 ASEAN countries regarding road safety. They analyzed the major causes of accidents and trends in the number of casualties based on population, GDP, and vehicle registration; identified the most vulnerable road users; and presented the respective member countries' estimates of the costs of accidents. Oviedo-Trespalacios and Haworth (Oviedo-Trespalacios and Haworth, 2015) focused on the ASEAN region as a case study due to its different socioeconomic and road safety patterns. Moreover, they constructed a new index for measuring the road safety maturity (RSM) from numerical weightings given to measurable factors presented for each of the pillars that guide national road safety plans and activities, such as road safety management, safer road and mobility, safer vehicles, safer road users, and post-crash response. The results utilized the RSM index for comparing the performances across the countries and pillars and identified the differences, performances, and improvement opportunities in the ASEAN countries. Eusofe and Evdorides (Eusofe and Evdorides, 2017) examined the current institutional arrangements for the management of road safety in Malaysia in a systematic manner. They revealed that the efficiency and effectiveness of the road safety management system in Malaysia may be sustainably improved by addressing the current dependence of funding on government sources, fragmentation of the decision-making process of this de facto multidisciplinary area, road safety legislative framework, public awareness, local needs, and institutional capacity. Jameel and Evdorides (Jameel and Evdorides, 2019) developed a road safety index RSAI (ESA) that can assess the road safety performance in Southeast Asian countries by measuring to what extent the new vision "safe system" is considered in national road safety strategies, and they ranked the countries accordingly. As a result, they concluded that the countries with a high rate of road crashes have started to solve their road safety problems and that some other countries need to take further steps.

There have also been some analyses on using subjective data, such as near-miss accidents and Hiyari-Hatto. For example, Ahmed and Garba (Ahmed and Garba, 2019) analyzed the prevalence of road accidents, near-misses, and their associated factors among commercial tricycle drivers in Nigeria. As per their results, the prevalence of road accidents and near-misses were 46 % and 50.3 %, respectively. They clarified that only psychoactive substance use and having experienced more than one near-miss are significantly associated with having accidents in the bivariate analysis. Poulos et al. (Poulos et al., 2017) investigated the events in which cyclists, a cohort of 2,038 adult transport and recreational cyclists, perceive a cycling crash as a near-miss. They also calculated an exposure-based rate of near-misses and investigated near-miss circumstances from self-reported data collected from cycling diaries. Their results indicated similarities between the near-misses and crashes reported by this cohort during the same reporting period. Okamura et al. (Okamura et al., 2010) introduced a practical method of Hiyari map development based on Hiyari data collected from a face-to-face communicative method through Hiyari map developmental workshops, a community-based approach for improving traffic safety awareness by evaluating the effectiveness of the approach in Thailand. They clarified that the amount of Hiyari data collected from the Hiyari map used by local communities is very significant compared with the Japanese experienced cases.

However, many attempts have analyzed potential black spots using data, such as Hiyari (near-miss). There are few attempts, such as the case in Kamagaya (Nambu et al., 2007; Nambu et al., 2008), in which stakeholders hold a road safety workshop, share information with each agency, and formulate and implement road safety measures in actual societies. For example, Kobayakawa, et al. (Kobayakawa et al., 2011) selected Hiyari-Hatto experiences in Goyang, South Korea and compared them with the Kamagaya case.

3. Methods

3.1. Study overview

To reduce traffic accidents, this study proposed a data collection process for implementing countermeasures; however, it is extremely difficult for traffic accident countermeasures to solve all traffic problems in a single implementation. Therefore, this study applies the process framework as a PDCA (Plan, Do, Check, and Action) cycle to cases in Suphanburi, Thailand, in the form of critical points for analyzing traffic accidents and developing countermeasures based on the concept of the

"Kamagaya Model" (Nambu et al., 2007; Nambu et al., 2008). This concept can be applied by evaluating the effects after implementing the countermeasures, clarifying any remaining or newly generated issues, and continuously implementing them. The process from each step of the PDCA cycle is shown in Fig. 2. This cycle has five steps: (1) understanding the occurrence of traffic accidents, (2) identifying the accident factors, (3) planning of measures, (4) implementation of measures, and (5) evaluation of measures. This study proposed that residents, municipalities, and experts should jointly implement traffic safety countermeasures based on the PDCA cycle to succeed in the social implementation of road safety measures.

A comprehensive road traffic accident database is still under development in many developing countries, including Thailand. There are nonintegrated accident data collected from various sources of the different agencies in Thailand, but only the accident data of Highway Accident Information Management System (HAIMS) from the Department of Highways (DOH), MOT, and Accident Report Management System (ARMS) the Department of Rural Roads (DRR), MOT included the road accident locations and identified blackspots except Hiyari-Hatto or near-miss spots. Thus, in this study, the Hiyari-Hatto approach was employed in Suphanburi, mainly targeted traffic control on the intercity highway. The locations of the occurrences of dangerous events were identified based on "Hiyari-Hatto" data obtained from the residents/communities. This is because it is considered that implementing information sharing road safety measures while focusing on the locations at which dangerous events occur leads to the reduction of traffic accidents. Finally, this study proposes a method for implementing appropriate road safety measures for hazardous spots and clarifies the issues and limitations of applying the "Hiyari-Hatto" method in Suphanburi as a case study.

3.2. Study area

This study selected Suphanburi as a study area, focusing on the road segments in this province located 114 km away from Bangkok along the northwest direction (Fig. 3).

3.3. Data collection

This study collected Hiyari-Hatto data from the Hiyari map workshop and "ATRANS Safety Map" application.

3.3.1. Hiyari-Hatto data collected at workshops

This study used the Hiyari-Hatto data collected at several one-day workshops held in Suphanburi from 2017 to 2019. These workshops aimed to collect Hiyari-Hatto data and raise road safety awareness among participants. The participants were 40 individuals with local authorities and residents. Residents were chosen as a representation of those who are living near workshop venues. As the proceedings of the workshops, the concept of Hiyari-Hatto was first explained to the participants, and then the participants answered the questionnaire on Hiyari-Hatto. The questionnaire included questions to help participants understand Hiyari-Hatto events on the community roads in their daily life. Particularly, participants were asked to describe detailed information regarding where, when, and how the Hiyari-Hatto events occurred. Next, to identify the black spots for driving a car, driving a motorcycle,

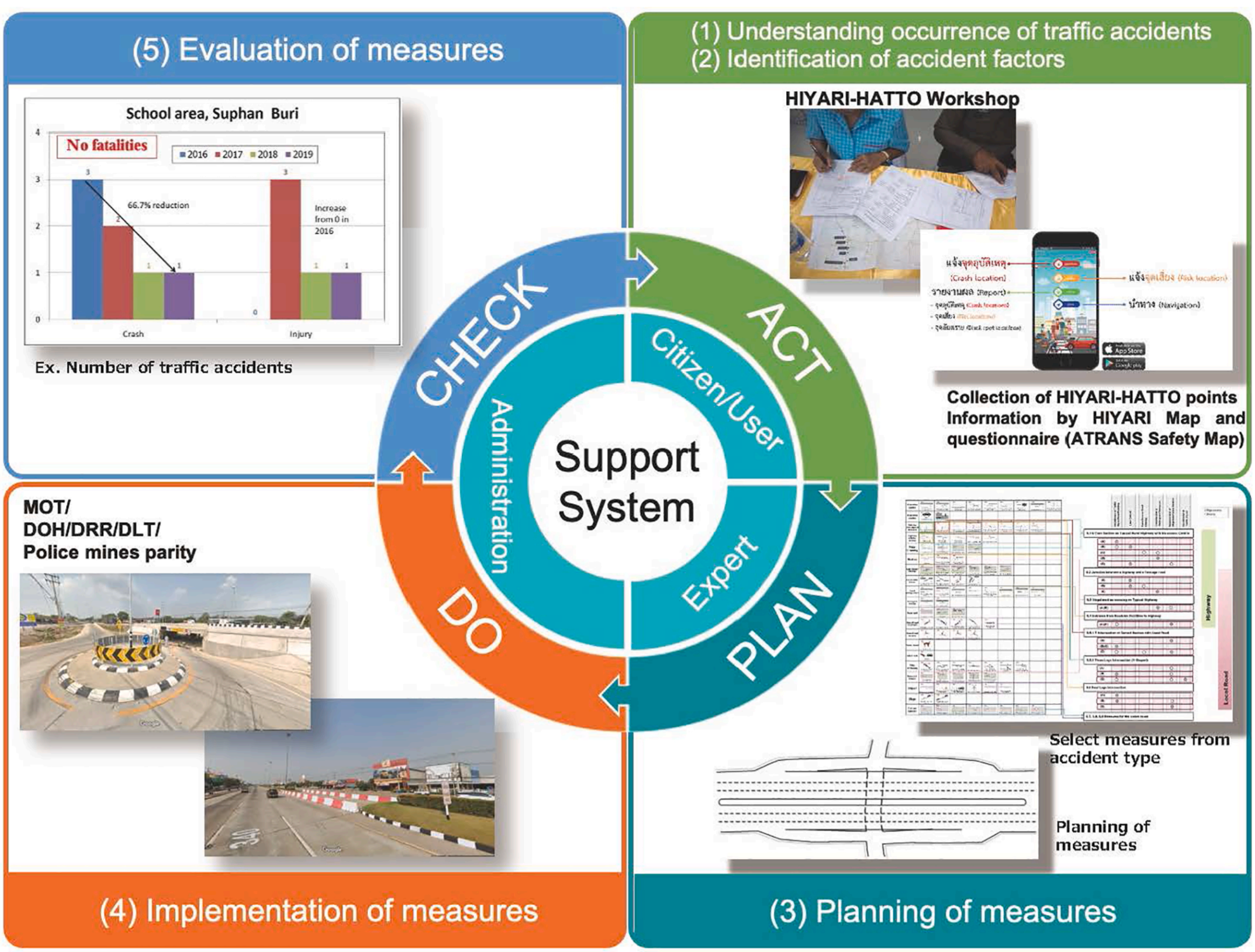


Fig. 2. PDCA cycle for the social implementation of the road safety measure.

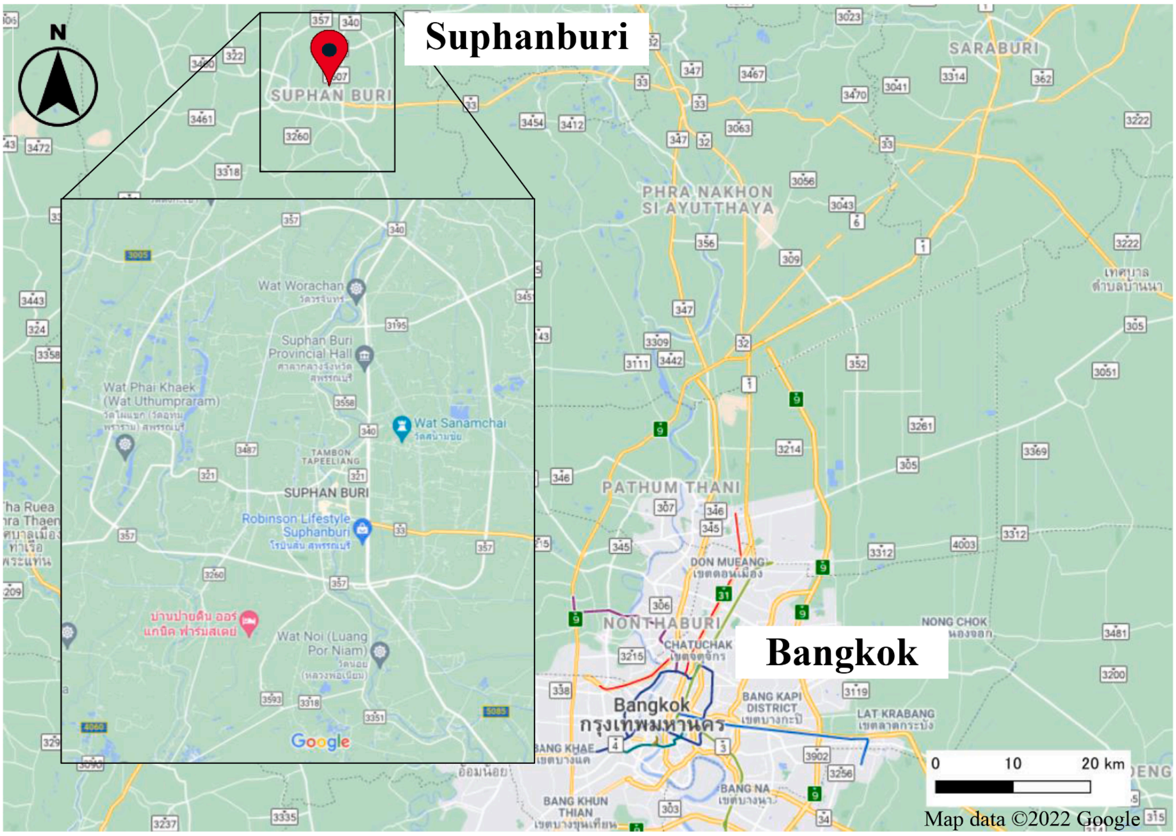


Fig. 3. Location of Suphanburi, Thailand.

or walking, the workshop participants put stickers of various colors with transportation modes (car (green), motorcycle (red), and walk (blue)) on the map based on answers for the questionnaire, as shown in Fig. 4. Hiyari-Hatto event locations were plotted by participants on a map based on where they experienced them while using each mode of transportation and the situation that occurred, as described on the questionnaire. Thus, the black spots in the community roads can be easily recognized from the Hiyari-Hatto types specified by the participants.

Finally, Hiyari-Hatto spots based on the answers from residents at the workshops were generated as the Hiyari-Hatto data. The criteria of Hiyari-Hatto spots decided the number of Hiyari-Hatto plotted by the participants.

3.3.2. Hiyari-Hatto data from the ATRANS Safety Map application

To collect Hiyari-Hatto data through the Hiyari map development workshop, this study used the ATRANS Safety Map application (Asian Transportation Research Society, 2017; Asian Transportation Research Society, 2021). The main purpose of this application is to collect and share Hiyari-Hatto experiences and traffic accident data from/with citizens. This application comprises four main functions: (1) crash location data, (2) risk location data, (3) data analysis report, and (4) navigation. For the collection of risk data, the users (anyone) can upload a photo(s) of the risk location, identify types of road users, and report the risk factor (s). Furthermore, users are able to access the application to review several reports of the crash data and risk data stored in the database (Fig. 5). In the case of Suphanburi, we provided guidance to participants on how to use this application in the Hiyari map development workshop and asked them to report their Hiyari-Hatto experiences.

3.4. Results

Hiyari-Hatto events were summarized as Hiyari-Hatto data; these data were obtained from the workshop and the ATRANS Safety Map application and analyzed to get the type of Hiyari-Hatto experiences. Based on the analysis of Hiyari-Hatto locations and experiences, this study proposed appropriate traffic safety measures. It also presented a case study of how the local government in Suphanburi had implemented road safety measures based on the suggested method of this study.

3.4.1. Analysis of the Hiyari-Hatto locations

The locations of the Hiyari-Hatto experience were initially identified using stickers on the Hiyari map to analyze Hiyari-Hatto locations. Since numerous stickers were attached to the map by workshop participants, the number of stickers does not objectively offer direct information regarding the occurrence rate. However, if many stickers are concentrated in one place, many Hiyari-Hatto incidents will probably occur there. This is because multiple residents have the Hiyari-Hatto experiences at that location. This study digitalized this information to analyze potential black spots using a GIS. It is also possible to easily add other information to the digitalized map, including information on road surface maintenance and administration, and to examine how different factors can relate to Hiyari-Hatto experiences.

Fig. 6 displays the Hiyari-Hatto locations analyzed from the data collected workshop in Suphanburi as a bar graph on the map. The Hiyari-Hatto location data had 236 total samples. The locations in the city where a relatively large number of Hiyari-Hatto events occur are dominated by cars, motorcycles, and pedestrians as a characteristic point. This indicates that the spot is a potential black spot and should be prioritized for traffic safety measures. Under the DOH, the Hiyari-Hatto locations occurred along the roads. Additionally, there are several black spots where Hiyari-Hatto for cars and motorcycles has occurred. This is because many residents often use those modes of transportation.

Furthermore, this study examined the locations of higher occurrence of Hiyari-Hatto along the roads under the DOH. By asking the workshop participants to answer a questionnaire on their daily travel routes and

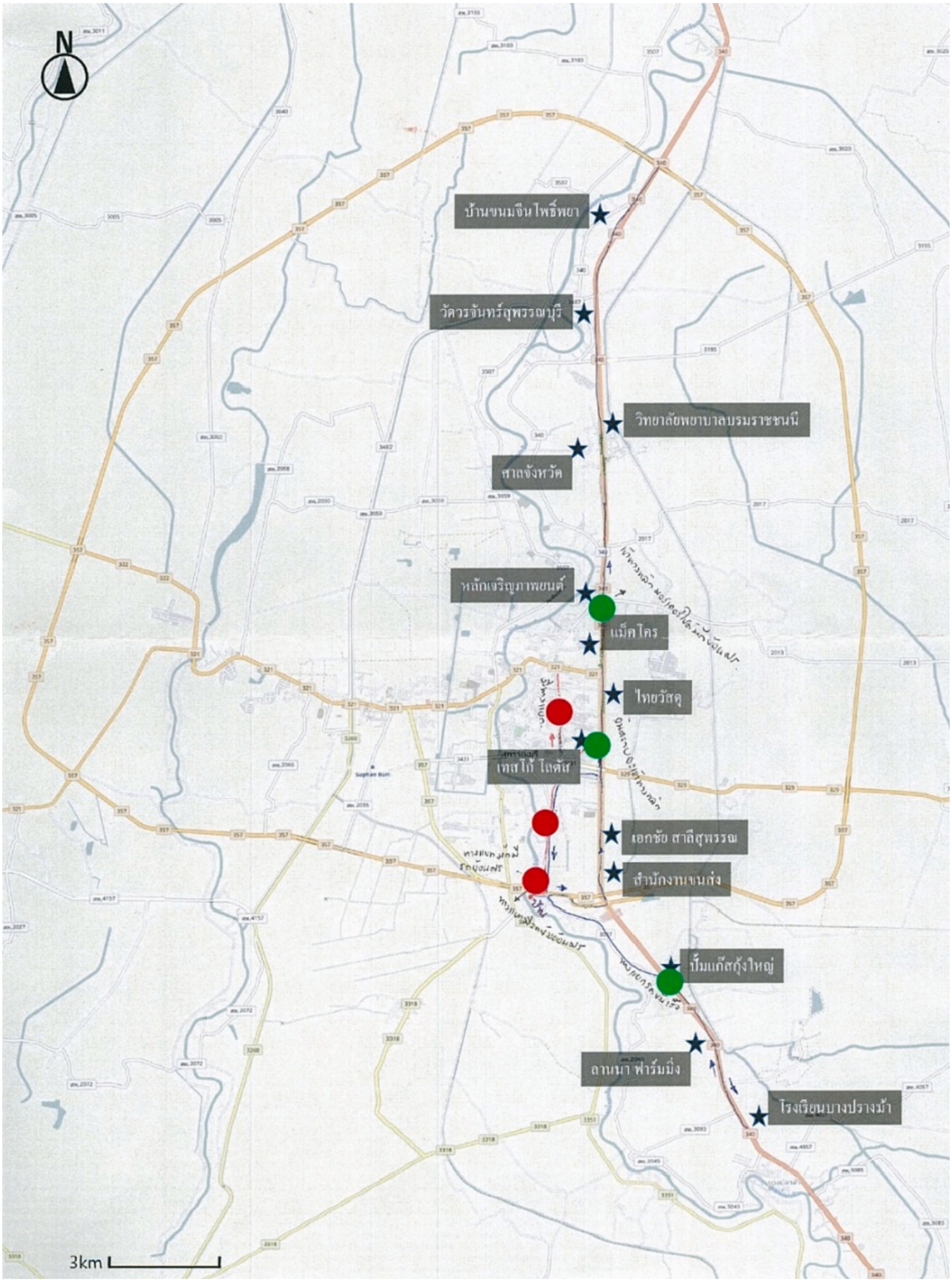


Fig. 4. Hiyari map for the Hiyari-Hatto locations (The Thai characters show the location names).

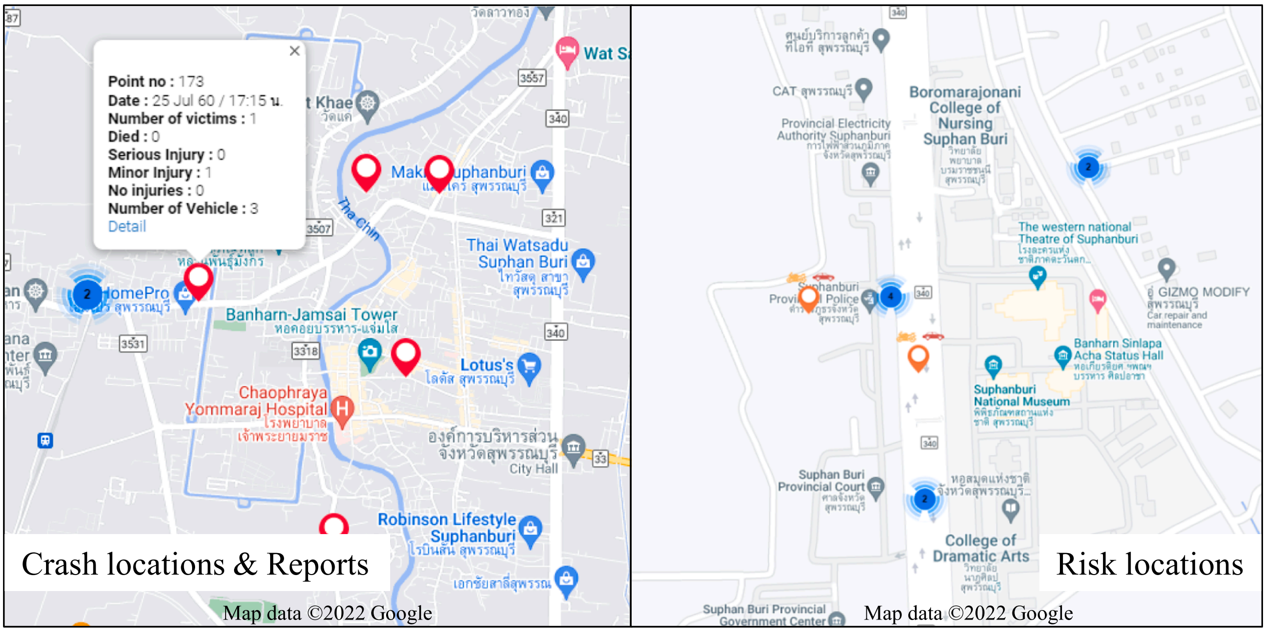


Fig. 5. Crash and risk locations on the ATRANS Safety Map (Nambu et al., 2008).

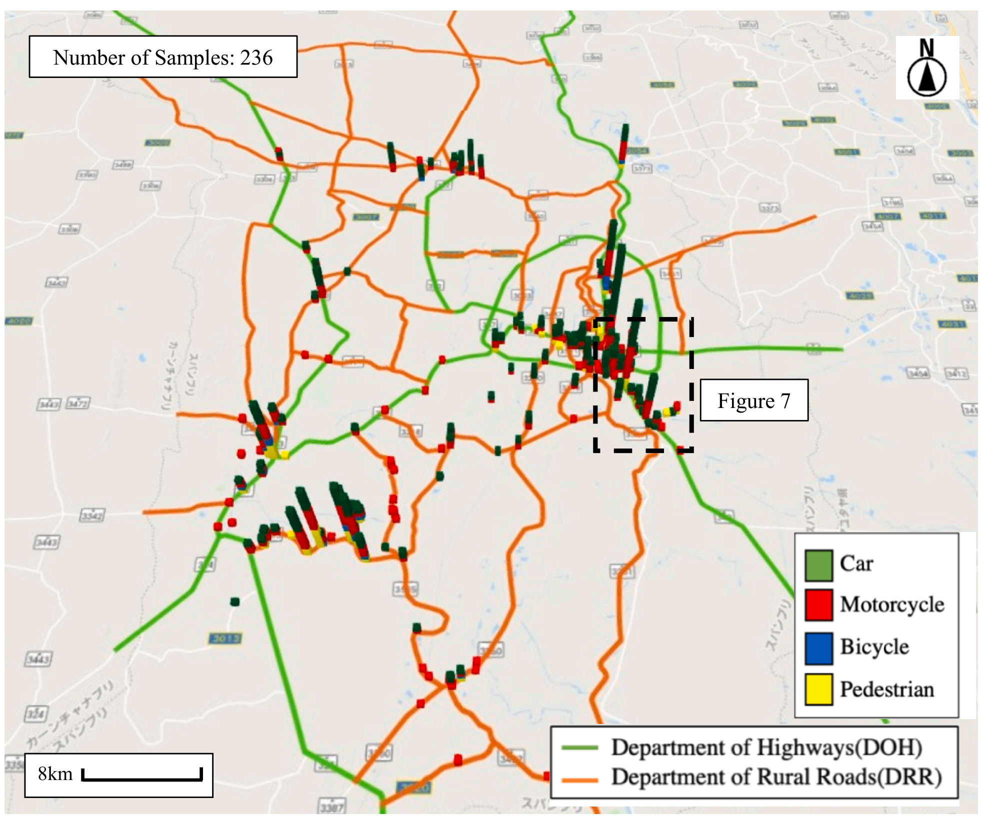


Fig. 6. Analysis result of the Hiyari-Hatto locations.

overlaying the results on the map, this study clarified the relationship between the points with several Hiyari-Hatto experiences and the participants' daily activities, as described in Fig. 7. This is why people choose the shortest route, even if they do not follow traffic rules. Therefore, it was discovered that several Hiyari-Hatto occurred. For example, to enter the national highway's mainline from the nearest interchange as much as possible, there were several cases of people driving in the opposite direction, causing more Hiyari-Hatto. This figure made such points as intersections, U-turns, or junction clearer. It clarified that many Hiyari-Hatto experiences occur in locations where various administrators cover different segments of similar routes.

3.4.2. Analysis of the types of Hiyari-Hatto experiences

Although the analysis of the Hiyari locations suggests some reasons for Hiyari-Hatto experiences, it is hard to clarify all reasons in detail. Each Hiyari-Hatto experience was examined in this study based on the

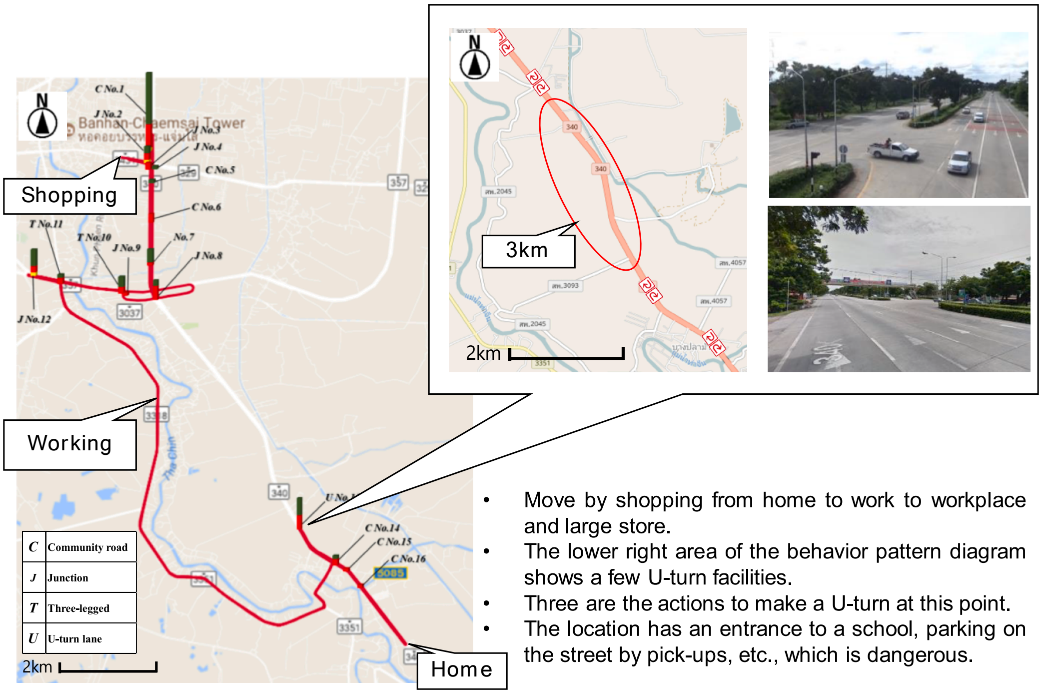


Fig. 7. Relationship between the Hiyari-Hatto locations and daily activities.

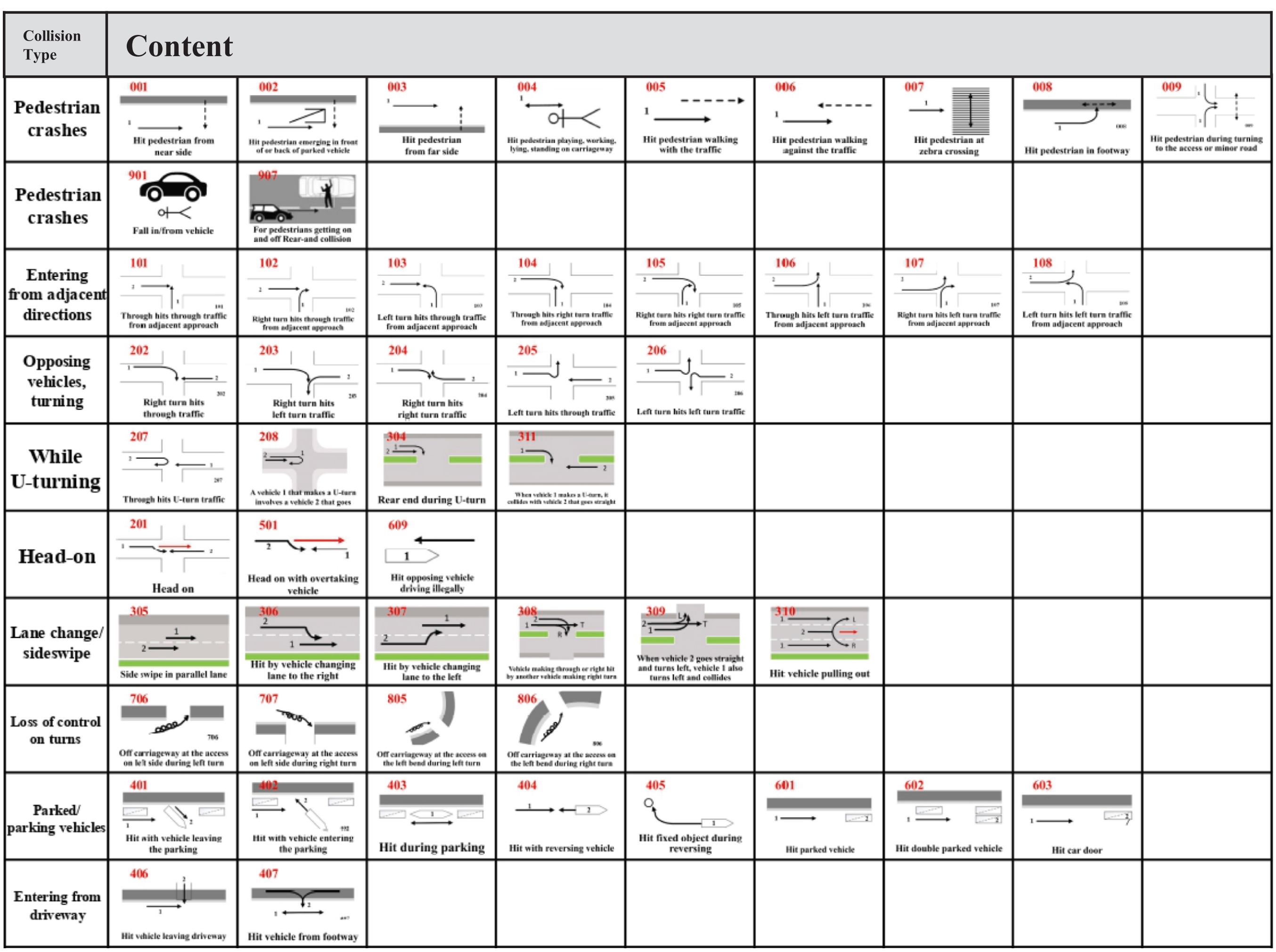


Fig. 8. Collision diagram.

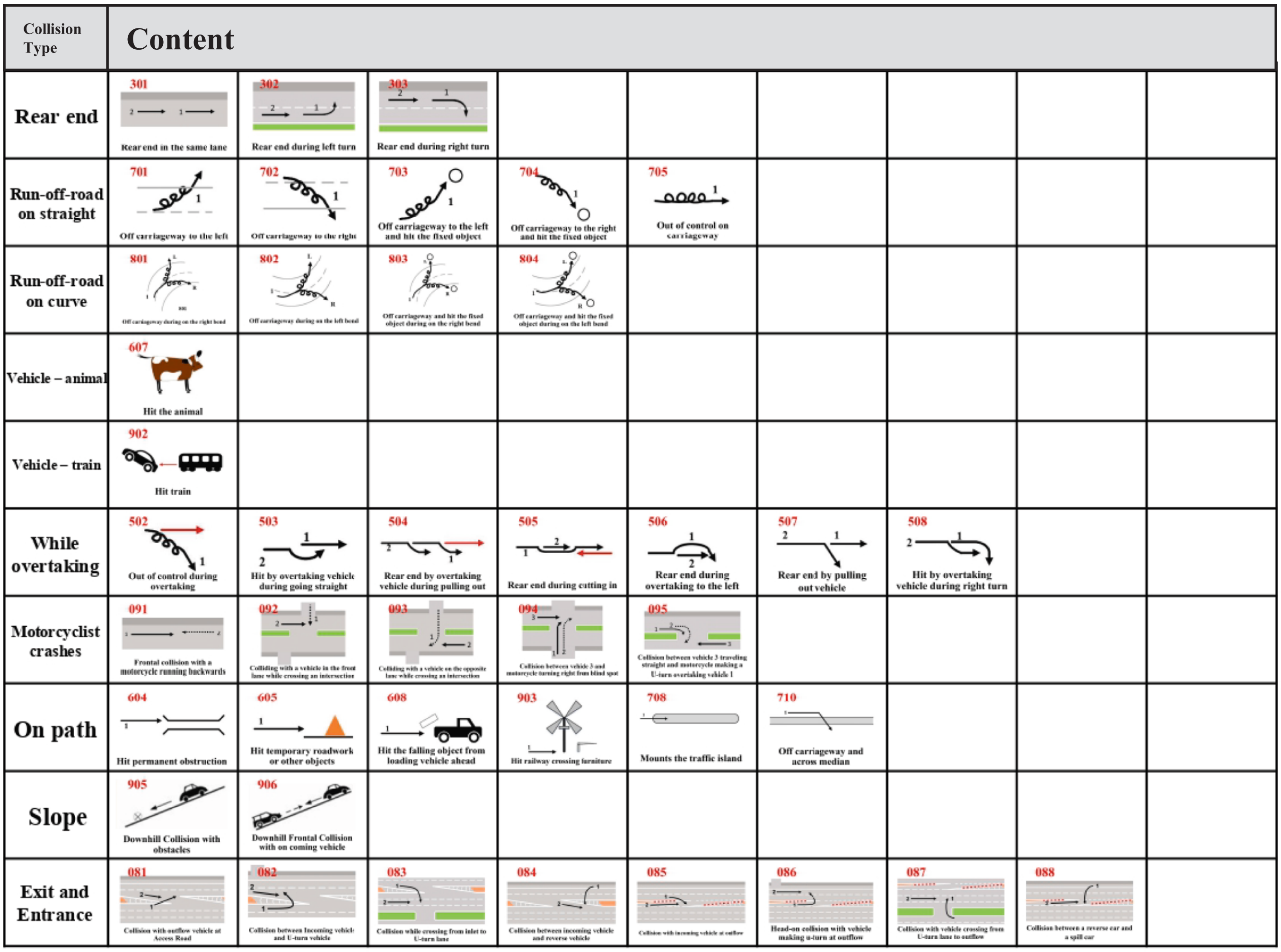


Fig. 8. (*continued*).

situation mentioned in the questionnaire and classified into the collision type. Therefore, selecting suitable road safety measures for each location of Hiyari-Hatto experiences is simple, although there are no traffic accident data. This study employed the collision diagram to classify the Hiyari-Hatto experiences.

The collision diagram typically identifies specific road traffic accident patterns to provide information on the type and number of accidents. In Thailand, the Office of Transport and Traffic Policy and Planning of the MOT designed the original collision diagram. To understand the road characteristics of in traffic accidents and aid in choosing appropriate road safety measures for each location of Hiyari-Hatto experiences, this study enhanced the original collision diagram considering the lack of characteristic events and classified traffic accidents into 20 collision types using the collision diagram.

According to the discussion in the previous section, several Hiyari-Hatto events occurred at U-turn lanes of Suphanburi. Considering these events, we added the collision type of U-turn and classified the Hiyari-Hatto events into collision types (Fig. 8). Fig. 8 depicts the collision diagram, which classifies traffic accident types according to their collision types. There are red numbers in each cell of the figure. These numbers are used to classify traffic accidents. The classification is based on the road accident classification table of the MOT in Thailand. The same number as the hundredth place shows the same type of traffic accident.

3.4.3. *Proposed appropriate road safety measures*

After identifying the black spots by analyzing the Hiyari-Hatto experiences and classifying them into collision types using the collision diagram, appropriate road safety measures should be proposed to reduce traffic accident risks. Road safety measures are of various types, from early warning measures, such as installing road signs and markings, to extensive and costly measures, such as improving road structures, installing traffic lights, and installing under/overpasses.

This study summarized the expected road safety measures based on the collision diagram (Fig. 9). This diagram systematically summarizes a collision diagram to identify each road accident risk factor and explains which road safety measures need to be implemented for each one. Particularly, based on the collision diagram summarized by the analysis of the types of Hiyari-Hatto experiences, it is feasible to classify the eight road sections (black spots), including the U-turn section, junction, median, and entrance to roadside facilities. Additionally, we suggested six road safety measures for these black spots; Fig. 9 summarizes which of the measures are effective against the black spots.

In order to propose appropriate road safety measures using the collision type classification table, this section describes the procedure of selecting the road safety measures for the U-turn section on a typical rural highway with no access control as the example.

In Suphanburi, many Hiyari-Hatto experiences and traffic accidents occurred at the road section near the U-turn sections. According to the Hiyari-Hatto experiences and traffic accidents, the causes of the road accidents that occurred in the U-turn sections are as follows (Fig. 10

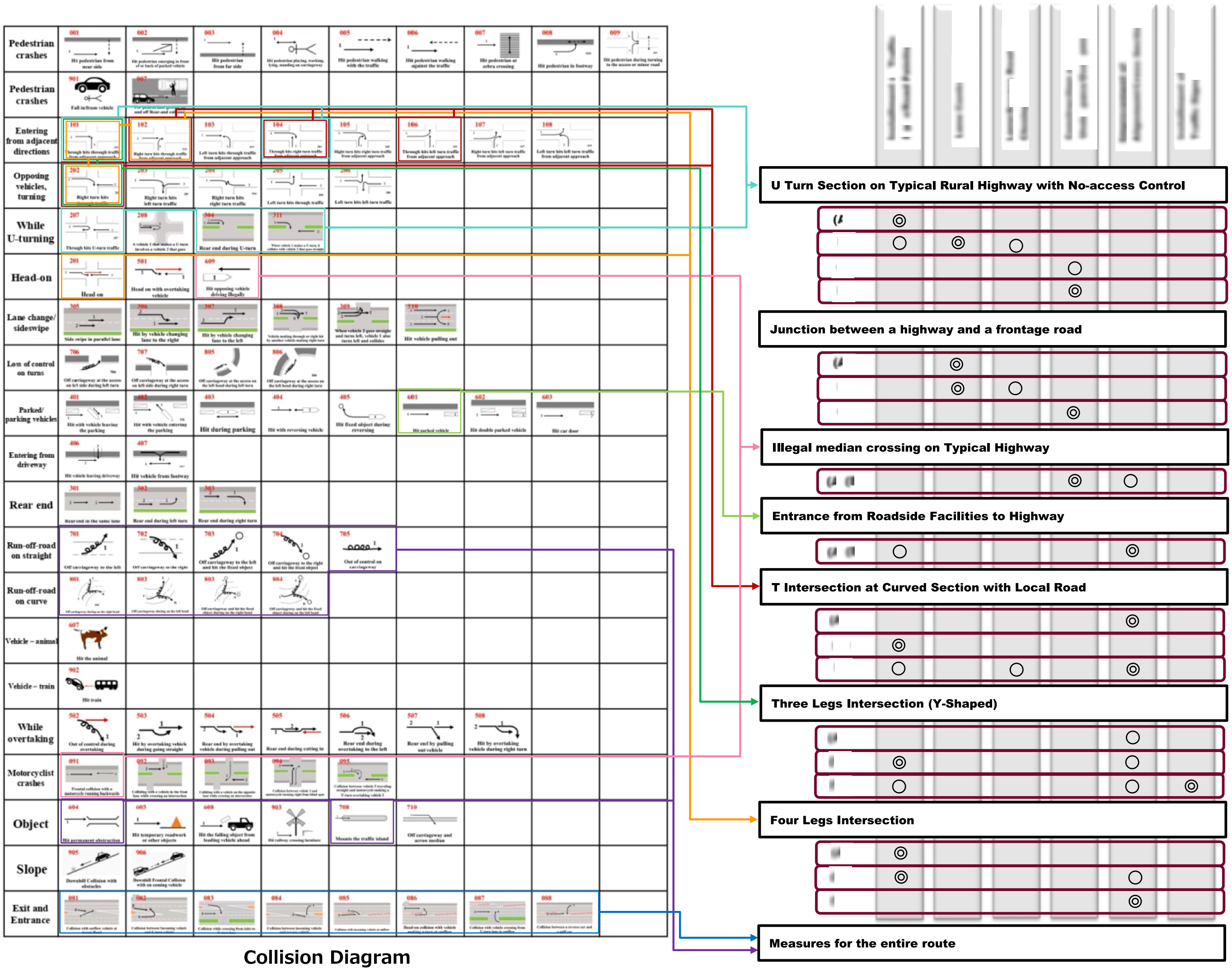


Fig. 9. Collision type classification table for checking the types of traffic accidents and selecting appropriate road safety measures.

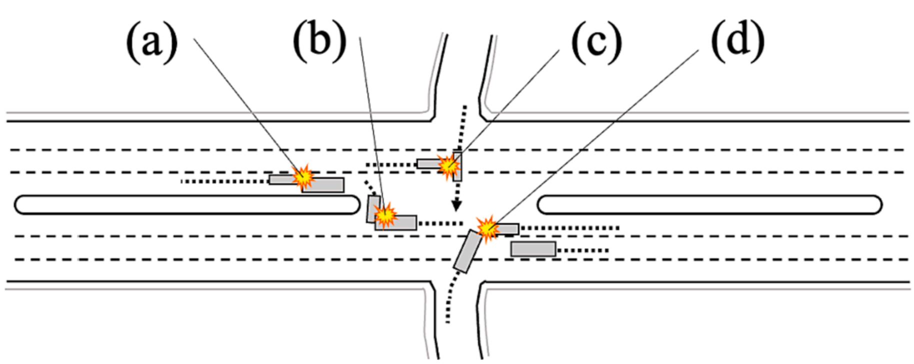


Fig. 10. Main causes of traffic accidents at U-turn sections (International Association of Traffic and Safety Sciences, 2019).

shows the location relation) (International Association of Traffic and Safety Sciences, 2019).

a) A rear-end collision occurs with a car coming at high speed from behind because the U-turn lane is located in the passing lane.
b) A collision accident at the U-turn section can also occur by a car coming from the opposite lane.
c) There is a risk that the cars entering the community road from the U-turn lane or crossing the highway using the U-turn can collide with others because the community road is connected to the U-turn section.
d) Multiple cars or motorcycles may enter the blind spot, resulting in unexpected collisions in a U-turn or crossing.

Based on the collision type classification table, this study selected the appropriate road safety measures at the U-turn sections as described in Table 1 ((A), (B), (C), and (D)). Each road safety measure is explained as follows.

a. Introduction of countermeasures via visual and physical alerts, such as rumble strips and road markings.
b. Laying a U-turn lane and/or coloring the pavement.
c. Close the U-turn lane if the traffic demand is not high.
d. Built an underpass or overpass and a frontage road to easily access this underpass or overpass if the traffic demand to cross this section is high.

3.4.4. Implementation of road safety measures

The implementation of the road safety measures proposed in the previous section is shown in Fig. 11. This is where the road safety measure (D) in Table 1 was implemented. It is a successful example of implementing the appropriate road safety measure by the proposed methodology. By utilizing the information sharing road safety measure, black spots can be shared among stakeholders, and the appropriate road traffic safety measures can be implemented early by analyzing them. These measures were implemented because each stakeholder was involved according to the utilization of the information sharing road safety measure, indicating that the measure is beneficial.

4. Conclusion

4.1. Discussions

This study introduces “information sharing road safety measures” based on a successful case in Kamagaya, Japan. The utilization of the “information sharing road traffic safety measure” was examined for its effectiveness in improving road safety and applied it to Suphanburi, Thailand, as a case study. Various studies indicate that the ineffectiveness of road safety measures in developing countries are the lack of cooperation and information sharing between the concerned agencies/stakeholders and poor data acquisition systems. This study clarified the implementation of road safety measures through collaboration with local authorities and the stakeholders as well as the community, particularly by using an engineering approach as the primary part of the “information sharing road traffic safety measure.”.

The findings of this study indicate that the “information sharing road traffic safety measure” method enhances the stakeholders from government sectors, academia, local citizens/residents/communities, and the private sector sharing road safety information based on their Hiyari-Hatto or near-miss experiences by identifying and clarifying particular problems at near-miss and black spots and selecting appropriate road safety measures to suit the local circumstances of the targeted areas.

Particularly, the proposed method of “information sharing road traffic safety measure” is useful in developing a system for acquiring and analyzing data regarding road safety measures. Data collection/acquisition via the Hiyari-Hatto method can be helpful to any developing country where there are inefficient and insufficient road traffic accident data. An application such as the ATRANS Safety Map is effective for acquiring Hiyari-Hatto data. The collaboration of each stakeholder enabled organizing successful workshops that enhanced data development and analysis in identifying the risk/near-miss spots and black spots and found appropriate road safety measures for treatments.

In the study area of Suphanburi, the different government agencies, such as the Department of Highways (DOH), Department of Rural Roads (DRR), Department of Land Transport (DLT), police, and city hall, are closely linked. This helps establish a cooperation between community residents and academia/road safety experts. The utilization of the “information sharing road safety measure” implicates local administrations to collect road accident information together with local citizens/experts/academia/engineers, identify the near-miss spots and the black spots, and implement appropriate road safety measures that suit their local contexts. This implies that this method/approach can be applied in other developing countries and may contribute to reducing traffic accidents in the countries with problematic collaborations among stakeholders.

4.2. Limitations and further studies

This study has the following limitations.

1) Lacking collaboration among stakeholders at an early stage.
2) Difficulty developing systems for acquiring data such as road traffic accidents and Hiyari-Hatto.
3) Delay in Actual implementation of road safety measures at the road sections caused by different road administrators.
4) Privacy issues in terms of personal information and how much information can be shared among stakeholders.

Hence, further studies are required to alleviate these limitations. Particularly, information on road accidents is so sensitive; establishing a single institution dealing with the sharing of this information with numerous stakeholders will help promote the “information sharing road safety measure” to entail optimal road accident countermeasures in developing countries effectively.

Despite the aforementioned limitations, utilizing the “information

Table 1
Appropriate road safety measures for the accidents at U-turn sections.

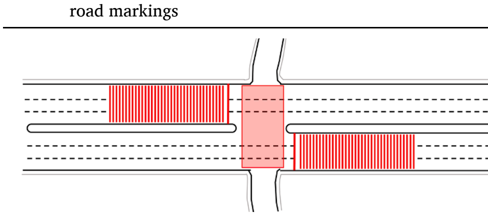
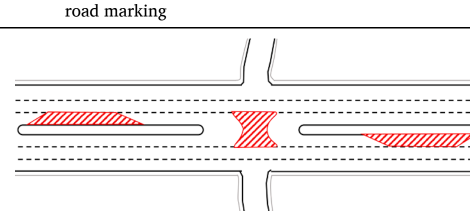
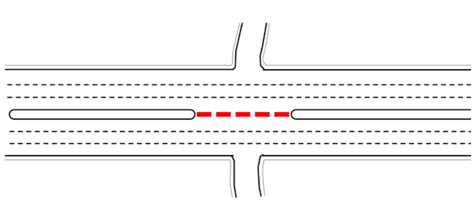
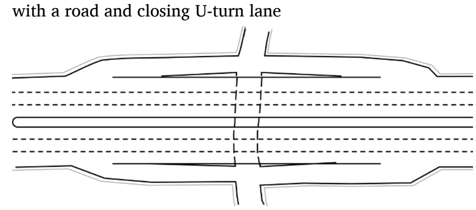
(A) Laying rumble strips and road markings	(B) Laying U-turn lane and road marking
	
(C) Closing U-turn section	(D) Laying a frontage road paralleled with a road and closing U-turn lane
	

Fig. 11. Implementation of the road safety measure (D) in Suphanburi.

sharing road safety measure" in Suphanburi may be considered a successful case study. The proposed method has been extensively used in the project on improving traffic safety measures for the capacity development and implementation of the Road Traffic Safety Agency in Thailand, the technical cooperation project of the Japan International Cooperation Agency (JICA).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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