IATSS Research 46 (2022) 14–25

Contents lists available at ScienceDirect

IATSS Research

Research Article

A multi-country survey for collecting and analyzing facts related to road traffic safety: Legislation, enforcement, and education for safer drivers

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ARTICLE INFO

Article history:
Received 9 September 2021
Received in revised form 18 January 2022
Accepted 31 January 2022
Available online 4 February 2022

Keywords:
International comparison
Speed limit
Fine
Penalty point system
Enforcement
Driving license system

ABSTRACT

Road traffic safety is a crucial global objective. It is important for every country to review and improve road safety policies and strategies, based on an objective understanding of its own road traffic safety situation in the world. With the aim of contributing to such a review and understanding, this study conducted a multi-country survey to gather information about various facts related to legislation, enforcement, and education, which are designed to achieve safer drivers in nine countries, by using a common format. This paper introduces the results of the survey with a particular focus on legislation and enforcement regarding speed limit violations and red-light-running as well as on education within the driving licensing systems. It highlights variations, in terms of penalty settings and enforcement levels, in different countries; it also examines the training durations necessary for acquiring a driving license and license renewal procedures. In this way, it demonstrates the potential and significance of understanding the relative position of each country in terms of road traffic safety through an international comparison despite its limited information.

1. Introduction

Road traffic safety is one of the most crucial global objectives. In the United Nation (UN)'s Sustainable Development Goals (SDGs), Target 3.6 aims to "halve the number of global deaths and injuries from road traffic accidents" by 2020; this target is included under Goal 3 which seeks to ensure healthy lives and promote well-being for all at all ages [1]. However, according to the UN's progress summary [2], the number of road traffic deaths has continued to increase, reaching 1.35 million in 2016; thus, the world failed to meet the established target by the end of 2020. The reduction of road traffic deaths and injuries remains a major challenge worldwide. Furthermore, the World Health Organization (WHO) highlighted the fact that low- and middle-income countries had higher road traffic death rates than high-income countries in 2016; there were no reductions in the number of road traffic deaths in any low-income countries between 2013 and 2016 [3]. WHO observations suggest that there is a link between countries' socioeconomic status and road safety standing; this indicates that UN road safety targets cannot be met without the establishment and maintenance of internationally coordinated action plans and policies.

To achieve this global objective, each country has a responsibility of developing and implementing effective measures to reduce road traffic crashes. Accordingly, it is important to monitor road safety trends in each country and carry out international exchanges of such information and experiences. This will help countries to understand their road traffic

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Peer review under responsibility of International Association of Traffic and Safety Sciences.

https://doi.org/10.1016/j.iatssr.2022.01.004

safety in comparison to the rest of the world as they progressively review their policies and strategies to improve road safety. The number of road traffic deaths and some of their related factors are usually reported and compared country-wise in the WHO [3] and the International Transport Forum (ITF) [4]. Along with direct road safety indicators, including the number of crashes and casualties, various safety performance indicators (SPIs) have been developed to evaluate the operational conditions of road traffic systems that influence road safety performance (e.g., [5,6]). Additionally, past research has analyzed road traffic safety culture, which is defined by the formed values, beliefs, and social norms of the country [7] or the socially constructed abstract systems of meanings, norms, beliefs, and values [8]. Arguably, to find effective safety improvement-related processes or best practices, it is important to understand road safety as a system that has different components including transportation infrastructure, vehicles, and legal and educational systems. These can affect road safety culture and performance, and are often the subjects of road safety policies.

Although previous reports and studies have highlighted several important aspects of road safety systems (e.g., [3]), not all road traffic safety-related information is available from outside countries. Because this information is often incomplete or inconsistent, it can be difficult to compare such information across different countries. Accordingly, this study aimed to highlight the importance of international comparison of road safety systems by focusing on a set of national indicators and facts which have been thought to influence road traffic safety in multiple countries. The comparative study is followed by a discussion on the similarities and differences in road safety-related facts observed across different countries. Drivers are major actors, who cause and/or are involved in road traffic crashes, and their personal and general beliefs and attitudes toward road traffic safety can affect both attitudes of acceptance toward risk-taking behaviors and commitment toward risky driving behavior [9,10]. Therefore, this study focuses on aspects related to enhancing safer drivers, such as traffic legislation, enforcement, and education.

To achieve the abovementioned objective, this study conducted a collaborative international survey to retrieve the data from nine countries, some of which were not easily accessible from outside the countries. The data were collected, compiled and then re-organized into a common format wherever possible to facilitate a comparative analysis. These data included both quantitative and qualitative facts, and this study attempted to compare these data to the greatest extent possible by introducing a simplified item normalization (for example, for fine and penalty/demerit points for traffic violations) in different countries. The results demonstrate the significance of sharing and comparing country-wide information in facilitating the provision of more comprehensive perspectives when reviewing road-safety policies in each country.

It should be noted that this study aimed to exhibit useful facts and indices for comparing the road safety systems of the country at the national level, while not considering the diversity of the detailed situation within the country and among individuals. We considered that such national-level facts and indices would directly and indirectly affect road traffic safety through their impacts on social norms and residents' attitudes. Therefore, these facts and indices are important for policy and strategy development. The results of such a study are expected to be utilized for conducting more advanced studies (for example, modeling the causal relationship of multiple factors to estimate the number of road traffic deaths, etc.).

2. Literature review

There are numerous facts that may affect road traffic safety performance; thus, their related literature encompasses a wide range. To classify the road traffic safety-related facts and the literature on them, this study utilized a conceptual framework that has often been used for planning road safety management. In line with the above-mentioned SDGs, the WHO formulated the Global Plan for the Decade of Action for Road Safety 2011–2020 [11] and encouraged countries to implement activities according to the five main pillars: 1) road safety management, 2) safer roads and mobility, 3) safer vehicles, 4) safer road users, and 5) post-crash response. Among these, Pillars 2, 3, and 4 are considered equally important for road safety, while Pillar 5 prevents severe injuries and death even when crashes cannot be avoided. Pillar 1 involves target setting, monitoring, and coordination as well as other efforts related to land-use and mobility policies.

From among these five pillars, this study selected facts related to enhancing "safer road users", especially drivers, for comparison. Furthermore, in 2018, the United Nations Road Safety Trust Fund (UNRSTF) [12] presented an updated road safety action plan-related framework. The new framework included five additional focus areas for achieving Pillars 2 to 5: (a) legislation, (b) enforcement, (c) education, (d) technology, and (e) international regulatory support. As (e) was not enforced in each country, the road traffic safety-related facts in each country could be further categorized into (a) to (d) based on this framework. Namely, to enhance safer drivers, countries must establish appropriate traffic rules for driving (legislation), enforce the traffic rules to ensure that drivers follow them (enforcement), train and examine drivers with regard to driving safety, increase their awareness regarding road safety (education), and develop supportive technology and equipment (technology).

"Legislation" has often been a major focus of past literatures that have compared safety across multiple countries. The WHO [3] and ITF [4] provide two of the largest global databases. These databases include information on national speed limits, blood alcohol content (BAC) limits, helmet use regulations, child restraint regulations, mobile phone use regulations, and regulations related to driving under the influence of drugs. This information can help to outline the traffic rules that drivers must follow in different countries. Regulations that penalize offenders are another crucial aspect of legislation. Penalties against the violation of traffic rules generally have two different levels: criminal penalties (e.g., imprisonment for dangerous violations) and softer penalties (e.g., economic sanctions such as fines and license deprivation including suspension or withdrawal) [13]. In many countries, license deprivation is applied using a penalty point (or demerit point) system, and this method is reportedly effective for reducing collisions and fatalities [14,15,16,17]. Penalty systems may influence the driver's attitudes of acceptance toward violating traffic rules; if fine or penalty points are not high enough, drivers may become less hesitant to make such violations. However, existing studies have rarely investigated the actual extent of each country's established penalty for each type of violation (speeding, red-light running, and so on).

"Enforcement" is an important means of making traffic regulations effective. The penalty systems may not be effective without some kind of enforcement [13]. Many existing studies have proven that adequate police enforcement can reduce the number of collisions and violations such as speeding, drunk driving, driving while intoxicated, and non-usage or wrong usage of seat belts [18]. In a WHO report [3], "enforcement scores" were used for presenting the level of traffic regulation enforcement in each country. These scores were defined as 0 (not effective) to 10 (highly effective) based on a national-level subjective assessment by respondents. However, many respondents stated that it was difficult to assess national-level enforcement because it often varies from region to region, and its intensity may vary at different times.

"Education" forms another important wheel working with enforcement to enhance the effectiveness of traffic regulations. Education promotes drivers to respect road traffic safety and spontaneously follow traffic regulations, whereas enforcement monitors and controls illegal behavior. Young novice drivers, or newly licensed drivers, are one of the most important targets of education; the effectiveness of educating these drivers has been discussed since the middle of the 1990s [19]. In the context of international comparisons, different education programs in driving license systems in different countries and states have been reviewed in [20]. However, this review has been limited mainly to North America and Europe. In addition, re-education of experienced drivers is also important because, with time, drivers may forget some rules

and road traffic regulations are sometimes added or changed. It could also be an important chance to improve drivers' awareness, attitude, and behavior, reminding them of their responsibilities in road traffic safety. Driving performance may have to be monitored over time because drivers' cognitive and physical functions decline with age. Elderly drivers, which are another age group that faces a higher risk of crashes besides young novice drivers [21], are the most typical examples of drivers who may require such a re-education monitoring. Thus, many countries have introduced driving license renewal systems; however, the extant academic literature has not paid much attention to this topic.

"Technology" refers to tools and equipment that can complement and strengthen legislation, enforcement, and education [12]. For enhancement of "safer driver", these include seatbelt reminder systems, drivers' e-learning systems, and so on. While this aspect has not been explicitly considered, it is included under the abovementioned three aspects (i.e., legislation, enforcement, and education).

Overall, although, in the international context, road safety-related facts and characteristics have been compared by focusing on specific aspects as mentioned above, few studies have covered multiple aspects in this regard. While there have been some comprehensive comparisons of multiple aspects, such as [22], the examined upon countries are limited to a few. Therefore, this study aimed to compare road safety-related facts across multiple countries in different regions by using broader perspectives.

3. Data collection

3.1. Outline of the survey

To collect information from multiple countries, various international cooperative researchers conducted the fact surveys under the project "International Comparative Study on Road Safety Culture" of the International Association of Traffic Safety Science (IATSS). The participant countries were the residential countries of the international cooperative researchers, namely, the United Kingdom (particularly, Great Britain), Germany, Italy, Egypt, Qatar, the United Arab Emirates, China, Japan, and Canada. Although it cannot be claimed that these countries can sufficiently represent the diversity of the world, these countries represent regional and cultural differences in different regions of Western Europe, the Middle East and North Africa, and East Asia, as well as differences between the countries within the same regions (i.e., three countries in Western Europe, three in the Middle East and North Africa, and two in East Asia). Hereafter, the names of these participant countries will be abbreviated as GBR, DEU, ITA, EGY, QAT, ARE, CHN, JPN, and CAN, respectively, according to the alpha-3 code in the ISO 3166 international standard.

This project aimed to understand road traffic safety culture across different countries and its impact on road traffic safety as well as to develop an international information exchange platform for supporting every country in considering and promoting more effective road safety measures. Under this project, besides the fact surveys, which are introduced in this paper, questionnaires were also distributed among sampled drivers to understand road traffic safety culture in the above-listed countries; the necessary details in this regard can be obtained from [23]. Although this paper does not deal with such questionnaires, the fact surveys in this paper were designed to be referenceable to the questionnaires in the future; therefore, the fact surveys were designed to collect information regarding the subject year during which the questionnaire was distributed, or the closest year to this subject year when the data were available as of 2019 in each country. Thus, these subject years vary slightly by country, as shown in Table 1.

First, a common format listing various road traffic safety-related facts was prepared for the survey. The researchers then filled it out regarding their own countries by referring to national statistics, regulations, and any other documents and/or by interviewing related organizations.

3.2. The surveyed information

The facts surveyed in this study are categorized into five aspects: general country profile, road and traffic conditions, legislation, enforcement, and education. The general country profile and road and traffic conditions supplementally outline the basic conditions of the surveyed countries. The general country profile covers population, land area, and gross national income (GNI) per capita. Road and traffic conditions are represented by statistics such as the total lengths of the road network and the number of registered motorized vehicles. Table 1 summarizes the statistics collected from this survey and its sources.

The facts were mainly compared based on the three abovementioned aspects: legislation, enforcement, and education for safe drivers. The technology aspect was not explicitly surveyed, but it was included in the enforcement aspect, as it focused on camera-based monitoring. *E*-learning could be included when surveying drivers' training duration under education. Table 2 lists the items introduced in this paper based on these subjects. In fact, along with these items, the survey covered items related to driving under the influence, seat-belt and helmet use, and mobile phone use while driving. As these items confirmed trends known in the existing literature, such as [3], they have not been introduced in this paper.

Regarding legislation, this paper particularly focuses on the laws against speed limit violations and red-light running (RLR). These offences occur rather frequently on roads, and tend to be penalized rather softly depending on the country, compared to those that are more strictly penalized (e.g., drunk driving often results in the penalty of losing one's license and imprisonment in most countries). Difference in regulations for different types of roads were investigated with regard to speed limit violations in this study, as the risks associated with such violations differ based on road type.

Similarly, investigations regarding enforcement also focused on speed limit violations and RLR. Initially, this study tried to collect quantitative information that could represent the degree of enforcement,

Table 1
Information from the statistics.

Item	GBR	DEU	ITA	EGY	QAT	ARE	CHN	JPN	CAN
Subject year of the survey	2018	2017/2018	2017	2018	2017	2017	2018	2017	2019
Population (Total number of inhabitants)	[24]	[32]	[39]	[42]	[47]	[50]	[54]	[59]	[64]
Land area [km^2]	[25]	[33]	[33]	[33]	[33]	[33]	[33]	[33]	[33]
GNI per capita	[26]	[26]	[26]	[26]	[26]	[26]	[26]	[26]	[26]
Total length of roads [km]	[27]	[34]	[40]	[43]	*	[51]	[55]	[60]	[65]
Share of motorways in total road network	[28]	[35]	[40]	[43]	*	NA	[56]	[60]	[66]
Number of registered motorized vehicles	[29]	[36]	[40]	[44]	[48]	[1]	[55]	[61]	[67]
Modal share	[30]	[37]	[40]	[45]	NA	[52]	[57]	[62]	[68]
Number of road traffic deaths - in each country's statistics	[31]	[38]	[41]	[46]	[49]	[53]	[58]	[63]	[69]
- WHO's estimate	[70]	[70]	[70]	[70]	[70]	[70]	[70]	[70]	[70]

* : No reference, information was collected via requests to the local authorities, etc.

Table 2
Surveyed items.

Legislation	Enforcement	Education
- Penalty point systems (condition of license suspension, withdrawal, valid period of penalties, and so on) - Maximum speed limit for passenger cars on motorways, secondary roads, urban roads, and residential roads - Fines for speed limit violation on motorways / secondary roads / urban roads / residential roads / school zones (depending on the excess speed) - Penalty points for speed limit violation on motorways / secondary roads / urban roads / residential roads / school zones (depending on the excess speed) - Fines for RLR - Penalty points for RLR	- Number of speed cameras on motorways / secondary roads / urban roads / residential roads / school zones [many; some; few; none] - Number of RLR cameras on motorways [many; some; few; none]	- Required duration of practical training for acquiring a normal driving license - Required duration of theory learning for acquiring a normal driving license - Driving license exam includes visual acuity testing / practical skill test / written exam [Yes/No] - Necessity and frequency of updating driving license for passenger cars - License renewal includes change of photocopy on the license card / visual acuity test / class lecture / practical training [Yes/No] - Special arrangement for young / newly licensed drivers - Mandatory training for elderly drivers to keep their driving licenses - System/policy for elderly drivers to return their driving license

such as the number of enforcement cameras installed and the number of speeding tickets issued per year. However, such information was not available in most countries. Therefore, instead of quantitative information, the number of enforcement cameras for detecting offences was roughly classified into four levels: none, few, some, or many. This classification was based on the subjective judgment of the researchers based on their experience and knowledge. These researchers had experiences of traveling by car in more than two of the participant countries and when giving their subjective judgment, they had several opportunities to check the judgements in other countries and revise their own one to make this evaluation as relative as possible. Here, the posed questions concerned different road types which were also considered in "legislation" section; they were designed to understand how resources were distributed in the road network.

Education covered three aspects. The first three items in Table 2 concern education and licensing systems through which drivers obtain their driving licenses for the first time in the country. The following two items relate to the renewal of licenses. The last three items are about education and licensing for young, newly licensed, or elderly drivers. These items were surveyed based on traffic regulations and related documents.

It should also be noted that, in CAN and ARE, regulations related to the abovementioned aspects varied by province/emirate in some cases. In such cases, Ontario for CAN and Dubai for ARE were taken as the representative province/emirate.

4. Road and traffic conditions

4.1. Road development and motorization

Fig. 1 shows the total length of roads in each country (per land area) as the vertical axis and population density as the horizontal axis, while the size of these plots changes based on the proportion of motorways to the total road network length. This outlines road development conditions. Generally, road network length increased when the land area and the population are larger. The plots showed that JPN, DEU, GBR, and QAT had denser road networks compared to other countries in terms of both land area and population. However, the percentage of motorways did not correlate with road density; for example, JPN had a denser road network but a smaller proportion of motorways compared to many other countries, whereas DEU had the largest proportion of motorways while having a higher density of roads.

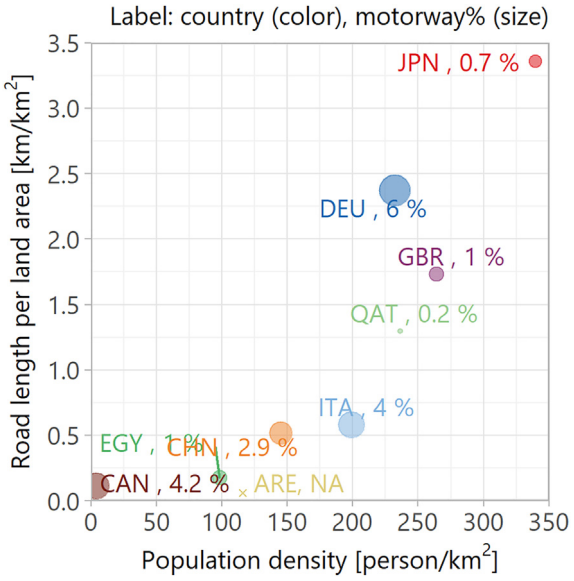

Fig. 1. Road development conditions.

Fig. 2 shows the number of registered motorized vehicles per capita and the share of private car trips in the modal share, overviewing the degree of motorization. The plots followed a general trend: when a given country had a larger number of vehicles, it also showed a higher share of private car trips. We can interpret that motorization is more progressed within countries located at the upper

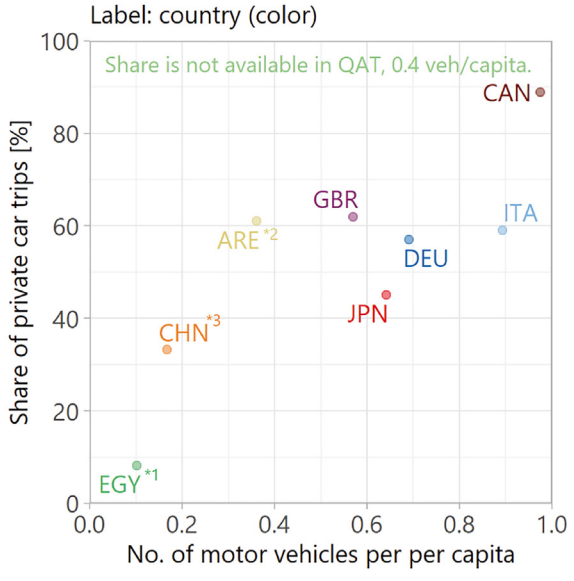

Fig. 2. Use of motorized vehicles.

right in the figure: CAN is the most motorized, whereas EGY is the least. The figure also showed that ITA, DEU, and JPN relied less on private car trips compared to CAN and GBR, among the countries that had relatively larger number of vehicles per capita. On the other hand, CHN and ARE were found to be more dependent on private car trips, even though their number of motor vehicles per capita was relatively small.

These basic conditions can indirectly influence the viewpoints of "safer drivers" because they imply the exposure of inhabitants to motorized vehicles and driving.

4.2. Number of road traffic deaths

Fig. 3 (left) depicts the number of road traffic deaths per 100,000 population based on relevant statistics from the surveyed countries; those in each country's statistics are depicted as the vertical axis, and those in the WHO's estimates are depicted as the horizontal axis. According to each country's statistics (vertical axis), QAT had the highest and GBR had the smallest number of road traffic deaths per population. Overall, the reported ones in the surveyed countries were lower than 27.5 which is the estimated world average, or even 8.3 in high-income countries [3]. However, it should be noted that the definitions of road traffic deaths in these countries did not necessarily match that of the WHO. If focusing on the WHO's estimated statistics (horizontal axis), ARE, CHN, and EGY were found to have a larger number of road traffic deaths per population than other countries including QAT.

Fig. 3 (right) depicts the number of road traffic deaths per 100,000 population based on each country's statistics; accordingly, it indicates age groups by different colors. It should be noted that age group-related classifications differ slightly across different countries because their original statistics were recorded in different formats; thus, it was not possible to apply a common classification to all the data. Basically, this figure's classifications apply to under-aged individuals aged 0–19 years (0–17 years in GBR and DEU), young individuals aged 20–24 years, middle-aged individuals aged 25–64 years, and elderly individuals aged ≥65 years. With regard to age groups, in EGY, a higher proportion of under-aged and young people suffered road traffic deaths compared to other countries. In contrast, in JPN, a larger proportion of elderly people suffered from road traffic deaths.

5. Comparison of the facts related to traffic safety

5.1. Legislation

5.1.1. Point systems for penalty

The point systems used to penalize traffic offences in the participant countries are summarized in Table 3. A point system had not been introduced in EGY as of the subject year (therefore, it is not included in Table 3), but was implemented recently in 2021. These point systems are categorized into two types: penalty point systems (PPS) applied in ITA and the demerit point system (DPS) applied in others. Under PPS, an initial number of points are assigned to drivers, and these are deducted when they commit any offense. Once the initial points have been reduced to a certain value, or zero, the offender's license is suspended or withdrawn. In contrast, under DPS, the points start at zero and are accumulated based on the driver's offences. Once these points reach a certain number, the offender's license is suspended or withdrawn.

"Number of points of suspension" in Table 3 indicates the number of points (deducted from the initial points in PPS / accumulated from zero in DPS within the period during which the points are valid) that can result in driving license suspension, in case when license is suspended for the first time. "Period of suspension" indicates the duration of the first suspension. These facts represent the basic conditions of penalization. In ARE, such points are valid for only one year, which is a relatively shorter period than that in JPN or CHN; however, once the license is suspended, it is not reinstated for a longer period of time. Furthermore, in the case of Dubai of ARE, drivers have to take a driving course and pass a test to reinstate their license. Here, DEU and ITA apply different license suspension rules compared to other countries. In DEU, suspension is not applied based on the accumulated points but decided by the authority when an offense amounting to two points or more is committed; furthermore, the validity period of the points depends on the offense—when greater points are allotted for the offense, its validity period is longer (e.g., 2 years and 6 months for 1 point, 5 years for 2 points, and 10 years for 3 points). In ITA, license suspension is not

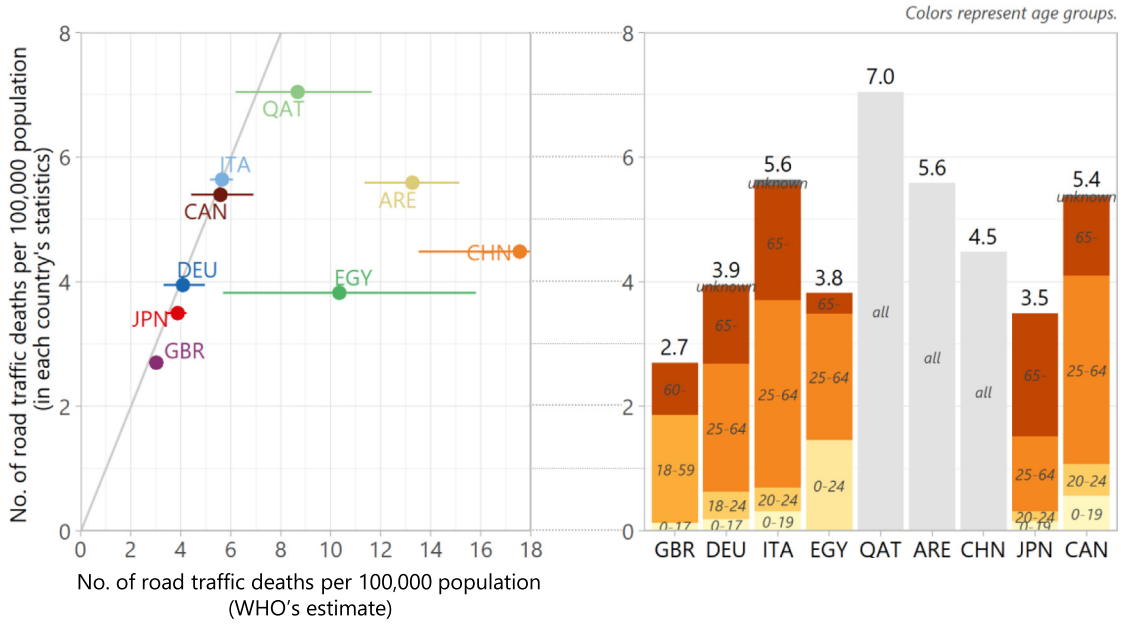

Fig. 3. Road traffic deaths per 100,000 population in the surveyed countries: comparison of each country's statistics and WHO estimates (left) and each country's statistics by age group (right).

Table 3
Point systems for penalty.

Country	GBR	DEU	ITA	QAT	ARE	CHN	JPN	CAN[*1]
Year of introduction	1988	1974	2003	2007	2008	2004	1969	1959
System	DPS	DPS	PPS	DPS	DPS	DPS	DPS	DPS
Number of points of suspension	12 within 3 years	2 or more at once[*2]	If a severe offense is committed/ same offense[*2] is committed twice within 2 years	14 within 1 year	24 within 1 year	12 within 1 year	6 within 3 years	15 within 2 years
Period of suspension	Maximum 6 months[*2]	Minimum 1 month, maximum 3 months [*3]	1–8 months [*2]	3 months	3 months	Minimum 7 days	30 days or more[*4]	30 days
Strict penalty for frequent offences	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Condition for withdrawal	If suspension lasts 56 days or more	If points reach 8 or in case of serious and/or repeated offences	If all points (20 when getting the license) are lost	The fifth time the points have reached to the threshold[*5]	The third time the points have reached to the threshold	In case of serious offences.	Depends on the number of suspensions and points within 3 years	If the offense with 4 or more points is committed for the third time
Reward for safe drivers	No	No	Yes	No	Yes	No	Yes (since 1994)	No

[*1] Case in Ontario [*2]: Depending on the type of offense [*3]: Depending on the type of offense and the individual violation record. [*4] Depending on the individual's total number of demerit points [*5]: Threshold decreases from 14 to 6 step by step.

based on the number of points but when specific offences are committed (e.g., speed racing using motor vehicles, exceeding the maximum permitted speed limit by more than 40 km/h, driving backward near corners) or when the other specific offences are committed twice in two years (e.g., RLR, missing seat belt, failure to give right of way, collision due to safety distance failure).

The above-mentioned conditions are applied only to a first-time license suspension in most countries, and stricter rules (e.g., smaller number of points, longer period of suspension) are applied if drivers' licenses have been suspended in the past. "Yes" in "Strict penalty for frequent offences" in Table 3 indicates the countries that apply such stricter rules. GBR, ARE, and CAN increase their suspension periods. QAT and JPN decrease the number of points required for suspension. DEU applies stricter rules and/or penalties (e.g., lower limits for necessitating the compulsory driver assessment after repeated offences).

"Conditions for license withdrawal", under which drivers must retake the license, are also summarized in Table 3. In many countries, these conditions depend not only on the number of points but also on the driver's historical records of offense and license suspensions.

Besides the rules for penalizing offenders, "Reward for safe drivers" in this table indicates that ITA and JPN provide some rewards for drivers who keep not having any offences (no point reduction in PPS / addition in DPS) in their point system. Specifically, in ITA, drivers who do not commit any offences for two years are rewarded two points to their initial number of points, and this addition continues every two years until their initial number of points reaches 30. This means that drivers who have not committed any offences for more than two years can have less strict condition for license withdrawal. In JPN, the number of accumulated points becomes zero when drivers have not committed any violations for more than one year. In ARE, although rewards are not given to the points, drivers who do not have any crashes or demerit points can get vouchers for discounted services at different participating establishments (restaurants, hotels, fitness centers, etc.). Furthermore, although it is not under the penalty point systems (therefore, not regarded as "Yes" in Table 3), in some countries such as DEU, QAT, JPN, and CAN, drivers who had not committed any crashes and/or penalties during a certain period can sometimes obtain discounts on their car insurance.

Along with the abovementioned considerations, some countries, such as DEU, ITA, and ARE, allow drivers who have reached a certain number of points to take voluntary traffic education seminars to reduce their points.

5.1.2. Normalization of penalty points and fines

It was crucial to compare the weight of each traffic offense, though the point systems differed across the surveyed countries. Therefore, for simplicity, this study defined "normalized penalty points" for each type of violation by dividing the number of points (deducted in PPS / accumulated in DPS) for committing an offense by the base number of points (in Table 4) with reference to the number of points of suspension. In ITA, where suspension was not determined by points, the base number of points was set as 10, which is half the number of points for meeting the condition of license withdrawal.

Similarly, in comparisons of the fines for each violation, local currency was converted into USD [71] and further divided by GNI per capita to consider different economic levels in the surveyed countries. This is called the normalized fine by GNI per capita.

5.1.3. Speed limit violation

Fig. 4 shows speed limits for different types of roads in the surveyed countries. These speed limits were the defined maximum legal speeds for specific road types. Locally adopted speed limits may vary from the ones presented in this figure because of local adjustments related to road geometry, land use, and traffic conditions. Noteworthily, not all countries define legal maximum speed limits for all road types that were considered in this figure. In fact, JPN has only two road classifications for differentiating the legal maximum speed—that is, motorways and others. Therefore, the speed limits for secondary, urban, residential roads, and school zones are all the same. Similarly, European countries often have three classifications, which distinguish the maximum speed for inside urban areas from those for outside urban areas (i.e., secondary roads), beside those for motorways. In these countries, further distinctions regarding speed limits can be made on a case-by-case basis, depending on local conditions. QAT, CHN, and CAN show more detailed differences according to road type.

Commonly, in all the surveyed countries, motorway speed limits are higher than speed limits for any other types of roads, varying from a minimum of 100 km/h in JPN to unlimited in DEU. Differences of

Table 4
The base number of points used for normalization.

Country	GBR	DEU	ITA	QAT	ARE	CHN	JPN	CAN
Penalty points	12	2	10	14	24	12	6	15

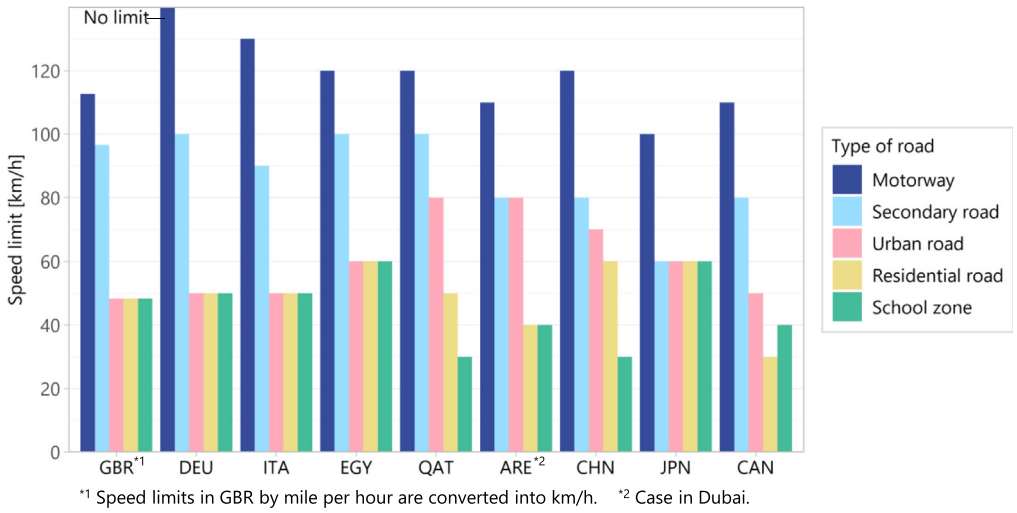

Fig. 4. Maximum legal speed limit by road type.
(*adjustments of the actually adopted speed limits by local authorities are allowed but not includEd.)

speed limits in different countries are highlighted for other types of roads in the following discussion.

First, speed limits for urban roads are much lower than those for secondary roads in European countries (GBR, DEU, and ITA) and CAN; this difference is not as large in QAT and CHN, and it even does not exist in JPN and ARE. Conversely, JPN has much lower speed limits for secondary roads than other countries.

Second, speed limits for residential roads are lower than those for urban roads in QAT, ARE, CHN, and CAN. In particular, CAN had the lowest speed limit of 30 km/h for residential roads. In reality, the speed limit of 30 km/h may also be applied in many other countries. Typically, these limits are managed as "30 km/h zones (or 20 mph zones)," but this is not always the case depending on the condition of road geometry, roadside environment, and so on.

Third, QAT and CHN set the speed limits for school zones as 30 km/h, which is lower than that for residential roads. In contrast, many countries, including GBR, DEU, ITA, JPN, and EGY, do not have specific speed limits for school zones; however, even in these countries, the typically adopted speed limits for such areas tend to be low (e.g., 30 km/h) as a result of local adjustments in many cases.

Fig. 5 provides normalized fines (by GNI per capita) for speed limit violation based on excess speed to the speed limit. It was found that most countries do not change the fine in accordance with road type; in this case, the exceptions are DEU, JPN, and CHN. DEU differs fines in case of outside and inside built-up areas. JPN's fines differ depending on whether the road is a motorway or not. CHN defines the fine to be levied based on the proportion of the offender's excess speed to the speed limit—that is, the fine differs according to the locally adopted speed limit. Therefore, as typical representative cases, the fines levied for motorways (left) and urban roads (right) were compared. In the case of DEU, fines of outside built-up areas were applied for motorways, and those of inside built-up areas were applied for urban roads. For CHN, the maximum legal speed limits shown in Fig. 4 were assumed to be the typical speed limits for motorways and urban roads for calculating the proportion of excess speed. Similarly, Fig. 6 represents the normalized penalty points based on the excess speed while driving on motorways (left) and urban roads (right).

The figures show that most countries set fines and penalty points that increase stepwise in accordance with the excess speed. GBR was the exception to this trend; the amount of fine to be paid is decided as

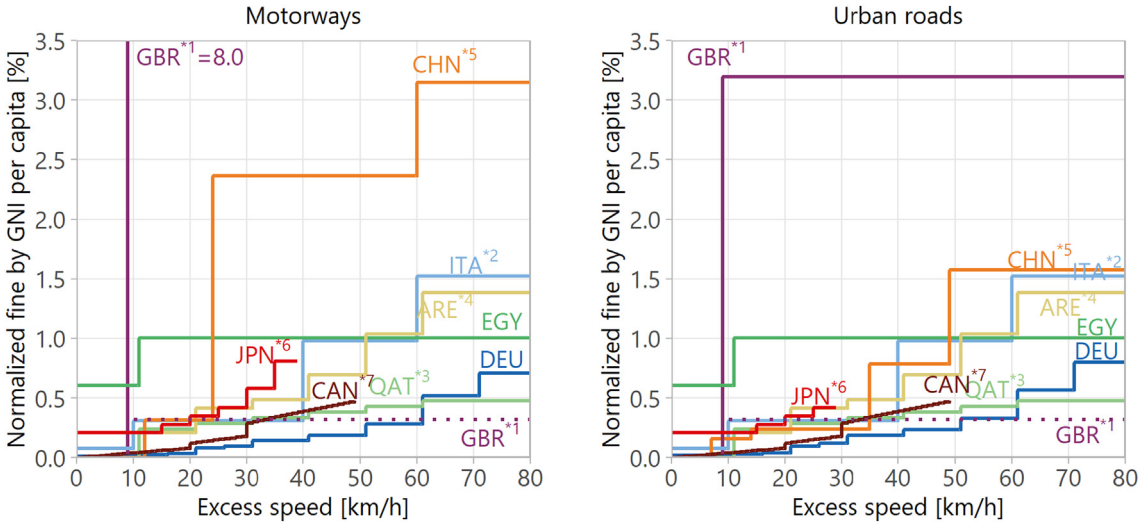

Fig. 5. Speeding fine by excess speed on motorways (left) and urban roads (right).

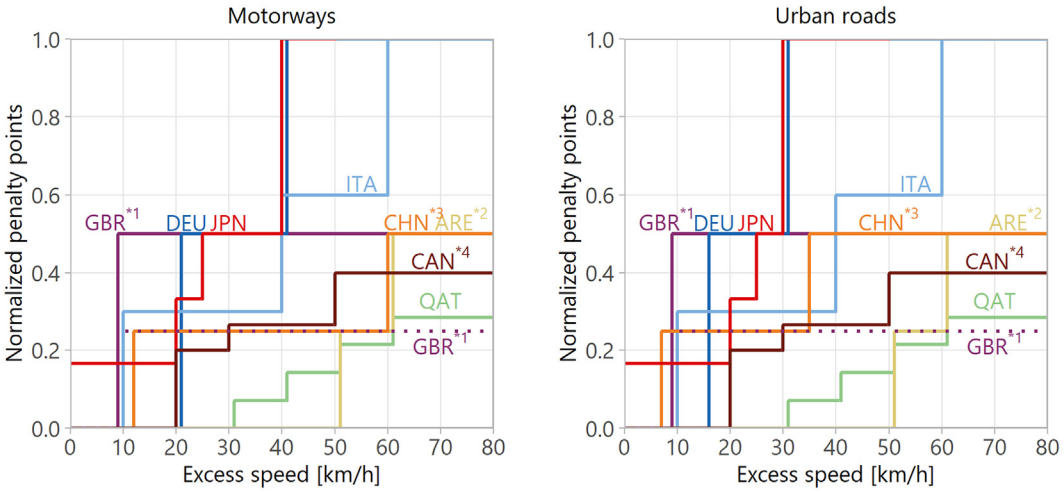

Fig. 6. Penalty points by excess speed on motorways (left) and urban roads (right).

between the minimum and maximum fines indicated in the figure depending on the speed limit and the excess speed, and usually calculated as a percentage of the offender's weekly income. In CAN (Ontario), the fines increase almost in a linear fashion, by a specific amount at every 1 km/h.

Regarding fines, if the excess speed is less than 10 km/h, most countries do not set it as a high amount (less than 0.5% of GNI per capita). Exceptionally, EGY's penalties are slightly higher even for such a small excess speed. When the excess speed is between 10 and 30 km/h, EGY and CHN tend to levy higher fines, while CAN and DEU tend to levy lower fines compared to other countries. In fact, as of 2021, DEU plans to increase its speeding fines in the near future. Regarding excess speeds of more than 50 km/h, CHN, ITA, and ARE levy relatively higher fines. JPN and CAN do not define fines for such cases, but instead, request the courts to decide the fines of speed limit violation.

Regarding normalized penalty points, DEU and JPN tend to levy greater amounts when the excess speed is over 20 km/h. In these countries, excess speeds over 40 km/h on motorways or over 30 km/h on urban roads leave points that can result in driving license suspension. This is also true in ITA when the excess speed is over 40 km/h (as mentioned in Section 5.1.1). In addition, in CAN, the possibility of license suspension is raised when excess speed exceeds 50 km/h, even though the points do not reach the threshold. However, notably, the suspension period and the valid period of points also vary across countries, as shown in Table 3.

With a focus on the differences of the penalties based on road types, DEU and JPN levy higher fines or penalty points for speed limit violations on urban roads compared to those on motorways; this situation contrasts with that in CHN.

Noteworthily, in addition to fines and penalty points, a prison sentence may also be imposed at a court's discretion when the excess speed is much higher; this is the case in QAT (possibly applies for excess speeds over 60 km/h), JPN (typically applies for excess speeds over 80 km/h), and Ontario in CAN (in relation to stunt driving; possibly applies for excess speeds over 50 km/h or 40 km/h where the speed limit is less than 80 km/h). In ARE, the offender's vehicle is impounded for a certain period if the excess speed is 50 km/h or greater.

5.1.4. Red-light violation

Fig. 7 shows normalized penalty points as well as normalized fines for RLR. QAT, ARE, DEU, and CHN levy the same level of penalty points for RLR, namely, two instance of RLR can result in license suspension. In ITA, normalized points for RLR seem to be higher than that in other countries in Fig. 7; however, this is because, in ITA, reaching the normalized penalty points to 1.0 does not lead to license suspension (as explained in 5.1.2). In fact, in ITA, RLR is one of the offences that result in license suspension if committed twice in two years; this regulation can be regarded as similar to that in QAT, ARE, DEU, and CHN. Among those countries, the fine seems to be much higher in QAT compared to the other countries. Besides, in Dubai, ARE, in addition to the imposition of a fine and penalty points, the offending vehicle that committed RLR is also impounded for 30 days. CAN does not impose a high number of penalty points but set the second highest fine.

5.2. Enforcement

Fig. 8 depicts the estimated number of cameras for detecting offences. For this figure, seven types of cameras were considered: the ones for detecting speed limit violations that have been installed on motorways, secondary roads, in urban areas, residential areas, and school zones, the ones for detecting speed limit violations that can be used flexibly by movable devices, and the ones used for detecting RLR.

As the approximate number of such cameras depicted in Fig. 8 is based on the subjective judgment of the authors in each country, any comparisons of countries with regard to their use of each type of camera

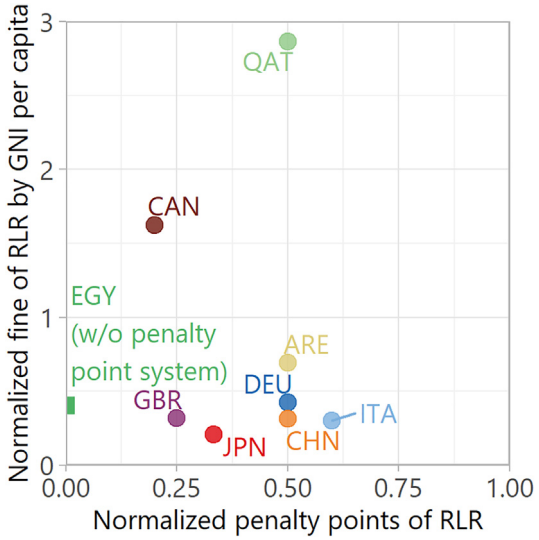

Fig. 7. Fine and penalty points for red-light running (RLR).

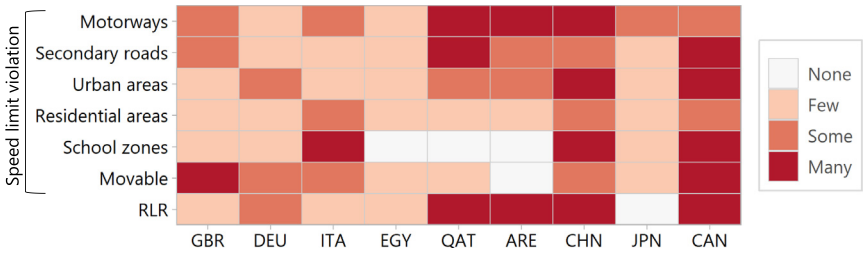

Fig. 8. Number of enforcement cameras.

may not be fair; nevertheless, it can be said that CHN and CAN installed many cameras for most of the cases shown in the figure, thus implying their higher enforcement levels for preventing speed limit violation and RLR. Furthermore, a comparison of the numbers for different road types within each country showed that DEU and CAN installed more cameras in residential areas than on motorways and urban roads, whereas GBR, QAT, ARE, and JPN carried out a greater number of such installations on motorways rather than on other types of roads. A clear contrast could be observed in school zones. ITA installed many cameras, whereas EGY, QAT, and ARE did not do so. QAT, ARE, CHN, and CAN installed many cameras for detecting RLR. DEU also seems to pay particular attention to RLR compared to other countries. This would be because, in DEU, not only the police but also local municipalities are allowed to enforce related regulations in urban areas.

5.3. Education

Fig. 9 shows training durations for residents who want to acquire driving licenses in each country. CAN requires its residents to spend the longest duration in drivers' training. In contrast, EGY does not require its residents to undergo practical or theoretical training before taking the license exam. European countries also tend to prescribe a relatively short training duration.

The survey confirmed that, to obtain a driving license, all countries require their residents to pass the visual acuity test, practical skill test, and theory exam.

Table 5 summarizes the frequency of—and required procedures for—renewing driving licenses (in the case of passenger cars). According to Table 5, most of the surveyed countries set a rather long duration—namely, 10 years—for the frequency of renewing driving licenses; JPN and CAN set a relatively short renewal interval period such as 5 years, and DEU set a relatively longer renewal interval period as 15 years. In QAT, non-Qatari drivers must renew their driving license every 5 years, while Qatari drivers do every 10 years. A similar requirement is applied in ARE. Regarding first license renewal after drivers have obtained their license, ARE, CHN, and JPN prescribe a shorter period than that of general renewals, while other countries do not make any such distinction.

In most of the surveyed countries, license renewal involves only a simple procedure—chiefly, the renewal of a personal photocopy on the license card. Some countries do not require even the visual acuity test. Among the participant countries, only JPN provides a short period of class lectures about changes in traffic rules, the latest situation of traffic crashes, and so on. The duration of the lecture ranges from 30 min to 2 h, depending on the driver's experience, age, and violation records. None of the participant countries provide practical training when renewing licenses.

The first row in Table 6 summarizes the presence of special arrangements for young or newly licensed drivers in the licensing system in each country. DEU, ARE, CHN, and JPN answered “Yes” to this section. Specifically, DEU prescribes stricter rules for drunk driving and imposed heavier penalties for certain traffic violations when the offending drivers have received their licenses within the past two years. Furthermore, the government plans to provide additional training measures for young drivers after they have obtained their driving licenses as of 2021. In ARE, drivers under 21 years must renew their licenses every year. In CHN, newly licensed drivers must paste or hang a practice sign on the rear section of the car. Similarly, in JPN, drivers who have received their licenses within the past one year must display a “beginner sign” on their cars. Furthermore, JPN's Road Traffic Law indicates that surrounding drivers are obliged to protect cars that carry the “beginner signs”.

Finally, regarding elderly drivers, the second and third rows in Table 6 summarize the existence of any special provisions for elderly drivers. JPN and CAN request elderly drivers to take training when they renew their licenses. For example, in JPN, drivers aged 70 years or older are required to pass cognitive function tests and attend a lecture and practical training in the test course.

GBR, DEU, CHN, JPN, and CAN have a system or policy that aids or requests elderly drivers to return their driving licenses. In GBR, where driving licenses expire when the driver reaches 70 years old, drivers

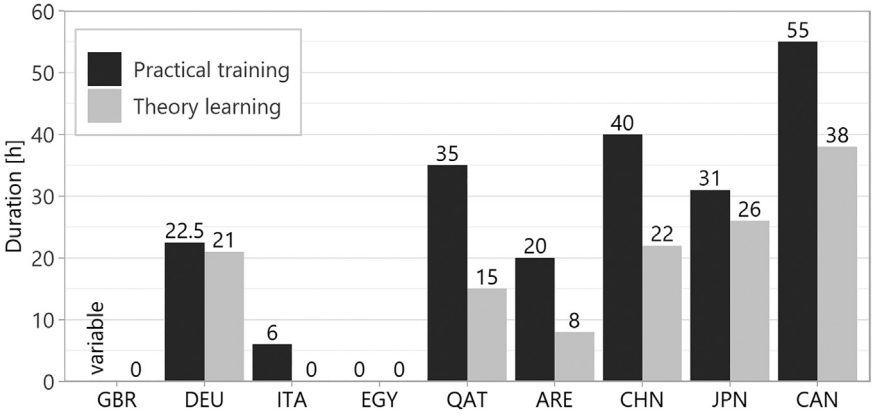

Fig. 9. Required training duration for acquiring driving license.

Table 5
Renewal of the license.

Country	GBR	DEU	ITA	EGY	QAT	ARE	CHN	JPN	CAN
Frequency of license renewal (general) [every – years]	10	15	10	10	10 or 5[*1]	10 or 5[*2]	10	5	5
First license renewal [after – years]	10	15	10	10	10 or 5[*2]	2	6	3	5
Renewal of personal photocopy	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Visual acuity test	No	No	Yes	No	No	Yes	Yes	Yes	Yes
Class lecture	No	No	No	No	No	No	No	Yes	No
Practical training	No	No	No	No	No	No	No	No	No

[*1] 10 years for Qatari citizens and 5 years for others.
[*2] 10 years for UAE citizens and Gulf nationals and 5 years for others.

who reach this age and wish to continue driving are required to renew their licenses. Following this, they are required to renew their license every three years. Although DEU does not prescribe any regulations for elderly drivers for private driving, professional drivers aged over 50 years must provide a special medical certificate when they renew their license. In CHN, people over 60 years are not allowed to drive large passenger cars, tractors, city buses, medium-sized passenger cars, large trucks, trolley buses, and trams. People aged 70 years are not allowed to drive low-speed trucks, tricycles, ordinary two-wheeled motorcycles, and wheeled self-propelled vehicles. In JPN, driving history certificates are issued to those aged 65 years and older only after they return their driving licenses. This certificate, which can be used as a self-ID card, can be used to obtain certain services from local authorities and some private companies (such as discount fares in buses and taxis). In CAN, elderly drivers are typically required to renew their licenses more frequently, and the regulations concerning this type of renewal are stricter in many provinces. For example, in Ontario, British Columbia, and Alberta provinces, drivers over 80 years must renew their license every two years, and this process also requires them to submit a medical report from their doctor.

6. Discussion and conclusion

All the participant countries commonly distinguish the maximum legal speed limits for motorways and other roads. However, policies regarding more detailed settings often vary across countries. While some countries set lower speed limits for urban and residential roads—an important step for protecting pedestrians and other non-motorized mode users—, other countries do not have such regulations. Noteworthily, in this study, the examined speed limits were limited to legal maximum speed. In reality, all countries can adopt lower speed limits for urban and residential roads compared to those for rural or secondary roads; such adjustments often depend on local conditions. A more in-depth surveys and comparisons with regard to factors and methodologies for adjusting the speed limits based on local conditions could be one of the future works.

This study found a few cases where the fines and penalty/demerit points assigned for speed limit violation varied depending on different road types. These variations may have reflected the different conditions and risks inherent to different roads. For example, speed limit violations on motorways are prone to leave serious damage once they cause vehicular crashes; however, speed limit violations on urban or residential roads increase the risk of causing harm to other vulnerable road users such as pedestrians and may adversely influence the surrounding environment. It will be worth discussing the appropriate settings of the fines and penalty/demerit points for different road types by examining the findings from this survey with any information about each country's trends of speed limit violation.

Some countries, such as ITA and CHN, tend to implement relatively severe penalties and accompany these with stronger enforcement, whereas others, such as EGY, may lack adequate enforcement to make penalties effective. Even in JPN, although speed limit violation attracts a higher penalty on urban roads than on motorways, the number of installed enforcement cameras is smaller on urban roads than on motorways. Among the participant countries, countries that had a moderate level of road development and motorization tended to have stricter penalties and enforcement.

Regarding education, this study confirmed that residents in different countries are required to spend different training durations to acquire a driving license, but they all must pass the practical skill test and theory exam in all the participant countries. For detail, the position of driving schools (mandatory or optional; public, government-authorized or private; etc.) and the contents of training and examinations (including special licensing systems such as graduated licensing in some countries) could be investigated in the future. Furthermore, there is another issue of interest to researchers that could be discussed in future studies—namely, the issues surrounding education and licensing systems for foreign drivers who want to convert licenses issued in their home countries, because in QAT and ARE in particular, a considerable number of drivers belong to foreign countries.

The driving license renewal process may be a potential opportunity to re-educate drivers by enabling drivers to update their knowledge regarding new regulations, technological developments (e.g., driving assistant systems), and current safety problems and by raising drivers' awareness of changes in their driving ability—particularly among elderly drivers. However, such re-education does not seem to be realized; license renewal is required less frequently (e.g., every 10 years) in many of the participant countries, and its contents mostly deal with administrative procedures in most cases. The sustainable education of drivers is thus a challenge in many countries. The assessment of driver's fitness to drive in each country will better be analyzed in the future work, because it is influenced by various historical and cultural backgrounds and would affect licensing and testing systems of each country, too.

Based on these results, it became possible to find the characteristics of each country, what is common and different from other countries, in each aspect related to enhancing safer drivers. Thus, this study showed the potential research benefits of comparing different countries and understanding the relative position of each country, although the number of participant countries was limited, and the accuracy of data differed across different countries. It will be crucial and useful to monitor and review the situations of each country with objective and broader viewpoints by continuously conducting this kind of survey, updating

Table 6
Licensing arrangements for young and elderly drivers.

Country	GBR	DEU	ITA	EGY	QAT	ARE	CHN	JPN	CAN
Special arrangement for young /newly licensed drivers	No	Yes	No	No	No	Yes	Yes	Yes	No
Mandatory training for elderly drivers to keep their license	No	No	No	No	No	No	No	Yes	Yes
System / policy for elderly drivers to return their license	Yes	Yes	No	No	No	No	Yes	Yes	Yes

relevant data, and improving these data's accuracy as part of international activities for road traffic safety. Furthermore, the information collected through this survey could be utilized for understanding the causal relationship between multiple factors and road traffic safety by combining it with other data through advanced quantitative analysis and modeling. Therefore, the development of a sustainable survey framework and the inclusion of a greater number of countries in the research are significant future tasks.

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.

Acknowledgement

This work was supported by the International Association of Traffic and Safety Sciences (IATSS). The authors are grateful to the members of IATSS's project for their valuable comments on our survey and results and Politecnico di Milano, Politecnico di Torino, Regione Lombardia in Italy, Prof. Axel WOLFERMANN of Hochschule Darmstadt in Germany, Eng. Mustafa Almallah of Qatar Transportation and Traffic Safety Center, Junjie Zhou of Tongji University in China, and Sushreeta Mishra of the University of Manitoba in Canada for their contributions to data collection.

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