Exposure Data and Risk indicators for Safety Performance Assessment in Europe

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Abstract

The objective of this paper is the analysis of the state-of-the-art in risk indicators and exposure data for safety performance assessment in Europe, in terms of data availability, collection methodologies and use. More specifically, the concepts of exposure and risk are explored, as well as the theoretical properties of various exposure measures used in road safety research (e.g. vehicle- and person-kilometres of travel, vehicle fleet, road length, driver population, time spent in traffic etc.). Moreover, the existing methods for collecting disaggregate exposure data for risk estimates at national level are presented and assessed, including survey methods (e.g. travel surveys, traffic counts) and databases (e.g. national registers). A detailed analysis of the availability and quality of existing risk exposure data is also carried out. More specifically, the results of a questionnaire survey in the European countries are presented, with detailed information on exposure measures available, their possible disaggregations (i.e. variables and values), their conformity to standard definitions and the characteristics of their national collection methods. Finally, the potential of international risk comparisons is investigated, mainly through the International Data Files with exposure data (e.g. Eurostat, IRTAD, ECMT, UNECE, IRF etc.). The results of this review confirm that comparing risk rates at international level may be a complex task, as the availability and quality of exposure estimates in European countries varies significantly. The lack of a common framework for the collection and exploitation of exposure data limits significantly the comparability of the national data. On the other hand, the International Data Files containing exposure data provide useful statistics and estimates in a systematic way and are currently the only sources allowing international comparisons of road safety performance under certain conditions.

Key words: risk; exposure; data; collection methods; data availability; data quality.

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1. Introduction

In road safety research and management, exposure data are used in order to obtain risk estimates, those being defined as the probability of being involved (or injured) in a road accident, and calculated as the number of accidents (or casualties) divided by the amount of exposure of a road user population over a time period. These risk figures may also concern the probability of being injured once involved in a road accident (severity rates), calculated as the number of casualties divided by the number of road accidents (or persons involved in road accidents). Risk figures may be used for different purposes, such as international comparisons, monitoring of road safety problems, in-depth road accident analyses and research, road and traffic operations analyses, epidemiological analyses etc.; however their main use concerns the comparison of safety performance among different units, populations or countries.

The assessment of risk, by means of the analysis of risk rates, may serve as a tool for researchers and policy makers involved in the monitoring of road safety performance and especially the related international comparisons, in two ways: first, by the decomposition (or disaggregation) of risk for the comparison of safety performances by modes of transport, by types of road infrastructure, by types of road users etc.; and second, by further analysis of the risk in terms of temporal evolution, spatial distribution, impact of risk factors etc.

In theory, continuous exposure measurements of different road user categories in different modes and different road environments would be required and could provide detailed exposure estimates, i.e. to the degree of disaggregation of the respective accident data. In practice, such measurements are not possible (Yannis et al. 2005). Consequently, road safety analyses need to compromise to some (approximate) estimates of exposure, whith various levels of accuracy and representativeness of the true exposure of the examined population (Golias & Yannis, 2001).

Currently, there is an important potential for road accident analysis in Europe, as a national framework for the collection, processing and analysis of accident data is operational in all European countries. The development of the CADaS European system for the collection and analysis of accident data, including comparable disaggregate data, is a major step forward in this direction. However, the absence of a European system for exposure data collection and exploitation considerably limits the possibilities of reliable and useful analyses of accident data.

In this framework, the objective of this research is the review and analysis of the state-of-the-art in risk indicators and exposure data for safety performance assessment in Europe, in terms of data availability, collection methodologies and use. This review and analysis were carried out within the SafetyNet research project of the 6th Framework Programme of the European Commission and was further updated within the DaCoTA research project of the 7th Framework Programme.

The scope of this review is related to risk assessment within international comparisons of road safety performance, and therefore concepts and methods related to smaller units of time or space are not explored here. Moreover, severity rates are not addressed, given that in most cases they can be easily calculated from the road accident data alone. The paper aims to explore the theoretical properties of selected exposure measures in use in road safety (e.g. vehicle- and person-kilometres of travel, vehicle fleet, road length, driver population, time spent in traffic etc.). Moreover, it aims to present an overall picture of the existing methods for collecting exposure data for national risk estimates (e.g. travel surveys, traffic counts, databases and registers etc.), as well as the availability and quality of risk exposure data in the European countries. Finally, the potential for international risk comparisons is investigated, through the most relevant International Data Files with exposure data (EUROSTAT, ECMT, UNECE, IRTAD and IRF).

In order to meet these objectives, a review of the international literature on risk and exposure data was carried out. A survey was also carried out, by means of a specially designed questionnaire, including detailed information on the availability, characteristics and collection methods of exposure data for national risk estimates in the European countries. The questionnaire was filled by the National Experts group on road accident statistics of the European Commission. Furthermore, a separate survey was devoted to the analysis of exposure data in the International Data Files, by means of personal interviews with the maintainers of the related databases.

2. Theoretical background

As the basic concepts of road accident statistics play a central role in road safety analysis, this section first discusses this topic. After an introduction to the statistical properties of the accident process, the related consequences on the general use of accident risk rates are discussed. Using that as a starting point, the needs and uses of risk figures are described, focusing on an assessment of the theoretical properties and characteristics of exposure measures.

2.1. Probabilistic background

2.1.1. The Poisson Theorem for accident counts

A good starting point for a discussion on the basic concepts of road accident statistics is the work by Poisson (Elvik, 2004; Feller, 1968), who investigated the properties of binomial (Bernoulli) trials, i.e. trials with two possible outcomes: success or failure. Modern versions of this standard theorem (in many textbooks f.i. Feller, 1968; Shorack, 2000) do not require the probability of each trial to be the same, and state that under reasonable conditions the probability distribution of the sum S_n of all successful trials would tend to a Poisson probability distribution. Feller, (1968, p. 282) concludes “We conclude that for large n and moderate values of $\lambda = p_1 + p_2 + \cdots + p_n$ the distribution of S_n can be approximated by a Poisson distribution.”

The following remarks in the context of road safety research should also be taken into account:

- The trials should be considered as situations that may result in *one* accident.
- The results indicated above mean that the number of accidents will be approximately Poisson distributed *given* the pedestrian crossings, near misses and other information determining both the number of trails n and their nature reflected in the values $p_1,\ldots,p_n$. This is detailed information on exposure.
- This result is relevant to the distribution of the number of accidents, not the number of victims or other outcomes of accidents (except being an accident).
- It is *assumed* that the outcomes of the events are independent. It may be a good idea to further research this aspect.
- Only registered accidents exceeding a certain level of severity are usually considered. This would yield that the relevant p-value would be : "a small probability of resulting in an accident with a certain severity *and* being registered".
- The registration system cannot be saturated by the accident process (e.g. limited police resource allocation to less severe accidents would have an effect on the applicability of the theorem above).

Note that although these results suggest that the number of accidents should be distributed according to a Poisson distribution, in practice, the distribution of accident counts will never be exactly according to a Poisson distribution, if only due to the limited number of trials on which it is based. If a count is based on a high number of trials (e.g. annual national counts), it is likely that for all practical purposes the count follows a Poisson distribution. However, care must be taken when the actual number of trials is rather low (Lord et al. 2005).

In practice, variants of the Poisson distribution are commonly used in the analysis of road safety count data, see for instance Lord et al. (2005) and the references therein.

2.1.2. The role of trials in exposure

In the context of risk exposure data, the number of trials plays a central role. The number of trials is the number of times road users in general are exposed to a possible accident. Therefore, the number of trials should be the best theoretical measure of road accident risk exposure. All other things kept equal, the expected number of accidents increases with the number of trials. In most practical situations, however, the relationship is more complicated and it is reasonable to assume that a change in the number of trials will coincide with a change the probability of an accident given a trial. It is underlined that, once the accident probability per trial is affected by the number of trials, the assumptions of Poisson distribution are violated.

In road safety research, the basic unit of exposure (e.g. trial) can be considered the trip, which can be characterized by a distance and a duration, and be divided accordingly in sub-units over space or time. In that case, the risk model is continuous rather than discrete. Furthermore, the use of both distance and time for characterising each trial is required, because trips are bound to be different.

In practice thus one has to resort to more practical measures of exposure than the number of trials, such as the vehicle- and person-kilometres of travel, the time spent in traffic, the length of the road network, and vehicle fleet etc. Some of these measures may not adhere closely to the theoretical concept of exposure; moreover, they have different levels of practical usability, and different conceptual properties, advantages and limitations. These issues are discussed in detail in the next section.

2.2. Needs and use of risk figures

2.2.1. General definition of risk

As discussed in Hakkert and Braimaister (2002), there are a number of definitions of risk in use in different forms of safety science, road safety and elsewhere. The approach taken in the present discussion is practical: a risk is the expected road safety outcome, given a certain exposure (i.e. per unit of exposure). The outcome is usually the number of accidents or victims of a certain type, but fundamentally need not be. For instance it could also be expressed in monetary terms, encompassing the full socio-economic consequences of road accidents.

2.2.2. The need for risk figures

If one needs to compare the road safety levels of different situations (e.g. between road categories or different modes or different countries), one somehow has to measure the road safety performance in each situation and compare the measurements according to a selected scale.

The leading candidate road safety performance measure is the number of (serious of fatal) accidents or the number of victims, or a combination of such measures (per unit of exposure). However, although the number of road fatalities is an important and informative road safety performance measure, it may not adequately address all analyses needs. For instance, if the road safety problem is to be compared with other health hazards, it is common to compensate for the number of persons at risk of being killed in a road accident. On that purpose, the annual number of persons killed in road accidents in a certain year divided by the relevant population size is often used. Accordingly, a number of other road safety performance measures were and still are being introduced for specific purposes. The general basic form of road safety performance measures, commonly called a risk or rate, as well as its various forms and uses, are discussed in this section.

2.2.3. Definitions and usability of risk

The above general definition of risk can be written as follows:

[the expected number of accidents] = [units of exposure] * [risk (factors)]   (1)

This equation effectively defines risk as a function, mapping exposure onto safety outcomes. In this sense, risk could be modelled as a function of risk factors; this function is called a "safety performance function" (Hauer, 1995). This definition is consistent with the ‘risk as a probability’ approach, allowing to estimate the individual risk as a very small number (between 0 and 1), provided that exposure is continuously measured over time and space.

For comparison purposes, however, risk will be often considered as an (incidence) rate (between 0 and infinity) (Vandenbroucke, 2003), in which both the nominator and denominator are expressed per time unit. Such rates consider multiple events over time and, although they are more time-dependent - e.g. it is often argued that “incidence rates can not distinguish between a few persons followed for a long time vs. many persons followed for a short time” (Vandenbroucke, 2003) - they are more easily compared:

Risk rate = [the number of accidents] / [the amount of exposure].

Thus, as a consequence:

[the number of accidents] = [the amount of exposure] * [risk rate]   (2)

In equation (2), outcomes are expressed as the number of accidents; however, in several cases, other types of safety outcomes may be relevant e.g. number of casualties, number of persons or vehicles involved in accidents, or even number of near-misses, other incidents etc.

It should be noted that, in order to remain compatible with the safety performance function approach by Hauer (1995), risk can be defined as the original safety performance function divided by the amount of exposure. It is important to note this and its consequence that risk cannot be regarded independent from exposure, if only because of its definition. A similar argument can be used in relation to other influences like time, region, country, or other conditions.

Furthermore, for many applications comparing road safety performance, it is actually assumed that risk differs because of differences in the conditions present during the observations. The risk function is a non-linear one, and there are specific conditions enabling a reliable linear approximation. More specifically:

- The consequences of not considering a non-linear safety performance function will be most important when exposure varies significantly within a given unit, for instance studying hourly observations on a road section over all hours of a day. When variations are small and relatively stable, for instance when national accident statistics with population figures are considered, as is the case in the present paper, the relationship may be well approximated by a linear function.

- Because such an approximating function not necessarily crosses the origin, as is assumed in (2), the prominent "mistake", as described by Hauer (1995), in the use of risk outside its 'linear validity range', is still relevant.
- One can only use a function that is known. Effectively exploiting the approach by Hauer (1995) requires that the safety performance function is known for each level of aggregation (e.g. country) considered in a comparison.
- In many cases, actual observation units consist of monthly or longer time aggregations. If the aggregation is over a heterogeneous set of road sections, it will be very difficult to assess the safety performance function of the aggregation even if it were available for all contributing sections.

It is therefore assumed that in many cases the benefits of using safety performance functions do not outweigh the disadvantages of their complex estimation. It is suggested to use risk rates in the sense of the number of accidents or victims per amount of exposure, and limit its use to initial comparative analysis. More complex, predictive analysis should be based on more elaborate (non-linear) models (safety performance functions), when possible. In each case, however, the risk rate could be assimilated to an individual risk (i.e. a probability); this is the definition used in epidemiology with an incidence rate and risk for the cumulative incidence (Vandenbroucke, 2003).

2.2.4. Statistical implications

As already mentioned in the beginning of this section, if one needs to compare the road safety level between e.g. countries, some measurements of road safety have to be compared. On that purpose, it is important to determine how accurate these measurements are. In particular, the following issues are relevant:

- Observations are likely to be biased: not all accidents are counted and / or exposure may be under- or over- estimated. Moreover, estimates for these biases may be missing. If biases appear to be large and one is unable to correct for them, no reliable comparison can be made.
- The number of accidents is intrinsically variable: it is impossible, except for the case in which no accident can possibly occur, to predict the exact number of accidents. If one has to assess the potential variation in one observation, a Poisson approximation may be sufficient when the actual count is large enough. However, if two apparently equal areas need to be compared - or even the same area for a different time period - overdispersion issues have to be considered.
- The exposure figures are likely to be estimates themselves, inducing thus bias in the risk rates. This means that the variance in their estimates (i.e. the variance of the measurement error in the estimates) needs to be accounted for as well.
- In addition to the variance due to the fact that exposure figures are estimates (measurements), it also has to be considered that the exposure measures are approximations, proxies to the "true" exposure (e.g. one

vehicle-kilometre may correspond to a different number of trials (i.e. trips) if it is travelled on a motorway or on a parking lot; the same number of vehicles may be used for more kilometres in a different time period).

The potential errors and biases mentioned above have to be borne in mind and, when possible, corrected or accounted for. Sometimes knowledge of bias may prohibit further analysis. The consequences of unknown accident and exposure variations can only be assessed in the context of a statistical model; however no general model is available. It should be noted that the presentation of related models is not within the scope of this paper. As far as exposure measurement errors are concerned, these should be accounted for in risk estimates, and this may be the most significant limitation in the use of exposure estimates. The different methods for obtaining exposure estimates may account for measurement inaccuracies to a more or less efficient way.

3. Exposure measures and their properties

In road safety analysis, different risks (rates) may be used according to the objectives of the analysis, as well as the most suitable exposure data available. The measure of exposure is mostly selected based on its theoretical importance. However, quite often the preferred exposure measure is unavailable or in an inadequate level of disaggregation. In such cases, an alternative (proxy) exposure measure may have to be selected.

The exposure measures under review in this paper can be roughly classified into two groups:

- Traffic estimates: road length, vehicle-kilometres, fuel consumption and vehicle fleet.
- Persons at risk estimates: person-kilometres, population, number of trips, time in traffic and driver population.

This categorisation is somewhat arbitrary and some measures can well be considered within the other category. For instance, often person-kilometres are preferred over vehicle-kilometres when fatalities are to be compared, because differences in vehicle occupancy rates may be captured by person-kilometres (and not by vehicle-kilometres). However, when the subject of a study is the occupancy rate, a comparison based on vehicle-kilometres may be more reasonable. In the following, the various exposure measures are discussed according to their importance and usefulness.

3.1. Vehicle / person-kilometres

The number of vehicle- or person-kilometres is probably the most often preferred exposure measure. One important practical advantage of the use of vehicle- or person-kilometres (over road length, fuel consumption, driver population and vehicle fleet) is that, in theory, it may be available to a significant level of disaggregation: time, vehicle type, road type, driver characteristics etc. None of the other exposure measures can usually allow for this level of detail. For that reason it is probably the preferred measure to capture the regional and temporal variations in the accident process. It can be useful for international comparisons, but also for analyses on specific road safety problems e.g. young drivers, motorcyclists, road types, both at national and international level.

It should be noted however, that, in practice, the availability and the level of disaggregation of vehicle- and person-kilometres may vary significantly and is strongly dependent on the type and features of the data collection method. For instance, vehicle-kilometres obtained 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.

The number of person-kilometres applies mostly towards casualty counts. However, due to the fact that the person- and vehicle-kilometre estimates are sometimes obtained through the same data source (e.g. travel surveys, traffic counts etc.) person-kilometres can be derived from vehicle-kilometres and vice versa. Moreover, driver-kilometres, which are sometimes used to substitute vehicle-kilometres, can often be derived from person-kilometres.

In general, depending on the way person-kilometres are obtained, their values may be available at an even higher level of disaggregation than vehicle-kilometres, i.e. including the road user category (driver or passenger) or trip purpose classification. In practice, however, these additional parameters are rarely available in accident statistics. As it is the case for vehicle-kilometre estimates, the characteristics of the collection method may significantly affect the final outcome in terms of estimated values. For example, in the case of travel surveys, a substantial sample error or bias should be considered.

3.1.1. Fuel consumption

Fuel consumption - or sales, in most cases - is not an exposure measure by itself, but a proxy for vehicle-kilometres and a component of some methods for estimating vehicle-kilometres (Fridstrøm, 1999; Cardoso, 2005). One of the drawbacks of this measure, compared to the actual vehicle-kilometres of travel, is that short term fluctuations in road use may not be easily captured. Obviously, fuel is consumed some time after sale, which cannot be determined precisely. Accordingly, it is also difficult to determine where fuel is consumed. Therefore, fuel sales are probably best used at an aggregated level, possibly national and annual. However, additional parameters should be taken into account when comparing countries, such as fuel efficiency of motor vehicles, pricing differences, differences in the coverage of the transport sector (e.g. road, air) etc.

3.2. Number of trips

The number of trips can be regarded as similar to the number of person-kilometres. If trip length remains the same (e.g. home / work travel), results using the number of trips as exposure and the number of person-kilometres should be similar. For the same reasons that vehicle fleet figures may still be informative when vehicle-kilometres are available, the number of trips may be informative when person-kilometres are available. It is most likely that data on the number of trips and on the number of person-kilometres are based on the same sources, consequently the same level of disaggregation will be available with respect to road user and vehicle characteristics; however it is unlikely to have trip data by road characteristics.

3.3. Vehicle / person – hours or time spent in traffic

The same comments as those for the number of trips apply to the vehicle / person – hours of travel or the time spent in traffic, except that time in traffic is likely to follow person-kilometres more closely than the number of trips. The main difference is that time in traffic may to some degree account for the development of (and the differences in) the average travel speed. Moreover, the background idea may be different: only while being in traffic - moving or halted - is one exposed to being involved in an accident. However, difficulties may be encountered in the disaggregation of time spent in traffic, especially as regards comparisons. For example, comparing the time spent in motorway and urban area traffic, or between riding a bicycle, travelling by bus and driving a car, may be complicated.

3.4. Road length

Road length is a basic measure used for the estimation of accident density. It may also be used for the calculation of exposure, if some measurement of traffic density is available – which is seldom the case, at least in secondary roads. As opposed to person- and vehicle-kilometres, it does not capture 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. On the other hand, road length may be a very useful proxy of an exposure measure in developing countries, or for correcting for the sheer size of countries. Moreover, it can be a useful measure for those involved in road design, maintenance and operation.

3.5. 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 vehicle-kilometres under certain conditions. However, it is not recommended to be used as a general replacement of vehicle-kilometres, as it is possible that vehicles on average drive more kilometres over time.

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 vehicle-kilometres, may be available for the vehicle fleet. Related risk estimates may be useful for international comparisons, but also for vehicle industries. Influences of foreign vehicle fleets (e.g. from neighbouring countries) may have to be considered.

3.6. Driver population

The amount of traffic (vehicle-kilometres) in a country is related to both vehicle fleet and driver population. For many purposes, driver population, although not an exposure measure, may be considered as an alternative to vehicle fleet information. The measure is likely to share most of the information available for population figures, but may also include an estimate of the drivers' experience. This may be particularly useful in analyses by those involved in driver training and experience, as well as those interested in e.g. novice drivers, older drivers etc.

However, it should be noted that the amount of time a driver holds his license may not be an accurate estimate of his experience. Moreover, it may not be comparable between countries, due to differences in the licensing and registering frameworks. Driver population figures may be used in a way similar to population figures when driver casualties are considered.

3.7. Population

The relation between population figures and health hazards is often studied, especially in the epidemiological or demographic context, e.g. when analysing fatality risk by different causes. An advantage of the use of population figures over most of the other exposure measures is that in many cases the figures are largely available and relatively accurate. Population figures may be disaggretated by several variables, most likely according to age and gender. Figures for specific groups of road users (e.g. schoolchildren) may also be obtained. A special note concerns the effects of migration, foreign visitors etc., who may or may not be taken into account in population censuses.

3.8. Comparative assessment of exposure measures

In road safety analyses, different exposure measures or proxies of exposure may be used, according to data availability and quality, as well as the particular objective of the analysis. Measures may vary significantly in terms of the potential level of disaggregation and the possible underlying bias in their estimates. It should therefore be noted that no general rule is known concerning the preferred measures of exposure. Vehicle- and person-kilometres of travel, and vehicle / person – hours or the time spent in traffic, are conceptually closer to the theoretical definition of exposure and can be available (in theory) to a satisfactory level of detail. However, they are largely based on travel and mobility surveys or traffic counts systems, which are sampling methods subject to a number of errors affecting their accuracy - these are discussed in sections 4.1 & 4.2. Despite these errors, the accuracy of these exposure measures is often satisfactory as regards the comparisons of basic road users or trip types (e.g. passenger car occupants vs. motorcyclists, young drivers, older drivers, daytime vs. night, motorways vs. other roads etc.), especially for the purposes of international risk comparisons.

On the contrary, vehicle fleet or driver population are incomplete measures of exposure if one considers the trip as the basic trial. In fact, driver population, vehicle fleet and the number of trips (by car) can be considered as exposure measures, only if they are completed with some measurement of time or distance travelled, or considered over a one year period, to get for example an accident rate per driver/vehicle*year. Moreover, vehicle fleet and driver population are not suitable for assessing the exposure of non-motorised road users, such as pedestrians and bicyclists. Accordingly, road length only provides a measurement of accident density. However, under certain conditions, these measures may be efficient for the purposes of a particular analysis. They may also have other, explanatory or descriptive, uses. Table 1 summarizes the above discussion as far as the advantages, limitations and optimal use of different exposure measures.

*** Table 1 to be inserted here***

It should be noted, however, that the features presented in Table 1 concern the theoretical potential of exposure measures. In practice, the availability, quality and disaggregation level of exposure measures may be compromised by limitations and particularities of the respective disaggregate data collection methods and the features of the calculation process of the exposure estimates. For example, sampling methods may impose errors in the estimates. Additionally, the use of data sources that were not designed to provide exposure data may result in difficulties in the full data exploitation as exposure data.

4. Methods for collecting exposure data

There is no standard method for the collection of each exposure measure (FHWA, 1997). Different exposure measures may be derived from one collection method (i.e. a travel survey may be used to collect vehicle-kilometres, number of trips, time spent in traffic, etc.). Furthermore, data collected by different methods may be combined to produce one exposure estimate (i.e. person-kilometres may be obtained by using vehicle-kilometres from traffic counts and vehicle occupancy rates obtained through surveys).This section includes a presentation of the various methods used to collect disaggregate (i.e. "raw") exposure data, i.e. data that are used to derive exposure estimates. A presentation of the characteristics (advantages and limitations) of each collection method is also carried out. Moreover, this section discusses the random and systematic errors in the data. This information collection was carried out within the SafetyNet project and refers to the situation on year 2008.

4.1. Travel and mobility surveys

In travel surveys, the population sample usually consists of actual persons or households, vehicle owners etc., intended to be representative of the entire target population with respect to their travel patterns. The representativeness achieved with the sampling process depends on the quality of the survey design, with impacts on both random and systematic errors..

There are essentially two ways (potential) respondents may be selected for travel surveys in Europe (Yannis et al. 2005):

- Respondents are drawn from a database concerning the target population (e.g. telephone directory or other demographic database) and are contacted by telephone or mail.
- Respondents are randomly selected and contacted, on the roadside or by telephone, and then it is verified whether each respondent is a member of the target population (e.g. by verifying the respondents age, license holdership etc.).

Most travel surveys in Europe use telephone communication for contacting respondents, even if the questionnaire is on paper or in electronic form. Moreover, nowadays most surveys feature some sort of "call-back" system, in order to retry to contact respondents that could not be contacted in the first round. E-mail and internet surveys also start to appear (FHWA, 1994).

Three main kinds of errors may result from the survey sampling method (Cochran, 1963):

- Sampling error: The error in the data caused by the fact that only a sample of the examined population is interviewed.
- Non-response error: The error caused by the fact that some individuals that could or should have been interviewed are not interviewed.
- Measurement error: The error caused by wrong or inaccurate answers provided by some interviewed individuals.

Usually travel surveys are designed to capture all travel by a respondent on a prescribed day, mostly the day before the contact with the respondent.
The data reported by travel survey respondents may concern the distance travelled, the time spent in traffic and the number of trips, usually by mode of travel. The main advantage of travel surveys (compared to other methods for collecting the above exposure data) is that they have individuals as units, allowing for the exposure data to be decomposed by person characteristics such as age, gender, driving experience, nationality etc., and also allowing to collect data on all kinds of trips, motorised or non-motorised.

However, in some countries not all modes or age groups are examined. Experiences with travel surveys indicate that particular short journeys (by foot and by bicycle) are often underreported, whereas motorized trips are often overestimated, both in terms of time and distance. Country differences in definitions may complicate comparisons even more. Other limitations include the fact that no systematic information on variations over time can be made available by means of travel surveys.

Perhaps the most important limitation of the exploitation of travel surveys is that it is not clear how the disaggregate data collected is translated to exposure measures, such as vehicle-kilometres or person-kilometres (Yannis et al. 2005).

4.2. Traffic counts

In most European countries traffic counts systems are in place. Those can be divided into "human" and machine versions. Counting procedures based on human observations have some advantages due to the fact that humans are able to intelligently categorize vehicles and conditions, however, human involvement is expensive and only performs properly while traffic intensity is moderate.

In the ultimate case in which all road sections are equipped with a counting system, the total vehicle-kilometres driven during a given unit of time can be computed. In practice, for obvious reasons, outside tolled roads, counts are made for only a limited number of road sections or sites, which are usually located on main interurban network. The information collected is usually available by vehicle class (to the extent that this can be captured by sensors) and road type.

Moreover, the counting process may not be continuous over time. In particular, a choice may be made to "rotate" the vehicle measurement equipments, allowing for a more comprehensive coverage of road sections, at the expense of not having continuous coverage of traffic in a much smaller sample of locations/road sections – however, this introduces an additional sampling error to the data.

The main advantage of traffic count systems (compared to travel surveys) is the potential of continuity of measurements over time. However, traffic count systems only count vehicles, and there are practical problems involved in the calculation of vehicle-kilometres from traffic volumes. Moreover, measurement points may not be fully representative of the national / regional traffic, as local or urban roads are usually not included. Finally, problems may also result from vehicle misclassification.

4.3. Databases and registers

Vehicle fleet and driving license databases are two other important sources of exposure data in most European countries (number of vehicles in use and number of drivers). The main problem with such registers is that only crude estimates of exposure can be derived. Moreover, no combined analysis per driver and vehicle characteristics is possible.

Both kinds of registers may share the problem of insufficient updating; the removal of invalid entries (e.g. scrapped vehicles or deceased drivers) is not always carried out systematically. More accurate data on the actual number of vehicles in use and of active drivers could be obtained by other registers, such as vehicle inspection databases (not available in most cases) and vehicle taxation or insurance databases (both not accessible in most cases).

Additionally, road inventories are available in most countries and can be used to extract road length information. The usability of the data depends on the coverage of the road network by the register (usually only main national and rural roads are included).

4.4. Other methods

4.4.1. Statistical modelling

Technically, this method derives exposure data from other exposure data and relies on model assumptions. The basic idea is that, if the average fuel consumption per kilometre is known for the vehicle fleet, the total fuel consumption provides a rather reliable estimate of the total number of kilometres travelled (Cardoso, 2005; Fridstrøm, 1999). Obviously, the more aggregate the analysis is, the more reliable the results would be.

4.4.2. Odometer readings

Another emerging method for the estimation of vehicle-kilometres is based on the use of odometer readings at regular vehicle inspections, providing the total number of kilometres travelled by a vehicle since the previous technical inspection. However, the vehicle-kilometre estimates are usable only at the aggregate level. The main advantage of this method is that it can be used to benchmark or validate other methods.

5. Exposure data availability and quality

In the previous sections, the methods for collection of disaggregate exposure data in the European countries were presented. These disaggregate data are processed, either alone or in combination with other data, in order to produce national and regional exposure estimates. It was demonstrated that each method has advantages and limitations, and is subject to different types of errors, resulting in various levels of under- or over-estimation of exposure estimates. Moreover, implementation of methods for collecting more sophisticated exposure estimates is demanding in resources and coordination. As a result, the availability and quality of exposure data in the European countries vary significantly.

National exposure data are gathered and published by a number of international organisations. The comparability of these data among countries depends on the quality and the characteristics of the national data. In this framework, this section summarises the availability and quality of exposure data in the European countries, and in the international data files (IDFs).

5.1. Exposure data availability and quality in the European countries

In the framework of the present research, an in-depth analysis of the availability and quality of risk exposure data in Europe was carried out. A questionnaire was dispatched to the European countries, through the National Experts group on road accident statistics of the European Commission. The questionnaire included detailed questions about the availability of exposure data (i.e. exposure measures, and possible disaggregations per variables and values), as well as the features of the collection methods used in each case. The information was initially collected on 2006 within the SafetyNet project, and was checked and updated within the DaCoTA project.

The results are summarised in Table 2. The first column of Table 2 concerns the exposure measure examined, where the different collection methods are examined separately for each exposure measure (e.g. vehicle-kilometres collected by surveys or by traffic counts), and the second column concerns the basic variables into which it can be decomposed. For more detailed information on the values available for each variable the reader is referred to Yannis et al. (2008).

The availability and quality of the data is then presented for each European country as follows:

- A tick mark indicates that the data is available and conforms to common international definitions. International definitions are considered those that exist in the CADaS database for road accident data in Europe e.g. for area type (inside / outside urban area), person class (driver, passenger pedestrian) etc., or in the Eurostat databases e.g. for motorways, road types, vehicle types etc.
- A bullet indicates that the data is partially available, or does not conform to international definitions. Partial availability may refer to cases where not all values of a certain variable are available, for example person-kilometres data being collected only for drivers and passengers but not for pedestrians, road length data not being collected for urban roads, vehicle fleet data not being available for mopeds, etc.
- A grey cell indicates that the data is not available.

Table 2 to be inserted here

Overall, it can be deduced that the following exposure data are widely available and currently comparable among European countries:

- Driver population data collected per driver age, driver gender and driving license age
- Road length data per motorway (yes/no) and per NUTS region (NUTS stands for 'Nomenclature of territorial units for statistics' and is the hierarchical system used for dividing up the economic territory of the EU by Eurostat)
- Vehicle fleet data per vehicle type, vehicle age and vehicle engine size

On the other hand, the more interesting and useful exposure measures, namely vehicle- and person-kilometres of travel, as well as the time spent in traffic, are available only for a limited number of countries:

- Vehicle-kilometre data estimated by traffic counts systems, per motorway (yes/no) and per vehicle type
- Vehicle- or person-kilometre data estimated by travel surveys, per person class (driver, passenger), person age and gender and possibly by vehicle type and road type.

The quality of this data, and thus their comparability, is significantly affected by the features of the respective collection methods. In Tables 3 and 4, information on the characteristics of the collection methods for person and vehicle-kilometres is presented, i.e. for travel surveys and traffic counts respectively on the basis of the questionnaire responses.

Table 3 to be inserted here
Table 4 to be inserted here

It can be seen that, although most examined travel surveys have persons as units, making it possible to calculate person-kilometres rather directly, they are carried out by means of different types of personal interviews on samples of the entire population (with different age thresholds) and they are subject to a number of unknown or undocumented errors. On the other hand, traffic count systems have vehicles as units and only allow for the calculation of driver- or vehicle-kilometres; they only provide time series of traffic data and have variable coverage rates over the road network.

It can be deduced that a series of problems, namely poor data availability, insufficient comparability and inappropriate disaggregation are the main limitations of the existing risk and exposure data in Europe. It is also obvious that the most useful exposure measures are the least available. Moreover, the potential of the existing exposure data for detailed analysis and safety performance assessment is limited. For instance, the exposure per region and road type can be estimated through road length only, whereas the exposure per vehicle type and road type can be estimated through vehicle-kilometres collected by traffic counts only. The possibility of calculating exposure per combinations of person, vehicle and road characteristics exists only in very few countries.

Most importantly, it is noted that the disaggregation level theoretically possible for an exposure measure (see Table 1) is seldom achieved in practice. Taking into account that even the theoretical disaggregation potential of exposure data is by far lower than the respective disaggregation level of accident data, it is obvious that the disaggregation potential of risk figures (i.e. number of accidents per amount of exposure) is mainly determined by the respective disaggregation potential of exposure data.

To sum up this section, national exposure estimates, when available, are seldom fully comparable at European level, especially as far as vehicle- and person-kilometres are concerned. The number of vehicles, drivers and the length of the road network, are alternative exposure measures that can be used in risk assessment analyses with specific objectives.

5.2. Exposure data availability and quality in the International Data Files

National exposure estimates are collected, used and published through a number of International Data Files (IDFs) in the field of transport and road safety. The main IDFs involved in road accident data and exposure data in Europe are the Eurostat, the ECMT (European Conference of Ministers of

Transport), the UNECE (United Nations Economic Commissions for Europe), the IRTAD (International Road Traffic and Accident Database) and the IRF (International Road Federation) data files. In the framework of the present research, a questionnaire was filled in for each IDF, by means of personal interviews with the persons responsible for the IDFs, in order to gather detailed information on the data collected and the processes followed.

In Table 5 an overview of the IDFs examined in the framework of the present research is presented, focusing on the data collection methods, the availability of exposure data, the related available disaggregations and the risk estimates published.

Table 5 to be inserted here

It is interesting to notice that the exposure data available in the IDFs are statistics and estimates, i.e. in a much more aggregate form than the exposure data collected at national level, as reported by the countries. Additionally, it is not always known whether the IDFs receive more (disaggregate) data than they publish. There is an indication that the more disaggregate national exposure data are not exploited at international level, at least within the context of IDFs.

The availability of exposure data among the data files varies significantly, as regards both countries and years. Moreover, data availability in the different IDFs does not imply comparability. Apart from the intrinsic comparability issues due to the national collection methods, as discussed above, other issues may further compromise the comparability of exposure data in the IDFs, not only between countries, but also among IDFs. More specifically, it has been demonstrated that differences in the published exposure estimates are observed among the IDFs, these differences being more significant for the more "sophisticated" exposure measures (i.e. vehicle and passenger kilometres) (Cardoso et al. 2007).

For example, in Figures 1, 2 and 3 some basic exposure figures published are compared among different IDFs, using the ratio of the exposure figures published on a given year by two different IDFs for each country; a ratio equal to 1 indicates accordance between the exposure figures published by the two IDFs. It is noted that Eurostat, ECMT and UNECE data are not compared with each other, given that a common questionnaire for collecting the data is used by the three IDFs. In Figure 1, the vehicle-kilometres of travel for passenger cars published by the Eurostat, the IRF and the IRTAD for year 2008 are compared. Considerable differences are detected, as the ratio of Eurostat to IRF data ranges from 0.75 to 1.45 and the ratio of IRTAD to IRF data ranges from 0.85 to 1.45.

In Figure 2, IRF, IRTAD and Eurostat figures are compared as regards the number of passenger cars for year 2010. The calculated ratios range from more than 0.95 to less than 1.05, revealing that the differences as regards passenger cars fleet are minor. Finally, in Figure 3, IRF, IRTAD and Eurostat figures are compared as regards the length of motorways for year 2010. The calculated ratios suggest that Eurostat estimates are systematically lower than the IRF ones, as all related values are between 0.75 and 1, with the exception of Austria. The motorway length ratios between IRTAD and IRF present larger variation, ranging from 0.75 to 1.65.

Figure 1 to be inserted here
Figure 2 to be inserted here
Figure 3 to be inserted here

It is also noted that there is a discrepancy between what the individual countries have reported in terms of vehicle-kilometres availability in the SafetyNet survey (see Table 2) and what can be found in the IDFs. Some countries reported having data which can not be found in (all) the IDFs (e.g the Netherlands and Norway) while others report no data availability, but estimates are available in the IDFs (e.g. Belgium and Latvia).

These differences may be attributed to the fact that some of the exposure estimates in the IDF may be based on national estimates while others may be based of internal estimates of the IDF, and the actual data source is not always known. Additionally, another reason may concern insufficient data quality control, which may be either not carried out at all, or limited to the correction of only obvious mistakes by checking the totals and comparing with other IDFs. Further analysis – not presented here – revealed that the ratios of some countries are different when comparing different years, suggesting that the errors are not systematic.

Despite these limitations, the considerable effort made during the last decades for gathering and exploitation of exposure data and road safety data in general is clearly reflected in these IDF. The fact that there are various IDF for exposure data at European level is positive for the users, because they can choose from a variety of information. However, particular caution is required from data users, in order to optimally use the available information in reliable road safety analyses.

6. Discussion

6.1. Summary and conclusions

From the results of the present research, it can be concluded that comparing risk rates at international level for safety performance assessment is not straightforward. Both accident counts and exposure measures have theoretical and practical limitations and are subject to errors, which may compromise their usability. Especially as far as exposure is concerned, road safety analyses need to compromise to some approximations of the actual exposure, their accuracy and representativeness not being uniform. Different exposure measures may be used, according to data availability and quality, as well as the context of the analysis, and no general rule can be stated on the preferred measures of exposure.

However, it can be deduced that, generally, the most appropriate measures of exposure are vehicle- and person-kilometres of travel, because they are closer to the theoretical concept of exposure and can be available, in theory, to a satisfactory level of detail. In practice, however, the quality of these exposure measures is compromised by limitations and particularities of the respective collection methods, namely travel surveys and traffic count systems.

Because of the difficulties in the implementation and operation of such surveys and systems, in several countries the vehicle fleet, driving licenses and roads registers are used to represent exposure; however these are crude estimates of exposure, giving uncertain risk estimates. It should also be noted that databases with such data are known to lead to some (but often uncalculated) overestimations, due to insufficient updating of the registers.

From the analysis of the existing exposure data in European countries, it was found that the availability, disaggregation and comparability of exposure measures (in terms of definitions, variables etc.) is quite diverse. It was also revealed that the disaggregation level theoretically possible for an exposure measure is seldom fully achieved in practice. The comparability of the exposure figures is further complicated by differences in features and specifications of their data collection methods. In several cases, especially as regards vehicle- and person-kilometres, data from different sources may function complementarily for the calculation of a single exposure measure. Moreover, it is not always clear which method is used to calculate exposure estimates from the disaggregate data collected.

National exposure estimates are collected, exploited and published through several International Data Files in the field of transport and road safety. These data files are useful and accessible data sources for statistics and estimates, as a result of several decades of important data collection efforts. However, they have multiple objectives; they collect different data in various forms and structures, in some cases by different national sources, and are maintained by organizations with different scopes and policies. Consequently, the availability of exposure data among the data files varies significantly, in terms of both countries and years available, as well as presented variables and values. Differences were observed among the IDFs in the published figures for several exposure measures; these differences are more important for more "sophisticated" exposure measures (i.e. vehicle and passenger kilometres) and may be attributed to different national sources and / or poor data quality control.

6.2. Current potential for risk and safety performance assessment

Overall, it can be said that, despite the important efforts made at national level and international level, the lack of a common European framework for the collection and exploitation of exposure data (i.e. common data requirements, definitions and collection methods) limits significantly road safety analyses at European level. International Data Files provide useful statistics and estimates in a systematic way and are currently the only sources allowing international comparisons.

Consequently, currently road safety performance assessment in Europe can be carried out on the basis of the CADaS road fatality data and the exposure data available in the IDFs, namely as regards:

- Comparing countries: fatalities per million vehicle- or person-kilometres, vehicle fleet, road length, population
- Comparing road types: fatalities per road type and road length (with focus on the comparison motorway / non motorway, for which standard definitions exist)
- Comparing transport modes: fatalities per vehicle type and per million vehicle-kilometres or vehicle fleet (with focus on passenger cars and possibly motorcycles)
- Comparing road user groups: fatalities per person age and gender, per population

Vehicle- and person-kilometre data are less likely available in the IDFs, and their sources, estimation methods and other properties are not well known. Vehicle fleet and road length data, on the other hand, are more homogenous but likely to be an overestimation of actual exposure. Nevertheless, these limitations are more likely to be critical when comparing particular groups of road users (e.g. motorcyclists, young drivers etc.), while the use of the data for comparing countries' annual figures requires less accuracy (i.e. main country differences and rankings are not likely to be largely affected). Moreover, risk estimates on the basis of different exposure indicators should be examined when possible (e.g. passenger car vs. motorcycle fatalities per vehicle-kilometres and per vehicle fleet), taking into account the properties of each indicator, in order to cross-check the risk estimates.

6.3. Recommendations

A number of recommendations can be outlined towards the improvement of risk exposure data in Europe. From the analysis presented above, it is revealed that the major limitations in exposure data in Europe concern:

- The comparison of groups of road users, for which only population data are available
- The comparison of combined groups of road users e.g. motorcyclists and passenger cars per driver age, currently not possible
- The analysis of trends over time, for which very few countries have complete time series of the preferred exposure measures (e.g. vehicle-kilometres)
- The uncertainty in the data comparability, which is higher in the case of more "sophisticated" exposure measures (e.g. vehicle-kilometres).

A number of steps for the improvement of the potential for analysis in the short term can be taken, especially as regards the first and the fourth point above. First, the driver population (driver license registers) data should be collected by IDFs; these data are largely available in individual countries, and may provide an acceptable proxy of exposure per driver age, gender and experience, in a similar way that vehicle fleet data are used for comparing vehicle types. Second, vehicle- and person-kilometres data per road user characteristics should be collected by the IDFs; although very few countries are expected to be already able to provide this information, it would be a first step for motivating the systematic collection of this data both at country and at European level. Third, the collection and publication of more detailed meta-data by the IDFs (e.g. data collection method at country level, main assumptions, known errors etc.) will assist the data users in assessing the quality of the data and the reliability of the risk estimates.

Meanwhile, in order to deal with current needs, gathering and harmonization of existing information (i.e. definitions of exposure measures, variables and values) between countries (at the most disaggregate level), as well as within the International Data Files, would be an important step to improve the usability of the existing exposure data. Additional data sources or methods (e.g. odometer readings at mandatory vehicle inspections) could be exploited to validate the exposure estimates.

In a medium to long term, a common European framework for the collection and analysis of exposure data may eventually address all the issues discussed above. First, priority should be given to the collection of vehicle and person-kilometres of travel. Moreover, the common framework should focus on the collection of disaggregate time series of exposure by road user, mode and network characteristics, and should be organized to provide data in a consistent and systematic way. This implies the use of both travel surveys and traffic count methods, allowing for both detail and continuity over time in the exposure estimates, although the implementation of a European travel survey appears a better option as a first step. The definition of standardised specific calculation procedures for exposure measures would be equally important within this framework.

It is clear that the establishment and implementation of such a common framework would be a complex and time-consuming task, which would also involve significant resources, both at national and European level. However, given the importance of improved risk and exposure data availability and quality, to support and monitor evidence-based road safety policies, it is critical to promote its implementation.

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Table 1. Properties of the analysed measures of exposure

	Unit		Analysis context								Disaggregation				Accuracy / errors				
Measure of exposure	Traffic	Persons at risk	Traffic	Mobility	Road operations	Vehicle industry	Driver training	Epidemiology	Temporal variation	Regional variation	Road User category	User characteristics	Vehicle characteristics	Road characteristics	sampling	non-response	measurement	**Other possible bias**	**Optimal use**
Vehicle - kilometres	•	•	•		•				•	•		•	•	•	•	•	•		
Person - kilometres		•	•	•					•	•	•	•	•	•	•	•	•		
Road Length	•		•		•					•				•				economic influences	developping countries
Fuel consumption	•	•	•			•			•				•					pricing differences, vehicle efficiency	aggregate level
Vehicle Fleet	•		•			•							•						when average distance travelled is the same
Population		•						•		•	•	•			•			foreign population	comparing health hazards
Driver population		•	•				•	•				•						licensing framework	when average distance travelled is the same
Number of trips	•	•	•	•	•				•	•	•	•	•	•	•	•	•		when average trip length and speed are the same
Time in traffic		•	•						•	•	•	•	•	•	•	•	•		

Table 2. Availability and collection methods of exposure data in European countries – results of the SafetyNet survey (2008)

	Variable	AT	BE	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HU	IE	IT	LT	LU	LV	MT	NL	NO	PL	PT	SE	SI	SK	UK
Time in traffic (survey)	Person class					•	•				•	√							•	•	•						√
	Vehicle type					•						√								•		•					√
	Vehicle age											•								•							•
	Area type					√						√										•					√
	Year					√	√					√										√					•
	Person age		√			√	√				√	√								√	√	√					√
	Person gender		√			√	√				√	√							√		√						√
	Driver license age											√								√							
	Region						√																				√
Person-km (survey)	Person class					√	√				√									√	√	•		√		•	√
	Vehicle type					√	√				√									√	√	√		√		√	√
	Area type					√	√				√									√	√	√		√		√	√
	Road type					√	√				√									√	√	√		√		√	√
	Year					√	√				√									√	√	√		√		√	√
	Person age					√	√				√									√	√	√		√		√	√
	Person gender					√	√				√									√	√	√		√		√	√
Vehicle-km (survey)	Vehicle type	•				√						•								•	•			•	•	•	
	Vehicle age																			√							
	Area type						√														√				√		
	Road type	√					√					•											√		√		
	Year	√																		√	√						
	Driver age																			√	√						
	Driver gender																			√	√						
Vehicle-km (counts)	Vehicle type				√			•				•	√								•	√			√		√
	Area type							√													√				√		√
	Road type				√			•			√		√								√	√		√	√		√
	Year						√						√								√	√					√
	Month/day/hour							√					√									√					
Vehicle fleet (register)	Vehicle type	√	√	√	√	√	√	•	√	√	√	•	√	√	√	√	√	√	√	√	√	•	•	√	√	•	√
	Vehicle age	√	√	√	√	√	√	√	√	√	√	•	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Vehicle engine size	√	√	√		√	√	√	√	√	√	•	√	√	√	√	√	√	√	√	√	•		√	√	√	√
Road length (register)	Area type							√			√	√									√	√			√	√	√
	Road type	√	√	√	√	√	√	√	√		√	√	√	√		•	•	•	•	√	√	√	•	√	√	√	√
	Region	√	√	•	√			√	√			√								√	√	√				√	
Drivers (register)	Driver age	√	√	√	√			√	√	√	√	√	√	√				√	√		√	√	√	√		√	
	Driver gender	√	√	√	√			√	√	√	√	√	√	√				√	√		√	√	√	√		√	√
	Driver license age	√	√	√	√			√	√	√	√	√	√	√				√	√		√	√	√	√		√	
	Driver Nationality	√			√																√					√	

√ Available

• Partially available or not conforming to international definitions

(grey) Not available

Table 3. Characteristics of national travel surveys in European countries (2008)

Travel survey	DK	FI	FR	DE	NL	NO	SE	UK
1st survey		1974	1966	1994	1985	1985	1994	1965
Frequency		6-8 years	7-10 years	annual	continuous	4 years	5 years	Continuous
Last survey	2003	1999	1994	2004	2005	2005	2005	
Sample size (households / persons)			14000 hous.	2000 pers.	30000 pers.	35000 pers.	8000 pers.	15000 hous.
Survey type	Telephone	Telephone	Face-to-face	Telephone and diary	Face-to-face	Telephone	Telephone	Face-to-face and diary
Response rate		64%			70%	50%	73%	60%
Sample limitations - age	16-80 years	>6 years	>5 years	>10 years		>12 years	>6 years	
Geographical limitations		yes						yes
Respondent's length of time covered	1 day	1 day	1 day 1 weekend	1 week	1 day	1 day		1 week
Survey duration			1 year	1 year		1 year		Continuous
Other data used to estimate the exposure	yes			yes				
Known errors	yes			yes				yes

Table 4. Characteristics of traffic counts systems in European countries (2008)

Traffic counts	**DK**	**FR**	**HU**	**NL**	**NO**	**PT**
Coverage	National	National	National	National	National	National
Number of permanent stations		250			230	61
Total number of stations		1500				712
Continuity	continuous	continuous	rotating		continuous	every 5 years
Estimates	traffic volume	AADT	AADT	AADT	AADT	AADT
			traffic volume			traffic volume
Hourly variation		•	•			•
Seasonal variation		•	•			•

Table 5. Characteristics and data availability of International Data Files with exposure data (2012)

	Eurostat	ECMT	UNECE	IRTAD	IRF
Location	Luxembourg	ECMT, Paris	UNECE, Geneva	OECD/ITF, Paris	IRF, Geneva
Data File description					
Number of countries	38	50	56	34	192
Available time series	1960-	1960-	1960-	1965-	1995-
Transport statistics	•	•	•	•	•
Accident statistics	•	•	•	•	•
Other statistics	•	•	•	•	•
Data collection method	Common questionnaire			questionnaire	questionnaire
Type of data	aggregate	aggregate	aggregate	aggregate	aggregate
Access to the data	free/on-line	free/on-line	free/on-line	members only	members only
Exposure measures					
Time spent in traffic					
Passenger-kilometers by mode	•	•	•	•	•
Vehicle-kilometers by mode	•	•	•	•	•
Number of vehicles by type	•	•	•	•	•
Number of drivers					
Road length by road type	•		•	•	•
Fuel consumption	•	•			•
Risk indicators					
Fatalities per population	•	•	•	•	
-by age	•		•	•	
-by age and gender	•		•	•	
Fatalities per licensed drivers					
Fatalities per vehicles		•		•	
Fatalities per road user type		•		•	
Fatalities per vehicle-kilometres				•	•
-by area type				•	
-by road type				•	

Figure 1. Comparison of Eurostat, IRTAD and IRF data on vehicle-kilometres for passenger cars - 2008

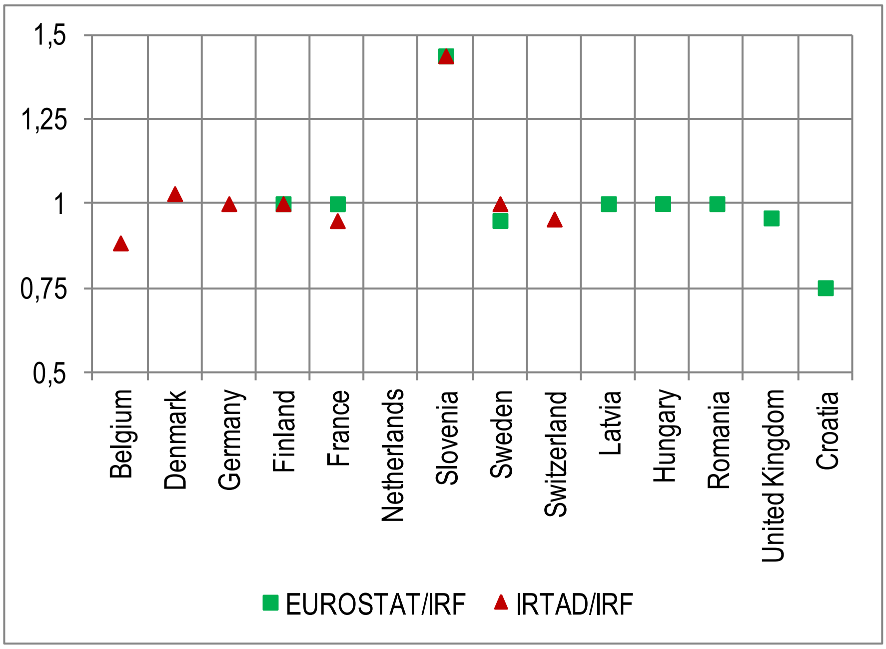
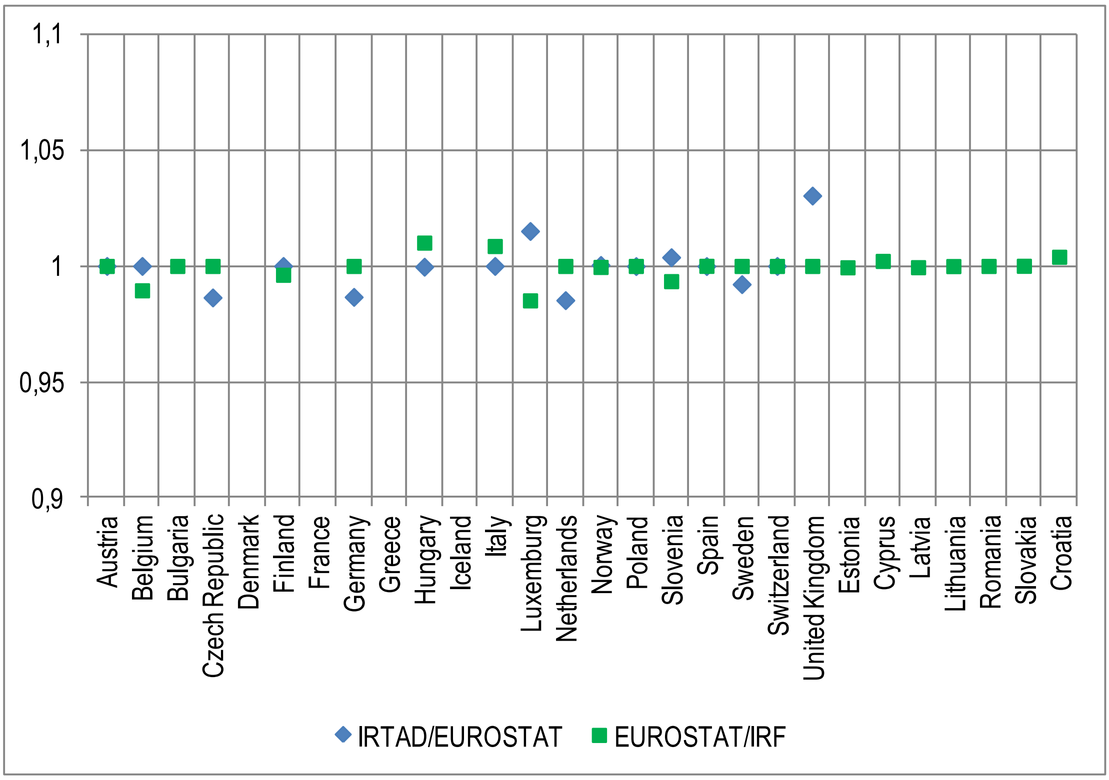


Figure 2. Comparison of Eurostat, IRTAD and IRF data on vehicle fleet for passenger cars - 2010



b

Figure 3. Comparison of Eurostat, IRTAD and IRF data on road length for motorways - 2010