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Comparative study on foreign drivers' characteristics using traffic violation and accident statistics in Japan

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ABSTRACT

Recently the number of foreign drivers has been rapidly increasing. Hence, the driving safety measures for foreign drivers have become more essential. This study aims to identify the characteristics of foreign drivers through analyzing traffic violation and traffic accident data in Japan. Chi-square test of independence and specialization coefficient were applied, in order to understand the specific violations and accidents with high tendency with respect to the region the foreign driver hails from. Also, multi-regression analysis was utilized to reveal the relationships between traffic violations and accidents. As a result, it was revealed that sense of priority, speed, and comprehension of rules affect traffic violations. Asian drivers tend to violate the rules related to priority in the road space, while North and South Americans violate rules related to speed, and South East Asian drivers violate rules related to priority and comprehension of traffic rules and road signs. Asian drivers tend to cause crossing collision while on the other hand North and South Americans are prone to head-on collision and rear-end collision. It was concluded that driving safety measures based on drivers' characteristics with respect to region were effective. This study seeks to contribute to the improvement of traffic safety for foreigners in Japan.

1. Introduction

Currently in the midst of an inbound tourism boom, Japan welcomed a record breaking 20 million foreign tourists in 2015, nearly four times as many as when the "Visit Japan" campaign was launched in 2003. The lowered currency rate, more low-cost flight offerings and eased visa regulations, along with an increase in individual disposable incomes in emerging economies around Asia have all contributed to this stunning development. Today, over 50% of foreign visitors to Japan are "repeaters visitors", while one quarter of the visitors have been to Japan four or more times. These "repeaters visitors" have a higher tendency to drive cars by themselves and explore more destinations than they did before. In 2015, the number of cars rented out to foreigners in Hokkaido and Okinawa increased by about 1.7 times as compared to that in 2014. It is also speculated that other famous sightseeing areas had a similar increase, although there is no numerical data. Basing on this information, we speculate that the rise in the number of foreigners visiting Japan increases the probability of them getting involved in traffic accidents. In addition, according to driver's license statistics by NPA, the number of foreigners holding Japanese driver's licenses in 2015 was approximately 800,000. This figure is 1.2 times that recorded in 2006 and also accounts for 1% of all Japanese driver's license holders. It is therefore becoming more essential for Japan to devise measures for the safety of foreign drivers as more are expected to visit the country.

1.1. License issues

With respect to driving licenses, temporary visitors need an international driver's license conforming to the Geneva Convention. But as of 2016, foreigners with driving licenses from Switzerland, Germany, France, Belgium, Slovenia, Monaco and Taiwan are allowed to drive in Japan. On the other hand, long term visitors and residents need a Japanese driver's license. There are two ways to obtain it, one is to take the standard Japanese driving exam, and the other is to switch a driver's license issued by a foreign administrative authority to a Japanese one. The former is similar to how Japanese ordinarily obtain driving licenses. In the latter, foreigners' knowledge of traffic rules and driving skills are checked.

As stated above, foreign drivers in Japan, except for the ones with a Japanese driver's license obtained through typical exams can drive without any prior instructions about Japanese traffic rules. That means driving behaviors of foreign drivers in Japan strongly depends on traffic culture such as the driver's license acquisition system, traffic rules, and habitual driving behavior in their countries. For example, people require

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13-hour instructions in total to get a driver's license in South Korea. The time required in South Korea is approximately a quarter of that in Japan. The time in Taiwan, on the other hand, is almost the same as that in Japan. However, some residents in Taiwan told the authors that driving schools in Taiwan seldom provide all the lectures and instructions, and the quality of the education is insufficient. This implies that traffic education standards can cause differences in the understanding of safe driving.

Various sectors related to traffic and safety are working towards ensuring the safety of foreign drivers in Japan. For example, in order for foreigners to obtain a Japanese driver's license, some local police stations provide the written test in foreign languages. Some driving schools have also started offering driving instructions in English. Rent-a-car associations and companies also provide information about driving safely in Japan to foreigners that they rent cars. MLIT has also standardized road signs to meet international specifications so that foreigners can easily understand them. Many more countermeasures have already been implemented, but most tend to focus mainly on language rather than the drivers' characteristics. Aspects like differences in driving habits, traffic regulations, attitude, etc. should also be considered if safety for foreign drivers is to be wholly achieved.

1.2. Literature review

The effects of social and cultural aspects on road safety parameters are widely examined via macroscopic cross-national analysis. Kopits et al. [1] examined the relationship between traffic fatality risk and per capita income, and used it to forecast traffic fatalities by geographic region. Paulozzi et al. [2] also analyzed the relationships between a country's stage of economic development and its motor vehicle crash fatality rate. These studies reveal that traffic safety depends on a country's economic situation. Moreover, Gaygisiz [3] investigated the relationship between governance quality, cultural dimensions and road traffic fatality rates with a sample space of 46 countries and concluded that both governance quality and cultural dimensions have an impact on traffic fatalities. Melinder [4] compared two periods (1989–1991 and 1997–1999) in order to understand the relationship between different socio-cultural factors, regulations related to traffic safety, and fatal traffic deaths. This study concluded that the type of religion and wealth of the country seem to be the most important factors affecting traffic accident forms and occurrence. These studies indicate that traffic safety varies from country to country because of differences in the social and cultural environment.

Recent studies show that drivers' characteristics are influenced by their respective societies and attitudes. Fruhen et al. [5] found that attitude and perception of the social norm impacted the drivers' aggressive behavior towards cyclists. Chung et al. [6] identified that the drivers' socio-demographic factors, e.g., gender, marital status, age, etc. also have an influence on the habitual driving style. Stanojevic et al. [7] discussed that the lack of enforcement encourages illegal driving behavior such as poor attitude towards speeding, wearing seat belts and drunk driving that breed riskier situations. Lheureux et al. [8] concluded that intention and habit are distinct and direct determinants of offenses, e.g., speeding and drunk driving. Yoshida et al. [9] reviewed the transition of the traffic safety situation in Japan and found that there is a relationship between the characteristics of traffic accidents involving young people and their perception of safety and travel mode. These studies demonstrate that drivers' characteristics, traffic accident occurrence and tendency to violate traffic regulations are influenced not only by an individual's cognition but also by the social and cultural environment.

Bone and Mowen [10] identified a set of personality traits predictive of aggressive and distracted driving propensity as a hierarchical model framework. This study revealed four hierarchies i.e. elemental, compound, situational, and surface traits affecting driving propensity. Elemental traits arise from genetics and early learning history while compound traits result from culture, sub-culture, the learning history of the individual. Cestec et al. [11]. examined the social influence of cultural values and random breath tests on drunk driving in 15 countries. The results confirmed the social influence of drunk driving and how it strongly differs from country to country. All these studies show the influence of social and cultural factors on driving behavior and habits.

Few studies focused on road safety issues of foreign and native drivers in the same country. Yannis et al. [12] investigated the relative accident fault risk distribution among different driver nationality categories in Greece. As a result, they revealed that the most significant effect on accident risk arises from the presence of foreign drivers at junctions. It was also found that immigrants and permanent residents appear to have a lower risk compared to tourists, regardless of the road environment.

1.3. The objectives

For this study, Fig. 1 shows the viewpoint from where the foreign drivers' characteristics are perceived. Doi et al. [13] classified the state of safety into two categories: functionally safe and inherently safe. Functionally safe is the state in which either the probability of accident occurrence or the magnitude of harm/damage is reduced through Enforcement and Engineering of the traditional 3 E's. While inherently safe corresponds to the state in which hazards are removed at the source, e.g., respecting priority leads to little or no chance of collision. Another explanation is that the driver can be helped to restrain or control hazardous energy/speed, e.g., maintain driving at an appropriate speed. Education, sophistication and promotion are crucial because inherent safety is realized by drivers' behaviors. However, both priority and speed are habitual factors formed in the respective drivers' country because of the differences in the driver's license systems, traffic rules, etc. In addition to these two factors, the correct comprehension of traffic rules and road signs is the key factor to reduce traffic accidents, particularly for foreign drivers. Thus, the PSC (Priority, Speed and Comprehension) concept is used as a basis to understand the differences of foreign drivers' characteristics in this study.

This study aims to find the characteristics of foreign drivers using the information available, albeit minimum. Thus, this study's importance is to find the facts related to the characteristics of foreign drivers. Takubo [14] stated that the analysis using traffic accident statistics data may help to understand the actual situation although this can't reveal the detailed causal relations. Therefore, this study is a baseline to suggest countermeasures for the safety of foreign drivers and perhaps more specialized studies related to foreign drivers.

2. Methods

2.1. Summary of the data used in this study

Recently the National Police Agency (NPA) in Japan has taken interest in the safety of foreign drivers, and thus started to include the information of drivers' nationality to statistics of traffic violations and accidents. The data used in this study is the number of the traffic violations and accidents reported by the local police agency in Japan. This data includes nationality but not gender, age, license type and so on. Furthermore, the comparison of the risk by nationality is difficult because of the limited data. For example, finding the exact number of foreigners may not be possible because international driver's licenses are issued in their home countries. This explains why this study centers on the analysis of the characteristics of traffic violations and accidents caused by foreign drivers in Japan.

The information availed by NPA is of the following countries: Korea (KOR), China (CHN), Taiwan (TPE), Philippines (PHI), Vietnam (VIE), Thailand (THA), Brazil (BRA), Peru (PER), United States (USA), Japan (JPN) and the other nationalities (Others). It should be noted that the data with reference to Taiwan is separate from that of China, but that

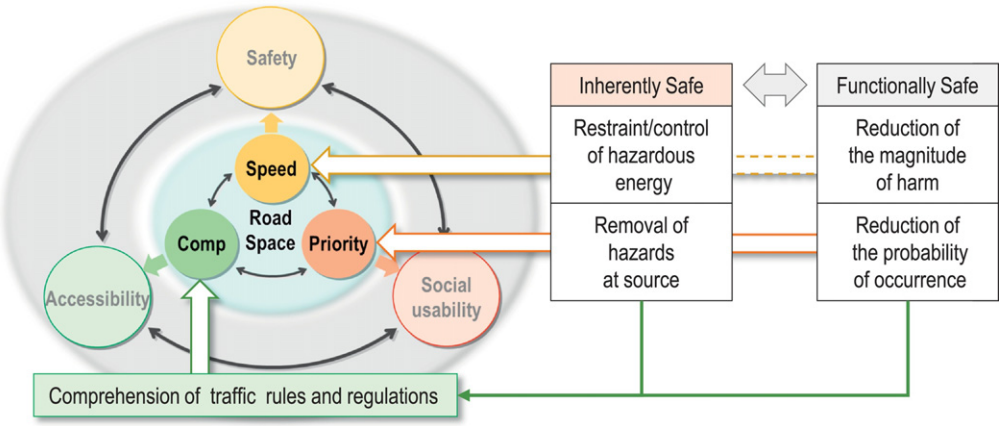

Fig. 1. PSC concept to understand foreign drivers' characteristics.

of Hong Kong is not. The traffic violation data from 2013 to 2015 and the accident data from 2011 to 2015 are also utilized in this study. NPA classifies the traffic accidents into 3 major categories: "vehicle-pedestrian," "vehicle-vehicle" and "vehicle alone" accident and the traffic violations into 17 categories as following the index in the Fig. 2. The data of violations in this study is recorded by police officers who generally note the most serious of the violations. But also depending on the situation, violations e.g. "Drunk driving," "no seatbelt," etc. are additionally recorded.

Fig. 2 shows the composition of various traffic violations, and it also clear to see that there are significant differences in the occurrence of these violations. These differences are attributed to the level of law enforcement. For example, offenses like "no seat belt," "no stopping or standing," and "traffic light violations" are more rampant because the police seems to be more lenient towards these offenses.

The PSC classification of traffic violations are shown in Table 1. Violations of "drunk driving" and "speeding" are categorized into the same violation-group based on the results of principal component analysis in which these two violations largely contribute to the identical "risk-taking" component. The summations of these respective categories are carried out per country, and the ratio of the violation classified into "Priority," "Speed" and "Comprehension as shown in Fig. 3. The diagonal lines running from top left to bottom right represent the ratio of priority-related violation, these increase downwards from 20% to 70%. While the diagonal lines running from bottom left to top right represent the ratio of speed-related violation, the ratios increase rightwards from 10% to 60%. Finally the horizontal lines represent the ratio of speed-related violation, and these increase upwards from 20% to 70%. From the purple eclipse in this Fig. 3, the ratio of the priority-related violation is almost the same as that of Japan for most of the foreign countries except the United States and the "other" nationalities. In terms of the difference in the type of traffic violation, the composition ratios of the speed-related and the comprehension-related violation are remarkable. Therefore, using the 40% Priority line as a baseline, we can deduce that bottom-right position means speed-related violation is more problematic than comprehension-related violation, and the converse is true for top-left position. From Fig. 3 it is shown that the composition ratio of speed-related violation among the Japanese and Brazilian drivers is high, while the composition ratio of the comprehension-related violation among the Vietnamese drivers is high.

On the other hand, Table 2. shows the composition ratio by types of traffic accident: "vehicle-pedestrian," "vehicle-vehicle" and "vehicle alone". The "vehicle-vehicle accidents" account for >80% of the total accidents throughout all the nationalities. Details of "vehicle-vehicle accident" are further illustrated in Table 3, which shows that "rear-end collision," "crossing collision" and "collisions while making a right-left turn" are the three outstanding "vehicle-vehicle accidents" from the viewpoint of the composition ratio.

2.2. Methods

2.2.1. Analysis of the relationship between nationalities and traffic violations

Two chi-square tests of independence are applied to determine whether nationality is related to the ratio of traffic violation. One is applied for the data of Japanese and foreigners and the other is conducted on the data of East Asians, South-East Asians and North/South Americans. The hypotheses are stated as follows:

H_0. Nationality and ratio of traffic violation are independent.

H_a. Nationality and ratio of traffic violation are not independent.

2.2.2. Analysis of the specific violations and accidents with high tendency by nationality

The traffic violation and accident data related to foreign drivers is very small as compared to that of Japanese drivers. Therefore, comparing the characteristic of each nationality, using a simple method is difficult. Thus, the specialization coefficients are applied to this analysis as indicators of the tendency of the specific traffic violation and accident with respect to each nationality. The specialization coefficients originally measure the degree to which a regional economic system specializes in one or more economic sectors compared to the national economy (Abe and Nogata [15]). In order to specialize the tendency of each representative driver, we suggested four specialization coefficients: Specialization tendency of traffic violation of each representative driver in comparison to Japanese drivers (VSCJ), specialization tendency of traffic violation in comparison to all foreign drivers in Japan (VSCF), specialization tendency of traffic accidents of each representative driver in comparison to Japanese drivers (ASCJ), and specialization tendency of traffic accidents of each representative driver in comparison to all foreign drivers are shown as Eqs. (1), (2), (3) and (4).

$$VSCJ_{ij} = \log\left(VR_{ij}/VRJ_j\right) \quad (1)$$

$$VSCF_{ij} = \log\left(VR_{ij}/VRF_j\right) \quad (2)$$

$$ASCJ_{ik} = \log\left(AR_{ik}/ARJ_k\right) \quad (3)$$

$$ASCF_{ik} = \log\left(AR_{ik}/ARF_k\right) \quad (4)$$

where,

i: nationality, j: category of traffic violation, k: category of traffic accident,

VR_{ij} : proportion of violation j to all violations by drivers of nationality i,

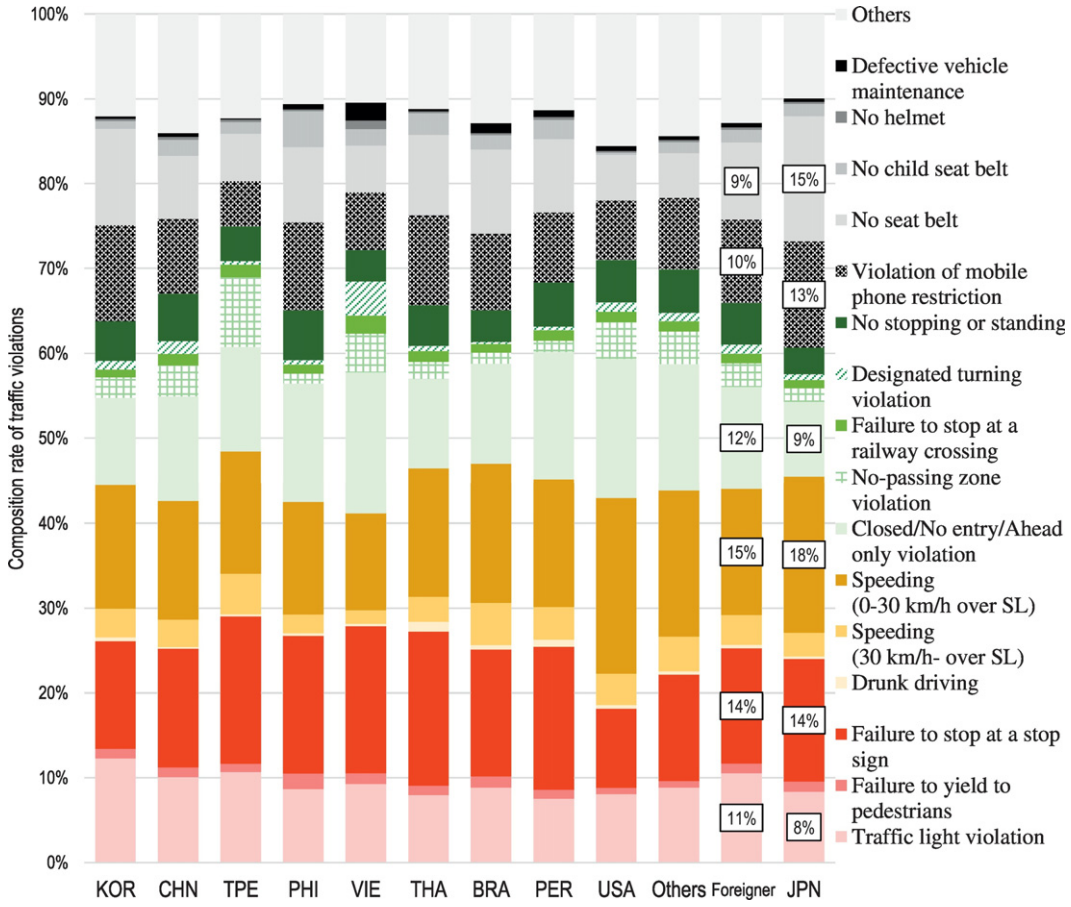

Fig. 2. Composition ratio in traffic violations.

VRJ_j : proportion of violation j to Japanese drivers,
VRF_j : proportion of violation j to all foreign drivers in Japan,
AR_{ik} : proportion of accident k by drivers of nationality i
ARJ_k : proportion of accident k to Japanese drivers, and
ARF_k : proportion of accident k to all foreign drivers in Japan.

When VSCJ is larger than zero, there is a stronger tendency among nationality i to cause violation j as compared to Japanese drivers. On the other hand, when VSCF is larger than zero, the tendency of nationality i causing violation j is stronger in this nationality than it is among other foreign drivers in Japan. In addition, when both VSCJ and VSCF of violation j is the largest, then the tendency of nationality i causing

Table 1
Classification of traffic violations.

P	Traffic light violation	**S**	Drunk driving
P	Failure to yield to pedestrians	**S**	Speeding (30 km/h–over SL)
P	Failure to stop at a stop sign	**S**	Speeding (0–30 km/h overSL)
C	Close/no entry/ ahead only violation	**O**	Violation of mobile phone restriction
C	No-passing zone violation	**O**	No seatbelt
C	Failure to stop at a rail crossing	**O**	No child seatbelt
C	Designated turning violation	**O**	No helmet
C	No stopping or standing	**O**	Defect of vehicle maintenance
		O	Others

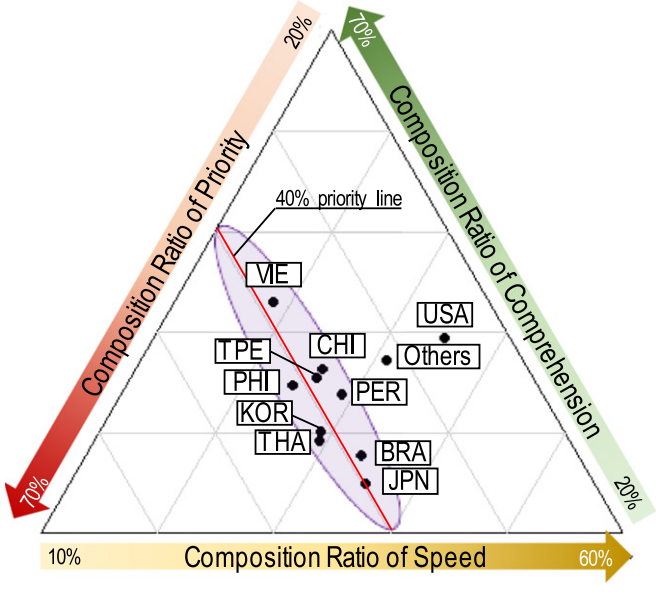

Fig. 3. Triangle diagram based on PSC.

Table 2
Composition ratio in traffic accidents.

	KOR	CHN	TPE	PHI	VIE	THA	BRA	PER	USA	Others	Foreigner	JPN
Vehicle-pedestrian	9.3%	6.5%	10.0%	5.9%	6.8%	8.1%	5.0%	3.2%	5.7%	6.3%	7.2%	9.1%
Vehicle-vehicle	87.4%	91.4%	88.0%	91.8%	91.6%	91.1%	88.2%	90.9%	92.6%	91.0%	89.4%	87.5%
Vehicle alone	3.2%	2.0%	2.0%	2.3%	1.6%	0.9%	6.8%	5.9%	1.7%	2.8%	3.4%	3.4%

violation *j* is the strongest among all nationalities. The same applies to ASCJ and ASCF. The specialization coefficient is a dimensionless relative value of the deviation of each nationality's proportion of violation and accident from the average and the benchmark.

2.2.3. Analysis of the relationship between traffic violations and accidents

Multi-regression analysis is applied to reveal the factors influencing a specific accident as common characteristics of foreign drivers by examining the relationship between specialization tendency of traffic violation and specialization tendencies of traffic accident using the VSCF and ASCF, except for those of Japanese. Because the number of the samples with respect to nationality is only 10, the number of explanatory variables used in this analysis should be <9. Therefore, the primary explanatory variables are selected as the following process:

1-a: Correlation analyses are applied to every pair of VSCF and ASCF.

1-b: The violations whose correlations to the accident are positive are selected.

1-c: No-helmet violations and the others are removed from the selected group in step 1-c.

In the abovementioned process, “no helmet” is excluded from the primary explanatory variables because the modal share of motorcycles is considerably small in Japan.

1-d: Correlation analyses are applied to every pair of VSCF.

1-e: One violation of the two proved to be related to each other with 5% level of significance eliminated from the group selected in 1-c to prevent multicollinearity in these analyses.

After the primary explanatory variables are selected, 2) the multi-regression models are selected using a step-wise method to minimize the Akaike's Information Criterion (AIC). Then, 3) when all the coefficients except for the constants are positive, the model is selected. Otherwise the explanatory variables whose coefficients are negative are removed from the primary explanatory variables and the same process is conducted. In this analysis, VSCFs are assumed to be distributed normally.

2.2.4. Procedure of the analysis

Fig. 4 shows the framework of this study. This study is composed of two types of data and three types of analyses. Firstly, analyses of the relationship between nationalities and traffic violation were conducted using the number of traffic violations. Secondly, specialization coefficients of both traffic violations and accidents were calculated. These coefficients identify the specialization tendency of each representative country in comparison with both Japanese drivers and all foreign drivers in Japan. Finally, the relationship between traffic violations and accidents was revealed based on the results from multi-regression analysis applied for VSCFs and ASCFs.

3. Results

3.1. Relationship between nationality and the ratio of violation

A chi-square test of independence was calculated comparing the ratio of traffic accidents caused by Japanese to those caused by foreigners (Table 4). A significant relation was found ($X^2 = 9427$, $p < 0.001$). Then H_0 was rejected and H_a was accepted. The results also statistically implied that Japanese drivers tend to violate the regulations related to priority and speed while foreign drivers violate those related to comprehension ($p < 0.01$). However, from the same view point, the difference of the ratio of the priority between Japanese drivers and foreign drivers is smaller than that of speed and comprehension.

Another chi-square test of independence was also calculated comparing the ratio of traffic accidents by East Asian, South East Asian and North and South American (Table 5). A significant relation was found (X-squared(4) = 6584, $p < 0.001$). Then H_0 was rejected and H_a was accepted. The results also implied that the violation tendencies related to priority, speed and comprehension were highest among the Asian drivers, North and South American drivers and South East Asian drivers respectively ($p < 0.01$).

3.2. Characteristics of traffic violations based on specialization coefficients

We calculated VSCJ and VSCF based on Eq. (1) and (2) and classified traffic violation by nationality depending on whether VSCJ and VSCF is larger than zero or not. Table 6 shows VSCJs, VSCFs and the result of the classification. The deeper red highlight (both VSCJ and VSCF > 0) indicates that the tendency of the violation is stronger in a given nationality as compared to Japanese drivers and all foreign drivers in Japan. The cell enclosed in a thick rectangle shows the country with the largest VSCF with respect to each violation.

There are no white and light red highlights in the row of “closed/no entry/ahead only” and “no stopping or standing,” which means all the VSCJs are larger than zero. Conversely, there are no yellow box and deep red box in the row of violations of “mobile phone restriction” and “no seat belt,” which means all the VSCJs are smaller than zero.

We can see from Table 6 that there are no VSCJ and VSCF larger than zero among drivers from East Asia. Korea represents the highest tendency of “drunk driving” and “traffic light” violations. Furthermore, violations of “mobile phone restriction” and “no seat belt” are strongest among the foreign drivers. All the violations related to comprehension are present among the Chinese drivers. Taiwanese drivers are mostly noted in violating the “no passing zone” restriction.

When it comes to South East Asian drivers, the VSCJ and VSCF of “failure to stop at stop signs” and “no child seat belt” is >0. Particularly, drivers from Thailand represent the strongest tendency of “failure to

Table 3
Composition ratio in vehicle-on-vehicle accidents.

	KOR	CHN	TPE	PHI	VIE	THA	BRA	PER	USA	Others	Foreigner	JPN
Head-on Collision	1.7%	1.9%	4.1%	2.4%	2.1%	3.5%	2.6%	3.4%	3.0%	3.5%	2.3%	2.6%
Rear-end Collision	35.6%	39.1%	30.3%	38.3%	37.7%	41.1%	49.9%	42.7%	51.5%	45.5%	40.9%	42.1%
Crossing Collision	30.4%	29.8%	38.5%	34.8%	31.7%	37.7%	27.7%	32.3%	17.1%	26.0%	29.1%	27.7%
Collision while overtaking	1.9%	1.9%	1.8%	1.0%	1.9%	2.8%	1.2%	1.3%	1.8%	1.6%	1.7%	1.6%
Collision while right or left turn	16.5%	15.8%	15.4%	13.7%	14.8%	7.9%	10.1%	9.0%	17.7%	13.5%	14.6%	15.0%
Others	13.9%	11.5%	10.0%	9.8%	11.8%	7.0%	8.6%	11.3%	8.9%	9.8%	11.4%	11.0%

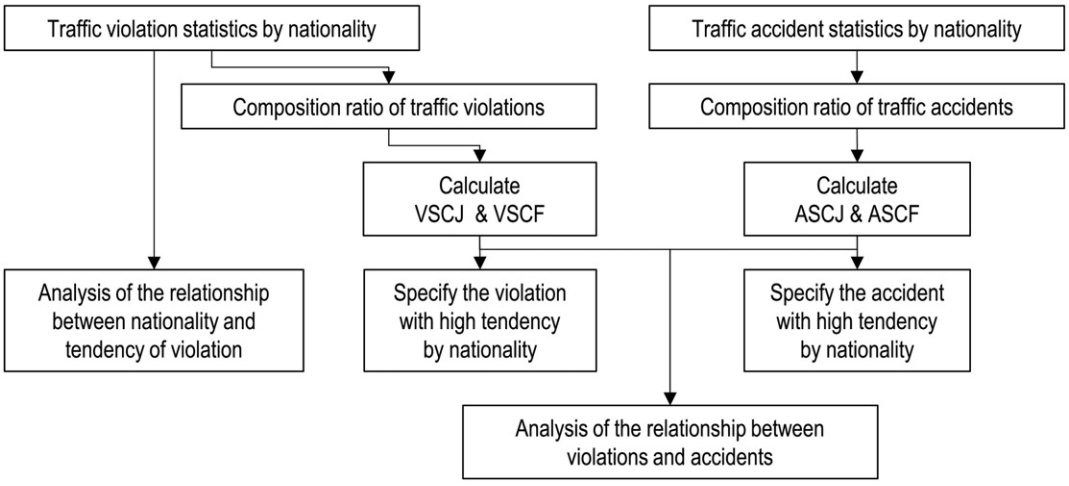

Fig. 4. Framework of the study.

stop at stop signs." Furthermore, Filipino and Vietnamese drivers represent the strongest tendency of "failure to yield to pedestrians." In addition to violations related to priority, those of comprehension are also remarkably high among South East Asian drivers. The VSCF and VSCJ of "no stopping or standing" among the Filipino drivers and that of "closed/no entry/ahead only," "failure to stop at a railway crossing," and "designated turning" among Vietnamese drivers are over zero.

Finally, with respect to North and South American drivers, the VSCJ and VSCF of "drunk driving" and "speeding (30 km/h ~ over SL)" are more than zero. The VSCF of "speeding (0–30 km/h over SL)" is also more than zero. Drivers from this region represent the strongest tendency of the violations related to speed. Particularly, Brazilian drivers represent the strongest tendency of "speeding (30 km/h ~ over SL)" while U.S. drivers commit "speeding (0–30 km/h over SL)" violations. In addition, all the violations related to comprehension by U.S. drivers are outstanding.

3.3. Characteristics of traffic accidents based on specialization coefficients

We calculated ASCJ and ASCF based on Eqs. (3) and (4) and classified traffic accidents by nationality depending on whether ASCJ and ASCF is larger than zero or not. Table 7 shows the result of the classification. The deep red highlight (both ASCJ and ASCF > 0) indicates that the tendency of a given nationality to cause an accident is higher compared to that among Japanese drivers and all foreign drivers in Japan. The cells enclosed in a thick rectangle symbolize the country with the largest ASCF.

The sub-total of the vehicle-vehicle ASCJ is greater than zero among all countries expect Korea. From Table 7, we can see that East Asian drivers are prone to cause accidents at intersections, while North and South Americans are prone to cause accidents that don't involve change in direction.

Table 4
Chi-square test of independence between Japanese and foreigner's violation tendency.

		Priority	Speed	Comprehension
Japan	Number of violation	6,126,357	5,484,118	3,860,562
	Ratio of violation	39.6%	35.4%	25.0%
	Adjusted residual	12.68**	69.53**	−91.00**
Foreigner	Number of violation	90,511	67,463	78,267
	Ratio of violation	38.3%	28.6%	33.1%
	Adjusted residual	−12.68**	−69.53**	91.00**

$X^2 = 9427.1$; df = 2; $\chi^2_2(0.001) = 13.82$.
** $p < 0.01$.
* $p < 0.05$.

Korean and Taiwanese drivers seem to have a higher tendency to harm pedestrians as compared to other foreign drivers. Brazilian and Peruvian drivers are prone to cause accidents that involve a single car.

3.4. Selection primary explanatory variables for multi-regression analysis

Table 8 shows the results of analysis between VSCFs and ASCFs, Japanese drivers' data is excluded. In this analysis, Pearson's correlation coefficient was used. The parts highlighted in Table 8 indicate a positive correlation between specific violation-and-accident pairs. The correlations between VSCF and ASCF were used to express the relationship between the trait of traffic violation and the trait of accident.

To select the primary explanatory variables for multi-regression analysis, first, the violations whose correlations to the accident are positive were selected for every accident type. "No helmet violation" and "others" were then removed from the selected group. Then, correlation analyses were applied to every pair of VSCF. Finally one violation of the two proved to be related to each other with 5% level of significance eliminated from the selected group to prevent multicollinearity in the multi-regression analyses. Table 9 shows the primary explanatory variables for multi-regression analysis through this process.

Table 5
Chi-square test of independence of the violation tendency among foreigners.

		Priority	Speed	Comprehension
East Asia	Number of violation	61,786	43,348	50,879
	Ratio of violation	39.6%	27.8%	32.6%
	Adjusted residual	6.66**	−7.57**	0.33
South East Asia	Number of violation	7178	4088	6534
	Ratio of violation	40.3%	23.0%	36.7%
	Adjusted residual	3.25**	−16.28**	12.25**
North and South America	Number of violation	12,758	11,406	10,551
	Ratio of violation	36.8%	32.9%	30.4%
	Adjusted residual	−10.20**	21.03**	−9.57**

$X^2 = 658.4$; df = 4; $\chi^2_4(0.001) = 18.47$.
** $p < 0.01$.
* $p < 0.05$.

Table 6
Specialization coefficients of traffic violations.

Top : *VSC**J*** Bottom : *VSC**F***	Nationality ***i***									
Traffic violation ***j***	East Asia			South East Asia			North and South America			
	KOR	CHN	TPE	PHI	VIE	THA	BRA	PER	USA	Others
Traffic light violation	0.39	0.19	0.25	0.04	0.11	-0.05	0.06	-0.10	-0.03	0.06
	0.15	-0.05	0.01	-0.19	-0.13	-0.28	-0.17	-0.34	-0.26	-0.18
Failure to yield to pedestrians	-0.05	-0.05	-0.23	0.41	0.03	-0.08	0.09	-0.13	-0.49	-0.42
	0.00	0.00	-0.18	0.46	0.08	-0.03	0.13	-0.08	-0.44	-0.37
Failure to stop at a stop sigh	-0.13	-0.03	0.18	0.11	0.18	0.23	0.03	0.15	-0.44	-0.14
	-0.07	0.03	0.25	0.18	0.24	0.29	0.10	0.22	-0.38	-0.08
Drunk driving	0.55	-0.29	0.01	0.21	-0.02	1.44	0.63	1.10	0.47	0.38
	0.16	-0.68	-0.39	-0.18	-0.42	1.04	0.24	0.71	0.08	0.01
Speeding (30 km/h–over SL)	0.19	0.15	0.53	-0.25	-0.56	0.05	0.58	0.32	0.27	0.37
	-0.04	-0.08	0.31	-0.47	-0.78	-0.18	0.35	0.10	0.04	0.15
Speeding (0–30 km/h over SL)	-0.23	-0.27	-0.25	-0.33	-0.48	-0.19	-0.12	-0.20	0.12	-0.07
	-0.02	-0.06	-0.04	-0.11	-0.27	0.02	0.09	0.01	0.33	0.15
Close/no entry/ahead only violation	0.15	0.34	0.34	0.46	0.64	0.18	0.30	0.54	0.62	0.53
	-0.16	0.03	0.03	0.15	0.33	-0.13	-0.01	0.22	0.31	0.22
No-passing zone violation	0.42	0.83	1.64	-0.29	1.05	0.25	-0.20	-0.16	1.00	0.89
	-0.14	0.27	1.08	-0.85	0.49	-0.31	-0.76	-0.73	0.44	0.33
Failure to stop at a railway crossing	-0.07	0.30	0.41	0.05	0.77	0.23	0.02	0.20	0.22	0.17
	-0.19	0.19	0.29	-0.07	0.65	0.11	-0.10	0.08	0.10	0.05
Designated turning violation	0.44	0.80	-0.49	-0.21	1.79	-0.07	-0.99	-0.47	0.50	0.42
	-0.05	0.31	-0.98	-0.70	1.30	-0.56	-1.48	-0.96	0.02	-0.07
No stopping or standing	0.40	0.58	0.27	0.63	0.17	0.43	0.17	0.51	0.47	0.49
	-0.05	0.14	-0.18	0.18	-0.28	-0.02	-0.28	0.06	0.02	0.04
Violation of mobile phone restriction	-0.10	-0.35	-0.85	-0.19	-0.61	-0.17	-0.33	-0.42	-0.58	-0.39
	0.14	-0.11	-0.61	0.05	-0.37	0.08	-0.08	-0.17	-0.34	-0.15
No seat belt	-0.27	-0.68	-0.97	-0.51	-0.98	-0.45	-0.40	-0.53	-1.01	-1.03
	0.22	-0.20	-0.48	-0.02	-0.50	0.04	0.09	-0.05	-0.52	-0.54
No child seatbelt	-0.45	0.25	-0.07	1.06	0.28	0.57	0.13	0.43	-1.76	-0.12
	-0.47	0.23	-0.09	1.04	0.26	0.55	0.11	0.41	-1.78	-0.14
No helmet	0.14	0.44	0.21	-0.12	1.53	-0.25	0.01	0.42	-0.01	0.15
	-0.13	0.17	-0.06	-0.39	1.26	-0.52	-0.26	0.15	-0.29	-0.12
Defect of vehicle maintenance	-0.36	0.08	-1.09	0.43	1.64	-0.27	1.07	0.70	0.31	0.14
	-0.59	-0.15	-1.31	0.20	1.42	-0.49	0.84	0.47	0.09	-0.08
Others	0.19	0.34	0.21	0.07	0.05	0.12	0.26	0.13	0.45	0.37
	-0.06	0.09	-0.04	-0.19	-0.21	-0.14	0.00	-0.13	0.19	0.11

:*VSC**J*** >0 & *VSC**F*** <0; :*VSC**J*** <0 & *VSC**F*** >0 ; :*VSC**J*** >0 & *VSC**F*** >0 ; : VSCF is the largest number of the row

Table 7
Specialization coefficients of traffic accidents.

Top : *ASC **J*** Bottom : *ASC **F***		Nationality ***i***									
Traffic accident ***j***		East Asia			South-east Asia			North and South America			
		KOR	CHN	TPE	PHI	VIE	THA	BRA	PER	USA	Others
Vehicle – pedestrian		0.03	-0.33	0.09	-0.44	-0.30	-0.12	-0.60	-1.04	-0.47	-0.37
		0.27	-0.09	0.33	-0.20	-0.06	0.12	-0.36	-0.81	-0.23	-0.13
Vehicle - vehicle	Head-on collision	-0.42	-0.26	0.47	-0.04	-0.13	0.35	0.01	0.33	0.20	0.36
		-0.32	-0.16	0.57	0.06	-0.03	0.45	0.11	0.43	0.30	0.46
	Rear-end collision	-0.17	-0.03	-0.32	-0.05	-0.07	0.02	0.18	0.05	0.26	0.12
		-0.16	-0.02	-0.31	-0.04	-0.06	0.02	0.18	0.06	0.27	0.12
	Crossing collision	0.09	0.12	0.33	0.28	0.18	0.35	0.01	0.19	-0.43	-0.02
		0.02	0.05	0.26	0.20	0.11	0.28	-0.06	0.12	-0.50	-0.09
	Collision while overtaking	0.16	0.20	0.13	-0.41	0.24	0.62	-0.28	-0.17	0.18	0.06
		0.09	0.13	0.06	-0.49	0.17	0.54	-0.35	-0.24	0.10	-0.02
	Collision while right or left turn	0.09	0.10	0.03	-0.04	0.03	-0.60	-0.39	-0.48	0.22	-0.07
		0.10	0.10	0.04	-0.04	0.03	-0.60	-0.39	-0.47	0.23	-0.06
	Others	0.24	0.09	-0.09	-0.06	0.12	-0.41	-0.24	0.07	-0.15	-0.07
		0.17	0.02	-0.15	-0.13	0.06	-0.48	-0.30	0.00	-0.22	-0.13
	Sub-total	-0.00	0.04	0.01	0.05	0.05	0.04	0.01	0.04	0.06	0.04
		-0.02	0.02	-0.02	0.03	0.02	0.02	-0.01	0.02	0.04	0.02
Vehicle alone		-0.06	-0.53	-0.54	-0.39	-0.76	-1.38	0.69	0.54	-0.72	-0.22
		-0.05	-0.52	-0.54	-0.39	-0.76	-1.37	0.69	0.54	-0.72	-0.21

:*ASC**J*** >0 & *ASC**F*** <0 ; :*ASC**J*** <0 & *ASC**F*** >0 ; :*ASC**J*** >0 & *ASC**F*** >0 ; : ASCF is the largest number of the row

Table 8
Results of correlation analyses are applied to every pair of VSCF and ASCF.

Violation \ Accident	Vehicle - pedestrian	Vehicle – vehicle							Vehicle alone
		Head-on collision	Rear-end collision	Crossing collision	Collision while overtaking	Collision while right or left turn	Others	Sub total	
Traffic light violation	0.72*	-0.56	-0.69*	0.16	0.12	0.56	0.56	-0.66*	0.01
Failure to yield to pedestrians	-0.05	-0.49	-0.28	0.57	-0.45	-0.21	0.10	-0.09	0.14
Failure to stop at a stop sigh	0.04	0.18	-0.53	0.93**	0.00	-0.59	-0.12	-0.17	-0.06
Drunk driving	-0.29	0.39	0.34	0.08	0.17	-0.80**	-0.50	-0.04	0.06
Speeding (30 km/h–over SL)	-0.09	0.42	0.14	-0.25	-0.15	-0.17	-0.27	-0.52	0.48
Speeding (0–30 km/h over SL)	-0.21	0.40	0.66*	-0.76*	0.01	0.03	-0.43	0.08	0.12
Close/ no entry/ ahead only violation	-0.51	0.23	0.39	-0.43	-0.26	0.31	0.18	0.67*	0.03
No-passing zone violation	0.58	0.19	-0.36	-0.15	0.53	0.61	0.16	-0.01	-0.48
Failure to stop at a railway crossing	0.13	0.14	-0.24	0.18	0.40	0.19	0.13	0.35	-0.46
Designated turning violation	0.25	-0.44	-0.06	-0.19	0.47	0.55	0.49	0.45	-0.50
No stopping or standing	-0.23	-0.01	0.14	-0.05	-0.15	0.10	0.09	0.50	-0.12
Violation of mobile phone restriction	-0.07	-0.47	0.20	0.12	-0.07	-0.34	-0.03	-0.04	0.10
No seat belt	-0.09	-0.42	-0.06	0.33	-0.20	-0.50	-0.01	-0.42	0.34
No child seatbelt	-0.12	-0.04	-0.34	0.85**	-0.25	-0.53	-0.04	-0.01	0.06
No helmet	-0.06	-0.29	-0.22	0.10	0.12	0.26	0.58	0.16	-0.03
Defect of vehicle maintenance	-0.62	-0.28	0.52	-0.22	-0.33	-0.14	0.13	0.39	0.30
Others	-0.02	0.11	0.48	-0.78**	0.09	0.42	-0.10	0.08	0.07

* : CC>0, significant at 1% level ** : CC>0, significant at 1% level : CC>0

3.5. Relationship between traffic violations and accidents

3.5.1. Accidents strongly related to priority

The results from the process shown in 2.2.3 imply that "vehicle-pedestrian" accidents, "crossing collision" and "collisions while making a right or left turn" are connected to violations related to priority. Table 10 shows the multi-regression model used to predict the violations with a high statistical relation to "vehicle–pedestrian" accidents. A significant regression equation was found ($F(2,7) = 5.61$, $p < 0.05$), with an R^2 of 0.506. The VSCF of "traffic light violations" significantly predicted ASCF of "vehicle–pedestrian" accidents ($t(7) = 2.265$, $p < 0.05$). Table 11 shows the multi-regression model used to predict the violations with a high statistical relation to "crossing collisions." A significant regression equation was found ($F(2,7) = 38.3$, $p < 0.01$), with an R^2 of 0.892. The VSCF of "traffic light violations" and "failure to stop at a stop sign" significantly predicted ASCF of "vehicle–pedestrian" accidents as shown by ($t(7) = 2.115$, $p < 0.10$) and ($t(7) = 8.629$, $p < 0.01$), respectively. Table 12 shows the multi-regression model used to predict the violations with a high statistical relation to "collisions while making a right or left turn." A significant regression equation was found ($F(4,5) = 8.85$, $p < 0.05$), with an R^2 of 0.778. The VSCF of "traffic light violations" and "close/no entry/ahead only" significantly predicted ASCF of "vehicle–pedestrian" accidents as shown by ($t(5) = 2.021$, $p < 0.01$) and ($t(5) = 4.396$, $p < 0.01$), respectively.

3.5.2. Accidents strongly related to speeding

The results from the process shown in 2.2.3 imply that "rear-end collisions" and "vehicle alone" accidents are connected to violations related to priority. Table 13 shows the multi-regression model used to predict the violations with a high statistical relation to "rear-end collisions." A significant regression equation was found ($F(4,5) = 24.93$, $p < 0.01$), with an R^2 of 0.914. The VSCF of more than "speeding (0–30 km/h over SL)" violations did significantly predict ASCF of "rear-end collisions" ($t(5) = 7.898$, $p < 0.01$) and also that of "defective vehicle maintenance" ($t(5) = 6.942$, $p < 0.01$). Table 14 shows the multi-regression model used to predict the violations with a high statistical relation to "vehicle alone accidents." A significant regression equation was found ($F(6,3) = 2.63$, ns), with an R^2 of 0.520. But the p-value was 0.229, and therefore, this model was not statistically significant. However, the VSCF of "speeding (30 km/h ~ over SL)" (Coefficient = 1.9, $t = 3.575$) showed a positive relationship to the ASCF of "rear-end collision."

3.5.3. Accidents strongly related to comprehension

The results from the process shown in 2.2.3 imply that "head-on collisions" and "collisions while overtaking" are connected to violations related to priority. Table 15 shows the multi-regression model used to predict the violations with a high statistical relation to "head-on collisions." A significant regression equation was found ($F(5,4) = 3.19$,

Table 9
Primary explanatory variables for multi regression analysis.

Vehicle - pedestrian	Vehicle –vehicle					Vehicle alone
	Head-on collision	Rear-end collision	Crossing collision	Collision while overtaking	Collision while right or left turn	
Traffic light violation	Failure to stop at a stop sigh	Drunk driving	Traffic light violation	Traffic light violation	Traffic light violation	Traffic light violation
Failure to stop at a stop sigh	Drunk driving	Speeding (0–30 km/h over SL)	Failure to yield to pedestrians	Drunk driving	Speeding (0–30 km/h over SL)	Drunk driving
No-passing zone violation	Speeding (30 km/h–over SL)	Close/no entry/ ahead only violation	Failure to stop at a stop sigh	Speeding (0–30 km/h over SL)	Close/no entry/ ahead only violation	Speeding (30 km/h–over SL)
Failure to stop at a railway crossing	Close/no entry/ ahead only violation	No stopping or standing	Drunk driving	No-passing zone violation	No-passing zone violation	Close/no entry/ ahead only violation
Designated turning violation	No-passing zone violation	Violation of mobile phone restriction	Failure to stop at a railway crossing	Failure to stop at a railway crossing	Failure to stop at a railway crossing	No child seatbelt
	Failure to stop at a railway crossing	Defect of vehicle maintenance	No seat belt	Designated turning violation	Designated turning violation	Defect of vehicle maintenance
					No stopping or standing	

: Violations related to priority : Violations related to speed : Violations related to comprehension : Other violations

ns), with an R^2 of 0.549. But the *p*-value was 0.142 and therefore this model was not statistically significant. However, the VSCF of "close/no entry/ahead only" (Coefficient = 1.035, $t = 2.339$), "drunk driving" (Coefficient = 0.359, $t = 2.220$) and "Speeding (30 km/h ~ over SL)" violation (Coefficient = 0.500, $t = 2.205$) showed positive relationships to the ASCF of "head-on collisions." Table 16 shows the multi-regression model used to predict the violations with a high statistical relation to "collisions while overtaking." A significant regression equation was found ($F(3,6) = 5.76$, $p < 0.05$), with an R^2 of 0.613. The VSCF of "no-passing zone" did significantly predict ASCF of "collisions while overtaking" ($t(6) = 2.791$, $p < 0.05$), that of "designated turning violations" ($t(6) = 1.953$, $p < 0.10$) and that of "drunk driving" ($t(6) = 3.066$, $p < 0.05$).

Based on the above-mentioned results of multi-regression analysis, Fig. 7 summarizes the notable causal relationships between traffic violations categorized by PSC and traffic accidents.

4. Conclusions

In this study, traffic violation and accident statistics were internationally compared to identify the characteristics of foreign drivers in Japan. The results show that tendencies to violate traffic rules and to cause traffic accidents are vary from region to region. Although most traffic violations and accidents cited from the foreign drivers' database are thought to be caused by residents rather than by short-term visitors. This, therefore, means that even if foreigners live in Japan, they still have their own region's or countries' characteristics when it comes to traffic violations and accidents.

In addition, Japanese highway design standards were influenced by U.S. standards and the other classes of roads were influenced by European standards, therefore Japanese roads are similar to those of other developed countries. However, there are two distinct characteristics of Japanese road. First is the loose land use control even along arterial roads, which is associated with demand for easy access to roadside facilities which reduce the design performance and often result in inefficient and unsafe traffic. Second is that the number of collector roads (roads connecting arterials and local roads) are not enough for hierarchical road system to perform effectively. However, it is assumed that these two distinct features do not impact on the characteristics of foreign drivers.

Comparing the Japanese drivers to foreign drivers, foreign drivers are prone to violate the traffic regulation related to comprehension.

Table 10
Multi-regression model result of "vehicle–pedestrian" accidents.

Traffic violation *j*		β	Std. Error	t-value	Pr(>|t|)
P	Traffic light violation	1.273	0.562*	2.265	0.058
C	No-passing zone violation	0.174	0.130	1.340	0.222
(Intercept)		0.069	0.107	0.642	0.541

Adjusted R^2: 0.506; F-statistic: 5.61; *p*-value: 0.035.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Table 11
Multi-regression model result of "crossing collisions".

Traffic violation *j*		β	Std. Error	*t*-value	Pr(>|t|)
P	Traffic light violation	0.354	0.167	2.115*	0.072
P	Failure to stop at a stop sigh	1.036	0.120	8.629***	0.000
(Intercept)		0.009	0.034	0.261	0.802

Adjusted R^2: 0.892; F-statistic: 38.3; *p*-value: 0.000.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Table 12
Multi-regression model result of "collisions while making a right or left turn".

	Traffic violation *j*	β	Std. Error	t-value	Pr(>|t|)
P	Traffic light violation	2.021	0.361	5.600***	0.003
S	Speeding (0–30 km/h over SL)	0.462	0.294	1.572	0.177
C	Closed/no entry/ahead only violation	1.274	0.290	4.396***	0.007
C	No stopping or standing	0.435	0.281	1.548	0.182
(Intercept)		0.070	0.063	1.102	0.321

Adjusted R^2: 0.778; F-statistic: 8.86; *p*-value: 0.017.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

This result implies that it is difficult for foreigners to comprehend Japanese traffic rules and road signs. Also, there are few opportunities for foreigners to understand the Japanese traffic situation, and language barriers largely account for this.

Foreign drivers tend to especially violate "close/no entry/ahead only" and "no stopping or standing" regulations more than Japanese drivers because all the VSCJ of "closed/no entry/ahead only" violations and "no stopping or standing" violations are larger than zero. This is probably because in Japan, "closed/no entry/ahead only" regulations are represented as road signs. It, therefore, implies that these road signs are difficult for foreign drivers to easily comprehend. The results also reveal that this violation was related to "head-on collisions." Therefore, easing the comprehension of "closed/no entry/ahead only" regulations can contribute to the reduction of "head-on collisions."

On the other hand, "no stopping or standing" violation is a consequence of the differences in habits and traffic regulations on parking. Most of the foreign countries do not have the law on garage registration, and this has led foreign drivers to habitually park, stop or stand on public roads. In proposing countermeasures, it is vital to comprehend the distinct differences between the traffic regulations and the habitual behavior of foreigners and Japanese.

With respect to the foreign drivers, there were notable differences among the East Asian, South East Asian and North and South American drivers. Asian drivers tend to violate the rules related to priority while North and South Americans do so for speed-related rules. In addition to this, the ratio of the violations related to comprehension by South East Asian drivers is higher than the other regions.

Korean drivers' tendency to "violate traffic lights" and "drunk driving" is more pronounced as compared with other foreign drivers and Japanese drivers. >80% of the Japanese driver's license holders with Korean nationality obtained the license by passing the general exam. This is because most of the Koreans have learned the Japanese rules as thoroughly as the Japanese themselves. In particular, the VSAF of "traffic light violations" by Korean drivers is the largest among the foreign drivers. From this fact, Korean drivers seem to neglect the implicit rules of priority in the road space. This conclusion is same as the result of IATSS Research Project H2760.

Table 13
Multi-regression model result of "rear-end collisions".

	Traffic violation *j*	β	Std. Error	t-value	Pr(>|t|)
S	Speeding (0–30 km/h over SL)	0.847	0.107	7.898***	0.001
C	No stopping or standing	0.141	0.120	1.171	0.294
O	Defective vehicle maintenance	0.159	0.023	6.942***	0.001
O	Violation of mobile phone restriction	0.091	0.080	1.142	0.305
(Intercept)		0.011	0.019	0.586	0.584

Adjusted R^2: 0.914; F-statistic: 24.93; *p*-value: 0.002.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Table 14
Multi-regression model result of "vehicle alone accidents".

	Traffic violation *j*	β	Std. Error	*t*-value	Pr(>|t|)
P	Traffic light violation	3.741	2.093	1.788	0.172
S	Drunk driving	0.568	0.510	1.114	0.347
S	Speeding (30 km/h over SL)	1.900	0.532	3.575**	0.037
C	Closed/no entry/ahead only violation	2.157	1.791	1.204	0.315
O	No child seatbelt	0.426	0.253	1.689	0.190
O	Defective vehicle maintenance	0.625	0.254	2.460*	0.091
(Intercept)		0.041	0.229	0.179	0.869

Adjusted R^2: 0.520; F-statistic: 2.63; *p*-value: 0.229.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

The number of Chinese drivers who have obtained Japanese driver's license as most Japanese do is >80% of the total. However, the analysis of VSCJ and VSCF reveals that Chinese drivers represent a higher ratio of all the violations related to comprehension as compared to Japanese drivers. It is therefore necessary for Chinese drivers in Japan to learn more about the Japanese traffic rules, road signs, etc.

It is also revealed that Taiwanese drivers' biggest traffic issues revolve around "traffic light violations," "failure to stop at atop sign," "closed/no entry/ahead only," "no passing" and "failure to stop at railway crossings" as compared to Japanese drivers. The result of high ratio of the violations related to priority and "no passing zone" also correspond with the results from IATSS Research Project H2760.

The number of tourists from East Asian countries who drive in Japan has increased greatly in recent years. Although the economic standards in Japan, Korea and Taiwan is almost the same, road users in Korea and Taiwan are not yet mature enough because the drivers from these two countries have problems concerning the implicit rule of priority in the road space. The results also implied that the violations related to priority can cause accidents at an intersection. Japan is expected to welcome many more tourists from Korea and Taiwan, and it is speculated that the probability of them causing fatal accidents at intersections will increase. Thus, the need to make Korean and Taiwan drivers recognize and understand the priority-related traffic rules and regulations is one of the most important countermeasures.

The ratio of the violations related to priority with respect to South East Asian drivers is as high as that of East Asian drivers. South East Asian drivers in comparison to Japanese and other foreign drivers seem to "fail to stop at a stop sign." Filipino drivers seem to have the highest tendency to "fail to yield to pedestrians," while Thai drivers "fail to stop at a stop sign." This explains the high ratio of "crossing accidents" among South East drivers. South East drivers also have problems when it comes to understanding Japanese traffic rules and road signs. East Asian people are most likely to neglect traffic rules, and this, therefore, causes the accidents.

Table 15
Multi-regression model result of "head-on collisions".

	Traffic Violation *j*	β	Std. Error	*t*-value	Pr(>|t|)
P	Failure to stop at a stop sigh	0.690	0.364	1.898	0.131
S	Drunk driving	0.359	0.162	2.220*	0.091
S	Speeding (30 km/h over SL)	0.500	0.227	2.205*	0.092
C	Closed/No entry/Ahead only violation	1.035	0.443	2.339*	0.080
C	No-passing zone violation	0.221	0.128	1.724	0.160
(Intercept)		0.047	0.084	0.556	0.608

Adjusted R^2: 0.549; F-statistic: 3.19; *p*-value: 0.142.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Table 16
Multi-regression model result of "collisions while overtaking".

Traffic Violation *j*		β	Std. Error	t-value	Pr(>|t|)
S	Drunk driving	0.443	0.144	3.066**	0.022
C	No-passing zone violation	0.333	0.119	2.791**	0.032
C	Designated turning violation	0.177	0.091	1.953*	0.099
(Intercept)		0.037	0.064	0.581	0.583

Adjusted R^2: 0.613; F-statistic: 5.76; *p*-value: 0.034.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

In most South East Asian countries, the motorcycle is the main form of transportation e.g. there are 2.15 million motorcycles, making up 42.6% of the transportation mode in the Philippines [16]. Motorcycle deaths also account for 34% of the total road traffic deaths in South East Asia as compared to the 23% of the world's total road traffic deaths [17]. Low perception of the priority in the road space and comprehension of the rules are indeed a problem in the societies that aspire to use motorcycles. This is so because motorcyclists chose faster speeds than the car drivers, overtook more, and pull into smaller gaps in traffic [18]. Recently, a higher number of East Asian people drive in Japan. Hence, it is vital for them to recognize the priority in road space usage in order to counteract the traffic problems identified.

The ratio of the violations related to speed is larger among drivers from North and South America. The results specifically imply that North and South American drivers represent a high tendency of "drunk driving" and "speeding (30 km/h ~ over SL)" in comparison with Japanese and foreign drivers. In addition to this, the ratio of "speeding (0–30 km/h over SL)" violations by U.S. drivers is the largest among all other nationals. The accidents caused by North and South American drivers are more likely to kill people. In fact, "head-on" and "rear-end" collisions are common among North and South American drivers. Furthermore, Brazilians and Peruvians are the only two nationals whose ratios of vehicle-alone accidents are higher than that of Japan. It seems that speeding causes driving recklessly and the inappropriate control of the vehicle, which leads to these types of accidents. Basing on this, it is important for this group of drivers to check their driving speeds and also learn to strictly follow speed limits.

It should also be noted that the results of this study are compared to the results of the interview survey for Korean and Taiwanese drivers from IATSS Research Project 1611A.The target area in this study was Hokkaido because of its famed high tourist numbers who usually rent a car to sightsee. In this survey, the opinion of the Koreans and Taiwanese were that Japanese stop signs are difficult to understand because they are different from international standards. They also said that the speed limit is unclear so they usually drove at the same speed as the surrounding vehicles without looking at the speedometer. This showed that Korean and Taiwan drivers' perception of speed is different from that of Japanese drivers. In addition, it was noted that the recognition of the signal was delayed due to the installation position of the signal and the arrangement of the lights. One of the Korean drivers said that in Korea, the length of the cycle time is longer than that in Japan, and because of this, he did not want to wait for the signal to turn green. This explains why some drivers enter the intersection the moment the signal turns red. As foreigners actually drive in Hokkaido, the problem of PSC became more noticeable. Signal disregard, a characteristic violation by Koreans and Taiwanese drivers in this study, is considered to be the main cause of these drivers' lack of speed consciousness and recognition of priority.

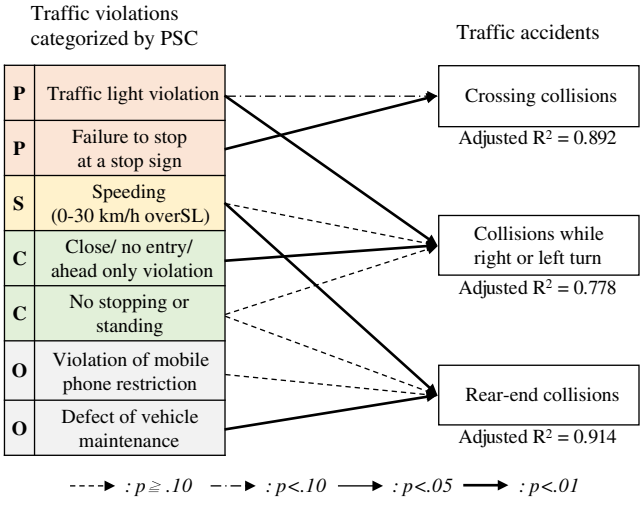

Fig. 7. Notable relationships between traffic violations and accidents.

As described above, the characteristics of each region were clarified comparing traffic violations and accidents of foreign drivers in this research. It is also indicated that sense of priority, speed and comprehension of rules affect the tendency of traffic violations. We can, therefore, conclude that the PSC concept is efficient to understand drivers' characteristics. Furthermore, relationships between traffic violations and accidents were revealed through multi-regression analysis. As a result, it is concluded that improvising safe driving measures based on drivers' characteristics with respect to region are effective.

This study identified the driving characteristic based on region, however superficial the result might be. Other sources such as probe-car and dash cameras can be utilized to attain more data for the purpose of comprehending these driver characteristics further.

The number of foreigners visiting Japan might continue to grow, and this will compel the responsible parties to quickly and effectively disseminate road safety information in many languages. Sense of priority and speed should also be emphasized as important aspects of road safety.

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References

[1] E. Kopits, M. Cropper, Traffic fatalities and economic growth, Accid. Anal. Prev. 37 (2005) 169–178.
[2] L. Paulozzi, G. Ryan, V. Espitia-Hardeman, Y. Xi, Economic development's effect on road transport-related mortality among different types of road users: a cross-sectional international study, Accid. Anal. Prev. 39 (3) (2007) 606–617.
[3] E. Gaygısız, Cultural values and governance quality as correlates of road traffic fatalities: a national level analysis, Accid. Anal. Prev. 42 (6) (2010) 1894–1901.
[4] K. Melinder, Socio-cultural characteristics of high versus low risk societies regarding road traffic, Saf. Sci. 45 (2007) 397–414.
[5] L. Fruhen, R. Flin, Car driver attitudes, perceptions of social norms and aggressive driving behavior towards cyclists, Accid. Anal. Prev. 83 (2015) 162–170.
[6] Yi-Shih Chung, Jinn-Tsai Wong, Investigating driving styles and their connections to speeding and accident experience, J. East. Asia Soc. Transportation Stud. 8 (2010).
[7] P. Stanojevic, D. Jovanovic, T. Lajunen, Influence of traffic enforcement on the attitudes and behavior of drivers, Accid. Anal. Prev. 52 (2013) 29–38.
[8] F. Lheureux, L. Auzoult, C. Charlois, S. Hardy-Massard, J. Minary, Traffic offences: planned or habitual? Using the theory of planned behavior and habit strength to explain frequency and magnitude of speeding and driving under the influence of alcohol, Br. J. Psychol. 107 (2016) 52–71.
[9] S. Yoshida, S. Izumi, Relationship between Transition of Young people's Perception and Traffic Accidents, Takata Foundation Research AssistanceISSSN 2185-8950 2013 (in Japanese).
[10] S.A. Bone, J.C. Mowen, Identifying the traits of aggressive and distracted drivers: a hierarchical trait model approach, J. Consum. Behav. 5 (5) (2006) 454–464.
[11] J. Cestac, S. Kraïem, J.P. Assailly, Cultural values and random breath tests as moderators of the social influence on drunk driving in 15 countries, J. Saf. Res. 56 (2016) 89–96.
[12] G. Yannis, J. Golias, E. Papadimitriou, Accident risk of foreign drivers in various road environments, J. Saf. Res. 38 (4) (2007) 471–480.

[13] K. Doi, T. Sunagawa, H. Inoi, K. Yoh, Transitioning to safer streets thorough an integrated and inclusive design, IATSS Res. 39 (2) (2016) 87–94.
[14] N. Takubo, An analysis of traffic accident data for mental workload and human error by drivers, IATSS Rev. 30 (3) (2005) 299–308 (in Japanese).
[15] H. Abe, M. Nagato, An analysis of regional industrial differences using regional specialization indices, Proc. Infrastruct. Plan. 12 (1989) 135–142 (in Japanese).
[16] H.-C. Chin, Sustainable urban mobility in South-East Asia and the Pacific, unpublished regional study prepared for Global Report on Human Settlements, http://www.unhabitat.org/grhs/2013 2013.
[17] WHO, Global status report on road safety, http://www.who.int/violence_injury_prevention/road_safety_status/2015/en/ 2015.
[18] M.S. Horswill, S. Helman, A behavioral comparison between motorcyclists and a matched group of non-motorcycling car drivers: factors influencing accident risk, Accid. Anal. Prev. 35 (4) (2003) 589–597.