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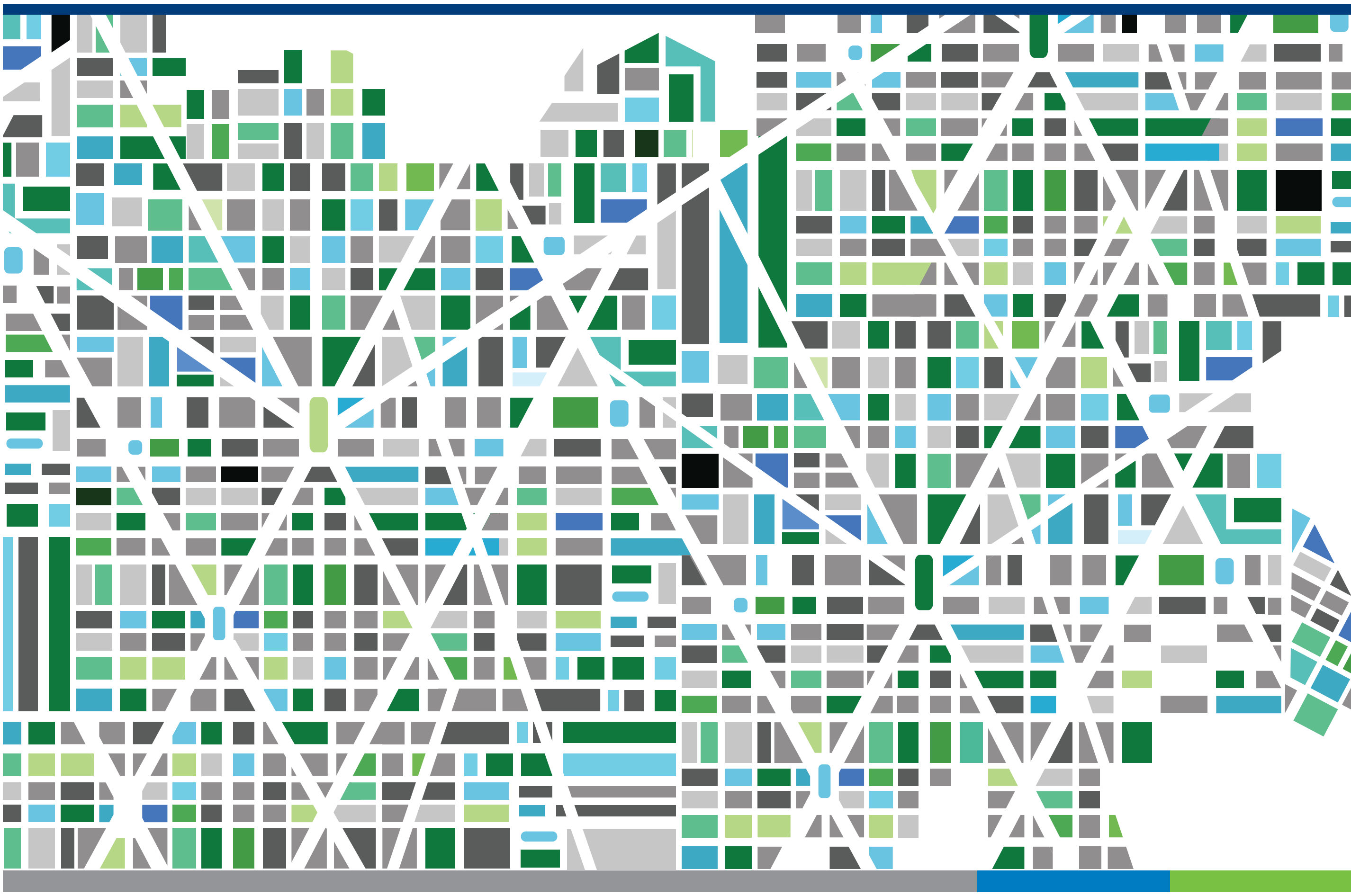

Safer City Streets

Methodology for Developing the Database and Network

Working Document

OECD

irtad
International Traffic Safety Data and Analysis Group

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The International Transport Forum

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Working Document

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About this document

In 2016, the International Transport Forum is launching a project called "Safer City Streets", for cities to better collaborate in relation to road safety data collection and analysis. A database for crash data is a key part of this project and will facilitate the monitoring and benchmarking of road safety performance in and across world cities. In the elaboration of the Safer City Streets network and database, the International Transport Forum (ITF) is building on the experience acquired through its permanent working group on road safety, known as IRTAD.

This document proposes a methodological framework to deliver the "Safer City Streets" project. The document is for discussion with experts interested in the development of the project. This document was commissioned by the ITF and prepared by George Yannis, Eleonora Papadimitriou and Katerina Folla, from the National Technical University of Athens.

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1. Introduction

1.1. Background

The International Traffic Safety Data and Analysis Group (IRTAD Group) is a permanent Working Group of the International Transport Forum (ITF) at the OECD. The IRTAD Group is a forum of exchange on road safety data collection, reporting and analysis. It is composed of safety experts and statisticians from a wide range of ITF and non-ITF countries. Over the last 25 years, the IRTAD Group has become the focus point of the ITF on safety issues and has played a growing role in providing high quality safety data analysis.

The main outputs of the IRTAD Group are:

- the IRTAD database of traffic safety data, which includes aggregated data on road crashes and casualties as well as exposure data for 33 countries
- road safety data analysis
- a permanent forum of exchange on road safety
- twinning projects with low and middle income countries to provide support in enhancing their national crash data systems
- periodic international conferences.

While, the focus of the IRTAD Group has been on collecting and analysing safety data at national level, the ITF has been approached by city representatives and other stakeholders regarding the possibility to develop a similar network and database at city level. Indeed cities worldwide are facing important road safety challenges. It is estimated that 45% of global death occur in urban areas, and this share is likely to increase as by 2050 around two-thirds of the population worldwide will live in urban areas.

National road safety data provide useful insight on the overall road safety performance of a country and the IRTAD database has been a longstanding and recognised tool to benchmark performance of countries. However, national data do not provide the level of data required to precisely analyse the specific issues of road safety in cities. In particular, the mobility and safety of vulnerable road users is a key priority of all cities.

Local authorities have an essential role in defining and implementing local road safety strategies that respond bests to their specific local road safety issues. A forum for road safety experts from cities and a mechanism to collect, share and analyse urban road safety data will certainly be a very valuable tool.

The International Transport Forum and the IRTAD Group are willing to offer their experience gained through the IRTAD Group to develop such a tool and network “IRTAD and the cities”, also called “Safer City Streets”. The development phase of the project is partly funded by the FIA Road Safety Grant Programme and the project will also benefit from FIA’s extensive worldwide network.

The Safer City Streets project also responds to the requirements of the Sustainable Development Goals 2030, adopted by the United Nation in September 2015, which clearly identifies road safety as a main target for cities. "By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons."

In order to examine the feasibility of the development of Safer City Streets, identify relevant safety indicators for cities and discuss some methodological aspects, the IRTAD Group undertook a pilot study with the participation of nine cities: Barcelona, Bogota, Chicago, Copenhagen Lisbon, London, Lyon, New York and Paris. In this pilot study the following data were collected: population, passenger-kilometrage by road user, fatalities and hospitalised by road user and road type (streets/urban motorways), and other exposure data (area of the city, length of the road network, number of trips).

The pilot study confirmed the interest in establishing such a network, and more particularly to have a forum to discuss methodological issues related to crash data collection and analysis in cities; and a mechanism to gather comparable data for benchmarking and learn from the experience of other cities. The pilot study also underlined a number of challenges and issues that will need to be clearly reflected in the project:

- Geographical scope of a city: should the project be limited to city centres or also include suburbs? The pilot project showed that it may be useful to collect data for both the municipality and its metropolitan area.
- Casualty data: to conduct useful analysis, it is important to collect not only fatality data but also data on the number of people seriously injured. While IRTAD recommends defining a serious injury based on the Maximum Abbreviated Injury Scale (MAIS3+), only a very limited number of cities have these data already available.
- Exposure data: population data are easy to collect, however they might not be the best exposure data to assess the road safety performance of a city. "Passenger-kilometres" are a better indicator, but more complex to collect.
- Grouping of cities: to conduct meaningful analysis, it is necessary to define criteria for several groupings of cities.

1.2. Objectives

This report develops a methodological framework that will delineate the scope of the project, address the issues identified in the pilot study and define the list of data and indicators that will be collected for inclusion in the database. It will make proposals for future data analysis, taking into account the size and development level of the participating cities and identify areas which will benefit from further research and co-operative work within the IRTAD and the city Group.

More specifically, this report aims to:

- Review international activities on urban traffic safety, in order to ensure complementarity of the Safer City Streets project with other international initiatives and foresee possible future co-operation:
  - Conduct a literature review of major projects related to road safety data analysis in cities; identify the common road safety issues, methodologies used to assess road safety performance in cities; and identify common safety indicators and exposure data.

  - List and describe international initiatives involved in road safety in urban areas.
  - Identify existing sources of international traffic and road safety data in urban areas.
- Provide an overview of road safety situations and data challenges in urban areas.
  - Provide a detailed description of the scope, expected outcome and output of the project, highlighting its added value compared to other existing international projects and its limitations. Describe the various desirable outputs of the project: the network, the database, the annual reports and other possible future outputs.
  - Provide a comprehensive description of the data needed to develop the Safer City Streets database.
  - Define and discuss the general data of various road user categories that need to be included in the database; define the various road categories that need to be included in the database; define and discuss the city area(s) that need to be included in the database.
  - Provide a detailed description of crash data required, including their definition. This will include: fatality data for different user categories, road type, and injury data.
  - Define and discuss the various exposure data to normalise crash data (pro and cons of each), information on the data collection methodology and highlight comparability: population, traffic (veh-km, passenger-km, trips), public transport share, length of the road network, other.
  - Review relevant performance indicators to assess the safety performance of cities and undertake meaningful benchmarking analysis. Identify performance indicators that could be integrated in the database and collected in a systematic and on a regular basis.
  - Make recommendation on other qualitative information/data that should be collected regularly in the framework of the Safer City Streets initiatives and that would benefit from storage in a common platform (for example local road safety strategy, mobility plan)
  - Based on the above analysis, make suggestions for a minimum set of data to develop the database and suggestions on particular features of the database.
- Make proposals on typical analysis that could be made, taking into account the limitations of the various data.
- Identify topics that would deserve common reflection and research.
- Propose city grouping criteria; as the network is expected to gather cities from a wide diversity (culture, size, level of motorisation), make proposals on relevant criteria to group cities for different types of analysis.
- Discuss the role and organisation of work of the network of experts.

1.3. Structure of the report

In Chapter 2, a review of major related projects, research studies and international initiatives was carried out. First, international methods and practices as regards the definition of the city are discussed. Moreover, a literature review of projects related to road safety data analysis in cities was carried out, in order to identify the common issues, methodologies and safety indicators and exposure data. Furthermore, international initiatives on road safety in urban areas are listed and described. Finally, existing sources of international traffic and road safety data in urban areas are identified and analysed. A synthesis of the literature review identifies the main issues and challenges for analysing road safety at city level, including data availability and comparability issues.

Chapter 3 analyses the data needs for the development of the Safer City Streets network and database; it presents a detailed definition of the scope of Safer City Streets, as well as its expected outcomes. First, an appropriate framework for data definition and selection in Safer City Streets is proposed. Data elements concerning road casualties, exposure, performance indicators and other indicators (e.g. demographic and socio-economic, road safety measures and policies) are presented, in terms of their definitions, data availability, limitations, and variables/values. Moreover, recommendations for the structure of the database are proposed (see Appendix A1).

In Chapter 4, a definition of the city is proposed, tailored to the needs of the project and the expected data availability of the participating cities, as well as cities grouping criteria, both in terms of geographical and city size criteria. Chapter 5 includes proposals for the analyses to be carried out and the related project outputs and Chapter 6 presents a discussion of the scope and organisation of the network of experts. The report is summarised in Chapter 7, where critical issues are proposed warranting further common research, for the improvement of the Safer City Streets data in the future.

2. Literature review

In order to ensure complementarity of the Safer City Streets project with other international initiatives and foresee possible future co-operation, a comprehensive review of related projects, research studies and international initiatives was carried out.

First, a dedicated part of the review was devoted to the analysis of international methods and practices as regards the definitions of the city (typically on the basis of administrative boundaries) and the distinction of urban areas of different types on the basis of various thresholds and criteria. Moreover, a literature review of projects related to road safety data analysis in cities was carried out, in order to identify the common road safety issues, methodologies used to assess road safety performance in cities, and identify common safety indicators and exposure data. At the same time, international initiatives involved in road safety in urban areas were listed and described. Finally, existing sources of international traffic and road safety data in urban areas were identified and analysed. A synthesis of the literature review highlights the main data issues and challenges for road safety analysis dedicated to urban areas.

2.1. Definition of "city"

2.1.1. Municipality

The most common definition of a city is that of municipality. A municipality is usually an urban administrative division having corporate status and powers of self-government or jurisdiction. A municipality is a general-purpose administrative subdivision, as opposed to a special-purpose district. The territory over which a municipality has jurisdiction may encompass:

- a single-populated territory such as a city, town, or village
- several such territories (e.g. early jurisdictions in the state of New Jersey as townships governing several villages, Municipalities of Mexico)
- only parts of such territories, sometimes boroughs of a city such as the 34 municipalities of Santiago, Chile.

Although a municipality has clear administrative and territorial definition, there may be large discrepancies between the within-territory spatial structures, i.e. variations in landscape, population density and urbanisation. Consequently, it will be difficult to compare municipalities based on indicators other than administrative and main socio-demographic. On the other hand, it is most likely that transport data collection is carried out at municipality level, and the data may be available at this level of administrative grouping.

2.1.2. Urban agglomeration

An urban agglomeration is the de facto population contained within the contours of a contiguous territory inhabited at urban density levels without regard to administrative boundaries. Urban agglomerations are thus determined by density; the agglomeration ends where the density of settlement drops below some critical threshold.

2.1.3. Metropolitan area

In large cities, the city area may far exceed that of the municipality and are referred to as metropolitan areas. The OECD (2006) identifies metropolitan areas as large concentrations of population and economic activity that constitute functional economic areas, typically covering a number of local government authorities. An economic area denotes a geographical space within which a number of economic links are concentrated: labour markets, networks of firms, important parts of supply chains, and relations between firms and local authorities. According to their population distribution and existing internal links, different types of metropolitan regions can be distinguished:

- **Monocentric metropolitan regions** have a single dominant core with a hinterland of towns and rural areas. However, many of those have grown to become monocentric metropolitan regions with smaller multiple nuclei, which in addition to a dominant core, have a number of separate cities within reasonable proximity and well connected to each other (e.g. Stuttgart, London, Seoul).
- **Polycentric regions** are a number of urban areas close to each other which grew over the years to become un urban network, comprising built-up or urbanised territory (e.g. Randstad-Holland comprising Amsterdam, Rotterdam, The Hague and Utrecht or the Rhine-Ruhr comprising Bonn, Cologne, Dortmund, Dusseldorf and Essen).
- **Mega-cities** are characterised by a huge concentration of population, often found in cities that have recently experienced strong population growth (e.g. Mexico City, Seoul, Istanbul).

Four criteria were proposed for identifying and distinguishing metropolitan areas:

- Population size of at least 1.5 million people.
- Population density at least 150 people per km^2.
- The area includes a small number of important cities in their national context.
- The area represents a contained labour market. In order to define labour markets, commuting flows are used to calculate net migration rates. Hence, metropolitan areas are those for which the net commuting rate does not exceed 10% of the resident population.

It is noted, however, that in practice it is likely that metropolitan areas may be defined more frequently as a group of neighbouring administrative units, and less so on the basis of the above quantitative and qualitative criteria. Nevertheless, metropolitan area is still a more comprehensive concept than the urban agglomeration.

2.1.4. City proper

A definition often used within the field of demography is city proper. City proper is one of the three basic concepts used to define urban areas and populations; the other two are urban agglomeration, and the metropolitan area (Bloom et al., 2010). In some countries, city limits that act as the demarcation for the city proper are drawn very wide, in some very narrow and this can be cause for recurring controversy and eventually complicate the comparison of cities.

The United Nations defines the term as "the single political jurisdiction which contains the historical city centre" (United Nations, 2002). In this sense, a city proper is the area contained within city limits. However, a city proper may not be limited to a city; it can describe the complete area of any locality that fits the definition (United Nations, 20109; Potter and Potter, 1978). One should not automatically assume that "city proper" always refers to "administrative area" (e.g. municipality).

More specifically, in the UN demographic prospects yearbook, the population of a city proper is defined as "the population living within the administrative boundaries of a city, and may not include suburban areas where an important proportion of the population working or studying in the city lives”.

A United Nations University working paper (Bloom et al., 2010) reviews the most commonly used data sources, and highlights the difficulties inherent in defining and measuring the size of urban versus rural populations. "The city proper is determined by legal and administrative criteria, and typically comprises only those geographical areas that are part of a legally defined, and often historically-established administrative unit. However, many urban areas have grown far beyond the limits of the city proper, necessitating other measures.”

2.1.5. Classification of urban areas

2.1.5.1. Eurostat definitions

The nomenclature of territorial units for statistics, (NUTS) (from the French version nomenclature des unités territoriales statistiques) is a geographical nomenclature subdividing the economic territory of the European Union (EU) into regions at three different levels (NUTS 1, 2 and 3 respectively, moving from larger to smaller territorial units) (http://ec.europa.eu/eurostat/web/main/home). Above NUTS 1, there is the “national” level of the Member States:

- NUTS 1: major socio-economic regions
- NUTS 2: basic regions for the application of regional policies
- NUTS 3: small regions for specific diagnoses

This classification is defined by the “Regulation (EC) No 1059/2003 of the European Parliament and of the Council of 26 May 2003 on the establishment of a common classification of territorial units for statistics (NUTS)”, which is regularly updated. The NUTS classification is a hierarchical system for dividing up the economic territory of the EU for the purpose of the collection, development and harmonising of European regional statistics and the socio-economic analyses of the regions.

NUTS classification is based on the following principles and characteristics:

- Principle 1: The NUTS regulation defines minimum and maximum population thresholds for the size of the NUTS regions (see Table 2.1). Despite the aim of ensuring that regions of comparable size all appear at the same NUTS level, each level still contains regions which differ greatly in terms of population.
- Principle 2: NUTS favours administrative divisions (normative criterion). For practical reasons the NUTS classification is based on the administrative divisions applied in the Member States that generally comprise two main regional levels. The additional third level is created by aggregating administrative units.
- Principle 3: NUTS favours general geographical units, which are normally more suitable for any given indicator than geographical units specific to certain fields of activity.

Table 2.1. **NUTS classification population thresholds**

Level	Minimum	Maximum
NUTS 1	3 000 000	7 000 000
NUTS 2	800 000	3 000 000
NUTS 3	150 000	800 000

Source: Eurostat (2016).

To meet the demand for statistics at local level, Eurostat has set up a system of Local Administrative Units (LAUs) compatible with NUTS. At the local level, two levels of LAU have been defined:

- The upper LAU level (LAU level 1, formerly NUTS level 4) is defined for most, but not all of the countries.
- The lower LAU level (LAU level 2, formerly NUTS level 5) consists of municipalities or equivalent units in the 28 EU Member States.

Since there are frequent changes to the LAUs, Eurostat follows up its development from year to year.

Eurostat currently further classifies urban areas in three categories (Eurostat, 2016):

- City is a LAU where the majority of the population lives in an urban centre of at least 50 000 inhabitants.
- The functional urban area consists of a city and its commuting zone. This was formerly known as larger urban zone (LUZ).
- The “greater city” is an approximation of the urban centre when this stretches far beyond the administrative city boundaries.

2.1.5.2. UN definitions

In the UN demographics statistics, city proper and urban agglomeration are the classification used for urban areas. Table 2.2 shows examples of city population figures for the two classifications.

It can be observed from the original table that the vast majority of cities provide the data under only one of the two city categories; in the few cases where both figures are provided, the difference is very pronounced, as shown in Table 2.2. Nevertheless, the numerous footnotes on the meta-data of the original table clearly demonstrate the different definitions used for the same term by different cities (which may also reflect differences in the understanding of the terms).

Table 2.2. **Cities population for city proper and urban agglomeration**

	Population	
City	**City proper**	**Urban agglomeration**
Amsterdam	742 884[1]	1 022 487
Auckland	428 300	1 272 800
Belgrade	1 313 994	1 611 333[2]
Brussel	144 784[3]	1 018 804
Buenos Aires	2 965 403	11 298 030
Chicago[4]	2 836 658	…
Delhi	9 879 172	12 877 470[5]
Genève	178 574	495 262
Kishinev	660 726	782 693
Ljubljana	250 953	252 639
London[6]	…	8 278 251
Montreal	…	3 695 790
Paris	2 125 017[7]	…
Phnom Penh	703 963	1 234 444
Reykjavik[8]	117 598	194 460
Tokyo[9]	8 489 653	12 576 601
Zagreb	691 724	779 145

Notes:
[1]Data for cities proper refer to administrative units (municipalities).
[2] Data for urban agglomeration refer to communes which are administrative divisions.
[3] Data for cities proper refer to communes which may contain an urban centre and a rural area.
[4] City refers to a type of incorporated place in 49 states and the District of Columbia, that has an elected government and provides a range of government functions and services.
[5] Data for urban agglomeration include New Delhi.
[6] "Greater London" conurbation as reconstituted in 1965 and comprising 32 new Greater London Boroughs.
[7] De jure population, but excluding diplomatic personnel outside the country and including foreign diplomatic personnel not living in embassies or consulates.
[8] The boundaries of a city are related to the boundaries of a commune. The urban agglomeration of the capital area is much bigger and includes eight communes.
[9] Data for city proper refer to 23 wards (ku) of the old city. The urban agglomeration figures refer to Tokyo-to (Tokyo Prefecture), comprising the 23 wards plus 14 urban counties (shi), 18 towns (machi) and eight villages (mura). The "Tokyo Metropolitan Area" comprises the 23 wards of Tokyo-to plus 21 cities, 20 towns and two villages. The "Keihin Metropolitan Area" (Tokyo-Yokohama Metropolitan Area) plus nine cities (one of which is Yokohama City) and two towns, with a total population of 20 485 542 on 1 October 1965.
Source: UN (2009).

2.1.4.3. OECD/EC definitions

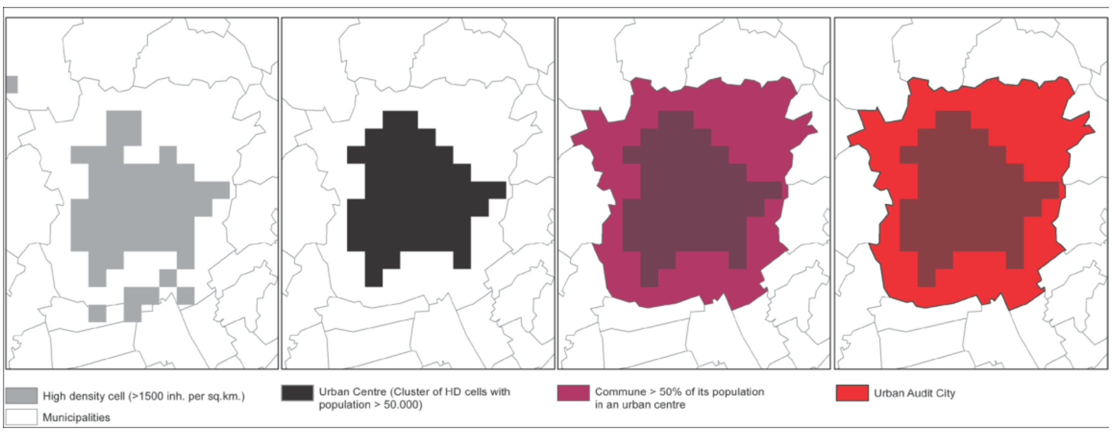
A new OECD-EC definition (http://ec.europa.eu/eurostat/web/cities/publications) identified 828 (greater) cities with an urban centre of at least 50 000 inhabitants in the EU, Switzerland, Croatia, Iceland and Norway. In addition, this methodology identified a further 492 cities in Canada, Mexico, Japan, Korea and the United States. As regards European cities, half of these European cities are relatively small with a centre between 50 000 and 100 000 inhabitants. Only two are global cities (London and Paris). These cities host about 40% of the EU population. These cities do not include towns and suburbs which cover another 30% of the EU population according to the revised degree of urbanisation classification.

Each city is part of its own commuting zone or a polycentric commuting zone covering multiple cities. These commuting zones are significant, especially for larger cities. The cities and commuting zones together (called Larger Urban Zones) account for 60% of the EU population.

This definition works in four steps and is based on the presence of an "urban centre" a new spatial concept based on high-density population grid cells (see Figure 2.1).

- Step 1: All grid cells with a density of more than 1 500 inhabitants per km^2 are selected.
- Step 2: The contiguous high-density cells are then clustered, gaps are filled and only the clusters with a minimum population of 50 000 inhabitants are kept as an 'urban centre'.
- Step 3: All the municipalities (local administrative units level 2 or LAU2) with at least half their population inside the urban centre are selected as candidates to become part of the city.
- Step 4: The city is defined ensuring that 1) there is a link to the political level, 2) that at least 50% of city the population lives in an urban centre and 3) that at least 75 % of the population of the urban centre lives in a city.

Figure 2.1. **How to define a city: High-density cells, urban centre and city (Graz)**



Source: Dijkstra & Poelman (2012).

Once all cities have been defined, a commuting zone can be identified based on commuting patterns using the following steps:

- If 15% of employed persons living in one city work in another city, these cities are treated as a single city.
- All municipalities with at least 15% of their employed residents working in a city are identified.
- Municipalities surrounded by a single functional area are included and non-contiguous municipalities are dropped.

The Larger Urban Zone consists of the city and its commuting zone.

A crucial innovation of this methodology is the possibility of comparing functional urban areas of similar size across countries. A classification of urban areas into four "types" according to population size is proposed:

- small urban areas, with a population below 200 000 people
- medium-sized urban areas, with population between 200 000-500 000 people
- metropolitan areas, with a population between 500 000 and 1.5 million people
- large metropolitan areas, with a population of 1.5 million or more.

In some cases, the urban centre is stretches far beyond the boundaries of city. This problem is called an “underbound” city, in other words the city is too small relative to its centre. This can be resolved in three ways: 1) create a greater city level, 2) cover a single centre with multiple cities, or3) a combination of these two approaches.

> The definition of the degree of urbanisation specifies that, as local administrative units level 2 (LAU2s) vary considerably in area, this methodology will lead to a closer match between a high-density cluster and densely populated LAU2s in countries with small LAU2s than in those with large LAU2s. To take this difference into account, the classification can be adjusted as following:
>
> - A densely populated LAU2 can be classified intermediate as long as 75% of its high-density cluster population remains in densely populated LAU2s.
> - A thinly populated or intermediate density LAU2 can be classified as densely populated if it belongs to a group of LAU2s with a political function and if the majority of population of this group of LAU2s lives in a high-density cluster.

The methodology developed provides an estimate of the population of an urban centre. Two elements may reduce the accuracy of this estimate: geographic features and the source of the population grid data. The methodology does not take into account the specific geography of a city. Some geographic features, such as steep slopes, cliffs or bodies of water may lead to an underestimation of the population of the urban centre. This affects particular cities with a small centre.

This method works best when a bottom-up grid or high-resolution hybrid grid is available, both grids ensure that the population per km^2 is very accurate. In the countries where such a grid is not yet available, LAU2 population had to be disaggregated based on land use data. This is called a top-down method, which is less accurate. It tends to underestimate the population cells with a moderate to high density and overestimate population in grid cells with a low population density. Due to this imprecision there remains a margin of error, especially for smaller centres.

2.2. Review of projects related to road safety in cities

In this section, the main projects, research studies and other related initiatives on road safety in cities are presented. In order to facilitate the synthesis of results, the following key elements are outlined for each study: objectives; cities examined; city definition; road safety data examined; exposure and performance indicators data examined; and summary of the findings.

2.2.1. Major projects on road safety in cities

SUNflowerNext: Towards a composite road safety performance index

Objective: To examine how the SUNflower approach could be applied at regional or city level. A review of the available practices and analyses was made and factors playing a significant role in regional or city comparison were explored. Authors proposed indicators that should be included in the city comparison.

Cities examined: none.

City definition: not applicable.

Road safety outcomes indicators: casualty numbers by road type and user group.

Exposure and performance indicators:

Demographics and socio-economics: city population, population density, economic indicators of activity, road safety plans, policies and programmes, organisation and funding of road safety programmes, road safety measures implemented over at least a 10-year period by road type (engineering and behavioural).

Transport demand and exposure: length of road and average traffic volumes by road type, transport and traffic policies and modal split, typical frequency and types of junctions by road type.

Performance indicators: speed limits by road type and length, seatbelt wearing, speeding, alcohol involvement in accidents.

Summary: The available practices and analyses examined in the report are gathered in four thematic areas: the safety of different roads within cities; the type of local authority; the changes in safety performance; and the effect of city size. First, it is noted that there is big difference in road function between main traffic arteries and residential access roads. Another finding is that fatality rates for all road users vary across different groups of local authorities, while pedestrian rates are more uniform. In addition, it is remarked that changes over the same period can differ substantially between cities, which may be associated with the initial casualty rates. As regards the effect of city size, it is shown that city size does not have a direct relation with the total KSI casualty rates, although it does appear to have an impact on the exposure and road safety performance of particular road user groups.

Based on the above findings, it is suggested that the primary task should be to select a set of cities with well-documented road safety policies and compare how these inputs have developed over the last 10-20 years and how the safety outputs have changed over the same period. Moreover, assessing separately the roads serving different traffic functions is a first step to define performance. Data should also reflect all the levels of SUNflower safety pyramid. Especially for road safety outcomes, both fatalities and injuries are preferred, since fatal injury data are limited at the level of cities. Useful data would be also the existence of a local safety strategy, the executive responsibilities of local managers, the availability of funds, and the extent of local safety analysis and scheme implementation skills. Finally, the boundaries of the examined areas have to be defined and similar urban areas are suggested for comparison.

ETSC "En route to safer mobility in EU capitals" ***(ETSC, 2008; Pin Flash 11)***

Objective: To highlight the road safety issue in the EU capitals by comparing their progress over time (see Figure 2.2).

Cities examined: Amsterdam, Athens, Berlin, Bern, Bratislava, Brussels, Bucharest, Budapest, Copenhagen, Dublin, Helsinki, Jerusalem, Lisbon, Ljubljana, London, Madrid, Nicosia, Oslo, Paris, Prague, Riga, Rome, Sofia, Stockholm, Tallinn, Vienna, Vilnius, Warsaw.

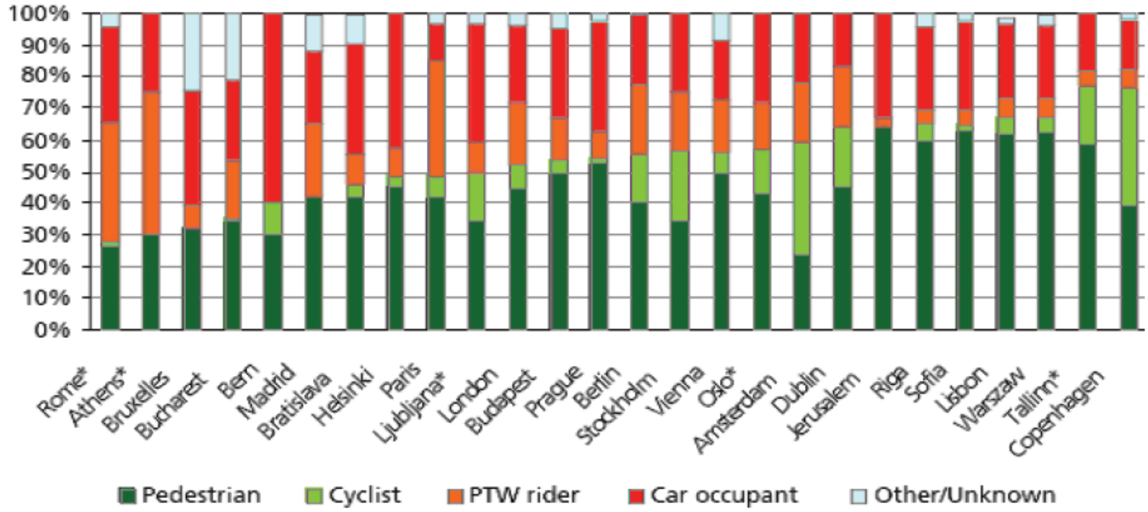
City definition: NUTS 3.

Road safety outcomes indicators: number of people killed in road accidents.

Exposure and performance indicators: not used.

Summary: The EU-27 capitals were compared through the percentage reduction over time in the number of people killed per 100 000 inhabitants, the ratio of road mortality in the capital to that in the rest of the country and the distribution of road deaths by road user group. The report was confined to these comparisons since available data did not take into account the differences among capital cities in commuting patterns, public transport availability, settlement structures, modal split or proportion of the administrative area that is urbanised.

Figure 2.2**. Distribution of road deaths by road user group in European cities.**



Note: Based on the average values for the year 2004, 2005 and 2006 and ranked according to the share of pedestrians and cyclists together.
Source: ETSC, (2008).

The POLIS network pillar "Transport Safety and Security"

Objective: Polis is a network of 61 European cities and regions working together to develop innovative technologies and policies for local transport. For that purpose, a data collection template was released in 2011 and interested local authorities were invited to fill it and provide POLIS with available data regarding urban road safety since 2001.

City definition: -

Road safety outcomes indicators: number of people killed, seriously injured and slightly injured by gender, age group and transport mode, number of fatal, seriously injury and slightly or unknown injury accidents by road type (by speed limit and existence of junction or not) and by involving transport mode.

Exposure and performance indicators:

<u>Demographics and socio-economic</u>: land area, total population and population by age group, population density, driving license ages by transport mode.

<u>Transport demand and exposure</u>: traffic volume (in billion km and vehicles per km) by transport mode and modal split, total road length and road length by type of road, number of licensed vehicles and number of driving license holders by vehicle type.

Summary: An attempt was made for the creation of a database related to road accidents in cities, however there has not been any publication yet, regarding the availability of the requested data.

The eSUM (European Safer Urban Motorcycling) project

Objective: The eSUM project (*www.esum.org/index.html*) initiated in 2008 by a group of European cities (Barcelona, London, Paris and Rome), together with manufacturers (ACEM, BMW and Piaggio), researchers (Universities of Athens and Florence, plus Altran) and the General Traffic Directorate of Spain (DGT) and the support of the European Commission, with main purpose to identify, develop and demonstrate measures aiming for safer urban motorcycling.

City definition: not specified.

Road safety outcomes indicators: number of (total and powered two-wheelers [PTW]) injury accidents per 1 000 inhabitants, per number of motor vehicles, per number of motor vehicle-kilometres, risk zones, conflict zones (black spots), PTW riders involved in an injury accident/PTW riders, PTW riders involved in an injury accident by years of driving experience/ PTW riders by years of driving experience.

Exposure and performance indicators:

Demographics and socio-economic: urban density (population/surface), kilometre road length per area, kilometre bus lane per area, kilometre bicycle lane per area.

Vehicle stock and mobility: number of motor vehicles per inhabitant, motor vehicle-kilometres per inhabitant, motor vehicle-kilometres per motor vehicle, number of motorcycles and mopeds per inhabitant, daily trips per inhabitant, percentage of motorcycles and mopeds of motor vehicles, percentage of motorcycles trips and mopeds trips of all trips.

Performance indicators: Speed controls and alcohol controls per inhabitant, speed controls and alcohol controls per vehicle.

Summary: An Action Pack and a Good Practice Guide were produced to provide guidance to municipal authorities and engineers, road designers and road safety practitioners. Data were retrieved by several sources such as: local administration (demographic distribution, social-economic factors, distribution of space, road network, vehicle fleet, mobility); local police information (circumstances of accidents); death register (road traffic accident fatalities); emergency hospital information (information about seriousness and type of injuries); hospital admissions (information about the seriousness, type and progress of injuries); mobility and travel surveys (information about risk exposure factors and associated indices).

2.2.2. Research studies on road safety in cities

2.2.2.1. International studies

Multilevel comparative analysis of road safety in European capital cities (Yannis et al., 2015)

Objective: The comparative road safety analysis in selected European capital cities, aiming to a better understanding of road accident characteristics and causes in European megacities.

Cities examined: Athens, Brussels, Bucharest, Budapest, Lisbon, London, Madrid, Paris, Prague.

City definition: NUTS 3.

Road safety outcomes indicators: number of persons killed (at 30 days from the accident) by age, gender, road user type, traffic unit type, month, day of the week, weather conditions of the accident.

Exposure and performance indicators:

Demographics and socio-economic: population, urban population density.

Transport demand & exposure: length of road per thousand inhabitants, the rate of annual private motorised passenger-kilometres per annual public transport passenger-kilometres.

Summary: Factors found with a statistically significant effect concerned city characteristics (road network length, population density, public transport use) and accident characteristics (road user and vehicle type). Especially for the city characteristics, it was found that when urban population density (persons/ha) increases, the number of road fatalities decreases, while the indicator "annual private motorised passenger-kilometres/annual public transport passenger-kilometres" has a positive correlation with road fatalities. In addition, the comparison between the European capital cities showed that the larger the city's road network is, the higher the level of road safety is in this city.

Safer Than You Think! Revising the Transit Safety Narrative. (Litman, 2015)

Objective: Public transit risks in terms of traffic safety and community security are evaluated in comparison with automobile risks. The perceptions of citizens and transportation professionals are also discussed and better ways to communicate transit safety impacts are recommended.

Cities examined: US cities.

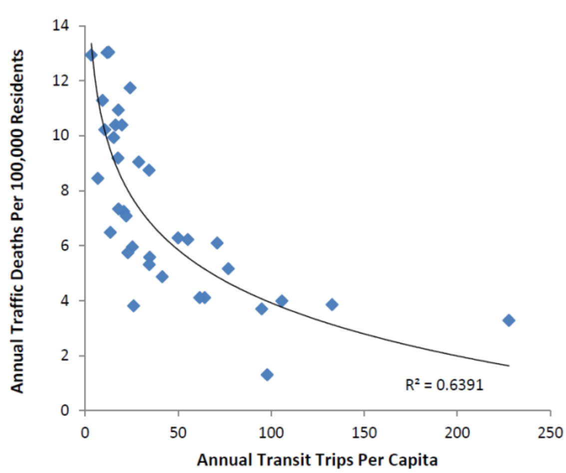
City definition: not specified.

Road safety outcomes indicators: traffic fatalities per 100 000 population.

Exposure and performance indicators: annual transit trips per capita.

Summary: The relationship between per capita transit ridership and total (including pedestrian, cyclist, automobile occupant, and transit passenger) traffic fatalities for 35 large North American cities was explored. As transit travel increases, traffic fatalities tend to decline significantly (Figure 2.3). Cities with more than 50 annual transit trips per capita have about half the average traffic fatality rate as regions with less than 20 annual trips per capita, indicating that relatively modest increases in transit travel are associated with large traffic safety gains.

Figure 2.3. **Relationship between per capita transit ridership and total traffic fatalities for 35 large North American Cities**



Source: Litman (2015).

The relationship between urban street networks and the number of transport fatalities at the city level (Moeinaddini et al., 2014)

Objective: The relationship between street network factors and transport fatalities is explored in different contexts with a macro-level scale by considering street network variables.

Cities examined: Barcelona, Bologna, Copenhagen, Geneva, Glasgow, Graz, Hong Kong, Lisbon, London, Lyons, Madrid, Marseilles, Munich, Nantes, Paris, Rome, Seville, Stuttgart, Turin, Vienna.

City definition: not specified.

Road safety outcomes indicators: number of passenger transport fatalities.

Exposure and performance indicators:

<u>Transport demand and exposure</u>: blocks per area, nodes per selected areas, length of roads per million inhabitants and length of motorways per ten thousand inhabitants.

Summary: Increases in fatalities are correlated with an increasing number of blocks per area, number of nodes per selected areas and length of the motorways, with the last two variables having greater effects on passenger transport fatalities. The length of road per inhabitant is inversely associated with transport fatalities.

Road Safety in two European Megacities: London and Paris (Schoettle and Sivak, 2012)

Objective: The focus is on crash patterns in the megacities of London and Paris in comparison with crash patterns for the entire UK and France respectively.

Cities examined: London, Paris.

City definition: City of London and the 13 boroughs that comprise Inner London and city/department of Paris, plus the three departments that comprise the "inner ring" ("petite couronne") of Paris.

Road safety outcomes indicators: number of fatal and injury crashes (including fatal crashes) by day of the week, time of the day, journey purpose of the driver, road type, location of pedestrian casualties, vehicle type, road user type, casualty type, driver gender, driver age, casualty gender, casualty age, number of vehicles involved, speed limit, weather conditions, road surface conditions, lighting conditions.

Exposure and performance indicators:

<u>Demographics and socio-economic</u>: population (age of population, population density), immigration, level of education, housing, income per capita.

<u>Transport demand and exposure</u>: travelling to work (by private vehicle, public transportation, foot).

Summary: Crashes and fatal crashes in London and Paris differ in several aspects from crashes in the entirety of each respective nation. The main differences are when and where the accident occurred, the weather and lighting conditions, who was involved in the accident and how many vehicles were involved in the accident. Also, these two European megacities are compared with New York and Los Angeles. The comparison is based on findings of this study and of Sivak and Bao (2012). More crashes during weekends and at night are recorded in the US megacities than in the whole nation, while more crashes on weekdays and during morning in London. In addition, more crashes involving multiple vehicles occurred in the US megacities, but fewer accidents of this type in London. In Paris, fewer fatal crashes involving bicycles were recorded compared to France as a whole, with the opposite finding for the other three megacities.

Analyzing the relationships between the number of deaths in road accidents and the work travel mode choice at the city level (Moeinaddini et al., 2015)

Objective: A city-level (across cities) model to estimate the relationships between the number of deaths in road accidents (as the dependent variable) and several work travel mode choice indicators in different cities in Europe.

Cities examined: Brussels, Antwerpen, Gent, Liege, Brugge, Namur, Leuven, Mons, Kortrijk, Oostende, Plovdiv, Varna, Burgas, Pleven, Ruse, Vidin, Stara Zagora, Sliven, Dobrich, Shumen, Pernik, Yambol, Haskovo, Pazardzhik, Blagoevgrad, Veliko Tarnovo, Dublin, Dublin (greater city), Cork, Limerick, Galway, Waterford, Helsinki, Oulu, Espoo/Esbo, Lahti/Lahtis.

City definition: NUTS 3.

Road safety outcomes indicators: number of deaths per 100 000 population.

Exposure and performance indicators:

Transport demand and exposure: number of registered private cars. Work travel mode choice indicators: percentage of journeys to work on foot, percentage of journeys to work by cycling, percentage of journeys to work by public transport, percentage of journeys to work by motorcycle.

Summary: A greater number of journeys to work by motorcycle is correlated with more road accident deaths. The cities that have more journeys to work by public transport mode have fewer fatalities. This model also indicates that more journeys to work by bicycle and foot are correlated with fewer transport fatalities.

Multilevel analysis of road accident characteristics in urban areas in Europe (Choustoulaki and Yannis, 2013)

Objective: The multilevel analysis of road accident characteristics in urban areas in Europe.

City definition: NUTS 3.

Road safety outcomes indicators: road fatalities by weather conditions, lighting conditions, transport mode, person gender, person age group.

Exposure and performance indicators:

Demographics and socio-economic: population in urban areas, vehicle fleet, GDP per capita.

Summary: The use of hierarchical data structures and nested data structures, for data concerning accident in urban areas of Europe is necessary for the correct estimation of the parameters impact. A differentiation in the number of fatalities in the various European urban areas was found, depending on the specific characteristics of these areas. Significant effects include weather conditions, vehicle type, and fatality age.

Cities safer by design (Welle et al., 2015)

Objective: To suggest some key indicators contributing to monitoring and evaluating the progress of traffic safety policies and projects.

City definition: not specified.

Road safety outcome indicators: traffic crashes, fatalities, and injuries over mode or passenger distance traveled, traffic fatalities per 100 000 inhabitants, killed and seriously injured (KSI) (see Figure 2.3).

Exposure and performance indicators:

Exposure: kilometres traveled by mode, traffic volume by mode, mode share of trips or commuting trips.

Infrastructure and design: number of safety engineering treatments per section of street network, characteristics of community design that reduce speed or offer good conditions for walking, cycling and mass transport facilities and volume, average vehicle speeds by road type.

Perceptions: perceived safety of bicycling and walking, percent of residents who feel safe crossing the street, percent of residents satisfied with pedestrian, cycling, and public transport facilities.

Summary: This report provides real-world examples and evidence-based techniques to improve safety through neighborhood and street design. This suggested design focuses on pedestrians, bicycling, and mass transport, and on reducing speeds and unnecessary use of vehicles. Descriptions of the different measures and elements that make up the key design principles of urban road safety are also provided.

Urban mobility in the developing world (Gakenheimer, 1999)

Objective: Mobility in cities of the developing economies in view of rising motorization and falling mobility. Focus is on personal mobility and access, rather than on external impacts.

Cities examined (indicatively): Dhaka, New Delhi, Jakarta, Manila, Rabat, Bogota, Warsaw, Kingston, Kuala Lumpur, Rio de Janeiro.

City definition: not specified.

Road safety outcomes indicators: not examined.

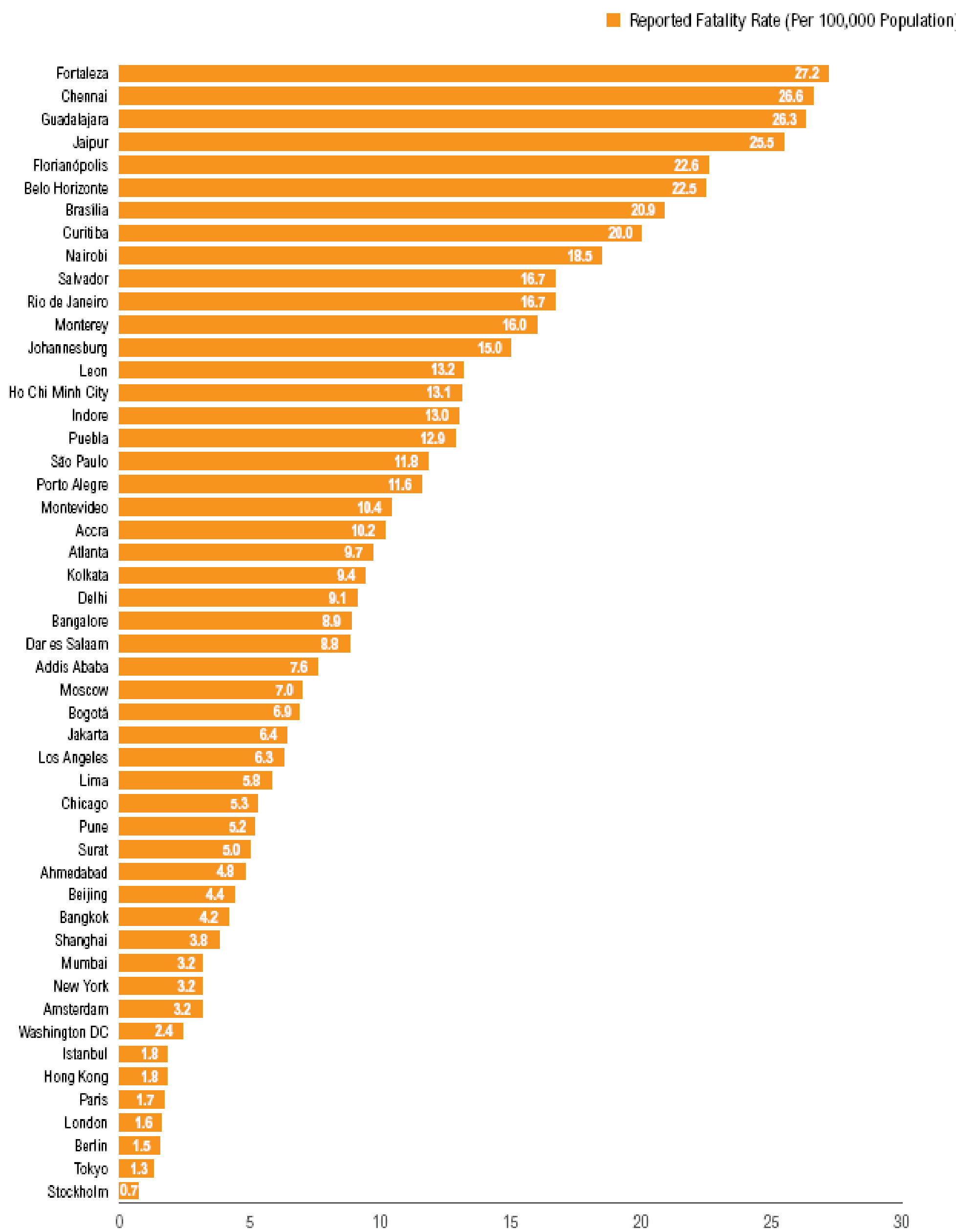
Exposure and performance indicators:

Demographics and socio-economic: urban population, family income, private consumption, industrial production, value of foreign trade/GDP, net current transfers, percentage of population in the labor force.

Mobility: cars per 1 000 population (country), journey to work, travel time.

Summary: Mobility and accessibility are declining rapidly in most of the developing world primarily due to the rapid pace of motorisation. Despite the fact that developing cities have adopted measures, borrowed from the developed countries, like significant leadership in vehicle use restrictions, new technologies, privatisation, transit management, transit service innovation, transportation pricing, only a few have recorded important progress. As regards the motorisation, it was found that cars per 1 000 population correlates with the annual income of the top 20% of population of the low income developing countries, as well as with the percentage of the population in urban areas. Other economic indicators, such as private consumption, industrial production (as a percent of GDP), openness of the economy (value of foreign trade/GDP), net current transfers and percentage of population in the labor force, perform very poorly in explaining patterns of motorisation. It is suggested that experiences from developing countries have to be interpreted carefully, before their application in cities with different historical experiences in transportation.

Figure 2.4. **Reported traffic fatalities per 100 000 Inhabitants in selected world cities**



Source: Welle et al. (2015)

Mobility in cities database- Synthesis Report (UITP, 2015)

Objective: This report provides information on the evolution of urban mobility patterns in the last 20 years, highlighting new trends and different trajectories for different groups of cities. Data used in this report were collected for 60 metropolitan areas worldwide for the year 2012.

Cities examined (indicatively): Vienna, Paris, London, Oslo, Prague, Geneva, Barcelona, Berlin, Munich, Helsinki, Hamburg, Glasgow, Tokyo, Tehran, Casablanca, Delhi, Hong Kong, Budapest, Singapore, Dubai.

City definition: metropolitan areas.

Road safety outcomes indicators: not examined.

Exposure and performance indicators: The database covers demography, the economy, urban structure, the number and use of private vehicles (including taxi), the road network, public transport networks (infrastructure and rolling stock, supply and demand, farebox revenue), and mobility patterns for cities in developed and developing countries.

Summary: The report shows which policies underpin strong growth in the modal share of public transport and other sustainable modes. The report also highlights important relationships between the modal share of public transport and the characteristics of the urban transport system.

Transport in Megacities - development of sustainable transportation systems (Emberger et al., 2010)

Objective: The programme "Sustainable Development of the Megacities of Tomorrow" supports knowledge exchange and mutual learning about good practice examples for sustainable urban development. A brief overview of the different transport related challenges six cities face is provided, as well as the suggested mitigation and adaptation strategies.

Cities examined: Gauteng (South Africa), Tehran-Karaj (Iran), Ho Chi Minh City (Vietnam), Hyderabad (India), Hefei and Shenyang (People's Republic of China).

City definition: megacities

Road safety outcomes indicators: not examined

Exposure and performance indicators: not examined

Summary: All cities under investigation in this mega-city programme face the challenge of increasing demand for car traffic. Besides the growth of population and urbanisation, car-oriented settlement structures, income growth and new production methods as well as distance intensive trading relations are key drivers for transport demand. The transport concepts currently applied or in development in these cities can be characterised by an extensive expansion of the existing transport infrastructure, with a dominating focus on road infrastructure provision and to a less extent on public transport infrastructure improvement.

Macroscopic review of metro networks in Europe and their role in the city development (Yannis et al., 2009)

Objective: The examination of the metro rail network extensiveness versus city's needs based on a set of meaningful indicators resulted from research and analysis of successful and "mature" metro rail networks in Europe. A set of selected indicators relating metro network elements and main city characteristics were developed.

Cities examined: Athens, Barcelona, Berlin, Brussels, Bucharest, Budapest, London, Madrid, Minsk, Moscow, Munich, Naples, Paris, Rome, Stockholm, Vienna.

City definition: not specified.

Road safety outcomes indicators: not examined.

Exposure and performance indicators: 3 criteria: demography, network structure, system's success.

Data for city comparison: population, area, density, length of network, number of stations, number of lines, annual ridership

Indicators chosen: population influenced (the ratio between network length and the reference territory population); network extension (the ratio between network length and the network diameter); network diameter (the length of the shortest route connecting the farthest stations of the network); access density (the ratio between number of stations and the reference territory surface that is city's urban area); served surface (the territory extension where network is attractive); average range of influence (the largest distance accepted on average by a walker to access to a generic metro station); spatial accessibility or network covering degree (the ratio between the served surface and the reference territory surface), traffic density (the ratio of annual network ridership per km of line).

Summary: There is high correlation between the indicators spatial accessibility and served surface and therefore, the spatial accessibility was chosen as the more indicative one. In addition, the indicators of population influenced, network extension, network density and traffic density are highly indicative for network's length influence (performance and width) and density. Thus, they were used to estimate the adequacy of network's kilometres. Access density and spatial accessibility, are highly indicative for stations' influence and density. Thus they were used to estimate the adequacy of network's stations number.

Motorization and the Provision of Roads in Countries and Cities (Ingram and Liu, 1997)

Objective: To explore the trends in motorisation and the provision of roads and to examine the ratio of motor vehicles to roads in a production function framework at national and urban level.

Cities examined: a total of 35 cities worldwide (indicatively: Adelaide, Amsterdam, Bangkok, Chicago, Frankfurt, Honk Kong, Jakarta, L.A., London, Melbourne, New York, Paris, Seoul, Stockholm, Tokyo, Toronto, Vienna).

City definition: not specified

Road safety outcomes indicators: not examined

Exposure and performance indicators:

Demographics and socio-economics: urban population, urban land area, per capita income, population density, income density, road network density, per capita road length

Transport demand and exposure: total motor vehicles per 1 000 population, passenger cars per 1 000 population

Summary: A significant difference between national and city-level analysis is the flexibility of urban boundaries over time. Their definition also varies across the cities and consequently issues of comparability are likely to arise. For the city analysis, data of 35 cities worldwide (25 advanced and 10 developing cities) were used from two points in time (1960 and 1980). Among the results, it is shown that there is a positive relationship between motor vehicle ownership and population density for high density cities, in contrast with the lowest density cities. It was also found that road provision at the urban level is negatively associated with population density and is strongly influenced by past physical endowments. In addition, per capita road provision and population densities vary substantially across cities with high per capita incomes, but are very similar across cities with low per capita incomes. Finally, cross-city data show that a saturation level exists for urban road network density.

2.2.2.2. **National studies**

Road Safety in New York and Los Angeles: U.S. Megacities Compared with the nation (Sivak and Bao, 2012)

Objective: The focus of the investigation is on crash patterns in the megacities of New York and Los Angeles in comparison with crash patterns for the entire US

Cities examined: New York, Los Angeles.

City definition: cities of NYC and LA (not metropolitan areas).

Road safety outcomes indicators: number of fatal crashes and total number of crashes by day, time of the day, roadway alignment, traffic way flow, junction type, speed limit, number of involved vehicles, crash manner, first harmful event, atmospheric conditions, road surface conditions, light conditions, number of fatalities, person type of fatality, driver gender, driver age, driver alcohol use, driver use of safety belts, driver avoidance maneuver.

Exposure and performance indicators:

Demographics and socio-economic: population, language, level of education, housing, income per capita

Transport demand and exposure: travelling to work (travel time, driving alone, carpooling, public transport, walking)

Summary: Both crashes and fatal crashes in these cities tend to differ in several aspects from typical crashes and fatal crashes in the entire US. The main differences are when and where the accident occurred, the weather and lighting conditions, who was involved in the accident and what the driver's actions were.

Multilevel investigation of road accidents characteristics in Greek cities (Spanakis and Yannis, 2013)

Objective: To investigate the effects of characteristics concerning drivers, the road environment and vehicles, as well as city-related characteristics, on road accidents in Greek cities via a multilevel analysis.

Cities examined (indicatively): Patra, Larisa, Volos, Ioannina, Kavala, Lamia, Kalamata, Trikala, Serres, Agrinio, Katerini, Drama, Hania, Halkida, Rodos, Komotini.

City definition: municipalities with population higher than 30 000 inhabitants (excluding the two largest cities Athens and Thessaloniki)

Road safety outcomes indicators: number of fatalities, seriously injured and slightly injured by existence of median strip, light conditions, night light conditions, weather conditions, road surface conditions, accident type, traffic regulation, casualty gender, casualty age, vehicle type, safety equipment, driving license.

Exposure and performance indicators:

<u>Demographic and socio-economic</u>: population, vehicle fleet, GDP per capita.

Summary: From the results, conclusions were deducted for the impact of some of the examined parameters in the number of fatalities, serious and slight injuries in Greek cities, such as existence of median, operation of technical night lighting, accident type, vehicle type, casualty age and vehicle fleet. From the second level analysis it was found that there is significant variation of the impact of the size of the vehicle fleet registered each city to the number of casualties in road accidents.

Effects of red light camera enforcement on fatal crashes in large US cities (Hu et al., 2011)

Objective: To estimate the effects of red light camera enforcement on per capita fatal crash rates at intersections with signal lights.

City definition: US cities with more than 200 000 inhabitants.

Road safety outcomes indicators: fatal crashes at intersections with signal lights, fatal red light running crashes.

Exposure and performance indicators:

<u>Demographics and socio-economic</u>: population, population density (in thousands of people per square mile for each study period), land area (in square miles for each study period), study period (after vs. before), and city group (cities with camera programs during the after period vs. cities without cameras).

Summary: Red light camera enforcement programs were associated with a statistically significant reduction in the citywide rate of fatal red light running crashes and a smaller but still significant reduction in the rate of all fatal crashes at signalised intersections.

Modeling spatial relationships between multimodal transportation infrastructure and traffic safety outcomes in urban environments (Tasic and Porter, 2016)

Objective: To examine the relationship between multimodal transportation infrastructure in urban environments and expected crash frequency, by crash type and severity, for motorised and non-motorised users.

City examined: Chicago

City definition: not specified

Road safety outcomes indicators: vehicle only crashes, vehicle only fatal crashes, non-motorised user crashes, non-motorised user fatal crashes.

Exposure and performance indicators:

Spatial analysis units: area of land, area under water, total area.

Demographics and socio-economic: population, population density, median population age, population older than 65, percentage of male population, percentage of female population, total number of households, total number of family households, level of education, population older than 16, employed and unemployed population, population not in labor force, average household income, average family income, income per capita.

Land use: total number of land uses, dominant land use, residential, shopping malls, urban mix with dedicated parking, urban mix with no dedicated parking.

Transport demand and exposure: Total length of roads, road density, expressways as percentage of road network, arterials as percentage of road network, total percentage of expressways and arterials, collectors as percentage of road network, local streets as percentage of road network, alleys as percentage of road network, daily vehicle miles traveled, total number of intersections, intersection density per mile of road, total length of light rail in miles, total number of light rail stops, total length of bus lines, total number of bus stops, total length of bike lanes, total number of bike racks, sidewalk area, parking fare per hour, parking in the central business district, drive alone trips to work, carpool trips to work, public transit trips to work, walking trips to work, other means to work, work from home.

Summary: The results show strong association between the variables related to multimodal transportation availability and usage, and both motorised and non-motorised crashes.

Road Risk and Vulnerable Road User Working Paper (Transport for London, 2014)

Objective: The purpose of this document is to provide a summary of the work undertaken by Transport for London to further its understanding of the level of risk experienced by road users in London.

City examined: London.

City definition: mega-city.

Road safety outcomes indicators: killed or seriously injured casualties by road user category, by age, by gender, nationality, by time of the day.

Exposure and performance indicators: passenger-kilometres.

Summary: An overview of the road user risk analysis in London is provided in the document, determining specific road user groups who are at greater risk than others or locations with greater casualty rates. Vulnerable road users are identified (pedestrians, cyclists and motorcycle riders), for whom a further risk analysis and detailed conflict analysis are provided.

Towards safer urban roads and roadsides: Factors affecting crash risk in complex urban environments (Stephan and Newstead, 2012)

Objective: To identify the characteristics of the road and roadside, surrounding environment and socio-demographic factors that affect crash risk in complex urban environments, namely shopping centres.

City examined: Melbourne.

City definition: metropolitan area.

Road safety outcomes indicators: casualty crashes.

Exposure and performance indicators:

Demographics and socio-economic: population density, percentage of population aged 75 and over, percentage of population that were males aged 15 to 24, index of relative socioeconomic advantage and disadvantage (IRSAD) decile, passenger vehicle ownership rate, motorcycle vehicle ownership rate.

Transport demand and exposure: thousand vehicle-km travelled (travel density: thousand vehicle-km travelled per lane), traffic mix: percentage commercial vehicles, presence of buses, heavy vehicle approved routes, speed limit: 6 categories (4 categories, or variable indicating whether the segment was a strip shopping centre variable speed zone).

Safety Performance indicators:

Enforcement: presence of speed/red light cameras.

Roadside environment: predominant development height, presence of shops on one or both sides, nature strip, offset from buildings, total number of poles on side of road per km (frangible and non-frangible), total number of poles on median per km (frangible and non-frangible).

Facilities in environment: number of late night liquor licences per km, other non-late night on premises liquor licences per km, packaged liquor outlets per km, presence of schools, tertiary institutions, railway stations, community facilities, childcare facilities, medical centres, hospitals, sporting facilities, places of worship, emergency services, petrol stations.

Road characteristics: presence of curves, carriageway width, number of lanes, lane width, divided (median type, median width, number of mid-median accesses per km), number of right and left turn lanes per km, number of driveways/laneways per km, presence of service road, number of service road accesses per km, total number of signalised intersections per km (number of different types of signalised intersections per km), number of minor intersections per km (number of different types of minor intersections per km), number of roundabouts per km, presence of bike lanes (bike lane width, type of bike lane) number of pedestrian crossings per km, presence of fencing at pedestrian crossings, presence of on-street parking (presence of different types of on-street parking), number of off-street parking facilities per km, presence of clearway on one or both sides, presence of pavement distress, presence and degree of pavement roughness, trams (type of tram-lane), number of bus stops per km, number and type of tram stops per km, road type, presence of low tram wires, low clearance, presence of level crossings.

Summary: The results indicate that traffic and road segment characteristics that reflect an increased opportunity for conflict between road users, increased visual complexity in the environment and increased workload for the driver increase crash risk. Traffic density, an increased number of lanes, an increased rate of minor intersections, narrow lanes (< 3m wide), parking on both sides of the road and the presence of level crossings in a segment were all found to increase crash risk. Primary state arterials were also found to have a higher crash risk than secondary state arterials, even after taking traffic density and the number of lanes into account.

Evolution of road risk disparities at small-scale level: Example of Belgium (Eksler and Lassarre, 2008)

Objective: To demonstrate usefulness of a simple spatiotemporal modeling of road accident outcomes at small-scale geographical level.

City definition: The first level covers 589 communities (finest administrative entities) and the second one covers 43 arrondissements.

Road safety outcomes indicators: accidents with injuries, accident fatal injuries

Exposure and performance indicators:

Demographics and socio-economic: population.

Transport demand and exposure: vehicle-kilometre.

Summary: Small-area spatiotemporal models revealed the existence of spatial correlation in accident data and provided a mechanism to quantify its effect. The models were run for Belgium data for the period 2000-2005. Analysis of spatial effects allowed the identification of clusters with similar risk outcomes pointing toward spatial structure in road accident outcomes and their background mechanisms. From the analysis of temporal trends, different developments in road accident and fatality rates in the three federated regions of Belgium came into light. Increasing spatial disparities in terms of fatal injury risk and decreasing spatial disparities in terms of accident risk with time were further identified.

Road accident models for large metropolitan cities of India (Valli, 2004)

Objective: To develop models by analysing the road accident data at an all-India level as well as for major metropolitan cities. The data for the 25-year period from 1977 to 2001 were analysed to build models to understand the nature and extent of the causes of accidents using the concept of Smeed’s formula and Andressen’s equations.

Cities examined: Ahemadabad, Bangalore, Chennai, Delhi, Hyderabad, Kolkata, Mumbai.

City definition: metropolitan cities (one million plus population).

Road safety outcomes indicators: total accidents, fatalities, injuries.

Exposure and performance indicators:

Demographics and socio-economic: population, number of motor vehicles.

Summary: The data collected for selected metropolitan cities could not be fitted collectively to express the accident model properly. Hence, different models were developed for different cities depending upon the data trends of each city. However, the fatalities model accuracy is acceptable for all cities.

Urban Poverty and Transport: The Case of Mumbai (Baker et al., 2005)

Objective: To analyse the linkages between urban poverty and transport in Mumbai, India, through a household survey and focus group discussions that were carried out between August 2003 and February 2004.

City examined: Mumbai.

City definition: metropolitan area.

Road safety outcomes indicators: not examined.

Exposure and performance indicators:

Demographics and socio-economic: household characteristics by income group, spatial distribution of households by income group, distribution of workers across job locations, motor vehicle ownership, access to social services.

Exposure and transport demand: main mode to work, number of one-way trips per day, distribution of trips by purpose, percent attending school by age, walking time to school, distance from a bus stop or train station, cost and quality of public transport.

Summary: This study describes the significant facts about travel patterns in Mumbai, for both poor and non-poor households. An important finding is the extent to which all households - but especially poor households - rely on walking. A second finding is that public transit remains an important factor in the mobility of the poor, and especially in the mobility of the middle class. It also appears that transport is less of a barrier to the poor who live in central Mumbai than it is to the poor who live in the suburbs. Commuting distances are much higher for poor workers in the suburbs than for poor workers in the centre.

Urban change, mobility and transport in Sao Paulo: Three decades, three cities (Vasconcellos, 2005)

Objective: To analyse transportation and traffic conditions in Sao Paulo Metropolitan area and the factors that shaped them over the 1967-1997 period. In this context, transport and traffic policies, along with social and economic changes, are seen as explanatory elements, while actual transport and traffic conditions, as well as mobility (trips per person, per day), are seen as their outcomes.

City examined: Sao Paulo.

City definition: metropolitan area.

Road safety outcomes indicators: fatalities per population, vehicle occupant fatalities, pedestrian fatalities.

Exposure and performance indicators:

Demographics and socio-economics: population, education, jobs.

Transport demand and exposure: walking trips per day, motorised trips per day, all trips per day, person-trip by day for public and private transport.

Summary: Changes in urban structure, the job market and economic and social conditions in Sao Paulo during the study period interacted with the transport and traffic systems and so produced new ways of living and using the city. Data showed that high mobility differences among different income strata remained. In addition, due to supply and quality problems of public transport services, along with increasing fares and decreasing incomes for the poorer led to the exclusion of a large number of users. These changes also led to an increase in fatal accidents. These consequences can be attributed to lack of co-ordination of urban, transport and traffic policies. A summary of the planning process in other large cities in Brazil and in other developing cities shows that they may face similar consequences.

2.3. Review of international initiatives on road safety in urban areas

2.3.1. POLIS network

Polis (www.polisnetwork.eu) is a network of European cities and regions working together to develop innovative technologies and policies for local transport and promote sustainable mobility.

Its aim is to improve local transport through integrated strategies that address the economic, social and environmental dimensions of transport. To this end, Polis supports the exchange of experiences and the transfer of knowledge between European local and regional authorities, facilitates the dialogue between local and regional authorities and other actors of the sector and provides the decision makers with the necessary information and tools.

The activities of Polis are organised around four thematic pillars:

- environment and health in transport
- mobility and traffic efficiency
- transport safety and security
- social and economic aspects of transport

2.3.2. World Resources Institute Sustainable Cities

World Resources Institute (WRI) is a global research organisation that promote actions aiming at securing a sustainable future. In this context, WRI Ross Center for Sustainable Cities (http://www.wrirosscities.org/) was established in 2014 and through the combination of global research and on-the-ground experience in countries, such as Brazil, China, India, Mexico, Turkey and the United States, works to make urban sustainability a reality.

WRI Sustainable Cities aims to influence 200 cities with unique research and tools and focuses on a deep cross-sector approach in four megacities on two continents, and targeted assistance to 30 more urban areas, bringing economic, environmental and social benefits to people in cities around the globe.

The activities of WRI Sustainable cities are organised around the following thematic areas: building efficiency, energy and climate, health and road safety, sustainable urban mobility, urban climate resilience, urban development, urban governance and water.

The approach of WRI Sustainable Cities on Health and road safety lies on the perception that reducing car travel and urging people to move through safely designed mass transport, walking and biking infrastructure can make mobility safer. Emphasis is given to thoughtful design that protects all road users, especially pedestrians and bicyclists, from improved crossings and intersections to traffic calming that reduces high impact crashes.

2.3.3. Global Road Safety Partnership

Global Road Safety Partnership (GRSP) (www.grsproadsafety.org) is a non-profit organisation formed in 1999 and hosted by the International Federation of the Red Cross and Red Crescent Societies. Its role is to create and support multi-sector road safety partnerships that are engaged with front-line good practice road safety interventions in countries and communities throughout the world. The following are the most typical forms of partnership:

- An in-country "National Global Road Safety Partnership" organisation.
- A city-based partnership that brings together the city transport, education and health departments, the city police, local business and NGO partners. "Proactive partnership strategy" methodology is used to support these partnerships.
- A collaboration of local stakeholders from different sectors to implement good practice projects in their region of interest.

2.3.4. EUROCITIES

EUROCITIES (www.eurocities.eu) is a network of major European cities whose members are their elected local and municipal governments. It was founded in 1986 by the mayors of six large cities: Barcelona, Birmingham, Frankfurt, Lyon, Milan and Rotterdam. Today, EUROCITIES comprises the local governments of over 130 of Europe's largest cities and 40 partner cities.

Through six thematic forums, a wide range of working groups, projects, activities and events, a platform is offered to the members for sharing knowledge and exchanging ideas.

As regards road safety, the respective working group works towards the 2011-2020 European road safety targets. Road Safety working group provides a platform for cities to disseminate good practice and share experiences on delivering effective city projects. Its main objectives are the following:

- working towards the 2011-2020 European road safety targets
- encouraging and motivating members to commit to the European Road Safety Charter
- disseminating good practice and sharing experiences to deliver effective city projects
- supporting member cities in working towards their individual road casualty reduction targets
- contributing to European discussion and debate on road safety policy and legislation
- supporting and promoting the fourth road safety action plan at city level
- supporting road safety interventions to improve safety and reduce the vulnerability of road users
- researching opportunities for European funding to deliver working group objectives of reducing the severity of casualties in our cities

- continuing to share information on the progress of the ISO 39001 standard in road traffic safety management.

2.3.5. CIVITAS

The CIVITAS www.civitas.eu is an EU funded initiative to redefine transport measures and policies in order to create cleaner, better transport in cities. It was launched in 2002 and has helped introduce numerous innovations and measures that have already made transport more eco-friendly in over 60 European metropolitan areas dubbed “demonstration cities”.

In order to create sustainable urban mobility, CIVITAS actions focus on safety and security within the cities with purpose to make roads safer and more secure especially for “vulnerable” road users. As a consequence, CIVITAS cities are looking into new ways to ensure the safety of urban travellers (especially cyclists, pedestrians and the most vulnerable groups such as children and elderly people), such as traffic calming, improved cycling infrastructure and anti-vandalism activities.

2.3.6. Other networks and associations

2.3.6.1. ICLEI- the global cities network

ICLEI (www.iclei.org) is a global network of over 1 000 cities, towns and metropolises committed to building a sustainable future. It helps its members to make their cities and regions sustainable, low-carbon, resilient, ecomobile, and resource-efficient.

ICLEI encompasses a number of networks: a network of local governments that facilitates city-to-city co-operation; thematic networks that bring together cities leading the way on key sustainability issues like water quality and quantity, renewable energy, and urban disaster risk reduction; and a network of individuals, the leaders of their respective institutions.

The networks included in the ICLEI are:

- Asian Cities Climate Change Resilience Network (ACCCRN)
- EcoCities Network
- EcoMobility Alliance
- Fast Growing Cities Network
- Green Climate Cities Network
- Local Renewables network
- Procura+ Exchange
- World Mayors Council on Climate Change

2.3.6.2. EcoMobility Alliance

The EcoMobility Alliance is a network included in the ICLEI global cities network which was created in October 2011 in Changwon, Korea. It aims at engaging public and private actors from different sectors and segments from all over the world, as well as promoting and advocating for EcoMobility at a global level, both in industrialised and developing countries. The EcoMobility Alliance membership consists of leading global and regional-level organizations representing four different categories of stakeholders: policy makers, professional expertise, production-trade-services and users. In addition, the four different segments in which the EcoMobility Alliance active in four different segments: walking, cycling, wheeling and passenging.

The cities participating in the "Alliance cities" project are: Almada (Portugal), Bogota and Medellin (Colombia), Boulder and Portland (United States), Buenos Aires and Rosario (Argentina), Burgas (Bulgaria), Changwon and Suwon (Democratic People's Republic of Korea), Freiburg and Muenster (Germany), Kaohsiung (Chinese Taipei), Kochi (India), Mexico City and San Miguel de Allende (Mexico), Quito (Ecuador), and Sydney (Australia).

2.3.6.3. Cities Today

Cities Today is a global magazine containing analysis, comment and best practices on sustainable urban development, connecting local governments with public and private sector solutions. With an expert editorial advisory board comprising the World Bank, the United Nations Environment Programme and UN-Habitat; the planning associations ISOCARP and IFHP; and city associations ICLEI, C40, EUROCITIES, UCLG ASPAC, UCLG Africa, Sister Cities International, UCLG MEWA, FLACMA and Mercociudades, the publication highlights the challenges and opportunities facing city leaders and local governments in mobility, smart technology, safety and security, resilience, resource efficiency and sustainable urban development.

2.3.6.4. DEKRA Vision Zero - Urban Mobility

While working on the DEKRA Road Safety Report 2014 on the topic of "Urban Mobility", DEKRA Accident Research initially assessed the accident statistics of 17 European countries for 2009 to 2012. This initial assessment showed that hundreds of towns and cities with more than 50 000 inhabitants achieved the target of zero deaths caused by road accidents in at least a single year (www.dekra-vision-zero.com/). Sixteen of these towns and cities did not see a single death caused by road accidents in the entire period. There were also similar successes in some of the larger towns and cities with more than 100 000 or more than 200 000 inhabitants.

These findings were published in the DEKRA Road Safety Report 2014 and then set out graphically in an interactive map. Further statistical data has gradually been incorporated since then. Other countries have been added, and not only in Europe: There are examples of towns and cities that have already achieved the target of zero deaths caused by road accidents in the United States and Japan. In the interactive map, various filters can be used to analyse individual years, individual countries, or towns and cities of specific sizes. Overall, the figures show that "vision zero" is attainable in urban habitats and already a reality in many towns and cities.

2.4. Review of sources of international traffic and road safety data in urban areas

2.4.1. CARE database

CARE database is the road accident database of the European Union. Data for road accidents resulting in death or injury are included for the 28 EU countries, as well as the 4 EFTA countries. The purpose of CARE system is to provide a powerful tool which would make it possible to identify and quantify road safety problems throughout the European roads, evaluate the efficiency of road safety measures, determine the relevance of Community actions and facilitate the exchange of experience in this field.

CARE database includes data for road fatalities, seriously and slightly injured at NUTS 3 level, divided into four basic categories:

- accident data, including data related with accident type, time of accident, weather and light conditions
- road-related data, such as type of road or area, type of junction, road surface conditions, speed limits
- traffic-unit-related data, such as traffic unit type, traffic unit manoeuvre, registration country
- person-related data, like person age, gender, road user type, alcohol/drug test, safety equipment.

The data that are available at city or regional level follow the NUTS 3 classification of Eurostat. The data could be used by Safer City Streets, following an agreement with the European Commission.

2.4.2. Eurostat

Eurostat is the statistical office of the European Union situated in Luxembourg. Its task is to provide the European Union with statistics at European level that enable comparisons between countries and regions.

As regards regional or city data, the database includes:

- quick facts on European Regions with demographic and socio-economic indicators
- statistics related to demography, economy accounts, agriculture, health, tourism, transport, employment, society and energy by NUTS classification
- statistics related to demography, economy accounts, agriculture, health, tourism, transport, employment, society, energy by typology (metropolitan regions, maritime regions, urban-rural typology)
- statistics related to living conditions and welfare, labour market, tourism, society, education by degree of urbanisation
- statistics related to demography, education, society, employment, economy, transport, and environment in cities and megacities as well as in functional urban areas.

The data are freely available and could be used by Safer City Streets.

2.4.3. UITP database

UITP is a non-profit international association active in the field of public transport and sustainable development. UITP regularly publishes statistical findings in the form of statistics briefs, databases and in-depth reports which cover a wide range of topics relevant to the sector.

The dataset within the Mobility in Cities Database (MCD) (UITP, 2015) comprises 85 standardised indicators, covering all the 63 cities included in MCD 2015 such as: population, urban population density, GDP per capita, public transport vehicle-kilometres (per population and per urban hectare), passenger car vehicle-kilometres, public transport journeys, percentage of daily trips by private motorised modes (by type of mode), percentage of daily trips by public transport, length of road, number of vehicles per population (by type of vehicle), average speed on the road network, average duration of a trip. The data could be used by Safer City Streets, following an agreement with the UITP; this could allow access to important exposure indicators.

2.4.4. NHTSA database (United States)

The National Highway Traffic Safety Administration (NHTSA), under the US Department of Transportation, is tasked to carry out safety programs under the National Traffic and Motor Vehicle Safety Act of 1966 and the Highway Safety Act of 1966. It is also responsible for reducing deaths, injuries and economic losses resulting from motor vehicle crashes, conducting research on driver behavior and traffic safety.

Fatality Analysis Reporting System (FARS) is a nationwide census providing NHTSA, Congress and the American public yearly data regarding fatal injuries suffered in motor vehicle traffic crashes. FARS data tables are divided in the following categories:

- trends (general, occupants, large truck related, non-motorists, alcohol, restraints)
- crashes (time, location, circumstances, alcohol)
- vehicles (all vehicles, location, by each type of vehicle)
- people (drivers, occupants, restraints, motorcyclists, pedestrians, school bus related, pedalcyclists)
- states (crashes and all victims, occupants, pedestrians, alcohol, fatalities and fatality rates, laws).

Most of the available data can be retrieved through queries at state, county and city level. The data could be used by Safer City Streets, following an agreement with the NHTSA.

2.4.5. Eltis - the urban mobility observatory

The Eltis Platform is a project funded by the European Commission under the Intelligent Energy - Europe (IEE) programme with main purpose to facilitate the exchange of information, knowledge and experiences in the field of sustainable urban mobility in Europe. It is aimed at individuals working in transport as well as in related disciplines, including urban and regional development, health, energy and environmental sciences.

The platform includes:

- local, regional and European news related to sustainable urban mobility
- case studies with successful local examples of sustainable urban mobility initiatives and strategies
- facts and figures with a range of statistical data on sustainable urban mobility topics
- EU legislation and policy developments on sustainable urban mobility.

2.4.6. Urban Mobility Observatory (SMO): Corporacion Andina de Fomento (CAF)

CAF is a development bank created in 1970, owned by 19 countries - 17 of Latin America and the Caribbean, Spain and Portugal - as well as 14 private banks in the region. In order to respond to the lack of solid, reliable and updated information about the transportation and mobility sectors of the region, CAF has launched an Urban Mobility Observatory (SMO) for Latin America and the Caribbean, which began with the analysis of 15 metropolitan areas in nine countries of the region.

The indicators available in the SMO are divided into the following categories:

- socio-economic, such as employment, employment/population, population/km^2 urbanised metropolitan area, constructed metropolitan area, constructed urbanized metropolitan area
- costs and fees, such as automobile travel cost (USD/trip), public transport trip cost, motorcycle trip cost, vehicle-year fixed cost, annual expenditure (total, for public transport, for individual transport)
- individual transport, such as cars per 1 000 inhabitants, average age of cars, motorbikes and taxis, total taxis and moto-taxis fleet, number of motorcycles, total individual transport
- public transport, such as number of operating companies, features of rail services (legal instrument, organisation, property), rail class (metro, tram, train), kind of organisation
- infrastructure, such as km of total road network, percentage of roads with traffic lights, number of traffic light intersections, km of cyclist priority roads, public transport priority roads as a percentage of total roads
- mobility, such as daily trips by public transport or by individual transport, walking/biking daily trips, total daily trips
- traffic management, such as human resources used for traffic management, material resources used for traffic management
- time and distance, like millions vehicle-day for cars, bicycles, taxis, omnibus and public transport, total individual daily tours, bus average journey time, total transport time, individual motorised transport time, non-motorised transport time
- heritage, such as total equity value, total assets value per capita, rails value, value of car groups, urban roads value.

2.5. Overview of road safety situation and data challenges in urban areas

The literature review largely confirms the data and methodological challenges identified in the Safer City Streets pilot study. In this chapter, a synthesis of the literature is presented, from which the main methodological directions of the project are derived. These allow to determine the scope and the added value of the project, as well as its expected outcomes and its limitations.

From the literature review, it is confirmed that there are only few international projects or initiatives dedicated to road safety in cities, and very little concrete results have been made available. In most cases, a comparison of mortality rates at city level has been presented. Specific research studies have been published on the road safety situation in different cities. A large part of these are national studies, comparing cities of different size and characteristics within the same country. There are several international studies as well, but often only a couple of cities are compared, and emphasis is placed on mega-cities.

In most of these studies, the main limitation is the lack of traffic/exposure data, and the only partial consideration of contextual effects, i.e. city/country characteristics. Most studies focus on the socio-economic and demographic aspects, and less so on the traffic and road user behaviour aspects. The literature review was extended to include studies comparing cities not only on road safety aspects but on more general transportation and mobility aspects. These studies, although of a less relevant context than that of Safer City Streets, may provide useful insight as per the transport demand, exposure and urban characteristics indicators that could be useful for road safety comparisons, although these indicators may not be among the ones used traditionally in road safety analyses.

One clear outcome from the literature review is the large discrepancies in which the cities are selected or defined in the different studies; it may be noticed that in a considerable share of studies, the definition of the city used is not provided and while clearly administrative boundaries are used, the specific areas and criteria are not described. When examining the different definitions available in international databases in conjunctions with the available studies and publications, it is deduced that, even when a standard definition is proposed, in practice, deviations from this definition are allowed.

Fatality data alone may not be sufficient, especially for cities of small or medium size and it would be very meaningful to collect data on injuries as well. There are considerable difficulties in obtaining comparable injury data. Despite the common definition of a serious injury adopted or recommended by several international organisations (e.g. EC, ITF, etc.) as an injury of MAIS3 or higher, most countries/cities have not yet implemented the dedicated studies required to estimate the number of injuries on the basis of this definition. Research results further show that the under-reporting of injuries may be even more significant for motorcyclists, pedestrians, cyclists, and slight injuries overall.

Data availability and comparability issues are expected to be considerable also as regards the exposure data and safety performance indicators. Population data are easy to collect, however they might not be the best exposure data to assess the road safety performance of a city. “Share of traffic per mode” or “person kilometres” are more suitable indicators, but more complex to collect.

A critical factor defining the potential for meaningful comparisons is the type and quality of the data and indicators to be used. The review of the existing data in international databases clearly shows that there is little usable data available in international road casualty databases, and these are restricted to the number of fatalities at administrative unit level (e.g. NUTS 3). It is underlined that the city data available in international databases are limited overall, and largely inconsistent, as the different databases serve different purposes.

2.6. Key messages of Chapter 2

- There are relatively few international projects or initiatives dedicated to road safety in cities, and very little concrete results have been made available.
- On the other hand, there is a growing interest on road safety in cities, and several international initiatives have been identified.
- There are large discrepancies in the way cities are selected or defined in the different studies; even when a standard definition is proposed, in practice, deviations from this definition are inevitable.
- In most studies, fatality data or mortality rates are used as road safety outcomes indicator. The exposure and mobility indicators used vary considerably, and it can be observed that the most useful indicators (e.g. person-kilometres of travel, modal split) are the least available.
- Existing international databases include basic road crash and exposure data at city level, at least for European and US cities.

3. Data needs

This Chapter includes a comprehensive description of the data needed to develop the Safer City Streets database.

First, the framework for the data collection and analysis is provided, on the basis of an adaptation of the classical SUNflower representation of road safety systems. Moreover, the data scope and priorities are described, together with the criteria for distinguishing "core data/information" and "additional data/information".

Next, the data/information elements and indicators to be collected are described, including background road safety information, demographic and socio-economic indicators, road safety data (fatalities and serious injuries), transport demand & exposure, and Safety Performance Indicators. In each case, the data definitions are described, the data sources, the expected data availability and quality, related limitations, as well as the variables and values that need to be provided (data breakdown).

3.1. Data framework

3.1.1. Definitions, data needs and data sources

From the international experience in defining and describing city areas, it is clear that the "city centre" or "municipality" area is too restrictive, as most cities have grown beyond the administrative boundaries of the municipality. Most world capitals extend in an area including several administrative units. On the other hand, including the entire set of administrative units forming the greater area, e.g. that corresponding the NUTS 3 European classification, might include large parts of sparsely populated areas. Consequently, there is need to balance the inclusion of the actually urban (populated) area with the potential for obtaining the data, which is typically collected at administrative units level.

The cities (i.e. their authorities) themselves may have the clearest and most accurate view of the demographic and spatial characteristics of their areas; city representatives will be able to analyse the structure of their city and propose their approach of city definition. However, uniformity to a certain extent will be needed at the next stages of the Safer City Streets project so as city data can be comparable. For that purpose, an indicative definition of the city for the Safer City Streets project is proposed in Chapter 4.1 of this report as a first step of this process. This definition will allow describing smaller and bigger cities, while in case of mega-cities, it is suggested to be adapted in order to include the appropriate administrative units. It will be based on administrative units, to make sure that the data can be available, in combination with population density, to make sure that the entire urban area is included.

In the same context, the grouping of cities should take into account the type/size of city, as well as contextual information. In Chapter 4 of the report, concrete criteria are proposed for grouping the cities.

Data availability and comparability issues are expected to be considerable also as regards the exposure data and safety performance indicators. Population data are easy to collect, however they might not be the best exposure data to assess the road safety performance of a city. The volume of traffic by vehicle type, or the volume of passenger travel by mode, are more suitable indicators, but more complex to collect. As regards performance indicators, these have been noted as the "weak link" in international road safety analyses due to poor data availability.

In order to promote the use of the standard definition and motivate the cities/countries to conduct the necessary studies, it is proposed to encourage for injury data on the basis of the MAIS3+ definition; however, it should be allowed for cities not able to provide MAIS data to return their injury data on the basis of their current definitions. It is acknowledged that comparability will be initially limited, however several issues may be addressed at the data analysis phase. Progressively, more cities will be able to provide MAIS data, while at the same time appropriate data processing may improve the comparability for the remaining cities.

For Safer City Streets, the data is recommended to be collected from the cities themselves, on the basis of the specific Safer City Streets definition. However, they could be complemented with data from international road crash databases (e.g. CARE for the EU, FARS for the US) or exposure databases (e.g. Eurostat, UITP). There may be also useful city data at databases dealing with demographics and socio-economic aspects. Safer City Streets should investigate the possibility of using such data, in order either to complement the database, or to cross-check the estimates provided by cities themselves.

It should be noted, moreover, that while it may be very difficult to estimate the amount of travel at national level, it is less complicated to obtain an estimate at city level. Indeed, most cities should be able to provide an estimate of basic exposure data e.g. modal split, share of public transport, vehicle-kilometres travelled and speed on the main road network. Even when that is not possible, the length of the road network may be a quite usable indicator.

It is likely that the availability of exposure and SPI data may be better at local level than national level. On the other hand, local road safety performance indicators may suffer from sampling errors, due to the limited size of the samples used for sub-national indicators (Wegman et al., 2008). Moreover, in several cases, road safety management is implemented at regional or local level and there may be opportunities in obtaining and using information on local road safety programmes and policies. The differences in the extent of the responsibilities and budgets of regional and local authorities, the application of concrete measures and policies (e.g engineering measures, education programmes), may be better related to road safety outcomes at local level.

Moreover, Safer City Streets may place particular emphasis on road safety background information - such as road safety and mobility plans, road safety measures - and demographic and socio-economic aspects such as the household income, the employment rate, the presence of economically disadvantaged groups, the urban density, the population composition, the settlement type, the weather conditions and possibly the alcohol consumption.

On the basis of the above, it can be deduced that Safer City Streets should set ambitious data requirements, i.e. include all the necessary indicators and data elements for useful road safety analysis, but at the same time it should be acknowledged that at the early stages of the project a considerable part of these indicators will not be available or comparable. For that purpose, and in order to ensure that even the cities that do not meet all the ideal criteria defined for this project remain motivated to be involved in the project, it is proposed to adopt a two-level data collection and distinguish core data/information and additional data/information (see section 3.1.3).

3.1.2. Data analysis framework

In order to develop the Safer City Streets methodology and database, an appropriate framework is proposed, allowing for a meaningful structure in the data collection and analysis to yield usable indicators spanning the entire road safety system at city level. This framework is derived on the SUNflower pyramid (SUNflower, 2002; SUNflower+6, 2005), which reflects the structure of the road safety system.

The road safety system can be described as a structure that includes five layers (economy, programmes and measures, safety performance indicators, fatalities and injuries, and social costs). Within each layer, there are elements which reflect all the components of the system, i.e. Road Safety Management, Road Infrastructure, Vehicle, User and Post-Crash Services (Global Plan of Action WHO, 2011).

The SUNflower approach has been primarily developed for country benchmarking, but can be adapted for city analysis by means of: focusing on the background and socio-demographic aspects as a basis in the "structure and culture" layer; placing emphasis on the transport demand and exposure parameters, by means of a new separate layer; and focusing on the outcomes "fatalities and injuries" and less so on social costs.

The proposed data and information framework, is presented in Tables 3.1 and 3.2, along with example components for each layer:

1. **Fatalities and injuries**; core data include fatalities and serious injuries per road type and road user type.
2. **Transport demand and exposure**; core data include volumes of vehicular traffic and passenger travel (also for non-motorised travel), person-kilometres, vehicle fleet.
3. **Safety performance indicators**; core data include road user protection indicators (seatbelt and helmet use), and road infrastructure indicators.
4. **Demographic and socio-economic indicators**; core indicators include GDP per capita, unemployment rate, population/population density, road length.
5. **Road safety background**: road/infrastructure safety management, mobility plans, etc.

3.1.3. Data/information priorities

In the following analysis, an ambitious and exhaustive approach on data/information collection is implemented. A framework including all necessary data/information elements for high quality analysis at city level is proposed. It is acknowledged, however, that a considerable part of this data/information will not be available for most cities and a non-negligible part of the data/information will not be available even for the cities with the best data. In order to propose a realistic data collection plan, while at the same time maintaining and demonstrating a high level of ambition and scientific rigour in the project, a two-level data collection is proposed, with "core data/information" and additional data/information.

3.1.3.1. Core data/information

Core data/information are data/information elements that will be requested with priority by the participating cities. These will include basic data/information elements and indicators that are expected to have good data availability in most cities and will enable basic meaningful analyses to be carried out.

This will be routinely collected by Safer City Streets, either through the network of experts or through existing international databases.

3.1.3.2. Additional data/information

Additional data/information will be elements requested in addition to the core data/information, including more sophisticated indicators. These are expected to have lower availability than the core ones, but as is often the case in road safety, the most useful data is the least available (Papadimitriou et al., 2013).

Table 3.1. **Road safety data elements for Safer City Streets database**

	Core data	Additional data	Calculated indicators
1.Fatalities and injuries	Number of fatalities by road user type Number of serious injuries by road user type Evolution of fatalities/serious injuries (time series)	Number of fatalities by road type, accident type Number of serious injuries by road type, accident type	Fatalities/serious injuries per person-kilometres (by road user type) Fatalities/serious injuries per road length (by road type) Fatalities/serious injuries per number of vehicles Fatalities/injuries per population (for each age and gender group)
2. Transport demand and exposure	Number of trips by mode of travel Number of person-kilometres travelled by mode of travel Total number of vehicles registered at city by vehicle type including mopeds and motorcycles	Person-kilometres travelled by males Person-kilometres travelled by females Person-kilometres travelled by age group	
3. Road safety performance indicators	Daytime helmet wearing rates for PTW driver and for passenger (mopeds and motorcycles) Daytime seatbelt wearing rates on front seats of cars (aggregated for driver and front passenger) Daytime seatbelt wearing rates on rear seats of cars	Percentage of drivers above legal alcohol limit in roadside checks Mean age of the passenger car fleet Mean age of the motorcycle fleet Mean speed on principal arterial roads 85% percentile of speed on principal arterial roads Standard deviation of speed on main urban roads Share of High Risk Sites treated Length of road sections treated - traffic calming Mean EMS response time	

4.Demographics and socio-economic	GDP per capita Unemployment rate Population density Public transport network length Total length of the road network Length of urban motorways Length of unpaved roads Total number of inhabitants per age and gender	Commuter-adjusted daytime population Length of principal arterial roads Length of secondary arterial roads Length of residential roads Number of hospitals/doctors/Intensive Care (IC) beds per population	Length of motorways per 1 000 km of road network Length of non-paved roads per 1 000 km of road network Length of rail public transport network per 1 000 km of road network

There is added value, however, in pursuing the collection of this data/information, even if a very small number of cities will be initially able to respond. On one hand, even data for a few cities may allow for insightful comparisons and analyses, highlighting the added value of this data/information. Additionally, the request for this data/information, in conjunction with the publication of analyses from other cities on the basis of this data/information, may increase awareness on the importance of the data/information and motivate cities in initiating their collection. In the medium term, data/information will be available for more and more cities, enhancing the Safer City Streets analyses.

Table 3.2. **Road safety background information for Safer City Streets**

	Core information
1. Road safety background	Road Safety strategy/plan and targets Mobility Plan Speed limits for principal arterial roads (km/h) Speed limits for secondary arterial roads (km/h) Speed limits for residential roads (km/h)

3.2. General data

3.2.1. Road user category

It is suggested to collect data for the following road user types:

- passenger car occupants (drivers, passengers)
- powered two wheelers (PTW) riders (driver and passenger), with a distinction, when possible between mopeds (below 50 cc) and motorcycle (above 50 ccc)
- public transport passengers (bus, tramway)
- pedestrians
- cyclists.

All age groups will be considered, with emphasis children (0-14 years old) on young people (18-25 years old for car drivers, 15-25 years old for PTW riders) and older people (> 65 years old). Figures in cities will be too small to have individual age bands. Data for both males and females are suggested to be collected.

3.2.2. Road category

Typically, "urban or municipal roads" are a single and inclusive of many different road categories value in most national and international databases (e.g. CADAS, IRTAD). Urban roads, however, may include urban or peri-urban motorways (especially in megacities), principal arterial roads, secondary arterial roads and minor/residential roads (Wegman et al., 2008). This distinction is seldom made at national crash data, but it is likely to be available at city level.

For Safer City Streets, the following classification of the urban road network is proposed:

- Urban motorways
- Principal arterial roads
- Secondary arterial roads
- Minor/residential roads

In case the entire classification is not available for some cities, priority will be given on the share of motorways on the urban road network. A full definition of these road categories can be proposed once data becomes available. Moreover, a further distinction into paved/unpaved roads is proposed, which may provide useful insight on road risk in developing countries context.

3.2.3. Geographical scope

The geographical scope of Safer City Streets is global. Cities from throughout the world will be invited to participate, aiming to reach representation of all world regions. However, certain inclusion criteria should be considered, in a constructive and non-restrictive manner. The cities inclusion criteria should concern cities with proper quality data, capital cities and cities of a certain size (i.e. with more than 200 000 inhabitants). A balance between the following principles should be targeted:

- manageable total number of cities in the database
- prevention of extreme variations in city size (as if all cities wishing to participate were accepted), which would hinder road safety analyses, at least the first stages
- invitation of all capital cities, for a proper geographical coverage, without size restrictions.

Generally, it is expected that by organising cities into groups with similar characteristics (see Chapter 4.2.2), the similarities in size and characteristics required for statistical reasons will be achieved and meaningful conclusions on data will be produced.

3.3. Crash data

In order to analyse road safety in cities, analysis should include, apart from fatal injuries, also non-fatal injuries (serious), as several smaller cities may not have sufficient number of yearly fatalities to allow statistical analysis. Moreover, serious injuries may provide additional insights on the road safety problems of vulnerable road users (pedestrians, cyclists, older people, PTW riders). On the other hand, there is a lack of standardised data on serious injuries and comparability is expected to be limited, unless countries (or cities themselves) have implemented dedicated studies of matching police and hospital records for defining the actual number and severity of injuries.

In the following sections, the definitions and characteristics of the different types of data on road crash casualties are discussed, and the core and additional data elements to be included in Safer City Streets are presented (see Table 3.1).

3.3.1. Number of road crash fatalities

Definition: A road fatality is defined as a person killed within 30 days from the road accident.[1]

Data source: Police records are typically the data source for road fatality data. In most countries, the above definition is adopted and already used by the Police for decades. Existing data can be collected through the CARE European database and the FARS system in the US. In this case, the data may not comply with the proposed city definitions. Agreements with the EC and NHTSA respectively for the use of the data could be envisaged.

Data availability: Total number of fatalities are expected to be available for all cities. It is also expected that the number of fatalities by road type, road user type, user age and gender will be available.

Under-reporting: Under-reporting of fatalities is expected to be negligible for the vast majority of cities who have systems in place for collecting road crash data (e.g. police records). The presence of a data collection system for road crash data is a basic criterion for a city to join the Safer City Streets network.

Variables and values: Yearly figures (last 10 years), share per road user type, share per road user age and gender, share per road type, share per vehicle type. For a detailed breakdown of variables to be collected and their combinations see Table 6.2. The variables and values definitions to be used are those of IRTAD database, EC/CADaS database and Eurostat databases; however, other definitions are acceptable, provided that the specific definition will be provided by the city.

The level of disaggregation (i.e. combined variables and values) is considered taking into account the respective level of disaggregation of exposure data and safety performance indicators. Ideally, one would wish for disaggregate data combining road, user and vehicle characteristics; however, these would eventually have to be aggregated to the level of aggregation of the exposure data (e.g. per road user type, per year, etc.). For example, there is no exposure indicator that can be available per vehicle and user characteristics at the same time (e.g. person-kilometres of travel for motorcyclists per age group). On the other hand, road user characteristics (i.e. age and gender) are known to be available at least in population figures, and therefore it is meaningful to collect road crash figures per a combined classification of age and gender. Care should be taken, however, to correct for the daytime commuters population where relevant, as these may have different age and gender distribution.

Years: 2004-2014; the sum or average of 3-5 years will be sufficient for most cities, the ten year series will be useful in analysing the trends (time series) in the evolution of road safety in cities over a suitable horizon. In addition, a three- or five-year moving average may be defined for greater statistical reliability. Consequently, for five-year moving averages for example, the 2010 reference point will be defined as the average of 2006-2010 data.

3.3.2. Number of serious injuries in road crashes

Definition: A serious road injury is defined as a person suffering MAIS3[2] or higher, and a slight injury is defined as a person suffering lower than MAIS3 from the road accident.[3] In case MAIS data is not available, but hospital data are available or considered for assigning injury severity in police data, it is proposed to use the following definition: a person hospitalised for at least 24 hours. If no hospital data is available, injury data should be provided as collected on the basis of the existing national/local definitions, which should be also provided and described.

Data source: Ideally, injury data should be retrieved from hospital records, though a dedicated study of linking and matching with Police records. Such studies, either carried out systematically so that actual injury data are made available, or carried out occasionally but leading to conversion factors to correct the injury under-reporting or mis-classification in the police records, are the gold standard for reliable injury estimates (ITF, 2011; Broughton et al., 2010). It is well known, however, that very few cities (or countries) have established systems of police and hospital data linkage, or have estimated the appropriate conversion factors are typically the data source for road injury data. In most countries, the above definition has been adopted and already used by the police for decades. The crash data proposed to be collected for Safer City Streets are summarised in Table 3.1.

Data availability: Total figures are expected to be available for all cities. The share of specific road, vehicle, road user or accident categories may not be available for all cities (e.g. alcohol related accidents, road types) - although for the basic variables and values (e.g. year, age, gender, vehicle type) the data is expected to be available.

Under-reporting: Under-reporting of serious injuries is expected to be significant for cities which do not have systems in place for linking police and hospital records. Under-reporting is expected to be higher for pedestrians and cyclists than motorised road users. Comparability will be limited and analyses should be presented with caution and transparency over the differences in definitions.

Variables and values: A similar approach to fatalities is proposed; for a detailed breakdown of variables to be collected and their combinations see Table 6.1. The variables and values definitions to be used are those of IRTAD database, EC/CADaS database and Eurostat databases; however, other definitions are acceptable, provided that the specific definition will be provided by the city. The level of disaggregation will be also similar to that of fatalities, although in some cases data availability may be less satisfactory. More specifically, the most accurate MAIS/hospital-based data are unlikely to be available at a high level of disaggregation, while the standard Police data will be typically available at the same level of disaggregation as the fatality data.

Years: 2004-2014.

3.3.3. Casualty rates to be calculated

The analysis of fatality and injury data alone is not meaningful, and an exposure indicator should be used as a denominator for calculating risk rates. The preferred exposure indicators are (in order of priority):

- fatalities/serious injuries per person-kilometres (by age and gender, mode of travel)
- fatalities/serious injuries per road length (by road type)
- fatalities/serious injuries per number of vehicles (by mode of travel)

- fatalities/serious injuries per population (by age and gender).

Apart from risk rates, a number of other outcomes can be considered:

- evolution of fatalities/injuries (time series)
- average annual percentage reduction in fatalities/serious injuries
- share of moped/motorcycle fatalities/serious injuries
- share of pedestrian/cyclist fatalities/serious injuries
- share of alcohol related fatalities/serious injuries
- share of fatalities/serious injuries per road type
- share of fatalities at junctions.

It is noted that for large cities or mega-cities, the analysis of fatalities will be sufficient. For medium cities, the average number of fatalities for 3-5 years may provide the statistical significance required. For small cities, the analysis of fatalities may be totally unfeasible, and only injury data (e.g. killed and seriously injured [KSI]) will be of sufficient sample. It is recommended to limit the detailed analysis of injury data to small cities, due to the known differences in data comparability. For larger cities, serious injury or KSI data may be used for a few general indicators reflecting the scale of the problem.

3.4. Transport demand and exposure

There are different exposure data to normalise crash data, each one with different advantages, limitations and data collection needs. For full reviews, refer to Hakkert and Braimaster (2002), SafetyNet (2005a) and Papadimitriou et al. (2013). In the following sections, the proposed exposure data for Safer City Streets are presented, together with their definitions and expected limitations (including data comparability). It is noted that population figures and road length, which are typically used as a convenient and largely available denominator of casualty rates, are not included in this section, as they are assigned to the demographic and socio-economic indicators of section 3.6.

3.4.1. Modal split: Number of trips

Significant safety benefits have been recorded regarding projects and policies that aim to reduce private car traffic and promote cycling, walking and mass transit (sustainable transport), especially in urban areas (EMBARQ, 2013; Litman, 2015). Although the results of existing studies are largely inconsistent, making it extremely difficult to meta-analyse their results (Elvik, 2009), individual studies have shown that it is critical to explore the role of traffic mix and vehicle prevalence on long-run fatality trends within transportation growth scenarios, especially in the context of developing countries (Bhalla et al., 2007). The share of traffic per mode is therefore not only an exposure indicator but also a safety performance indicator. Certainly, the share of traffic (number of trips) for non-motorised travel needs to be included.

Taking into account the expected data availability, only the share of public transport is proposed to be included in the "core" data of Safer City Streets. Additional data may include the share of road/rail.

Definition: Share of public transport vs. private transport (out of total trips in the city); share of pedestrian trips; share of bicycle trips; share of road transport vs. rail transport.

Data source: Transport authorities of the agglomeration (e.g. public transport) or travel survey data.

Data availability: At least an estimate is expected to be available.

Limitations: Travel survey data, either through phone surveys or travel diaries surveys, would be the most accurate method for estimating the share of trips by mode. However, very few cities are expected to have implemented such surveys. In most cases, (public) transport authorities will be the source of data, in which case figures for some cities are likely to be estimates, or outdated. It is possible that not all transport modes are covered, especially non-motorised travel, depending on the transport authorities organisation and hierarchy.

Variables and values: 2014 or last available year.

3.4.2. Travel: Person-kilometres

The number of person-kilometres[4] of travel and the volume of vehicular traffic is probably the most often preferred exposure measure. One important practical advantage of the use of person-kilometres (over road length, population and vehicle fleet) is the calculation of risk figures which are the most meaningful representation of user experience in the city, in terms of e.g. the likelihood of being killed per 1 km of walk or cycle.

Moreover, in theory, it may be available to a significant level of disaggregation: time, vehicle type, road type, driver characteristics, etc. Only few other exposure measures can usually allow for this level of detail (e.g. time spent in traffic). However, in practice, the availability and the level of disaggregation of person-kilometres may vary significantly and is strongly dependent on the type and features of the data collection method (Papadimitriou et al., 2013). For instance, person-kilometres estimated by means of traffic counts are usually available per road and vehicle characteristics, while a disaggregation by person characteristics is only possible for data obtained by means of travel surveys.

For Safer City Streets, the total number of person-kilometres travelled is proposed as the “core” indicator, disaggregated by mode (including pedestrians and cyclists). Additional indicators, concern the disaggregation by gender and vehicle type (passenger cars, motorcycles).

Definition: The total number of person-kilometres travelled on the city’s road network; person-kilometres travelled by males; person-kilometres travelled by females; person-kilometres travelled by passenger cars; person-kilometres travelled by motorcycles; person-kilometres travelled by pedestrians; person-kilometres travelled by bicyclists.

Data source: Expected to vary significantly. In several cases, many different data sources are used to calculate the total estimated figure (e.g. combining traffic counts data, travel survey data, public transport data, etc.).

Data availability: Expected to be limited, especially in developing countries.

Limitations: The number of person-kilometres will be a good approximation of the total travel. In some cases, only the main road network or only motorised travel will be available. The characteristics of the collection method need to be examined in order to ensure data comparability between cities.

Variables and values: 2014 or last available year, gender, passenger car/motorcycle/pedestrian/bicyclist.

3.4.3. Vehicle fleet

The number of vehicles in the vehicle fleet is not an exposure measure by itself, but could be regarded as an alternative for traffic or person-kilometres under certain conditions. For instance, it is not recommended to be used as a general replacement of vehicle-kilometres, as it is possible that vehicles on average drive more or fewer kilometres over time (Yannis et al., 2005).

Nevertheless, comparing the number of accidents corrected for the number of vehicles is likely to be informative. Furthermore, vehicle information, mainly type, age, brand and other physical characteristics, which are not likely to be easily available for person-kilometres, may be available for the vehicle fleet. Related risk estimates may be useful for international comparisons.

Definition: Estimate of the vehicle fleet size; typically, total number of vehicles registered at city; motorcycles registered; mopeds registered; buses or coaches registered; lorries or trucks registered.

Data source: Vehicle registers are typically administered at regional/local level.

Data availability: Data are expected to be available through the local administrations. In almost all countries there is a vehicle register, and in the vast majority of countries the data are available at administrative unit level, so that the data can be retrieved for the examined city.

Limitations: Vehicle registers may not be systematically updated (e.g. scrapped vehicles not regularly removed) leading to over-estimations of the current fleet. Influences of other vehicle fleets (e.g. from neighbouring cities) are not considered.

Variables and values: 2014 or last available year, passenger cars/motorcycles/buses or coaches/lorries or trucks.

3.4.4. Weather

Weather is not an exposure measure by itself, but it may significantly affect exposure. Mean temperature, mean or maximum precipitation, the number of days with low temperature/ice or - on the contrary - the number of days with very high temperature, have been shown to significantly affect road crash occurrence (for complete reviews see Bergel-Hayat and Depire, 2004; Bergel-Hayat et al., 2013; Theofilatos and Yannis, 2014). Within Safer City Streets, weather data may have a two-fold interest:

- Differences in weather conditions may account for geographical differences in climate (continents, northern vs. southern cities) that are reflective of cultural differences (e.g. climate may affect the travel habits, mode choice and road user behaviour) and eventually exposure differences (e.g. seasonal patterns, total person-kilometres travelled).
- Meteorological data are typically collected at local level and it is expected that a higher level of accuracy can be achieved when investigating the weather effect on cities road safety compared to countries road safety (as in the latter case the data is aggregated or averaged from local measurements).

Nevertheless, weather is not considered a core indicator for the purposes of the project and it is suggested to be considered for inclusion at later stages of the project. The transport demand and exposure data proposed to be collected for Safer City Streets are summarised in Table 3.1.

3.5. Safety Performance Indicators

In the literature review of Chapter 2.2, relevant performance indicators to assess the safety performance of cities and undertake meaningful benchmarking analysis have been presented. The review was extended to cover also studies aiming to compare the performance of cities in other aspects in the broader transport, health and quality of life sectors. Most of the performance indicators identified in the latter studies are very specific to the purposes of specific analyses (e.g to assess the efficiency of public transport networks, to link socio-demographic, health and quality of life indicators with road safety) and therefore less useful to the purposes of Safer City Streets.

Consequently, the Safer City Streets safety performance indicators will be largely based on the traditional approaches of Safety Performance Indicators (SPIs) (e.g. SafetyNet, 2005; Hakkert et al., 2007; SUNflower, 2002; Wegman et al., 2008; Gitelman et al., 2010; Hollò et al., 2011) and enhanced with additional indicators from these broader studies (see Table 3.5).

3.5.1. Road user protection

Road user protection SPIs may concern seatbelt and helmet wearing rates, child-seats use, reflective clothing, etc. Safer City Streets should focus on the most common ones and consider expanding to more specific ones at a later stage.

Definition: Daytime[5] helmet wearing rates for driver and for passenger of PTW (mopeds and motorcycles separately, if available); daytime seatbelt wearing rates on front seats of cars (aggregated for driver and front passenger); daytime seatbelt wearing rates on rear seats of cars.

Data source: The data can be made available from roadside observation surveys.

Data availability: Existing data from national surveys typically include an estimate for the capital city, and possibly also other cities. It is possible that specific cities have implemented their own surveys. Seatbelt and helmet wearing rates may be more frequently available for drivers than for passengers.

Limitations: There may be survey coverage and sampling limitations, but it would be very difficult to identify and remove such bias.

Variables and values: 2014 or last available year.

3.5.2. Road infrastructure

Road infrastructure SPIs are focused on the rural road network, either in terms of appropriate functional class, or in terms of meeting design standards (e.g. SafetyNet, 2005; Weijermars et al., 2008; Yannis et al., 2013). No SPI dedicated to urban road networks has been proposed. Indicators related to the length of the road network and length of the public transport network can be used to calculate infrastructure safety performance indicators for cities. Three such indicators are proposed (these can be calculated on the basis of the data collected). Moreover, the share of roads treated (e.g. for high risk sites, traffic calming schemes, etc.) are also proposed:

Definition: Length of motorways per 1 000 km of road network[6]; Length of non-paved roads per 1 000 km of road network; Length of rail public transport network per 1 000 km of road network; Share of High Risk Sites treated; Length of road sections treated - traffic calming

Variables and values: 2014 or last available year.

As the road/rail network length data required to calculate the SPI are themselves basic transport demand and exposure indicators, their sources, limitations and data collection features are discussed in section 3.6.

3.5.3. Vehicles

SPIs for vehicle fleet may include indicators related to crashworthiness (e.g. the NCAP protection score of the vehicle fleet), mean vehicle age and technical inspections (Hakkert et al., 2007). For the purposes of Safer City Streets, a basic indicator related to the age of the vehicle fleet is considered. It is placed, however, in the additional data requirements, as it is not expected to be a critical determinant of road safety in cities.

Definition: Mean age of the vehicle fleet.

Data source: Vehicle register.

Data availability: Good data availability is expected. In almost all countries globally there is a vehicle register, and in the vast majority of countries the data are available at administrative unit level, so that the data can be retrieved for the examined city.

Limitations: Vehicle registers are established for different purposes than to provide data for road safety analyses, and therefore may not be systematically updated (e.g. scrapped vehicles not regularly removed) leading to over-estimations of the current fleet; this may also lead to an over-estimation of the mean age of the fleet.

Variables and values: 2014 or last available year, for passenger cars and for motorcycles.

3.5.4. Alcohol

Alcohol may be a key factor of road safety in cities, as it is expected to strongly affect road crashes of young drivers, night-time, weekends, etc. Assum and Sørensen (2010) provide a detailed overview of the difficulties in the definition, data availability and international comparability of SPIs related to alcohol. In general, as also pointed out in SafetyNet (2005), there are two types of indicators that can be considered for alcohol: the first one is related to the exposure of alcohol impaired road users and the second one is related to the share of alcohol related crashes (as a proxy of the exposure of alcohol impaired users). Although the first approach is theoretically closer to the operational level of unsafety due to alcohol, and thus closer to the ideal SPI, data availability difficulties often make the second approach a more realistic one. However, at city level, it is expected to have data available and less variation in the exposure of alcohol impaired road users (which may be significant at country level). Consequently, the first approach is opted for in Safer City Streets.

Definition: Percentage of drivers above legal alcohol limit in roadside checks (legal alcohol limit to be specified).

Data source: Police records of roadside controls and violations for the administrative units are expected to be available, allowing to calculate the SPI. In some cities, roadside surveys carried out for research purposes may be the source of data.

Data availability: Data availability is expected to be satisfactory in Western and capital cities, and poorer in smaller cities or cities in developing countries.

Limitations: There may be survey coverage and sampling limitations, but it would be very difficult to identify and remove such bias.

Variables and values: 2014 or last available year.

3.5.5. Speeds

Speeding is known to be among the key risk factors in urban areas. However, the measurement of road users' speeding behaviour is challenging and required ad hoc surveys. SafetyNet (2005) recommends not only the mean speed but also the variability of speed to be considered for an accurate assessment of the operational level of road safety in urban roads. For Safer City Streets, these data will be included as additional data, so as to gather the few existing data and encourage the implementation of the appropriate methods for collecting the data in all cities. The SPI is limited to principal arterial roads, as it is considered highly unlikely that data is available at lower-level roads.

Definition: Mean speed on principal arterial roads; 85% percentile of speed on principal arterial roads; standard deviation of speed on principal arterial roads.

Data source: The data can be made available from roadside surveys. In cities where a traffic operations and management centre is in place, the data is automatically collected either by fixed speed cameras or pavement cables.

Data availability: Few cities are expected to be able to provide the data.

Limitations: There may be sampling limitations, but it would be very difficult to identify and remove such bias.

Variables and values: 2014 or last available year.

3.5.6. Post-crash care

There are numerous SPIs proposed for post-crash care (SafetyNet, 2005). However, this is not a critical aspect for Safer City Streets, and therefore smaller emphasis is put on such SPIs. The typical SPI of EMS response time is proposed.

Definition: Mean EMS response time.

Data source: Local EMS services/administrative units. In some cases, police or hospital records may provide related estimates.

Data availability: Data availability at city level is expected to be limited.

Limitations: None considerable.

Variables and values: 2014 or last available year.

The SPI data proposed to be collected for Safer City Streets are summarised in Table 3.1.

3.6. Demographics and socio-economic

This set of indicators aims to reflect a basic layer of the road safety system in cities, that of demographic, urban and socio-economic characteristics.

3.6.1. Population

Definition: Number of inhabitants within city boundaries.

Data source: Population registers, national/regional statistics.

Data availability: Data are expected to be available for all cities.

Limitations: None considerable. It is well known that population is a very rough approximation of exposure, and mainly serves epidemiological analysis purposes (e.g. mortality rates). However, for international comparisons, it may correct for city size. Moreover, data are typically available per age and gender.

Variables and values: 2014 or last available year, age groups, gender.

3.6.1.1 Commuter-adjusted daytime population

Definition: Total resident population +Total workers working in city - Total workers living in city

Data source: Population registers, national/regional statistics.

Data availability: Data are expected to be available for megacities/metropolitan areas.

Limitations: None considerable.

Variables and values: 2014 or latest available year

3.6.2. Urbanisation

Definition: Population density; public transport network length (rail/bus).

Data source: Population registers, national/regional statistics.

Data availability: Data are expected to be available for all cities.

Limitations: None considerable.

Variables and values: 2014 or last available year.

3.6.3. Road length

Road length is a basic measure used for the estimation of accident density. As opposed to person-kilometres, it does not capture spatial or temporal variations in the use of roads in an area. Moreover, due to the time needed for planning and construction of road infrastructure, the measure may be sensitive to economic influences in a lagging manner. For this reason, road length may be a very useful proxy of an exposure measure in developing countries, or for correcting for the sheer size of countries.

Unfortunately, in most international databases, little information is available on the length or urban road networks. Nevertheless, cities are very likely to have more detailed data on their road networks, and therefore this data may be a most useful denominator for urban road safety risk rates. The number of junctions per km of road may be a most useful indicator of exposure in urban areas. Road length data can be also used to calculate SPIs, as discussed in section 3.7.2.

Definition: Total length of the road network; length of urban motorways; length of principal arterial roads; length of secondary arterial roads; length of residential roads; length of unpaved roads; number of junctions per km of road.

Data source: Regional statistics or city authorities.

Data availability: Total road length figures are available for most cities. Paved vs. unpaved roads may not be available in developing countries. Number of junctions are unlikely to be available in most cities.

Limitations: None considerable.

Variables and values: 2014 or last available year, motorways, urban roads, unpaved roads.

3.6.4. Socio-economic indicators

The relationship between socio-economic indicators and road safety has been established in several recent researches (OECD, 2015; Yannis et al., 2014; Kopits and Cropper, 2005). It has been concluded that income (e.g. GDP per capita) and employment rates are the indicators most representative and directly affecting road safety, although several other indicators related to the economy, general welfare and health of the population have been suggested (e.g. Human Development Index, alcohol consumption, etc.)

Definition: GDP per capita; unemployment rate.

Data source: National/regional statistics.

Data availability: Data are expected to be available for all cities.

Limitations: None considerable.

Variables and values: 2014 or last available year.

3.6.5. Post-crash care

Definition: Number of hospitals/doctors/Intensive Care (IC) beds per population.

Data source: National/regional statistics.

Data availability: Data are expected to be available for most cities.

Limitations: None considerable.

Variables and values: 2014 or last available year.

The background, demographic and socioeconomic data proposed to be collected for Safer City Streets are summarised in Table 3.1.

3.7. Background road safety information

Background road safety information aims to link the general policy aspects with the operational level of road safety. For Safer City Streets, a small set of selected indicators are proposed, aiming to capture the main road safety and mobility policy elements at city level.

The core indicators concern road safety management (strategy, targets) mobility plans, and infrastructure safety management information, namely speed limits. For the "additional information" section of Safer City Streets, a number of additional questions were considered, as described below. However, these are not eventually included in the data framework, but could be considered for future developments of the project (see Table 3.7).

3.7.1. Road safety management

In the recent years, several studies have acknowledged that road safety management aspects can be a safety performance indicator (ITF, 2008). A few indicators related to road safety management at the more strategic level are included, aiming to collect data on the city vision and strategy, targets, road safety and mobility plans, etc. Especially the presence of a dedicated budget to implement road safety/mobility plans has been shown to be significantly associated with road safety performance (Papadimitriou and Yannis, 2013).

More specifically, while road safety management is a structural aspect of the road safety system (Koornstra et al., 2002), the degree to which road safety management programmes and processes are implemented and monitored, the degree to which formal tools and appropriate methodologies are used to implement programmes and processes, etc., may be associated with the operational level of safety (Elvik, 2012; Papadimitriou and Yannis, 2013; Jost et al., 2012; Muhlrad et al., 2011).

Research results also suggest that the presence of a system to monitor road safety progress, through data collection and analysis, surveys for road user behaviour, etc. are indicative of the maturity of the road safety management system, and also positively associated with road safety progress (Papadimitriou and Yannis, 2013; Muhlrad et al., 2011).

However, only basic information on road safety strategy, targets and mobility plans are suggested to be included in the data framework; more detailed additional indicators (e.g. dedicated budget to implement road safety strategy, systems in place to monitor road safety progress, systems in place to monitor road user attitudes and behaviour, etc.) can be considered for future data collection.

Definition: Road Safety strategy/plan and target; mobility plan.

Data source: City representatives' response.

Data availability: Data availability at city level is expected to be satisfactory; the data can be obtained through the responses of a city stakeholder or data specialist (e.g. the city representative in the Safer City Streets network) with good knowledge of the road safety management system in the city and in the country.

Limitations: None considerable.

Variables and values: 2014 or last available year.

3.7.2. Infrastructure safety management: Speed limits

The core indicators suggested for collection concern speed limits at different types of urban roads.

Definition: Speed limits for main roads (km/h); speed limits for distributor roads (km/h); speed limits for residential roads (km/h).

Data source: City representative's response.

Data availability: Data availability at city level is expected to be satisfactory; the data can be obtained through the responses of a city stakeholder or data specialist (e.g. the city representative in the Safer City Streets network) with good knowledge of the road safety management system in the city and in the country.

Limitations: Speed limits for a given road type may vary within the city; a range of values (e.g. 50-70 km/h) is acceptable.

Variables and values: 2014 or last available year.

Additional indicators on infrastructure safety management, which can be considered for future inclusion in the project are systematic High Risk site identification and related interventions, road pricing schemes, traffic calming schemes, shared space/30-zones, etc.

3.7.3. Education and enforcement

In future developments of the project, the total number of enforcement controls (speed, alcohol, seatbelt, helmet, etc.) or the roadside police alcohol tests per 1 000 population could be considered, on the basis of police records of roadside controls for the administrative units. Moreover, road user education aspects could be considered in future developments of the project, such as the presence of compulsory/voluntary education programmes, education programmes for particular groups (e.g. elderly, bicyclists).

3.7.4. Proposed road safety background information for Safer City Streets

The road safety background information proposed to be collected for Safer City Streets are summarised in Table 3.2.

3.8. Key messages of Chapter 3

It is suggested that for the Safer City Streets project, cities are defined on the basis of administrative boundaries selected by the relevant stakeholders/data providers. For Safer City Streets, the data is recommended to be collected from the cities themselves. However, they could be complemented with data from international road crash (e.g. CARE/EU, FARS/US) or exposure databases (e.g. Eurostat, UITP). In many cities, fatality data need to be complemented with serious injury data, to be examined either as a separate indicator or as the sum of killed and seriously injured (KSI). It is proposed to request for serious injury data on the basis of the MAIS3+ definition; however, it should be allowed for cities not able to provide MAIS data to return their injury data on the basis of their current definitions.

For small- and medium-sized cities, the average of three to five last years may provide the necessary statistical significance; however, it is suggested to collect the data for the last 10 years, to allow monitoring the evolution of road safety in cities.

The availability of exposure and SPI data may be better at local level than national level. On the other hand, local safety performance indicators may suffer from sampling errors, due to the limited size of the samples for sub-national surveys. In several cases, road safety management is implemented at regional or local level and there may be opportunities in obtaining and using information on local road safety programmes and policies.

RTAD and the cities may place emphasis on background road safety information, as well as demographic and socio-economic aspects such as income, employment, economically disadvantaged groups, urban density, population composition, settlement type. A two-level data collection is proposed, with “core data/information”, including a minimum set of data/information that will be routinely collected and is expected to be available in most cities, and additional data/information, that will be pursued in the future to allow more detailed benchmarking analysis.

A data and information framework with five layers is suggested:

<u>Data</u>

1. **Fatalities and injuries**; core data include fatalities and serious injuries per road type and road user type.

2. **Transport demand and exposure**; core data include modal split/share of trips (also for non-motorised travel), person-kilometres, vehicle fleet.

3. **Safety performance indicators**; core data include road user protection indicators (seatbelt and helmet use), and road infrastructure indicators.

4. **Demographic and socio-economic indicators**; core indicators include GDP per capita, unemployment rate, population/population density, road length.

Information

5. **Road safety background**: road/infrastructure safety management indicators, mobility plans, etc.

Notes

[1]This is the standard international definition of fatality, used by WHO, IRTAD, EC/CADaS, Eurostat etc.

[2]The MAIS is the maximum AIS severity score of a casualty with several injuries. The AIS is a specialised trauma classification of injuries; it includes an anatomical descriptor of the tissue damage caused by the injury and an immediate severity score, which ranges from 1 to 6. The AIS is calculated from the International Classification of Diseases (ICD-9 or ICD-10) scores, developed collaboratively by the World Health Organization (WHO) and 10 international centres (WHO, 1992).

[3]This is the standard definition of injuries recently proposed or adopted by IRTAD, EC/CADaS, etc.

[4] Person-kilometres is also often referred to as passenger-kilometres. In the present report, person-kilometres is used as a more generic term, including the travel of drivers, passengers, pedestrians, cyclists.

[5]Typically, daytime wearing rates are considered, as in most cases the roadside observations can be more accurate during daylight.

[6]Length of motorways per total network length may reflect the size and urbanisation of the city. For example, several world capitals have peri-urban freeways, and several mega-cities are spanned by urban motorways.

4. City grouping criteria

In this Chapter, the city definition and grouping criteria for Safer City Streets are defined. First, a dedicated definition of the "city" for Safer City Streets is proposed, combining clear administrative boundaries with population density above a certain threshold. In this way, the data can be made available for all cities and minimum comparability of cities is ensured. Then, city grouping criteria are proposed, on the one hand on the basis of geographical and cultural differences, and on the other hand on the basis of city size. Existing standard international classifications are used for both groupings. Finally, a combined grouping on the basis of both criteria is proposed for improved comparability, if there is a sufficient number of cities participating in the project.

4.1. Safer City Streets proposed definition

Taking into account the different city definitions discussed in Chapter 2.1, and in accordance to definitions used by the various international organisations, an indicative city definition is proposed to be used within Safer City Streets.

The criteria for formulating this definition can be outlined as follows:

- The basic criterion is that the definition should be such that it would allow data to be available. Recent research (e.g. OECD, 2012) has provided very useful insight and tools to address the spatial complexity of different cities worldwide. However, the application of such methods and tools will require effort and resources from the participating cities (e.g. use of GIS tools, implementation of dedicated analysis, etc.) which will be hardly motivating for joining the Safer City Streets network. Moreover, in cities from developing or lessresourced countries, such analyses may be completely unfeasible.
- Consequently, and taking into account that any data collection is carried out at some type of administrative level (regional or local), the proposed definition of city should allow an appropriate area to be selected on the basis of existing administrative boundaries.
- The proposed definition should be as simple and generic as possible. Different types and sizes of cities should be distinguished to some extent, yet to the minimum extent necessary.

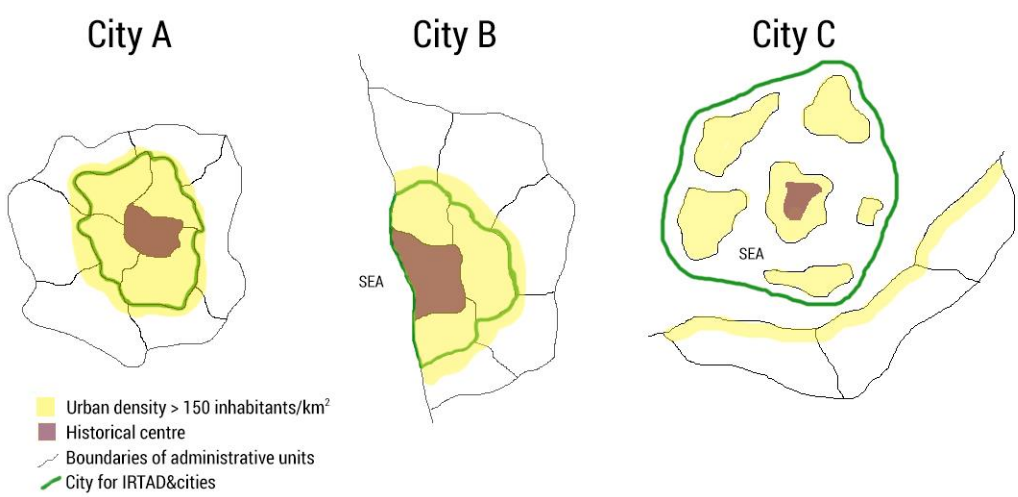
Consequently, a definition closer to the one adopted at the UN city statistics, seems the most appropriate to base IRATD and the cities project. On the basis of the above, the Safer City Streets definition of a city can be outlined as follows. In order to accommodate mega-cities (with more than 6 million inhabitants), an additional city definition will be used under the term "greater city".

The "city" can be defined as the area with clear administrative boundaries (one or more - or finer - administrative units), containing the historical city centre and the inhabited area. A minimum population density ranging between 100-150 inhabitants per km^2 is typically the threshold for defining the inhabited area (a lower threshold of 100 inhabitants per km^2 is allowed for smaller cities).

The "greater city" can be defined as the area outside the city (as defined above), containing an inhabited area with minimum population density ranging typically between 50-100 inhabitants per km^2. Cities may provide data for either one or both areas: the city and the greater city.

There is no prerequisite as per the selection of administrative units for city and greater city. In smaller cities, the city may coincide with the administrative boundaries of the municipality, while in larger cities it may include one or more administrative units. In small towns, the city may need to be defined at a finer administrative level than that of the municipality, given that it may include sparsely populated areas; in this case, a set of "urban districts" satisfying the population density criterion will be selected. In the same sense, the "greater city" may or may not coincide with the metropolitan area/agglomeration, depending on the population densities of the different administrative units comprised in the metropolitan area. An illustration of the city indicative definition is provided in Figure 4.1.

Figure 4.1. **City indicative definition in Safer City Streets**



Consequently, for each city, the boundaries of the administrative units forming the metropolitan area will be examined in conjunction with the population density, leading to the identification of the administrative unit(s) which include the historical city centre and the areas with the minimum population density. In this way, road safety and other related data can be available, as the area will be based on administrative units.

It should be acknowledged that the cities (i.e. their authorities) themselves may have the clearest and most accurate view of the demographic and spatial characteristics of the greater area. Consequently the final city area selection for participation in Safer City Streets will be a case-specific collaborative process, with city representatives analysing the structure of their city and proposing their approach for applying the definition, the Safer City Streets secretariat providing guidance and clarifications, and mutual feedback being exchanged until a common understanding and agreement upon the proposed area to be included is reached.

It is noted that full uniformity in the areas to be compared cannot be achieved at the early phases of the database and network development, and certainly not in the city selection process (i.e. when applying the definition). The comparability of data and cities will be improved in time and many comparability issues will be properly identified and tackled at the data analysis phase.

4.2. City grouping

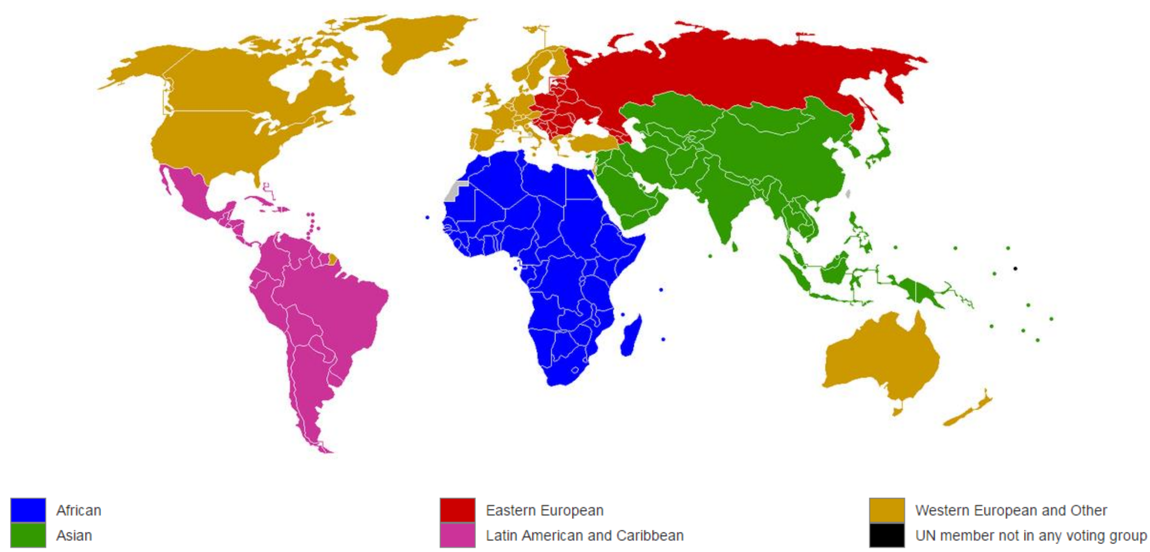
Apart from the definitions proposed above, it is acknowledged that comparability of data also depends on other demographic, socio-economic and cultural aspects. In order to enhance comparability, two types of grouping are proposed, as well as a combined grouping.

4.2.1. Geographical grouping

As cultural differences may be difficult to identify by purely geographical (e.g. continents) or economic criteria (e.g. developed vs. developing countries), it is proposed to adopt the UN Global regions grouping (www.un.org/depts/DGACM/RegionalGroups.shtml) (see Figure 4.2):

- the African Group, with 54 member states
- the Asia-Pacific Group, with 53 member states
- the Eastern European Group, with 23 member states
- the Latin American and Caribbean Group (GRULAC), with 33 member states
- the Western European and Others Group (WEOG), with 28 member states

Figure 4.2. **Geographical city grouping: the UN global regions**



Source: https://en.wikipedia.org/wiki/United_Nations_Regional_Groups

4.2.2. City size grouping

A classification of urban areas into four "types" according to population size is proposed (OECD, 2012); it is suggested to expand that classification by explicitly considering the "megacities" category as an additional category:

- small-sized urban areas, with a population below 200 000 people
- medium-sized urban areas, with a population between 200 000 and 500 000 people
- metropolitan areas, with a population between 500 000 and 1.5 million people

- large metropolitan areas, with a population of 1.5 million or more
- mega-cities, with a population of 10 million or more.

4.2.3. Combined grouping

A combined grouping of cities on the basis of the two criteria, geographical region and city size, may allow for an optimal grouping of cities and more meaningful analyses, as shown in Figure 4.3. More specifically, the assignment of cities in the "cells" of this combined grouping may identify the groups of cities that need to be considered for comparative analysis. The combined grouping requires a sufficient number of cities participating in the project, so that a minimum number of cities can be placed in each cell.

Figure 4.3. **Combined classification and grouping of cities for Safer City Streets**

Population	Small-sized city	Medium-sized city	Metropolitan area	Large metropolitan area	Mega-city
Region	< 200 000	200 000-500 000	500 000-1.5 million	1.5-10 million	>10 million
Western European and Others					
Eastern European					
Latin American and Caribbean					
African					
Asia-Pacific Group					

4.3. Key messages of Chapter 4

The basic criterion to propose a city definition for Safer City Streets is that it would allow data to be available. A definition based on administrative boundaries is opted for, taking into account the population density of the administrative units. The city is defined as the area with clear administrative boundaries containing the historical city centre and the inhabited area. A minimum population density ranging between 100-150 inhabitants per km2 is proposed for defining the inhabited area. The greater city is defined as the area outside the city (as defined above), containing an inhabited area with minimum population density ranging between 50-100 inhabitants per km2.

Cities may provide data for both areas: the city and the greater city. The final city area selection for participation in Safer City Streets will be a case-specific collaborative process. City grouping may be based on geographical criteria (UN global regions), city size criteria (OECD classification), or a combination of both.

5. Analysis types and outputs

This chapter describes the types of analyses and related outputs that are proposed for Safer City Streets. First, the proposed road safety outcomes absolute figures and indicators are summarised, taking into account the related necessary exposure data that are expected to be available. Moreover, the different types of descriptive or statistical analysis that can be carried out on the basis of the data collected, either as basic/routine analyses, or as dedicated and more sophisticated analyses that can be envisaged for the future. Finally, the main outputs of the Safer City Streets project are summarised, namely the on-line database, the Annual Report - including city comparisons and city profiles, and future Joint Research Reports on methodological questions or other critical road safety issues.

5.1. Analyses of fatality and injury data

As underlined in section 3.4, the analysis of fatality and injury data alone is not meaningful, and an exposure indicator should be used as a denominator for calculating risk rates. The preferred exposure indicators are (in order of priority):

- fatalities/injuries per person-kilometres (per age and gender, for cars and motorcycles)
- fatalities/injuries per road length (per road type)
- fatalities/injuries per number of vehicles (for cars and motorcycles)
- fatalities/injuries per population (per age and gender).

Apart from risk rates, a number of other outcomes can be considered:

- evolution of fatalities/injuries (time series)
- average annual percentage reduction in fatalities/injuries
- share of moped/motorcycle fatalities/injuries
- share of pedestrian/cyclist fatalities/injuries
- share of alcohol related fatalities/injuries
- share of fatalities/injuries per road type
- share of fatalities at junctions.

It is noted that for large cities or mega-cities, the analysis of fatalities will be sufficient. For medium cities, the average number of fatalities for three to five years may provide the statistical significance required. For small cities, the analysis of fatalities may be totally unfeasible and only injury data will be of sufficient sample. It is recommended to limit the detailed analysis of injury data to small cities, due to the known differences in data comparability. For larger cities, injury data may be used for a few general indicators reflecting the scale of the injury problem.

These risk rates and other outcomes can be further associated with other performance indicators, transport demand, socio-economic or road safety management characteristics, such as (in order of priority):

- share of public transport
- length of public transport network
- urban density
- speed/speed variability on main roads
- number of junctions per Km of road
- share of unpaved roads
- GDP per capita/unemployment
- enforcement (controls per population)
- traffic violations (speed/alcohol related violations per enforcement controls)
- seatbelt/helmet wearing rates
- mean age of the fleet
- weather indicators
- road safety management indicators
- EMS response time

While the comparison of road safety outcomes between different cities allows for benchmarking, the association of these outcomes with SPI, road safety measures, transport demand and exposure, and socio-economic indicators may enhance our understanding of the differences between cities and highlight the related safety problems and risk factors.

5.2. Thematic analyses

On the basis of the above, four types of analyses can be relevant to Safer City Streets:

- Benchmarking cities, i.e. by comparing different types of final outcomes and ranking cities, also in relation to various city characteristics. This type of analysis focuses on the “outcomes” layer, but may also include cities comparison as per performance indicators, road safety management indicators and background characteristics (demographics, urban structure, socio-economic indicators). The scope and extent of this analysis will be largely determined by the minimum set of core/additional data that will be available for a satisfactory number of cities. In each case, the combined grouping of cities should be implemented for meaningful comparisons.

- City profiles, i.e. identification of cities risk factors, by applying a bottom-up approach linking the various layers, from demographic and socio-economic factors to final outcomes, through each one of the individual layers. This type of analysis will be looking at each city individually, with more detailed presentation of the road safety, exposure and city characteristics. This type of analysis will also include any qualitative information that has been made available for each city (e.g. specific campaigns or education programmes, infrastructure measures, etc.). In this sense, this type of analysis will seek to exploit all the data provided by each city, regardless of the degree to which the data is available for other cities as well.

- Road safety issues analyses, i.e. fact-sheet type analyses, focusing on particular road user, vehicle or infrastructure characteristics affecting the road safety performance of cities. Examples are pedestrians, cyclists, young or elderly people, road infrastructure, socio-economic and cultural characteristics. These fact-sheets will include data elements from all the layers of the data framework related to the specific road safety issue.

- Statistical analyses, i.e. ad hoc statistical analyses and modelling can be considered for road safety in cities overall, or for particular road safety topics. These analyses may address questions such as the evolution of road casualties at city level vs. national level; the role of national policies, programmes and other country characteristics on the city road safety performance; and on the other hand the city-specific determinants of road safety performance, the geographic and cultural influences. The development of a composite indicator for road safety in cities is also a promising field for analysis. These analyses required dedicated techniques such as time series analysis, multilevel analysis, data reduction/structural equation models and other non-parametric techniques.

5.3. Outputs

There will be three main outputs of the project: the on-line database, annual report and joint research reports. The on-line database is suggested to be of similar structure and access as the IRTAD database with key data and indicators. Registered users/network participants will be able to access the database, visualise the data and/or query the database to retrieve aggregate statistics or cross-tabulated data.

At the first stages of the project, the main analyses and outcomes will concern the annual report, with city comparisons/benchmarking and city profiles, and progressively joint research reports with thematic analyses and dedicated statistical analysis will be scheduled once more data become available and the critical issues for analysis are identified.

The main output of the project will therefore be the annual report, which may include two distinct and complementary parts:

- Part A: City comparison and benchmarking, with analyses of main trends and figures for all cities, comparisons and benchmarking on the basis of road safety outcomes and other performance indicators. These analyses should be presented according to the combined grouping of cities.

- Part B: City profiles, with presentations of the road safety and other related data for each individual city, on the basis of the methodological and data framework of the project (i.e. fatalities and injuries, performance indicators, road safety measures, transport demand and exposure, demographics and socio-economic).

Additional outputs of the project will be the joint research reports, either in form of methodology guidelines for data collection and analyses, fact-sheets for particular issues, or statistical analyses of the data.

5.4. Key messages of Chapter 5

The analysis of fatality and injury data alone is not always meaningful, and an exposure indicator should be used as a denominator for calculating risk rates. The preferred exposure indicators are (in order of priority):

- fatalities/injuries per person-kilometres
- fatalities/injuries per road length
- fatalities/injuries per number of vehicles
- fatalities/injuries per population.

Apart from risk rates, a number of other outcomes can be considered:

- evolution of fatalities/injuries (time series)
- average annual percentage reduction in fatalities/injuries
- share of fatalities/injuries.

For large cities or mega-cities, the analysis of fatalities will be sufficient. For most cities, the average number of fatalities for three to five years may provide the statistical significance required. For small cities, only serious injury data will be of sufficient sample. It is recommended to limit the detailed analysis of serious injury data to small cities, due to the known differences in data comparability.

Four types of analyses can be relevant to Safer City Streets: benchmarking, city profiles, road safety issues analyses (fact-sheet type analysis), and statistical analyses. There will be three main outputs of the project: the on-line database, accessible to all participants for visualising the data and obtaining aggregate statistics; the annual report, with city comparisons and city profiles; joint research reports to be drafted in the future, in order to address methodological issues in data collection, carry out dedicated analyses on particular issues, including statistical analyses, etc.

6. Network of experts

6.1. Network participants

The Safer City Streets project will be strongly based on the network of experts involved. The participation in the network is suggested to be open for all authorities, institutes or individual participants with interest in contributing to the project, either as data providers or as experts.

More specifically, the network may include:

- **Participating cities representatives**, either officers appointed by the city authorities, or external experts appointed by the city authorities.
- **Other data providers**, representatives of international databases with data at city level.
- **Other experts** from research Institutes and other national or international organisations interested in contributing to the project.

6.2. Network role

The main role of the network of experts will be the management of the project, mainly though the city representatives, with additional advise from the other participants. The network of experts will be dealing with the collection of data for the participating cities, either through the city representatives, or through the international databases (for cities not represented in the network).

It is suggested that for each participating/examined city, one member of the network is responsible for the data collection for this city, either the city representative, or - in case of cities not represented in the network - the data provider/other expert able to provide data for this city.

Finally, the network of experts will contribute with their knowledge and experience in the data quality assessment, the review and assessment of analyses and outputs of the project. They may also identify "urgent" topics for analysis and further research.

6.3. Organisation of the network work

At the beginning of the project, a survey is proposed to be launched among city representatives/network members in order to identify the data, their sources and the definitions, variables and values that can be made available (e.g. Do they have access to data from hospitals? How do they measure exposure?). On the basis of this survey, it may be determined which data can be provided by the city, and what additional or external data sources may be exploited to collect additional data. This survey may be filled out at later stages by each new city joining the network.

The Safer City Streets network is suggested to meet regularly, in order to monitor the progress of the project and the development of the database, provide feedback and expertise on the data collection and analysis and plan the future activities and steps (e.g. joint research reports). Expertise from the IRTAD group may be exploited.

An annual survey for the collection of data is suggested to be implemented, in order to populate or update the database. It is underlined that the city data available in international databases are limited overall, and often inconsistent. It is therefore recommended that an ad hoc data collection process is implemented, through the city representatives/members of the network. The city representatives should have a good overall knowledge of the transport and safety system in their cities, and be able to access the related data sources at national/local level in order to provide the data. International databases are suggested to be queried for validation purposes or collection of data for cities not represented by an expert in the network.

6.4. Key messages of Chapter 6

The network of experts is suggested to include city representatives (appointed by the city authorities), other data providers (e.g. representatives of international databases), as well as additional experts from research institutes or other organisations interested in contributing to the project. Their main roles will be the management of the project, the collection and assessment of the data, and the feedback and contribution in the analyses and project outputs. The data will be collected primarily through an annual survey among members of the network, and complemented with additional data from other sources.

7. Conclusions

This report presents a methodological framework for the development of the Safer City Streets network and database. An exhaustive review of existing studies dealing with road safety in cities was carried out, as well as related international initiatives and existing databases. The main purposes for this review were to examine the methods used for the assessment of road safety in cities, the related road safety and exposure/safety performance indicators, as well as the way cities are defined and classified on the basis of administrative, geographic or other socio-economic criteria. For this reason, a number of studies comparing cities, but not with a road safety analysis purpose, but with transport and mobility analysis purpose, were also included in the review.

The review results revealed the main methodological and data challenges for road safety analyses at city level, allowing to better define the scope of the project, its added value as well as its limitations. A city definition is proposed, tailored to the data availability and analysis needs of Safer City Streets. Two city grouping criteria are proposed, a geographical one and a city size one, as well as a combined two-dimensional grouping, to enhance comparability of cities. Moreover, a methodological framework is proposed, as an adjustment of the classical five-layer structure of road safety systems dedicated for cities analysis: fatalities and injuries, road safety performance indicators, transport demand and exposure, demographics and socio-economic indicators, and road safety background information.

Furthermore, the data needs and collection procedures are defined. It is recommended that an annual survey among city representatives/network members is launched for the collection of the data, as the existing data in international databases are few and inconsistent. This approach may enable the collection of detailed city-specific data by a representative with good knowledge of the road safety system and access to the various different national or local data sources. However, additional data for missing data elements or for cities not represented in the network may be collected through international databases. Specifications for the data collection spreadsheet and the database structure are also provided in the Appendix. The prototype for the cities database will need to be designed once the structure and contents of the data collection form are finalised.

An ambitious list of indicators and data/information elements is proposed to be collected; however, these are distinguished into "core data/information" and "additional data/information" and emphasis will be put on the collection of core data/information, while keeping the cities motivated for providing the additional data/information to the greatest extent possible. An in-depth analysis of the various data/information elements of each layer is provided, including the data definitions, variables and values to be collected, data sources and expected data availability, as well as optimal use and limitations of each indicator.

It is recommended that for the analysis of fatality data averaged figures over three to five years will be used, which may improve statistical significance. In small cities, fatality data are unlikely to be informative, and therefore the number of injuries will be examined with priority. Overall, however, the number of injuries will be hardly comparable among cities in most cases, as very few cities are expected to be able to provide MAIS data. Nevertheless, the true potential of analysis on the basis of injury data will be assessed once the injury data are collected and processed, and their respective definitions per city are closely examined.

Exposure data and safety performance indicators are expected to confirm the general principle that "the most useful data are the least available". However, estimates of modal split or the total amount of travel on the main road network are expected to be available for most cities, even though these are seldom available at country level. These can be useful exposure indicators and, together with road length (preferably per road type) and socio-economic indicators, they may allow for several meaningful comparisons. Additional exposure and SPI data will be pursued, but data availability is still uncertain.

On the basis of the core and additional data, several types of analyses can be implemented, including benchmarking analyses and city comparisons, city profiles, thematic (fact-sheet type) analyses and, at later stages, in-depth or statistical analyses on particular issues. The main output of the project will be the Annual Report with city comparisons and individual profiles, to be complemented later with various ad hoc analyses and reports.

The review and methodology development presented in this report confirmed that Safer City Streets is a challenging project, with methodological complexities and data analysis difficulties to be addressed. However, it also confirmed the added value of the project to establish an innovative analysis approach and network on the critical question of urban road safety worldwide, addressing many of the critical issues that are identified at local level (e.g. road safety management, urban infrastructure, vulnerable road users, etc.). It was also demonstrated that there may be opportunities for more and better data and insights for the understanding of road safety problems at finer spatial level than at national/regional level.

It should be also acknowledged, however, that data availability and comparability may be challenging at the early stages of the project, and there are several issues which it may be possible to address only once the data is available, during the data processing and analysis. The establishment of the Safer City Streets network and database will be the first step for addressing future challenges to improve data quality, undertake innovative and useful analyses and eventually improve road safety in cities.

Several issues that would deserve common reflection and further research have been already identified, e.g. the methodologies to collect traffic and mobility data; the comparability of injury data; the role of cultural, geographical and climate aspects on road safety, the infrastructure safety assessment at city level; and the benchmarking of cities on the basis of composite indicators.

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Appendix - Recommendations for the structure of the database

On the basis of the above, the core and additional data to be collected within Safer City Streets were identified and described. The related database to be developed can be thus organised as follows.

A spreadsheet-type database is proposed (e.g. Miscrsoft Excel or similar) both for the collection of the data (data collection form) and STATWORKS for the storage of the data. A single spreadsheet should be used for each city for providing the data. Different sections are suggested to bring together data elements of the same dimensionality. The data collection form could be organised as follows (see Table I):

- Section 1 - Basic information: City name, geographical region and size (population); this will allow easier grouping for analyses purposes.
- Section 2 - Fatality and injury data
- Section 3 - Safety performance indicators data
- Section 4 - Transport demand and exposure data
- Section 5 - Demographics and socio-economic data

In all sections, the data items to be provided will be presented in rows and the data will be entered in a single column, for 2014 or the last available year (to be defined), with the exception of fatality and injury data, which should be provided for several years. The data will be organised thematically, with "additional data elements" cells highlighted with light grey and a related explanation. An additional column should be provided allowing for qualitative/descriptive information to be provided (e.g. definitions, data source, etc.).

Table A1. Structure of the Safer City Streets data collection form

	2000	…	2014	Comments
Number of fatalities				
Total fatalities				
Fatalities of motorcyclists				
Fatalities of moped riders				
Fatalities of buses or coaches occupants				
Fatalities of lorries or trucks occupants				
Fatalities of young riders (15-24)				
…….				
Safety Performance indicators			**2014***	(* or last available year - please specify)
Daytime helmet wearing rates for driver and for passenger for mopeds and motorcycles				
Daytime seat belt wearing rates on front seats of cars (aggregated for driver and front passenger)				
Percentage of drivers above legal alcohol limit in roadside checks				
Mean age of the passenger car fleet				
Mean age of the motorcycle fleet				
Mean speed on main roads				
……..				
……..				
Transport demand and Exposure				
Share of public vs. private transport				
Share of road transport vs. rail transport				
Share of passenger transport vs. freight transport				
Total number of person-kilometres travelled				
Total length of the road network				
Length of urban motorways				
Length of main roads				
Length of distributor roads				
Length of residential roads				
Length of unpaved roads				
Vehicle fleet				
Total number of vehicles registered at city				
Motorcycles registered				
……..				
Demographics and socio-economics				
GDP per capita				
Unemployment rate				
Population density				
Public transport network length				
Total number of inhabitants				
females				
age group 0-14				
age group 15-17				

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