ROAD SAFETY IN A GLOBAL PERSPECTIVE – ACCIDENTOLOGY IN ASIA AND EUROPE

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1. Background

Mobility is one of the basic needs of humanity. The various types of mobility available to us have different consequences. Almost everyone in the world has the opportunity to participate in road traffic, and they take advantage of it. In addition to the ecological consequences of road traffic (land consumption, sealing, resource requirements, etc.), there are also negative consequences for individuals. In addition to exposure to pollutants and particles, traffic accidents are particularly worthy mentioning here. They cause about 1.19 deaths worldwide and an estimated 100 million injuries. Traffic accidents are the leading cause of death for children and young people aged 5 to 29 years and they represent the 12th leading cause of death for all age groups. [1]

The WHO figures also show that low and middle-income countries in particular are responsible for a substantial proportion of road deaths. Although the level of motorization in these countries is still quite low in some cases, the population in these countries has an elevated risk of becoming fatally injured in road traffic [1]. In the context of the rapidly increasing level of motorization, particularly in the densely populated emerging markets of Asia, there will be interesting developments here in the coming years. This paper is intended as a kind of stock-taking, in which the accident situations in Asian and European countries are compared.

2. Overview

Since Asia, as the largest continent, is very heterogeneous in many respects, it is often subdivided into different regions. The WHO differentiates between the regions of South-East Asia, the Eastern Mediterranean Region and the Western Pacific Region. The latter also contains Australia, New Zealand and smaller countries from Oceania. The accident statistics for the three regions differ significantly, for example in the type of fatally injured road user. The WHO regions are used initially for some of the following analyses at global level. Selected countries are then considered, with WHO publications and other data sources being consulted. Later, in-depth databases from selected countries complete the view of the accident situations in different countries and regions.

Figure 1 initially presents the absolute numbers of fatalities and the population-based fatality rates in the year of the accident (2021) for the WHO regions of the world. We used the WHO projections for fatally injured road users and not the officially published numbers.

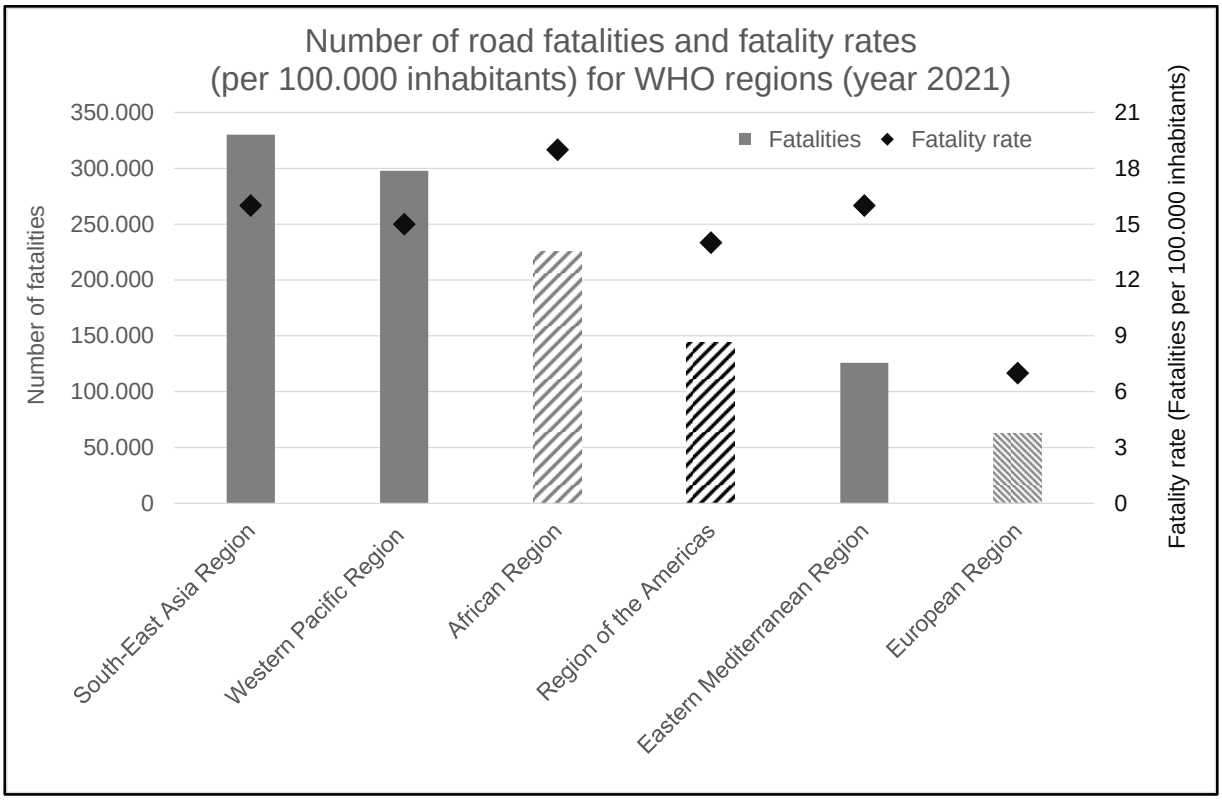

Figure 1: Number of road fatalities and fatality rates in different WHO regions [1]

The absolute figures show that the highest numbers of traffic deaths occur in Asia. This is not surprising considering the corresponding share of the world population. However, the population-based fatality rates are higher than in all other regions, except for Africa.

For this reason, the focus of further analysis is on those Asian regions and countries. Europe is used for comparison and as a benchmark, as it is the continent/region with the lowest fatality rate in road traffic worldwide. This is closely linked to the fact that the compared continents differ greatly in terms of structure and economy. About two-thirds of Europe consists of high-income countries, with an even larger proportion of the population living in these countries. Another 28% of the countries are in the "upper-middle income" group. In the "South-East Asia" region, which includes China and India, by far the most populous countries in the world, there are still no high-income countries, but two-thirds are lower-middle-income or low-income countries. The infrastructure, the level of motorization and the modal split of these countries significantly influence their traffic accident statistics.

3. Analyses based on national and international data sources

Data from road traffic accidents can be found in national statistics. They are usually based on police-reported accidents and cover the entire country. For most countries, statistics are published annually and are available at least in the national language. They usually contain data on injury severity, accident constellations, and other selected parameters. However, these often vary from country to country. There is no single globally harmonized parameter, although the vast majority of countries at least use a uniform definition of injury severity.

For this reason, there are various international harmonization and collaboration projects and committees that are working to harmonize terms and metrics and also aim to provide data for the largest possible number of countries. In addition to the WHO, which publishes its "Global status report on road safety" every three to five years, the International Traffic Safety Data and Analysis Group (IRTAD) is particularly committed to harmonizing and collecting data as part of international cooperation [2].

For this paper, data from the WHO report is used for the analyses on national level as it has by far the highest country coverage. It therefore enables comparisons to be made between almost all countries worldwide. The disadvantage is that the focus is mainly on fatalities. Thus, information about slightly and seriously injured road users is not available.

The following figure shows the significant differences in the road user distributions among fatalities. Europe is the only continent where occupants of 4-wheeled vehicles (cars) clearly dominate the statistics. In the region with the most fatalities, South-East Asia, users of powered 2-wheelers and 3-wheelers represent the biggest group of road traffic fatalities. There are even major differences between the three considered Asian regions. The Eastern Mediterranean Region, for example, is characterized by a rather high share of car fatalities and nearly no bicycles. Another interesting fact is the large share of “others” in Asia, Africa and America, including busses, trucks, and vehicles like agricultural tractors or animal-driven vehicles. This aspect illustrates the diverse and – compared to Europe – rather different circumstances and characteristics of road traffic in Asia. In Asia, public transport (mainly busses) is an important means of transport, especially for long-term trips. This can be interpreted as a consequence of low motorization rates in Asia, e.g. 113 cars / 1000 inhabitants for the ASEAN region, less than 50 cars / 1000 inhabitants in India and only 7 cars / 1000 inhabitants in Bangladesh in 2022 [3] compared to 564 cars / 1000 inhabitants in the European Union in 2020 [4].
For pedestrians, however, the shares are quite similar in all regions.

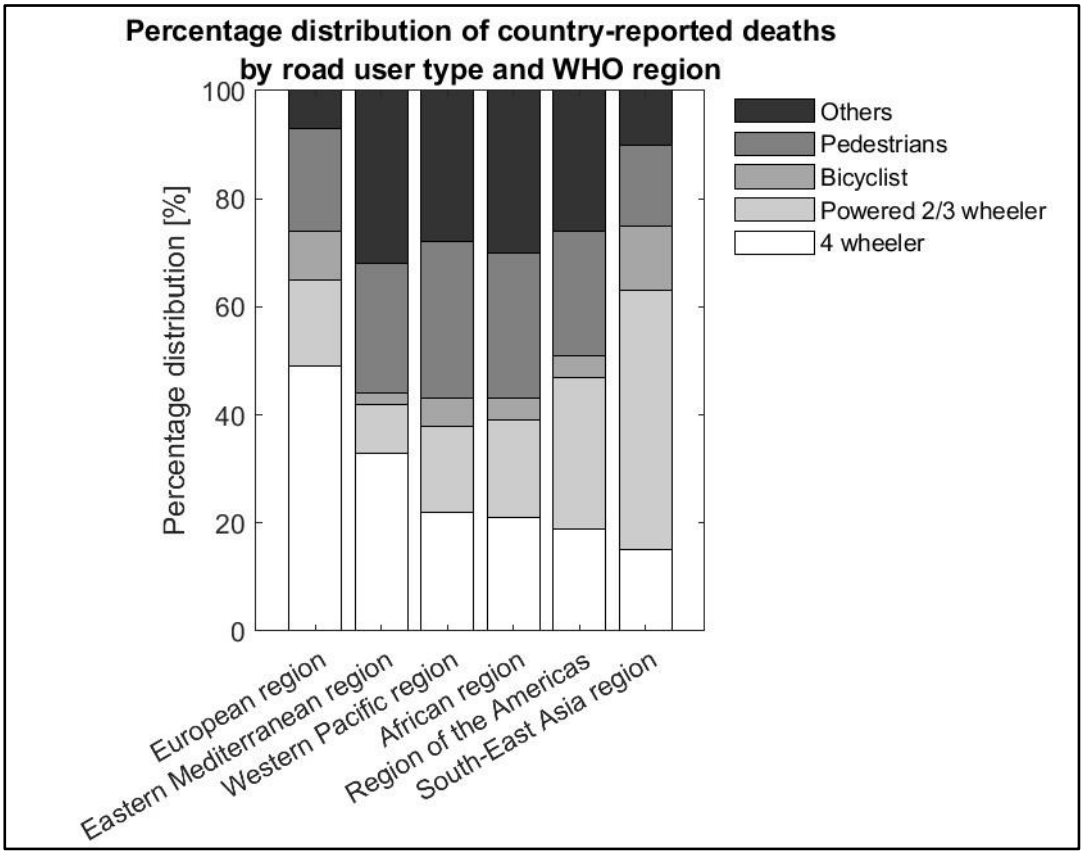

Figure 2: Distribution of road user type for fatally injured road users in WHO regions [1]

In the next step, more detailed analyses are done using WHO data, but with a focus on single countries. Therefore, the 15 biggest countries (according to population) for both continents are considered. Countries located on both continents (Turkey and Russia) were excluded in order to achieve a higher degree of selectivity. In Asia, these 15 countries represent an impressive number of 4.29 billion people which accounts for around 54% of the world's population. The 15 biggest countries in Europe are home to around 500 million people, which is, on the other hand, less than the half of the population of China or India.

The following diagram shows the absolute number of fatalities and population figures for the 15 largest countries on both continents. Almost all of the 15 Asian countries considered also have a significantly higher fatality rate (per 100,000 inhabitants) than the European countries. The dashed line separates the countries with a fatality rate above or below 10 fatalities per 100,000 inhabitants. In Europe, only two Eastern European countries, Ukraine (13.7) and Romania (10.3), exceed this threshold, while in Asia only the high-income countries of Japan and South Korea as well as the Philippines are below this mark.

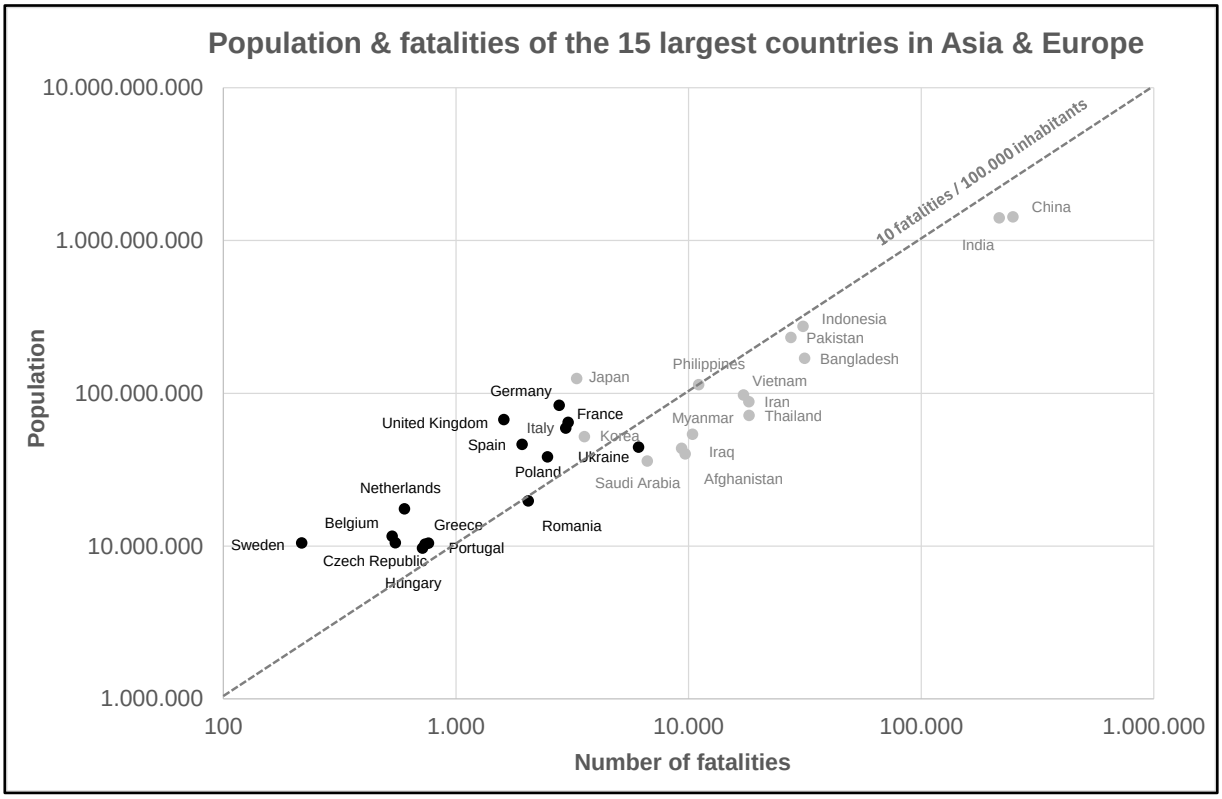

Figure 3: Population and road traffic fatalities of the 15 largest countries in Asia and Europe [1]

In addition to the outlined differences in the road user types, and fatality rates, differences in the type and reliability of data collection must also be pointed out. In the vast majority of European countries, national road accident statistics (based on police accident investigations) and can be considered reliable. In Asia, on the other hand, there are large discrepancies in some countries between the officially reported casualty figures and the figures determined by the WHO. One example is China, where an official figure of 62,218 traffic fatalities was published for 2021. The WHO, on the other hand, estimated around 248,000 fatalities, i.e. four times as many.

In addition, the data also contains some dubious information, the accuracy of which cannot be verified. For example, Iraq shows a share of 0% of all traffic fatalities for PTW/P3W, which is just as doubtful as the alleged share of 0% for car occupants in Thailand despite a motorization rate of 290 cars per 1,000 inhabitants.

However, the data is shown as published in the WHO report in the following diagram. Figure 4 shows the road user type of fatally injured road users for the considered countries (no data available for Afghanistan and Saudi Arabia). It can be derived from the data that in most European countries the car is still dominating as the biggest road user group of fatalities.

Car occupants account for 40 to 50% of fatalities in these countries. However, the long-term trend clearly shows decreasing shares of car occupants among fatalities with the implementation of even more passive safety measures as well as the increasing market penetration with active safety measures and ADAS. In 2009, car occupants accounted for 50 to 70 percent of fatalities in Europe [5]. This trend will continue in the next years if even more cars in the fleet comply with increased legal requirements and meet even more ambitious and continuously increasing Consumer Rating requirements.

In Europe, pedestrians represent the second biggest group of road fatalities, followed by users of PTW (there are hardly any P3W in the fleets). The share of bicycles is increasing steadily as a result of changing modal split and increasing bicycle use.

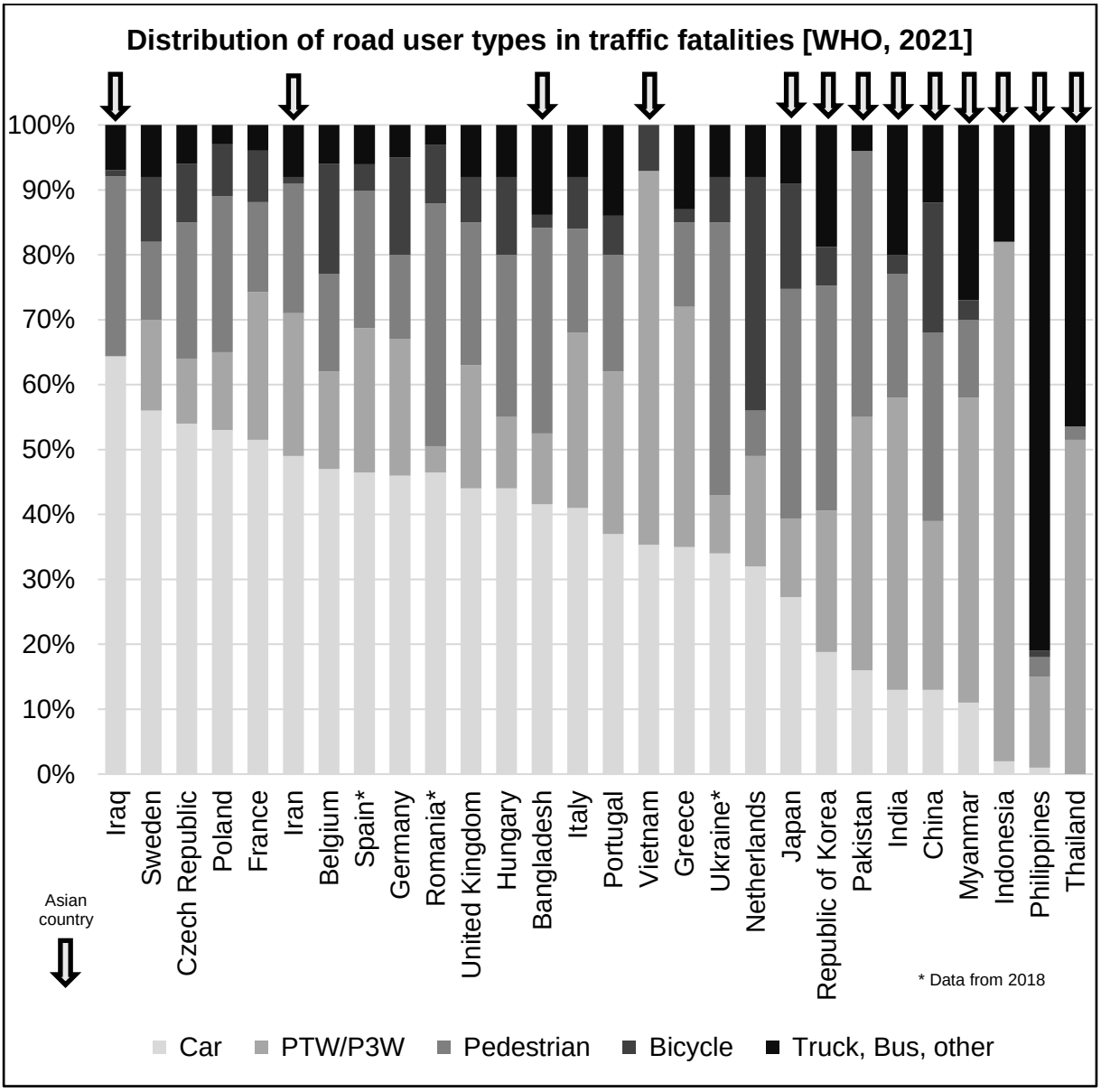

Figure 4: Distribution of road user types in traffic fatalities in Asian and European countries [1]

In Asia, the situation is completely different. Users of PTW/P3W are by far the biggest group of fatally injured road users. There are even more killed pedestrians and users of other vehicles (mainly busses and trucks) than fatally injured car occupants.

As already mentioned, the WHO data and other international data sources do not provide sufficient information for many interesting and relevant aspects. There is some data available for belt use and helmet wearing rates. However, these data are never taken from the total sample but are based on observations and counts. The reliability of this data is heavily dependent on the methodological implementation (e.g. representativeness, sample size, etc.) and will presumably also vary greatly between different countries.

The data from the WHO reports provide the following qualitative results with regard to the use of seat belts and motorcycle helmets:

- Seat belt usage rates are very high level in most European countries. The usage rates on the front seats are usually above 95% and slightly lower on the rear seats.
- Countries in Southern Europe and Eastern Europe show lower belt usage rates than countries in Western, Northern and Central Europe.
- Similar results can be derived for helmet use on PTW/P3W. However, the difference between European countries is not that high.
- Helmet use is very common for riders and passengers of PTW/P3W in Europe.
- The reported belt usage rates in Asia are significantly lower than in Europe for the majority of considered countries (except countries like Japan and Republic of Korea).
- The same applies to helmet usage rates. The helmet wearing rates of passengers are once again significantly lower than the rates for riders.

4. Analyses based on in-depth data sources

The biggest disadvantage of national and international data sources for road traffic accidents is the lack of detailed information about the accident circumstances as well as the involved persons and vehicles. Therefore, so-called in-depth data investigations have been established in some countries in the past decades. The main idea is to document interdisciplinary data directly on the accident scene, including technical, medical, infrastructural and psychological aspects. The corresponding datasets are usually characterized by a high level of detail and often, reconstruction data is available, providing crucial data from the pre-crash, in-crash and post-crash phases of accidents.

In-depth accident data is usually very expensive and not publicly available. Furthermore, several standards, investigations methods and sampling criteria are used throughout the globally spread projects. Thus, the corresponding data is not easily accessible and not directly comparable.

To address these challenges and to provide global accident data, the “Initiative for the Global harmonization of Accident Data” (IGLAD) was initiated in 2010. Today, IGLAD is an international, non-profit (self-funded) project and consortium. The main goals are:

- define and maintain a common in-depth accident data standard
- provide a yearly dataset with in-depth accident data from several countries [6]

Contrary to national accident statistics the data includes detailed information that is common to most in-depth accident studies, like:

- accident data (e.g. time, description, type, weather, constellation)
- participant data (e.g. type, vehicle data, active and passive safety systems)
- reconstruction data (e.g. initial speed, collision speed, EES, delta-v, CDC)
- personal data (e.g. age, gender, injury severity, belt / helmet use)

The IGLAD consortium currently consists of more than 20 members. The latest released dataset includes more than 11,500 cases from 14 data providers located in North America, South America, Europe, Asia, and Australia. The data originates from 12 different countries: Australia, Austria, Brazil, China, Czech Republic, France, Germany, India, Italy, USA, Spain and Sweden. In 2024, Korea joined as new Data Provider. Furthermore, Japanese data from ITARDA are expected from 2025 and there are also discussions with potential data providers from Pakistan and Thailand. More information can be found on the IGLAD website [7].

With five long-term data providers from Europe and two from Asia the IGLAD dataset is a suitable source to start detailed and comparative analyses of accidents on both continents. Therefore, the current IGLAD dataset (Effective 2024; containing accident data from member years 2013 to 2023) was analyzed with a focus on accident constellations and injury severities [8]. Later, car accidents are analyzed in detail. As the focus should be on comparisons between the two continents, the countries are grouped as follows for the following analyses. The number of available cases (only accidents with personal damage) per country are provided in brackets.

- Europe: Austria (750 cases), Czech Republic (1,045 cases), France (735 cases), Germany (2,100 cases), Italy (1,050 cases)
- Asia: China (1,620 cases), India (1,090 cases)

The other European countries that already delivered datasets to IGLAD are excluded as the overall case numbers are too low (Spain, Sweden).

The use of IGLAD data enables us to have a deeper look into accident constellations, injury severities, accident circumstances, accident causation and many other aspects. However, the data also has some limitations that should be mentioned here. The most important aspect is the reduced representativeness, compared to national statistics. In-depth investigations are usually performed in smaller geographic regions so that they never cover an entire country. Furthermore, the sampling processes differ between the global data providers in IGLAD. Thus, some countries (e.g. Germany, where the IGLAD data is a subsample of the GIDAS dataset that is considered representative for Germany) can provide quite representative datasets each year whilst other countries (e.g. China, India) are still strongly biased towards fatal accidents.

As the two Asian countries are not yet able to provide representative data (which is also a particular challenge in view of the sometimes dubious official statistics), most analyses are carried out with specific subgroups, which methodically correct this disadvantage of the data. The following table gives an overview about the number of cases and the accident severity distribution in the two considered regions. For both regions the share of fatalities is higher than in the national statistics.

IGLAD 2013 – 2023	**Accidents with …**					
	slight injuries		**serious injuries**		**fatal injuries**	
Europe (AT, CZ, DE, FR, IT)	**3,366**	59.4%	**1,369**	24.1%	**934**	16.5%
Asia (CN, IN)	**552**	20.4%	**687**	25.4%	**1,471**	54.3%

Table 1: Case numbers and accident severity distribution for IGLAD cases in Europe and Asia

The first analysis is dealing with the typical accident constellations. Therefore, all accidents (covering all types of road users and accident constellations) are analyzed regarding the accident type. This parameter describes the critical situation that caused the accident. Figure 5 shows the most frequent single accident types for the two regions. All accident types that reach a share of 2% or more in at least one region have been considered.
In both regions these 16 accident types make up 54% of all accidents. However, the distribution shows some similarities and differences. Accidents on crossings and junctions, especially during turning off or turning into a road, show similar proportions in both regions.

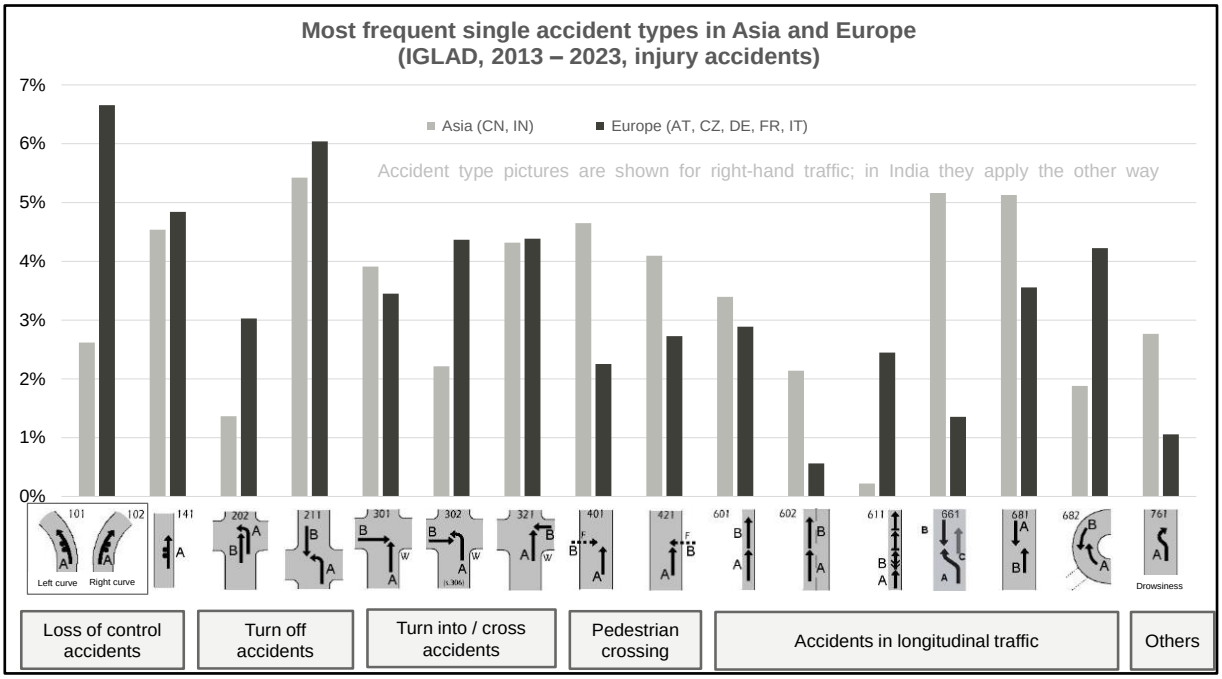

Figure 5: Most frequent accident types in Asia and Europe [all accidents]

In Asia, accidents in longitudinal traffic (during overtaking as well as conflicts with oncoming vehicles) are more frequent than in Europe. In Europe, more loss of control accidents (especially in curves) can be obtained. However, this is strongly affected by the modal split of these countries' traffic. Different road users are prone to different "typical" accident types.

Therefore, the same analysis is only done for fatal accidents and only those involving at least one car to get better comparability. The distribution is shown in Figure 6.

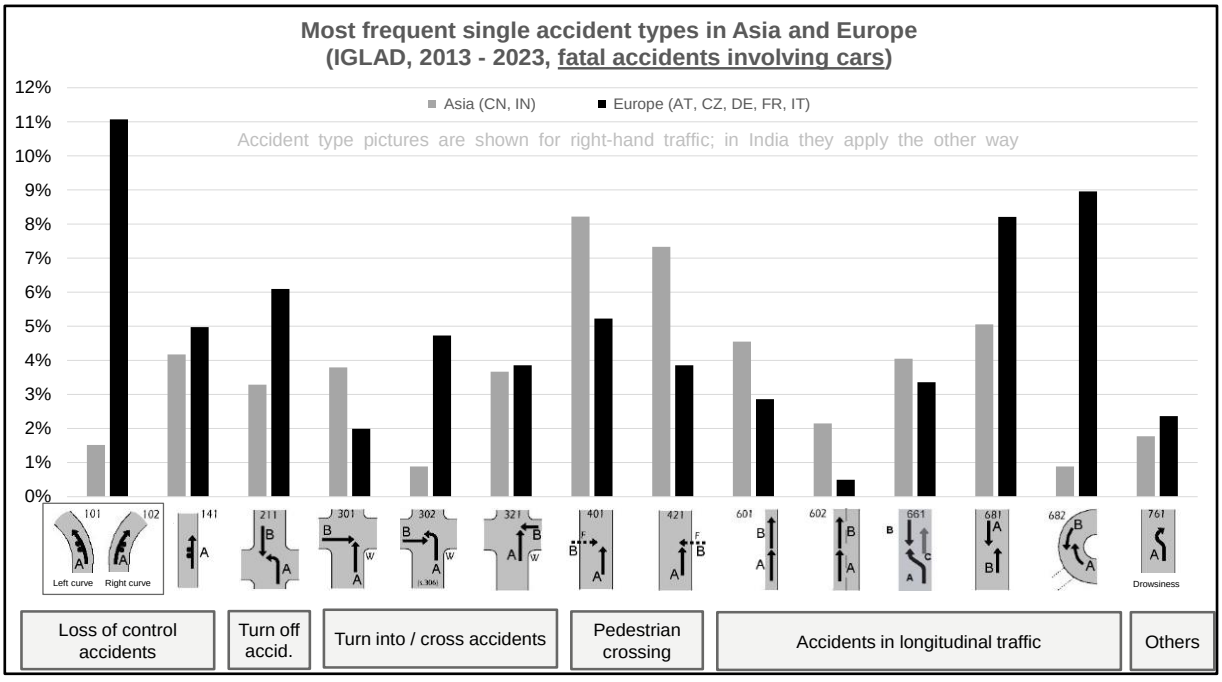

Figure 6: Most frequent accident types in Asia and Europe [fatal accidents involving cars]

Substantial differences can be obtained for loss of control accidents and accidents with oncoming traffic. In these accidents, the fatally injured road users are car occupants that collide with rigid objects (often trees) beside the road or with oncoming vehicles on rural roads (head-on collisions). In China and India, crossing pedestrians represent high proportions in fatal accidents involving cars.

These are actual differences between the regions as the accident location of the car accidents considered is quite similar between both regions (Table 2).

IGLAD 2013 – 2023	Accident location of car accidents		
	urban	rural	highway
Asia (CN, IN)	59%	23%	18%
Europe (AT, CZ, DE, FR, IT)	63%	26%	11%

Table 2: Accident location of analyzed car accidents in Asia and Europe

The aspect of accident constellations is subject to the next analysis. Again, the focus is on accidents involving cars. Figure 7 shows the accident constellations in accidents involving cars with personal damage for the five European countries.

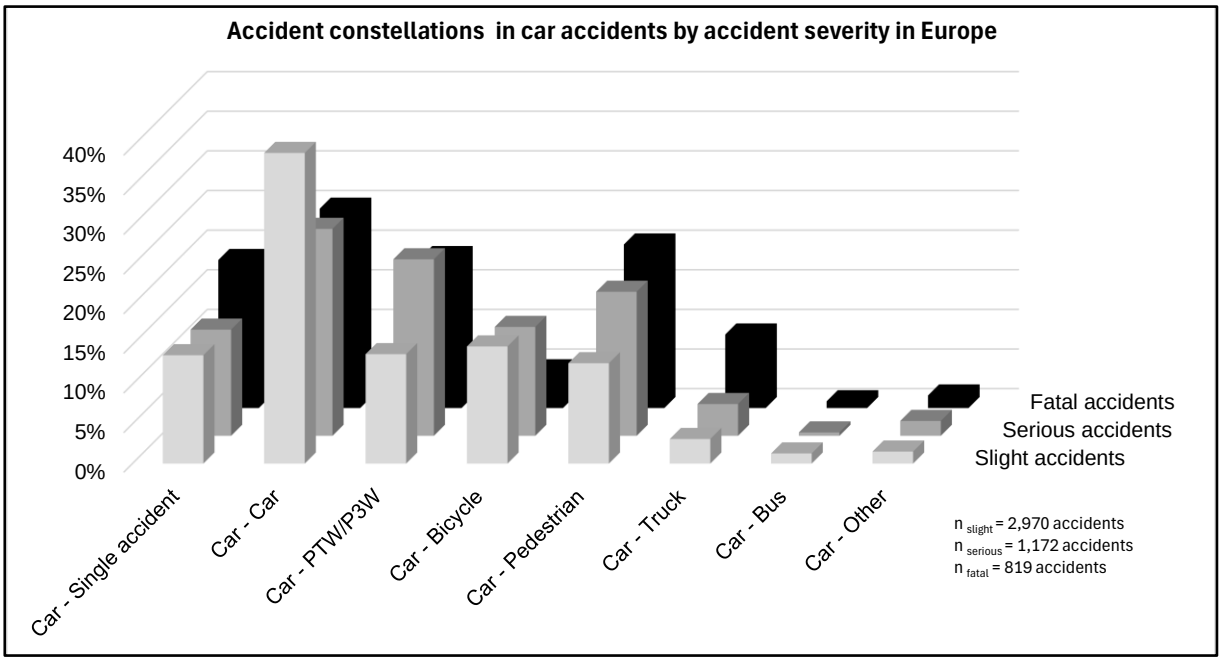

Figure 7: Accident constellations and accident severity in car accidents in Europe

The columns show that the majority of slight accidents are those between two passenger cars where car occupants are injured. There are also many slight accidents involving Vulnerable Road Users (VRU; including PTW/P3W, bicycles and pedestrians) where the car occupants usually stay uninjured.

With increased accident severity the relevance of pedestrians and PTW/P3W as collision opponents increases. Also, trucks play a larger role in fatal accidents. As observed in Figure 6, loss of control accidents (usually resulting in single accidents of cars) also have a higher relevance for fatal car accidents.

The comparison of European data with the data from China and India (Figure 8) shows that unmotorized VRU play a significantly higher role in the two Asian countries in serious and fatal accidents. The dataset provides nearly no fatal cases between two cars but emphasizes the importance of VRU protection in these countries.

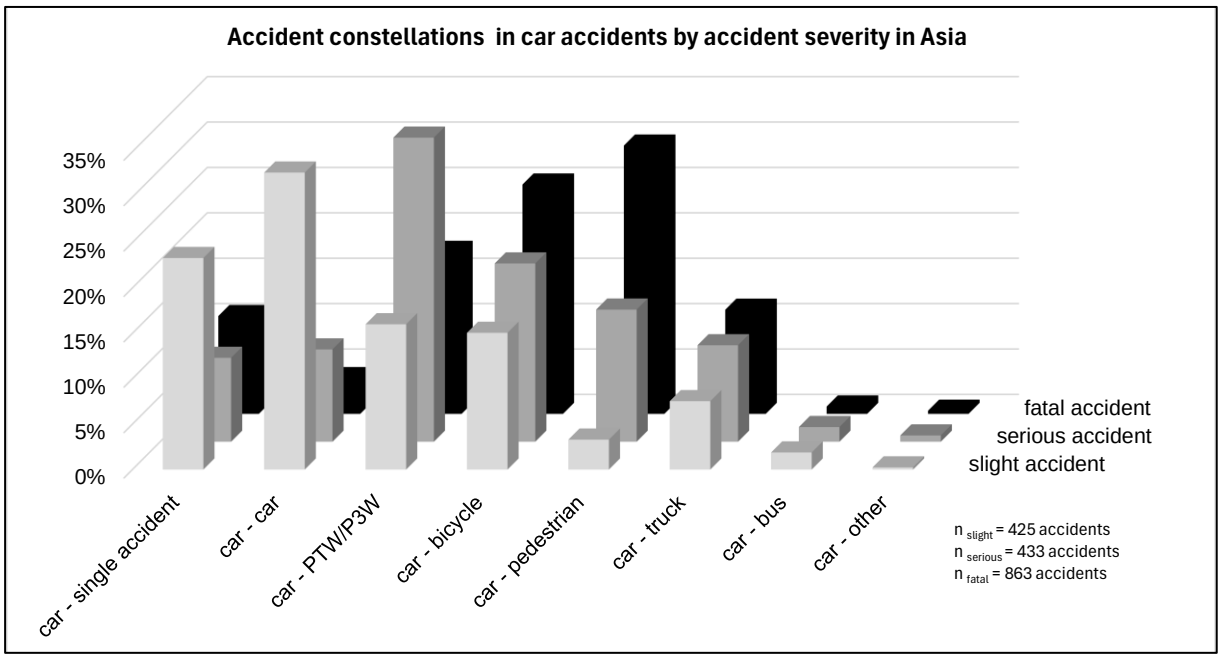

Figure 8: Accident constellations and accident severity in car accidents in Asia

Car accidents with serious injuries are dominated by PTW/P3W as the car's opponent. The relevance of single accidents and car-truck accidents is comparable to European countries.

The next part of the study deals with some reconstruction parameters. Therefore, the reconstructed collision speeds and crash severities of cars are analyzed. As seen in Table 2 the accident location of car accidents is similarly distributed in both regions. Assuming similar speed limits the collision speeds should be also comparable. Figure 9 shows the distribution of the reconstructed collision speeds of all involved cars. The collision speed describes the ego speed of the car in the moment of the collision. Here, the first collision is considered although this must not necessarily be the most severe collision. This time, the separation between single countries was kept to identify potential differences.

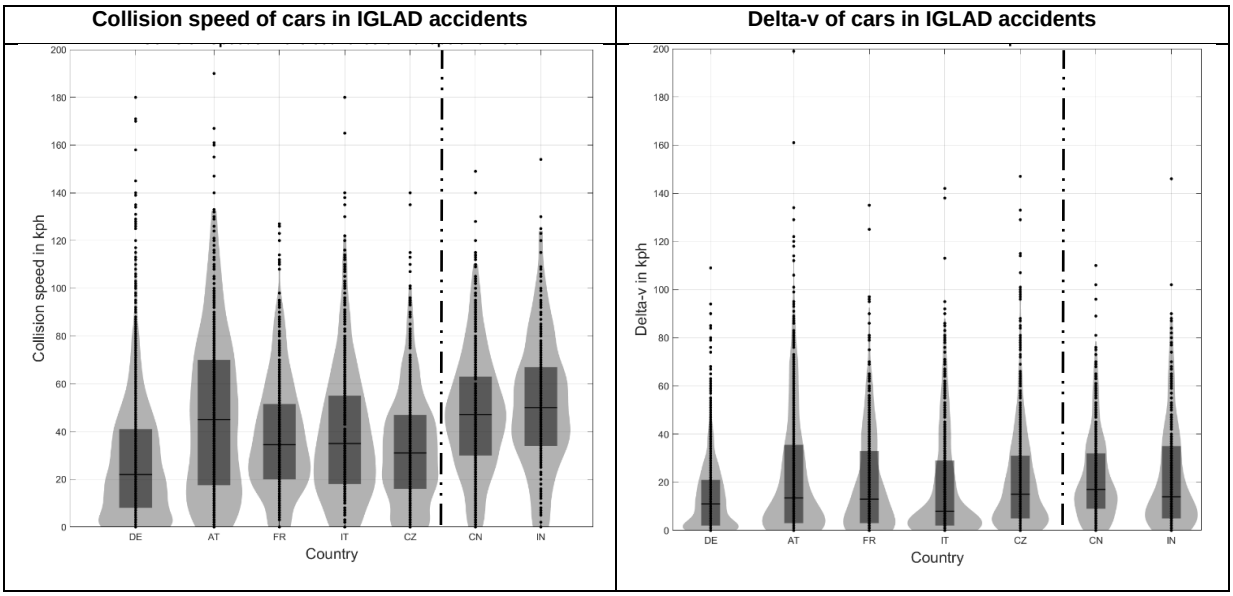

Figure 9: Collision speed and delta-v of cars in IGLAD accidents in Asia and Europe

At first glance, there are similarities between some countries. For example, the medians for France, Italy, and the Czech Republic are very close to each other and the distributions are very similar. The distribution in the German accident data differs somewhat, as the area of low collision speeds is more strongly represented here and the median is significantly lower (23 kph). This is due to the fact that the German data has been representative for the country since the beginning of the IGLAD data collections, whereas in many other countries serious and fatal accidents are or were initially over-represented. This is especially true for Austria where also the share of accidents on rural roads is higher than in other European countries (47%). Here, the median collision speed of cars on urban roads is 22 kph and thus, similar to the speeds in Germany (18 kph), Czech Republic (25 kph) or Italy (27 kph).

The two Asian countries show higher median values for the collision speed (around 50 kph) which is only partially explainable with the slightly higher share of highway accidents. They generally show higher car speeds on urban roads (median value of 40 kph in India and even 43 kph in China), what is corresponding to the higher share of fatalities.

The second diagram in Figure 9 (right side) illustrates the crash severity for the car, represented by delta-v. This parameter describes the vectorial speed change in the moment of the collision. It considers the car's velocity directly before and after the collision. It strongly depends on the own speed and mass as well as the opponent's speed and mass.

Here, the distributions are more homogeneous than for the collision speed. All seven countries have their median value below 20 kph although there was a significant difference in the collision speed values. This is the result of the large number of collisions with VRU in India and China, where the car only experiences a small velocity change.

Finally, the cars in the IGLAD dataset are analyzed in terms of passive safety aspects. Therefore, airbag equipment and belt usage rates are calculated for car occupants. To set an appropriate basis for comparisons, some filter criteria are applied before:

- Car registered in the year 2000 or later
- Only front seat occupants are considered (driver, passenger)
- Exclusion of unknown values each

The filter process shows that the cars in the provided datasets are comparable in terms of age (registration year) in Europe (median between 2007 and 2009). The cars in the two Asian countries are younger (median 2012). However, there are significant differences in the airbag equipment rates as shown in Figure 10.

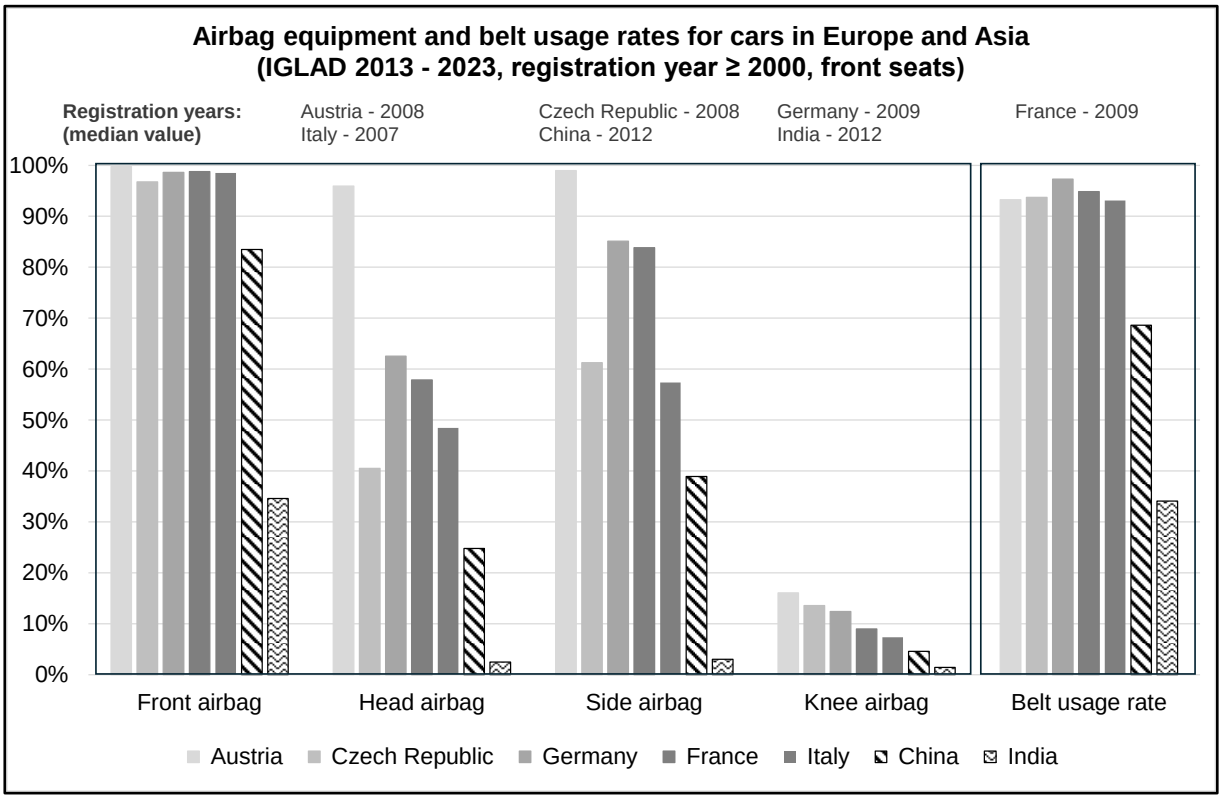

Figure 10: Collision speed and delta-v of cars in IGLAD accidents in Asia and Europe

Passenger cars in European countries show comparable airbag equipment rates (except for some conspicuously high values in the Austrian data). Nearly all cars have front airbags, around 60% to 80% are equipped with seat- or door-mounted side airbags and around 50% also have head airbags. Knee airbags are seldom in the considered cars with around 10% in European cars.

As mentioned in the first paragraphs, seat belt usage rates in Europe are quite high, reaching values between 93% and 97% in the five countries considered.

However, the situation is completely different in China and India. In China, the equipment rates reach around 80% of the European rates but Indian cars show very low equipment rates. Only every third car was equipped with a front airbag and all other airbag types show very marginal rates. This is despite the fact that the vehicles are newer on average than those registered in European accident data.
The same applies to seat belt use. Here too, China lags behind Europe at around 70%. The situation is much worse in India, where only around one in three car occupants was wearing a seatbelt during the accident.

5. Summary

The main subject of this paper was the comparison of accident data from Asia and Europe. International data sources have been used to generate general statements about the continent's accident scenarios. Due to the size and heterogeneity of Asia, there is not a "typical" Asian accident scenario but there are several regions with diverse characteristics in terms of road user types, modal split, motorization rates etc.
Generally, Asia is characterized by lower motorization rates, which means that the majority of journeys are made on foot, by bicycle and by PTW/P3W. It is assumed that also public road transport (busses) plays a larger role in most Asian countries. These countries, many of which are middle-income countries, also have significantly higher fatality rates than the mostly highly developed countries of Europe. In many of these countries, more than 60% of road traffic fatalities are Vulnerable Road Users (VRU).

As international and national data sources are limited in terms of level of detail, the IGLAD dataset with in-depth accident data from several global countries was used to characterize the accident scenario of selected countries in Asia and Europe. Different aspects could be identified, e.g. differences and similarities in critical situations. Later, the focus was on car accidents and typical accident constellations. The analyses of reconstruction data revealed that higher collision speeds in some Asian countries are linked to higher accident severities. Finally, the cars were compared in terms of airbag equipment, showing substantial differences between Europe and especially India. The same applies for seat belt use which is very low in India.

Finally, the study reveals a lack of data on national and international level. Furthermore, the available in-depth data is not enough yet and has to be enhanced in terms of global coverage and representativeness.

6. Limitations

The major limitations result from the available data. We used data from the WHO which is not available for each year and is usually limited to fatalities. There is no information about accident constellations, circumstances, injury severities and much more. There are similar hurdles with the IRTAD data, which only covers a few countries (e.g. the five biggest Asian countries are not covered). Generally, some official national statistics are not reliable.

The use of IGLAD data is also associated with limitations. On the one hand, the number of cases of in-depth data sources is usually low, and on the other hand, global coverage is also not given. For countries with data, the aspect of representativeness is the greatest challenge. Ultimately, IGLAD currently only has data from two Asian countries (at least, the two largest) and these are not yet representative and are biased towards serious and fatal accidents.

Literature

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