International Transport Forum

Methodology for Benchmarking Road Safety in Latin America

Working Document

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Working Document

About this document

This paper was prepared by Sandra Vieira Gomes, Laboratório Nacional de Engenharia Civil. It was reviewed by Fred Wegman (University of Delft, the Netherlands), Chairman of the IRTAD Group, as well as Shalom Hakkert (Technion University, Israel), Alberto Escobar (Automobile Club, Chile) and Elke Hermans (University of Hasselt, Belgium).

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Methodology for benchmarking road safety in Latin America

Background and objectives of the project

In 2014, the International Transport Forum (ITF) at the OECD and the Fédération Internationale de l'Automobile (FIA) signed a three-year co-operation agreement focusing on the improvement of worldwide traffic crash data collection and analysis. One of the projects jointly selected for implementation is the "Benchmarking of road safety performance in Latin American countries".

Countries may learn to improve road safety from their own experiences and analyses, but also from systematic comparison with other countries of both their safety performance and their safety interventions and policies. Benchmarking can be defined as a systematic process of searching for best practices, innovative ideas and highly effective operating procedures that lead to superior performance (Hammer and Stranton, 1995). Country benchmarking is a useful tool, used in many regions in many areas, to compare countries and learn from each other.

The objective of this project is to develop a methodology to assess road safety performance in a selection of Latin American countries and benchmark their performance against a set of indicators and best practices. The expected outcome is to offer policy makers in Latin America a tool to assess the weaknesses and strengths of each country and to identify areas deserving policy attention, where the experience of other countries may be usefully applied. The results from this benchmarking analysis will be useful to policy makers and researchers in better understanding road safety, and in learning from each other in order to design effective road safety policies.

This work inspires from the SUNflower[1] project which was conducted in Europe (Koornstra et al., 2002). Following the presentation of the project to OISEVI General Assembly in April 2015, ten countries expressed interest in participating in the project: Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, Mexico, Paraguay and Uruguay.

The project is implemented in five stages:

1. Development of a methodology – theoretical framework (November – June 2015)

2. Workshop with data experts from Latin America (July 2015)

3. Collection of data and information (November 2015 – January 2016)

4. Benchmarking analysis (February – April 2016)

5. Final Seminar with data experts and decision-makers (spring – summer 2016).

Methodological approach

The purpose of this paper is to describe the theoretical methodology to benchmark road safety performance in a selection of Latin American countries. The methodological approach is based on the road safety target hierarchy (see Figure 1) used in the SUNflower project (Koornstra et al., 2002). In this,

it is essential to have a clear understanding of traffic safety processes at different levels in the hierarchy, as well as the causes and consequences that lead to casualties and costs for society (Wegman and Oppe, 2010). The "structure and culture" layer captures country-specific characteristics relevant for road safety. The "structure" is related to the organisation of the policy context (who legislates, who deals with operational issues, etc.), and the "culture" relates to the societal perception of road safety problems and the respective responsibilities of individuals and the government. The next layer concerns safety measures and programmes (as road safety policy performance), followed by the layer of safety performance indicators (as intermediate outcomes). Nearing the top of the hierarchy is the layer of numbers of accident fatalities and injuries (as final outcomes), with the layer of social costs of accidents and injuries being at the very top.

Figure 1. **A target hierarchy for road safety**
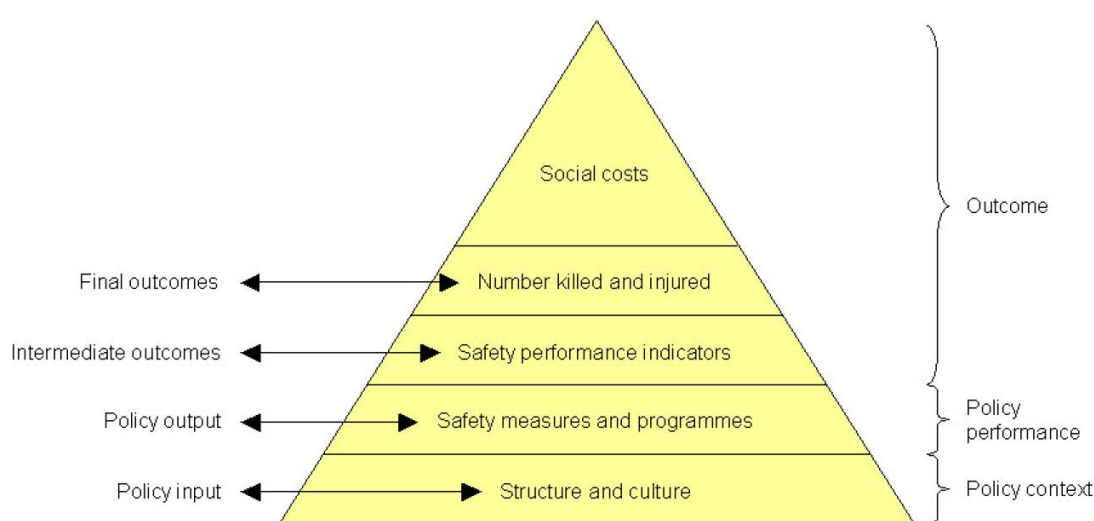
Source: Koornstra et al., 2002.

The methodological approach includes the development of a set of indicators, adapted to the road safety situation in Latin America. This includes final outcome indicators (for different road user groups, types of roads) and intermediate outcome indicators or safety performance indicators. The approach also includes the identification of road safety management practices in key road safety areas, as a basis for safety interventions benchmarking.

This project on road safety benchmarking in Latin American countries analyses information from all layers of the pyramid, as well as the relationships between them. This approach is in accordance with the three levels of road safety issues mentioned by Kare Rumar (Rumar, 2000). The first level issues are related to the way crash and injury statistics are analysed, collected and organised, which varies from country to country. Referring to the target hierarchy proposed in the SUNflower project (Figure 1), these issues can be seen as final outcome indicators.

The second level issues are revealed by a deeper analysis of the first level issues, for instance unclear road traffic rules, inefficient enforcement of license requirements and traffic rules, insufficient control of road condition from the safety point of view, and risk indicators for crashes and casualties – per inhabitant or vehicle number – amongst others. Referring to the target hierarchy of the SUNflower project (Figure 1), they correspond to intermediate outcomes as well as safety measures and programmes.

The third level issues are less visible. They are related to the underlying processes or conditions of the traffic situation, namely the organisation and management of road safety work – such as central or distributed responsibilities – or the values and knowledge of road safety measures that the citizens in a society may have. These issues correspond to the safety measures and programme level and the structure and culture level from the SUNflower project.

Literature review

It is well recognised, whatever the policy sector under review, that there are many lessons to be gained from the analysis of a country's performance and policy in relation to practices in other countries from the same region, or at the same level of development.

This type of analysis is called "benchmarking". It consists of a systematic process of searching for best practices, innovative ideas and highly effective operating procedures that lead to superior performance (Hammer et al., 1995). Benchmarking is a tool to learn from the performances of others "in the same class".

Different types of benchmarking can be distinguished (Shen et al., 2015). One example is product benchmarking, which compares road safety final outcomes, such as road traffic fatalities and injuries and mortality rates (ITF, 2013; OECD and ECMT Transport Research Centre, 2006). Programme benchmarking, on the other hand, compares activities related to human–vehicle–infrastructure performance, such as drink driving, seat belt wearing, vehicle and road safety ratings, and corresponding policy action. This approach has been frequently used in current road safety studies since these activities are causally related to crashes or injuries and can provide a better understanding of the process that leads to crashes (ITF, 2013; OECD and ECMT Transport Research Centre, 2006).

Strategic and organisational benchmarking compares national road safety strategies, resources, management and organisational framework. However, due to the lack of appropriate indicators characterising their features, only some initial attempts have been carried out to date, such as Al-Haji (2007), Wegman et al. (2008), and Eksler et al. (2009).

Integrated benchmarking requires the development of a road safety index, which combines individual indicator values into one single score (composite indicator). This type of benchmarking is particularly useful for international comparisons, when a number of indicators are already available. Regular comparisons per indicator may only give a simplified vision of the road safety situation, and can be misleading, since different countries may operate in different circumstances. The use of a composite road safety indicator (or index) allows to achieve a meaningful benchmarking (Wegman et al., 2008).

Various types of road safety benchmarking have been undertaken in several countries (mainly in Europe). The sections below provide a summary of the most important road safety benchmarking projects and provides a literature review of the published results.

SUNflower Project

The first SUNflower project (Koornstra et al., 2002) compared road safety performances, programmes and policies in Sweden, United Kingdom and The Netherlands. The objectives were to identify key factors that contributed to road safety improvements in these countries, and how these could be used in other countries to further improve their performance. The three countries were chosen because, although being considerably different, they present very similar and good safety records. They had all implemented, in the preceding decades, targeted and well-planned road safety programmes, and their policies had similar objectives. However they differed in their implementation in several aspects.

The main goal of the project was to better understand the relationship between the developments of road risks (through the reduction of the number of deaths and serious injuries) and the road safety policies, programmes, and measures effectively implemented in Sweden, United Kingdom and The Netherlands. Road safety was described as a pyramid consisting of several layers (as shown in Figure 1).

The analysis focused on assessing the effectiveness of the main road safety measures implemented in each country and identifying the most effective ones. The analysis then assessed the potential benefits for each of the three countries of a full implementation of these measures; areas where the countries could further progress were thus identified. Furthermore, the analysis focuses on national road safety strategies and fatality risks of comparable road types, road user modes and collisions between modes. The analysis also included four case study subjects: drinking and driving; seat belt and child restraint use; local infrastructural improvements on urban and minor rural roads; and safety on main inter-urban roads. The project examined changes in overall national risk and several, more specific risk trends between 1980 and 2000. Based on these analyses, the fatality reductions between 1980 and 2000 were attributed to road safety measures and discussed in the context of the targeted fatality reductions up to 2010.

The main conclusions were:

- All three countries achieved similar levels of safety through continued planned improvements.

- Policy areas targeted in these countries were similar, but policies implemented differed at a detailed level.

- Differences in focus for safety programmes result from both different relative sizes of accident groups, and differences in the structure of road safety capability which influences their ability to deliver different types of policy.

- Progress was achieved through directing improved policies to all three areas: vehicle, road and road users.

Specific recommendations and conclusions with respect to differences between the SUN countries are presented in Annex 2.

SUNflower+6 Project

In a second study, SUNflower+6, a similar method was applied to analyse the road safety performance of nine countries (Eksler et al., 2005; Hayes et al., 2005; Lynam et al., 2005; Morsink et al., 2005; Wegman et al., 2005). To facilitate the benchmarking exercise, countries were classified in three groups with similar road traffic patterns:

- The SUN countries: Sweden, United Kingdom and The Netherlands.

- Southern European countries: Greece, Portugal, Spain and the Autonomic Community of Catalonia.

- Central European countries: Czech Republic, Slovenia and Hungary.

According to the specificity of each group, practical recommendations were proposed for their most problematic areas like vulnerable roads users, enforcement, legal system or speeding, amongst others. Important differences were found between the Northern Europe and Southern Europe. The specific recommendations and conclusions for each group and country are presented in Annex 2.

SUNflowerNext

The SUNflowerNext study (Wegman et al., 2008) focused on 27 countries. The objectives were to identify the best performing countries, understand why they were performing better than other countries, and analyse how outstanding practices from the countries which perform "best-in-class" could be adapted to other countries (Gitelman, Doveh, and Hakkert, 2010; Wegman et al., 2008).

Different ways for creating a composite road safety index and evaluating the robustness of the basic indicators involved were explored. The road safety performance indicator (RSI) combined three types of performance indicators (see Figure 1): road safety performance indicators, implementation performance indicators and policy performance indicators.

A composite road safety index combining these indicators was developed. Two weighting procedures (principal component analysis[2] and factor analysis[3]) were examined, based on the data collected for 27 European countries (see also Papadimitriou et al., 2013). This allowed ranking and grouping the countries according to their safety performance.

The performed analysis revealed that the country rankings – based on the combination of indicators – was different from the traditional ranking of countries – based on mortality rates or fatality rates only. The inclusion of information on policy performance and implementation performance to the ranking and grouping process improved the results and made them more meaningful. It gave a more complete picture of road safety than a ranking based only on fatality rates, which is currently the most common practice.

DaCoTa project

The DaCoTa project was a follow-up of the SafetyNet and the SUNflower related projects, which had developed the pyramid structure and the concept of road safety performance indicators, and first calculations were made. The Dacota project had the following four aims:

- investigate whether indicators for road safety management can be used in the Road Safety Index

- extend the work on indicators for structural and cultural differences among countries

- aggregate the indicators into one single score per layer of the pyramid

- investigate whether further integrating the four layers into one single score for the composite index as a whole would provide any added value.

The DaCoTa project aimed at delivering an instrument to facilitate the comparisons of the overall road safety situation between countries (Bax et al., 2012). This instrument results from the combination of indicators called the overall Road Safety Index (RSI) of a country, which describes the road safety outcomes and the road safety policy performance. These performance indicators were compared at three different levels (see Figure 2): final outcomes (injuries and crashes), intermediate outcomes (safety performance indicators such as drink driving, speeding, car safety) and policy output (safety measures and programmes).

A method to combine the indicators of final outcomes, intermediate outcomes and policy output layers into one single composite index was developed. The authors calculated the composite index for each layer and then investigated the value of combining the composite layer-indices in one overall Road Safety Index. This was done using weighting procedures in order to deduce a weight for each indicator

and to compute an index score for each country subsequently. However, different weighting procedures have their own advantages and limitations, and imply different end results.

Ideally, an overall Road Safety Composite Index would provide an unambiguous ranking of all countries, taking into account all indicators of safety outcomes. However specific theoretical and practical problems on the weighting of layer-indexes were encountered, which required further research.

International benchmarking of road safety: State of the art

Countries within the same region, or that have already passed through similar stages of challenges and development, usually have several common problems that can be identified in close co-operation and improvements can be expected by learning lessons from existing best practices in other countries (even if the final solutions or priorities may differ from one country to another, in accordance with their own safety characteristics) (Shen et al., 2015).

Shen et al. (2015) presented a road safety benchmarking cycle, adapted from Wegman et al. (2008), with five core activities (see Figure 2):

- determine the key components for road safety benchmarking

- identify the benchmarking partners (or countries)

- construct indicators for meaningful comparisons and data gathering

- examine gaps in performance and their root causes

- set targets (on final and intermediate outcomes) and monitoring progress.

The development of a road safety index, along with some theoretical and practical issues on this subject, was discussed. Shen et al. also refer to the work of Al-Haji (2007) and Hermans et al. (2008). Al-Haji proposed a road safety development index (RSDI), considering three main areas: fatality rates, road user behaviour and system components (safer vehicles, safer roads, socio-economic level, enforcement, and organisational performance). For this purpose, four weighting procedures were used: equal weighting, expert judgments, subjective weights based on previous experience and principal component analysis.

Hermans et al. (2008) proposed a road safety performance index for cross-country comparison. One safety performance indicator was defined for each one of the six risk factors: alcohol and drugs, speeds, protective systems, vehicles, roads, and trauma management. Five weighting procedures were investigated to combine the separate indicators into one overall index: factor analysis, budget allocation, analytic hierarchy process, data envelopment analysis, and equal weighting. The results were then compared with the number of fatalities per million inhabitants. The data envelopment analysis method was considered the best approach to the road safety ranking.

Figure 2. **The road safety benchmarking cycle**
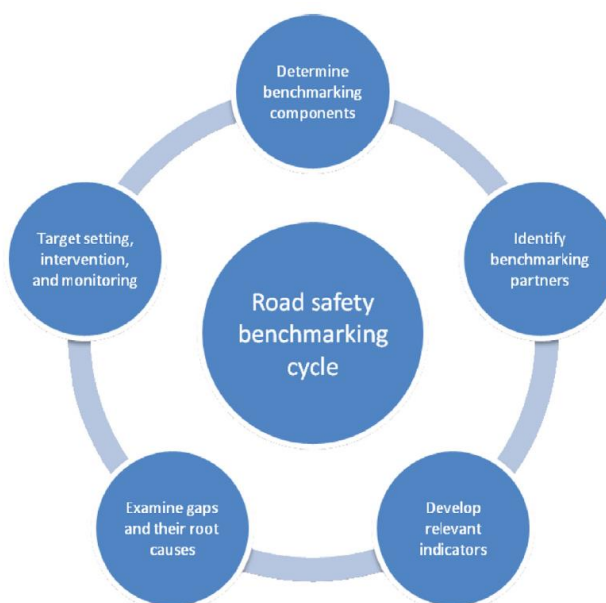
Source: Shen et al., 2015; Wegman et al., 2008.

Methodology to assess road safety performance in a selection of Latin America countries

For this project, the purpose is to compare – for different countries in Latin America – crash trends and characteristics, road safety strategies, policies, and measures that have been implemented, and to analyse which have been the most effective in reducing traffic casualties, and under which specific conditions. The results will form a starting point for participating countries to learn from each other. The comparison will identify similarities and differences between countries, in particular regarding factors, circumstances and developments that have influenced crash risk and the severity of their outcome. More specifically, the work will encompass the following tasks:

- Define indicators and collect the data required to analyse the specific case studies and overall policy.

- Provide insights concerning the quality of different data sources for comparing road safety policies and actions.

- Identify the strengths and weaknesses of each country or region through comparative benchmarking (data availability and quality).

- Develop a scientifically-based understanding of differences between benchmark values.

- Draw conclusions on effective interventions and measures and success factors in different areas, and propose how these could be applied in other countries participating in this project to improve their road safety performance.

To undertake this analysis, it is proposed to collect and analyse data and information in the following areas (see Annex I for more details):

- road safety policy and organisation

- general data on the road transport system

- road crashes and casualty data, and traffic and road safety trends

- case studies on key road safety areas.

In order to improve the benchmarking analysis, it is proposed to group the countries that present similarities on key indicators (see section on Country grouping). However, as data availability is not yet fully known, it was agreed that the final grouping, if needed, will be made at a later stage after a preliminary analysis has been made.

Data analysis: Overview

An initial task is to describe and analyse current road safety strategies, including key interventions and main stakeholders. Data and information will also be collected to describe the road transport system. This will include: population data, country area, road length, registered motorised vehicles, annual distances travelled by vehicles and passengers and fuel sales for motorised vehicles.

Safety data and case studies

Trends in fatal injuries and crashes will be analysed to explain differences identified by the benchmarking. This will allow to relate the outputs with the key measures implemented by each country and to identify the effects (positive or negative) of these measures. To identify major road safety issues in Latin America, the project will encompass the analysis of case studies among the following topics: pedestrians; powered two-wheelers; drink and driving; speed; seat belts and child restraint use; young drivers; road infrastructure; vehicle safety; and trauma management. The final selection of case studies will be made based on country interest and data availability. Case studies will only be undertaken when at least three countries have good quality data to provide.

Data availability and limitation

During a workshop held in July 2015 with data experts from participating countries, the availability of data was discussed – in particular regarding information on slightly and severely injured victims. Some countries do not make a distinction between slight and serious injury; and underreporting of injury data was also mentioned. As a result, it was decided to limit the benchmarking analysis to fatalities and fatal crashes – disaggregated by road user type, age group, location and involved vehicles. Data will be collected up to the year 2013. The analysis may be updated with 2014 data at a later stage.

Concerning time trends, each country will decide on the most appropriate time period – based on data availability and comprehensiveness – taking into account that the preferred option would be to have a long timeframe, with data collected in a consistent way. Depending on the data availability, the development of a composite index similar to the ones proposed in SUNflowerNext and DaCoTa projects might be considered. The feasibility of this approach will be decided on after the data collection.

In the case that a complete set of data will not be available in the participating countries, data could be collected at regional or municipal level, and a benchmarking analysis for three to four selected cities or provinces may be undertaken. Nevertheless, during the workshop held in July 2015, experts indicated they had enough data to participate at the national level, so neither the regional nor municipal analysis was considered.

Detailed description of the data and information

Road safety policy and organisation

- main road safety policies, plans and road network improvement programmes

- institutional issues, organisation of roads safety

- selected key road safety legislation (e.g. speed limits, maximum authorised level of blood alcohol content [BAC], seatbelt laws, etc.).

General data describing the road transport system

- population: age distribution, geographical (urban/rural) distribution

- driver licencing schemes: types, age limits

- area (km^2), road length (km) by type of road (urban roads, rural roads, motorways)

- registered motorised vehicles by type: passenger cars, heavy good vehicles ($\geq$ 3.5 tonnes), SUVs and light good vehicles (< 3.5 tonnes), powered two-wheelers (motorcycles and mopeds), coaches/buses, other motor vehicles, bicycles

- vehicle-kilometres (by type of vehicles) and passenger–kilometres (public transport, pedestrians).

Data on fatal road crashes

- overall number of fatalities

- number of fatalities by user type (car occupants, light-duty vehicle occupants, heavy-duty vehicle occupants, bus occupants, powered two-wheeler users, cyclists, pedestrians, other road users)

- fatalities distribution by age group and road transport mode (passenger cars, heavy-duty vehicles, light-duty vehicles, buses, cyclists, powered two-wheelers, pedestrians, others)

- number of fatalities resulting from collisions, by type of user (driver, car occupant, lorry occupant, bus occupant, motorcyclist, mopedist, cyclist, pedestrian, other road users) and in single crashes or in collisions with different types of vehicles (passenger car, lorry, bus, motorcycle, moped/cycle, animals, train/tram, other)

- crash data by location (type of road, urban roads/ rural roads)

- underreporting of road crashes and of road fatalities.

Case studies

Pedestrian

- number of pedestrian deaths in collisions with passenger cars, heavy-duty vehicles, light-duty vehicles, buses, powered two-wheelers, tram, trains and other type of vehicles

- age distribution of pedestrian fatalities

- trends in pedestrian fatality rates

- geographic distribution of pedestrian fatal crashes (urban areas/rural areas)
- pedestrian fatalities per month, per day of week and by time of day

Powered two-wheelers (PTW)

- number of PTW fatalities by type of accident and trends over time
- age distribution of PTW fatalities
- geographic distribution of PTW fatal crashes (urban areas/rural areas)
- PTW drivers and passengers killed, with and without helmet.

Drink and driving

- number of screening tests per year, per vehicle car
- number of drink and drive infringements
- screening tests positive in fatal and injury crashes
- number of fatal crashes with driver over the legal alcohol limit
- number of screening tests on drivers involved in fatal crashes
- number of screening tests performed per accident.

Speed

- speed limits per road type, vehicle class, and sanction regime
- mean speed per road type
- number of speed limits infringements on different types of roads
- number of crashes and casualties due to excessive speed on different types of roads.

Seat belts and child restraint systems

- seat belt use among drivers and passengers (front seat, back seat) for different road types
- seat belt use and child restraint systems (CRS) infringements
- seat belt use and CRS among fatal crashes (by age)

Young drivers

- number of drivers involved in fatal crashes by driving license holders' age
- number of loss-of-control crashes by age group
- number of new drivers (male/female)
- number of car drivers involved in fatal crashes by age group
- number of weekend night crashes by age group

Infrastructure safety data from International Road Assessment Programme

Data on infrastructure safety will be collected through the International Road Assessment Programme (IRAP). Star Rating of roads by road user group involves the proportion of roads classified as 1, 2, 3, 4 or 5 stars for different road users (where traffic volumes > 5 000 a day).

Road characteristics and adaptability to road users include:

- roads where pedestrians are present and speed flows at 40km/h or more and which have no footpath
- roads where bicyclists are present and traffic flows at 40km/h or more that have no bicycle facilities
- roads with high motorcycle flows (>=20% of total) and traffic flows at 60km/h or more that have no motorcycle facilities
- roads carrying traffic at 80km/h or more that are undivided single carriageways
- curves where traffic flows at 80km/h or more that have hazardous roadsides
- intersections where traffic flows at 60km/h or more that have no roundabout, protected turn lane or interchange.

Post trauma

- number of evacuations to trauma centre by type (self, regular ambulance, mobile intensive care unit, helicopter)
- average time for arrival at scene, treatment in the field and arrival for definitive treatment in hospital
- total length (in days) of hospitalisation
- number of Emergency Medical Stations (absolute number and per population)
- number of trauma beds in permanent medical facilities (absolute number and per population)
- length of hospitalisation in intensive care units
- number of Emergency Medical Station's vehicles (absolute number and per population).

Vehicles

- total number of vehicles listed by year of manufacture (or year of first registration)
- time series for the number of registered vehicles.

Country grouping

At the time of the development of this methodology, ten countries expressed interest in participating in the project: Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, Mexico, Paraguay and Uruguay. As mentioned earlier, a meaningful benchmarking analysis requires comparing subjects that are comparable. In this respect it was considered useful to distinguish two groups of countries based on their motorisation, geographical position, population patterns and other characteristics.

It is expected that country grouping will increase the degree of "natural association" among members of the same group, and help to distinguish members from different groups (Anderberg, 1973), thus offering a more feasible basis for the safety performance comparisons and the transference of successful experiences. An initial "grouping" analysis was undertaken, taking into account the following factors:

- population density

- share of the population in urban and rural areas

- motorisation rate

- road fatality rate.

Details of this analysis are presented in Annex 1. The results of this exercise allowed to group countries sharing similar characteristics (see Table 1).

Table 1. **Grouping assessment for benchmarking road safety**

| Based on	Group 1	Group 2
Population density	Colombia, Costa Rica, Cuba, Ecuador, Mexico	Argentina, Brazil, Chile, Paraguay, Uruguay
Geographical repartition of the population (urban / rural areas)	Colombia, Costa Rica, Cuba, Ecuador, Mexico, Paraguay	Argentina, Brazil, Chile, Uruguay
Level of motorisation	Chile, Colombia, Costa Rica, Cuba, Ecuador, Paraguay	Argentina, Brazil, Mexico, Uruguay
Mortality rate in relation to motorisation rate	Paraguay, Ecuador	Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Mexico, Uruguay

From these sets it is problematic to select two main groups, as similarities are not homogeneous. Nevertheless, it is possible to confirm that Argentina, Brazil and Uruguay are always together irrespective of the selected factor. In the same group it is possible to include Chile, (sharing similarities under three factors), and Mexico (sharing similarities under two factors).

Accordingly, the following country grouping is proposed (see also Figure 3):

- Group 1: Colombia, Costa Rica, Cuba, Ecuador, and Paraguay

- Group 2: Argentina, Brazil, Chile, Mexico, Uruguay.

The final grouping may evolve based on data availability, and will be decided once a preliminary analysis has been made.

Figure 3. **Country grouping proposal**
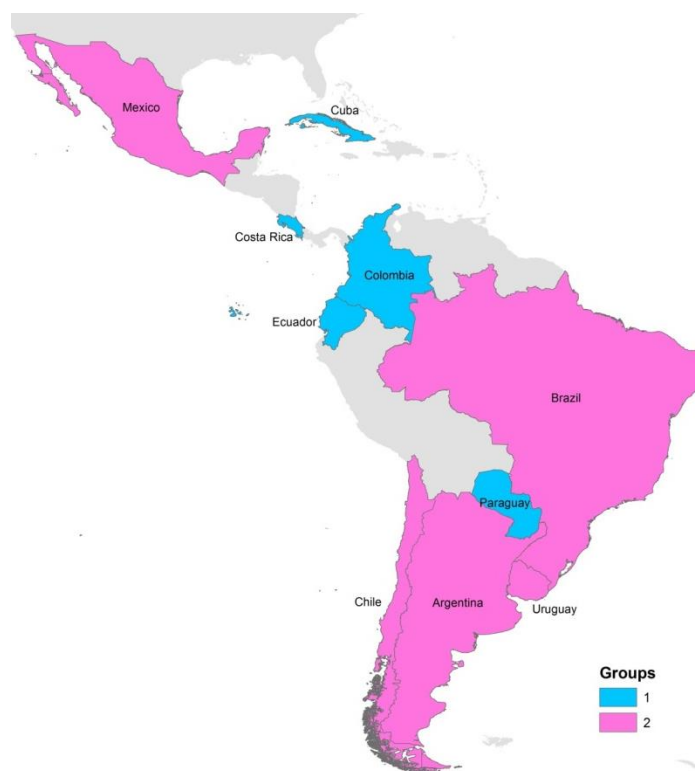
Next steps

The methodology described in this paper was adjusted with ITF and OISEVI, based on data and information available and on the outcome of the workshop that was held with experts from the participating countries in July 2015. At this workshop, a survey was undertaken to have an initial indication of the types of data and information available.

The data to be collected was organised in a template that was sent to the countries' representatives. This data collection is expected to be completed by mid-January 2016, following which the benchmarking analysis will be undertaken.

Notes

1. The SUNFLOWER project was originally developed to assess road safety in Sweden, United Kingdom and the Netherlands (SUN-countries), and thereafter was extended and applied to nine countries.

2. Principal component analysis (PCA) is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components.

3. Factor analysis is a statistical method used to describe variability among observed, correlated variables in terms of a potentially lower number of unobserved variables called factors.

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Annex 1. Country grouping analysis

A grouping analysis was made based on the following information for each country: population density, road length, motorisation and mortality rates (GADM, 2015; Index Mundi, 2015; World Health Organization, 2013).

Population density

Population density shows a great disparity and varies between 7.0 inhabitants/km² in Paraguay, to 104.5 in Cuba (see Table A1).

Two groups of countries can be distinguished:

- Group 1: Population density above 40 inhabitant/km²: Cuba, Costa Rica, Mexico, Colombia, Ecuador.

- Group 2: Population density below 25 inhabitants/km²: Brazil, Chile, Uruguay, Argentina, Paraguay.

Table A1. **Population density**

Country	Population (2010)	Area (km^2)	Density (hab/km^2)
Argentina	40 412 376	2 780 400	14.5
Brazil	194 946 488	8 515 767	22.9
Chile	17 113 688	756 950	22.6
Colombia	46 294 842	1 138 914	40.6
Costa Rica	4 658 887	51 608	90.3
Cuba	11 477 460	109 884	104.5
Ecuador	14 464 739	256 932	56.3
Mexico	113 423 052	1 958 201	57.9
Paraguay	6 454 548	919 247	7.0
Uruguay	3 368 786	178 141	18.9

Urban and rural population

Figure A1 shows the percentage of urban and rural population. All countries present a higher percentage of urban population; however, there are wide variations in the percentage of rural population, with several countries having more than a quarter of their population living in rural areas, including: Paraguay (39%), Costa Rica (36%), Ecuador (33%), Colombia (25%), Cuba (25%) and Mexico (22%). Conversely, the following four countries have lower percentages of rural population: Uruguay (8%), Argentina (8%), Chile (11%) and Brazil (16%). Based on this indicator, we can distinguish two groups of countries:

- Group 1 (more than 25% of the population live in rural areas): Colombia, Costa Rica, Cuba, Ecuador, Mexico, and Paraguay

- Group 2 (less than 20% of the population live in rural areas): Argentina, Brazil, Chile, and Uruguay.

Figure A1. **Distribution of urban and rural population**
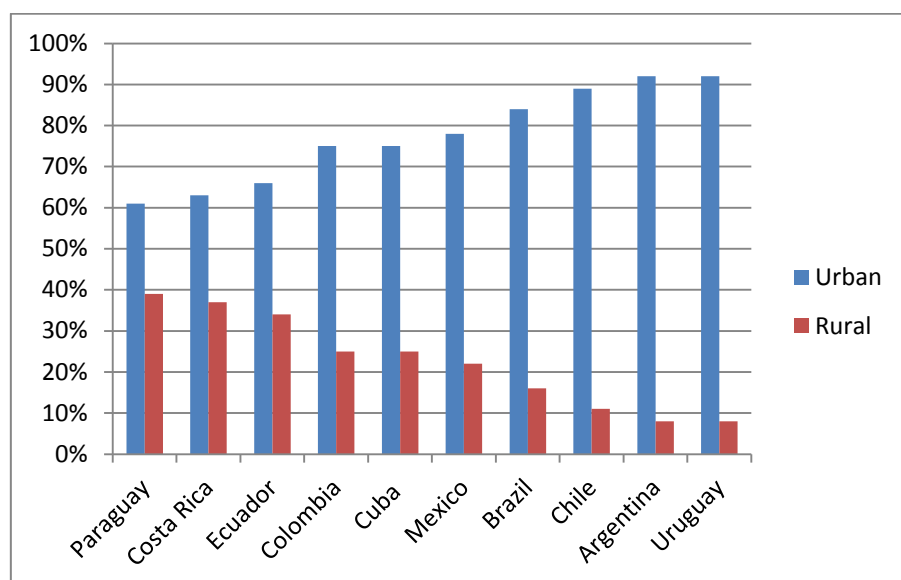
Road network length

Although indirectly, road network length can be related to road casualties as an exposure factor. Figure A2 presents the main road network length. Brazil has the largest, at 317 925 km, followed by Mexico (226 933 km) and Argentina (197 994 km). At a lower level, one can find the other countries: Colombia (51 780 km), Chile (46 518 km), Paraguay (21 198 km), Cuba (18 101 km), Uruguay (13 554 km), Ecuador (10 935 km) and finally Costa Rica (5 160 km).

- Group 1: Chile, Colombia, Costa Rica, Cuba, Ecuador, Paraguay and Uruguay

- Group 2: Brazil, Mexico, Argentina.

Motorisation rate

Figure A3 presents the number of motorised vehicles in 2010. Brazil is by far the country with the highest number of motorised vehicles. However, when normalised by the number of inhabitants, the motorisation rate is higher in Uruguay (390 vehicles/1 000 inhabitants) followed by Argentina (350 vehicles/1 000 inhabitants), Brazil (330 vehicles/1 000 inhabitants), Mexico (270 vehicles/1 000 inhabitants), Chile and Costa Rica (200 vehicles/1 000 inhabitants), Colombia (160 vehicles/1 000 inhabitant), Paraguay (140 vehicles/1 000 inhabitants), Ecuador (80 vehicles/1 000 inhabitants) and finally Cuba (50 vehicles/1 000 inhabitants).

- Group 1: Motorisation of 200 vehicles/1 000 inhabitants or below: Chile, Costa Rica, Colombia, Paraguay, Ecuador, and Cuba.

- Group 2: Motorisation rate above 250 vehicles/1 000 inhabitants: Argentina, Brazil, Mexico, and Uruguay.

Figure A2. **Main road network length (2010)**
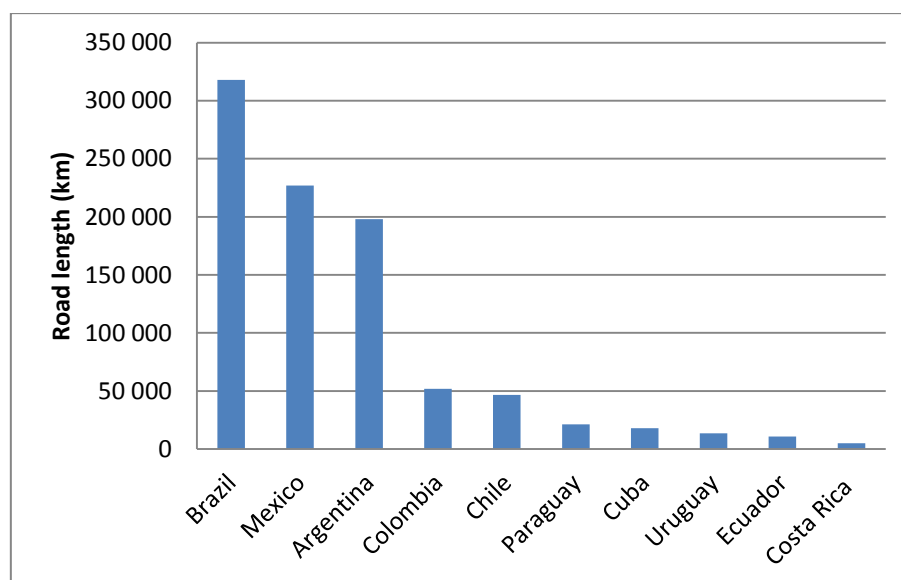
Source: Index Mundi, 2015.

Figure A3. **Number of registered motorised vehicles and motorisation rate (2010)**
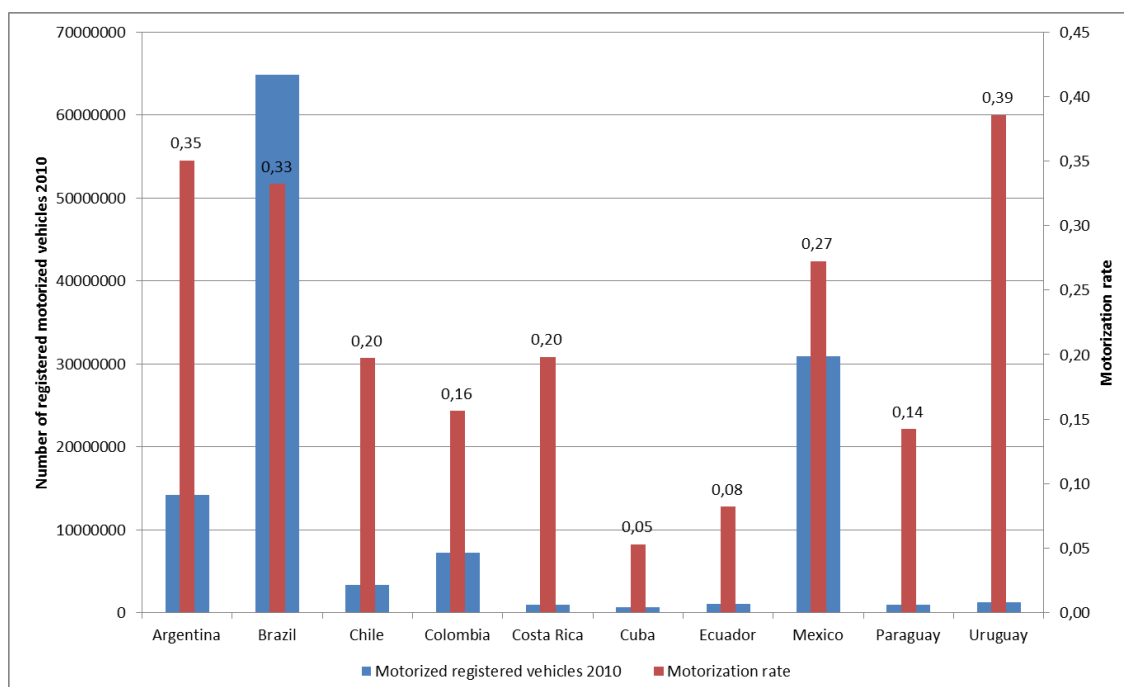
Source: World Health Organization, 2013.

Share of powered two-wheelers in the fleet

Figure A4 presents the number of motorised vehicles disaggregated by type in 2010. It shows that in Colombia, Cuba and Uruguay there is very high share (see Figure A3 above) of motorised 2- and 3- wheelers.

Figure A4. **Share of the vehicle fleet by type of vehicle (2010)**
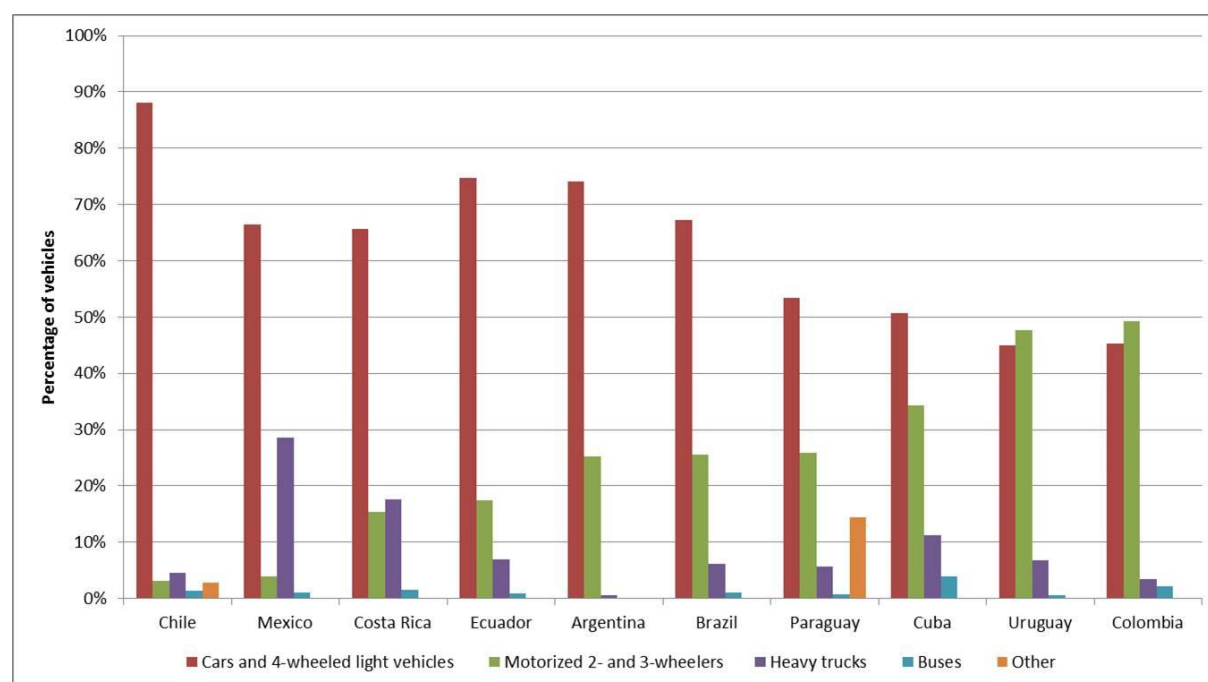
Source: World Health Organization, 2013.

Based on this indicator, one can identify the following groups:

- Group 1 (share of PTW above 30%): Colombia, Cuba, and Uruguay.

- Group 2 (share of PTW below 30%): Argentina, Brazil, Chile, Costa Rica, Ecuador, Mexico, Paraguay

Motorisation rate and mortality rate

Figure A5 presents a scatter plot of the motorisation rate versus the mortality rate for the year 2010. The countries which present a high motorisation rate and a low mortality rate have better results in terms of road safety. However, good results might also be considered if both the motorisation rate and the mortality rate are low. Bad performances are associated with low motorisation rates and high mortality rates. With these values it is possible to group Uruguay, Argentina, Brazil, Mexico, Colombia, Costa Rica and Chile. Lower road safety levels are presented by Paraguay and Ecuador.

- Group 1: countries with a low motorisation rate and a high mortality rate: Paraguay and Ecuador

- Group 2: countries with a high motorisation rate and a low mortality rate, or with a low motorisation rate and a low mortality rate: Uruguay, Argentina, Brazil, Mexico, Chile, Colombia, Costa Rica and Cuba.

Figure A5. **Motorisation rate versus mortality rate (2010)**
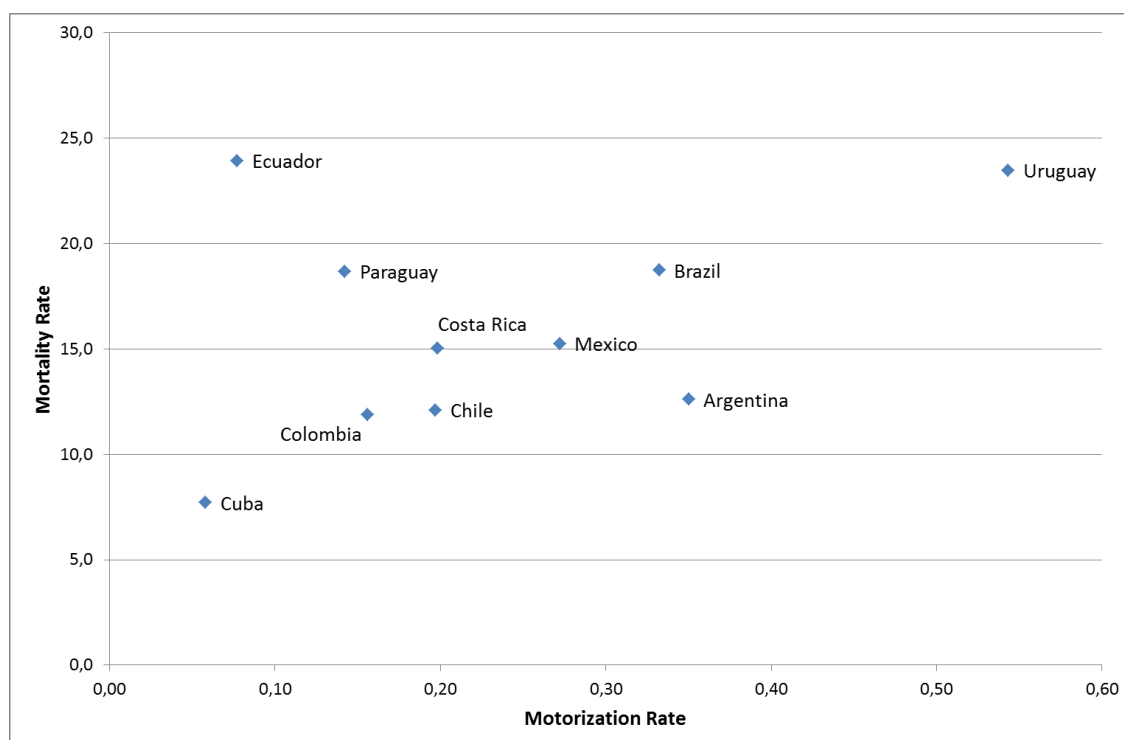
Source: World Health Organization, 2013.

Mortality rates

Other indicators may be considered in the grouping analysis, including mortality rates: road traffic deaths rates per population, per motor vehicles and per road length (see Table A2 and Figure A6).

Regarding road traffic deaths per inhabitants, the highest rate is found in Ecuador (with 23.9 deaths/100 000 inhabitants), followed by Uruguay with a similar value of 23.5 deaths/100 000 inhabitants. Lower values are found in Colombia (11.9 deaths/100 000 inhabitants) and Cuba (7.0 deaths/100 000 inhabitants).

This indicator, however, is not sufficient to assess the safety level of a country as it takes into account neither the motorisation rate nor the traffic volume. Nevertheless, it is a useful indicator to consider road safety from a health perspective.

Regarding the number of road traffic deaths per 10 000 motorised vehicles, the higher value was found in Ecuador, with 31 deaths/10 000 vehicles. Cuba and Paraguay follow, with 13.3 and 13.1 deaths/10 000 vehicles, respectively. The lower values were found in Uruguay and Argentina, with 4.3 and 3.6 deaths/10 000 vehicles respectively.

As for the number of road traffic deaths per 100 kilometres of road length, the highest value was presented by Ecuador, with 29.5 deaths/100 kilometres. Costa Rica, Brazil and Colombia follow, with 13.6, 11.5 and 10.6 deaths/100 kilometres respectively. The lower values are presented by Uruguay (4.1 deaths/100 kilometres) and Argentina (2.6 deaths/100 kilometres).

Table A2. **Road traffic deaths rates per population, per motor vehicles and per road length (2010)**

Country	Road traffic deaths	Population	Motor vehicles	Road length /km	Road traffic deaths/100 000 inhabitants	Road traffic deaths/ 10 000 mot. vehicles	Road traffic deaths/ 100 km road length
Argentina	5 094	40 412 376	14 163 125	197 994	12.6	3.6	2.6
Brazil	36 499	194 946 488	64 817 974	317 925	18.7	5.6	11.5
Chile	2 071	17 113 688	3 375 523	46 518	12.1	6.1	4.5
Colombia	5 502	46 294 842	7 229 373	51 780	11.9	7.6	10.6
Costa Rica	700	4 658 887	923 591	5 160	15.0	7.6	13.6
Cuba	809	10 477 460	607 675	18 101	7.7	13.3	4.5
Ecuador	3 222	1 039 364	1 039 364	10 935	23.9	31	29.5
Mexico	17 301	30 904 659	30 904 659	226 933	15.3	5.6	7.6
Paraguay	1 206	919 247	919 247	21 198	18.7	13.1	5.7
Uruguay	556	128 7012	13 554	13 554	23.5	4.6	4.1

Figure A6. **Road traffic deaths rates per population, per motor vehicles and per road length (2010)**
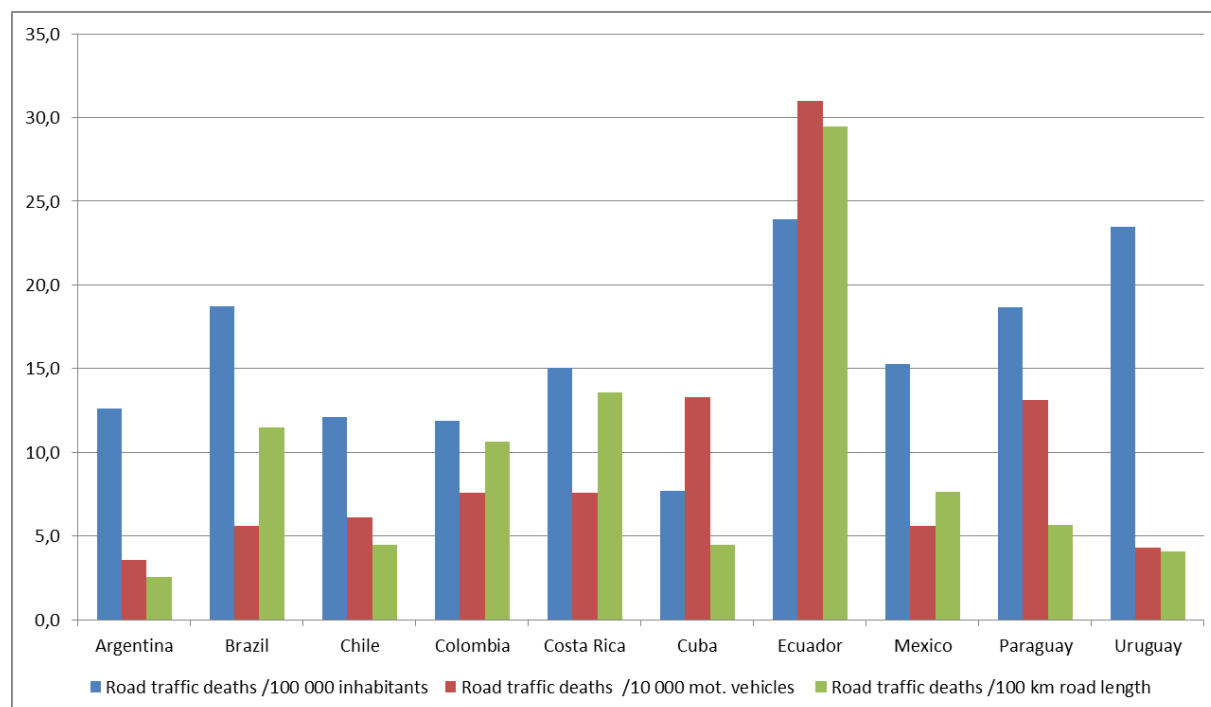
Conclusions

From the selected indicators it is not easy to identify two main groups. Nevertheless, Argentina, Brazil and Uruguay are always in the same group irrespective of the indicator (see Table A3). In the same group it is possible to include Chile (sharing similarities for three indicators), and Mexico (sharing similarities for two indicators).

Table A3. **Country grouping according to the selected indicators**

	Group 1	Group 2
Population density	Colombia Costa Rica Cuba Ecuador Mexico	Argentina Brazil Chile Paraguay Uruguay
Geographical distribution of population (rural / urban)	Colombia Costa Rica Cuba Ecuador Mexico Paraguay	Argentina Brazil Chile Uruguay
Road network length	Chile Colombia Costa Rica Cuba Ecuador Paraguay Uruguay	Brazil Mexico Argentina
Motorisation	Chile Colombia Costa Rica Cuba Ecuador Paraguay	Argentina Brazil Mexico Uruguay
Share of powered two-wheelers in the fleet	Colombia Cuba Uruguay	Argentina Brazil Chile Costa Rica Ecuador Mexico Paraguay
Mortality rate x motorisation rate	Paraguay Ecuador	Argentina Brazil Chile Colombia Costa Rica Cuba Mexico Uruguay

Accordingly, the following country grouping is proposed (see also Figure 3):

- Group 1: Colombia, Costa Rica, Cuba, Ecuador, and Paraguay

- Group 2: Argentina, Brazil, Chile, Mexico, Uruguay

The final grouping may evolve based on data availability and will be decided once a preliminary analysis has been made.

Annex 2. Conclusions and recommendations of the SUNflower+6 Projects

SUNflower Project

Specific recommendations and conclusions with respect to differences between the SUN countries:

- British risks were highest for pedestrians and for motorcyclists – but lowest for car occupants – compared to the other countries. Factors, which may explain these risk differences, include the higher traffic density on British roads, the greater use of roundabouts at junctions, and the lower average speed on main inter-urban roads.

- Car occupant risk was highest in Sweden. Factors that may explain this were the higher Swedish average speed on main roads – despite lower speed limits – and the lower traffic density and lower speed limit enforcement level.

- Dutch mopedists had almost twice as high the risk of those in the other countries and they drove more kilometres. Dutch cyclist risk was lowest, but still higher than car risk – even when the risk that cars inflict on other road users is included. And Dutch citizens cycle by far the most. Factors that may explain the low cyclist risk include the presence of large numbers of cyclists and the extensive implementation of cycle facilities.

- Sweden had 14% driver fatalities over 0.1% BAC in 2000, versus an estimated 17% in the Netherlands and a reported 20% in Britain. This may be explained by the differences in legal blood alcohol limits, enforcement policies, and penalties for offending in the three countries.

- The risk on Dutch roads other than motorways was about a third higher than the risk on these types of roads in the other countries. Factors, which might explain this include higher exposure and risk to mopedists, higher cyclist exposure, lower belt use, and higher junction density.

Main recommendations for future road safety improvements in the SUN countries:

- As car drivers had a higher risk in Sweden than in the other two countries; traffic safety efforts in Sweden should concentrate on car drivers and their speed behaviour.

- Britain would benefit from a lower blood alcohol limit for drinking and driving, more intensively enforced, but with some relaxation of penalties for the new, lower limit offences.

- Britain requires an infrastructure solution that enables pedestrian and motorised traffic to co-exist at lower fatality levels, for example by extending the length of urban roads with 20 mph (30 km/h) speed limits.

- Britain should also give greater emphasis to developing a more extensive, high quality road network of similar density to that in the other countries; this could encourage greater acceptance of lower speeds on other roads.

- The Netherlands needs to understand why its moped rider risk is so high in order to identify an appropriate solution.

- The Netherlands also requires to review its drink-driving problem, to identify how best to make further reductions in alcohol-related fatalities.

- The Netherlands needs to identify an effective strategy to increase seat belt wearing rates to a similar level as the other two countries.

SUNflower+6 Project

The main conclusions and recommendations for the SUN countries were:

Sweden

- Make the transport environment more forgiving, to reduce injuries when accidents occur. This could reduce the high proportion of elderly pedestrian and cyclist fatalities, and also reduce injuries among elderly car occupants.

- Consider further efforts to improve public acceptance of enforcement initiatives, possibly through more community partnerships. There would seem to be an opportunity to increase the use of automatic detection, mainly of speeding offenders. But increased enforcement also needs a change in the legislative system concerning both fines and vehicle owner responsibility to be as effective as possible.

- Seek, in the longer term, to move to a lower speed limit for two-lane rural roads, and develop a network of higher quality rural roads which can safely sustain higher speed limits.

United Kingdom

- Focus more effort on seeking innovative road designs which cater to mixed vehicular and vulnerable road user activities at the higher traffic flow levels evident in Britain.

- Improve facilities for cycling, especially in the context of the government's desire to increase cycling.

- Give more attention to helping drivers recognise the presence and behaviour of motorcyclists within the traffic flow, and give particular attention to countermeasures to reduce bend and overtaking accidents involving motorcyclists.

- Ensure that the latest policy statements on enforcement promising greater visible presence are accompanied by sufficient resources to achieve this. Ensure that senior police managers demonstrate a genuine commitment to road safety by maintaining an appropriate level of traffic policing.

- Improve its package of drink-drive measures and particularly increase the real level of detection, as opposed to the perceived level. The increasing number of speeding offences also suggests that the balance between enforcement and public awareness might be improved.

- Seek, in the longer term, to move to a lower speed limit for two-lane rural roads, and develop a network of higher quality rural roads which can safely sustain higher speed limits; through this approach there should be clearer separation in Britain between the road standards (and speed limit bands) in the rural network.

The Netherlands

- Continue to increase the share of 30 km/h roads in urban areas, and make pedestrian crossing design more consistent with road categories.

- Seek measures to reduce the high proportion of pedestrian fatalities involving mopeds.

- Continue to provide for physical separation of cyclists and motorised traffic on main roads, and traffic calming measures at intersections.

- Increase the training required by moped riders aged 16-17 before access to the road, increase (correct) helmet wearing rates, and introduce a more structured licensing system and vehicle registration plates to help enforcement of the behaviour of this group, especially as regards speeding.

- Seek ways of increasing the experience gained by young drivers before they take the driving test, including considering accompanied driving before the driving test.

- Seek ways to make the road environment assist in complying with relevant speed limits and, in particular, investigate the situation on 80 km/h roads which have a high fatality risk.

- Consider if the very high level of speeding offences suggests that a different approach to modifying speeding behaviour might be needed. Greater focus on enforcement of repeat, or extreme, offenders should be considered.

The main conclusions and recommendations for the Southern European countries were:

Greece

- Improving driver compliance with the existing seat belt law.

- Seek ways to improve pedestrian safety with new measures, such as artificial lighting or improvement of pedestrian visibility.

- Increase the level of helmet usage (both motorcycles and mopeds) by better police enforcement and increased sanctions.

Portugal

- Improve the use of seat belt wearing in rear seat occupants.

- Seek ways to facilitate safe pedestrian movements on both urban and rural roads passing through towns, with elderly people at night as the design criteria.

- Consider re-training courses and/or enforcement of helmet usage to reduce the proportion of elderly mopedist fatalities.

- Portuguese PTW users need improved training or the introduction of a points-based driving licence that can curb reckless driving.

Spain

- Improve the alcohol controls carried out at accidents.

- Stricter legal measures to be considered that include the setting of a standard BAC level of 0.2 g/l for motorcyclists; or the establishment of a common, minimum punishment of unconditional suspension of the driving licence for six months for anyone passing the limit.

- Seek measures to improve rear seat belt use.

- Consider the introduction of automatic detection of speeding drivers to reduce their numbers, and to change driver behaviour, in order to lower the number of fatalities due to speeding.

Catalonia

- Increase police controls in order to reduce the drink and drive problem.

- Extend speed camera control to the entire road network (of locations with speed-related accidents) to ensure a change in driver behaviour.

- Improve the use of child restraint systems and rear seat belts.

The main conclusions and recommendations for the Central European countries were:

Czech Republic

- Seek measures to reduce the high proportion of (elderly) pedestrians and cyclist fatalities, and increased involvement of HGV in road accidents.

- Consider more effort to improve public attitudes to enforcement possibly through more frequent community partnerships.

- Consider the application of the special regulations controlling vehicle use by novice drivers.

- Consider the recent system of police enforcement: make car owners responsible for the offences related to their vehicle, reconsider the amount of fines and make more transparent how they are used.

- Revise the methodology of road accidents reporting by the police in order to provide valuable information for the road safety research community.

- Reconsider speed management scheme, with a stronger emphasis on general deterrence and prevention; and possibly reconsider speed limits on road sections in rural areas. Give more support to zone 30 applications.

Hungary

- Consider the responsibility distribution, as it is not clearly defined which of the ministries has the main responsibility for road safety.

- Increase the resources for road safety improvement, as the existing budget for this purpose is inadequate.

- Focus on education and training courses for drivers in regard to road safety: fundamentally, the selection of the safe speed and, in general, the strict requirement for obeying rules must assume a greater role.

- Develop effective speed management.

Slovenia

- Consider the establishment of a central Road (Transport) Safety Agency with proper funding (budget) to co-ordinate and manage road (transport) safety activities.

- Apply legislation changes regarding driving under the influence of alcohol (introduction of zero BAC limit) in order to influence the patterns of social behaviour related to excessive drinking in general.

- Seek measures to reduce the high proportion of young drivers involved in injury accidents, especially those involved in weekend night accidents.

- Consider effective enforcement of zero BAC and pay even more attention to education and preventive work in the respective field.

- Encourage the implementation of effective speed management.

- Encourage further accelerated implementation of traffic calming schemes in built up areas.

- Improve the management of the road safety performance indicators data collection system, including regular research surveys on protective systems use, speeding and alcohol level distribution among drivers.