Transport Research Laboratory

Benchmarking Road Safety in Northern Ireland

by J Knowles, B Sexton, B Lawton and S Charman

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PUBLISHED PROJECT REPORT

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1   Introduction

1.1   Background

The Road Safety Division (RSD) within Northern Ireland's Department of the Environment (DOE) is responsible for Northern Ireland's Road Safety Strategy (RSS). The latest figures show that the current road safety target reductions, for the ten years up to 2012, had already been achieved by 2008 and so are likely to be maintained or exceeded in 2012.

Despite this success, the proportion of Northern Ireland's population killed or seriously injured as a result of road traffic collisions remains higher than for Great Britain (GB) and other high-performing European countries.

The Public Accounts Committee of the Northern Ireland Assembly has recommended that targets should be set to maintain this improvement, and to close the gap between the performances in Northern Ireland and other leading European countries including GB. In order to achieve this, a benchmarking performance threshold needs to be established against which performance can be measured and analysed appropriately. This approach will assist the DOE in determining reasons for the different levels of performance observed between Northern Ireland and GB, and will help to identify areas that offer the greatest potential for achieving higher performance levels.

DOE is currently publicly consulting on a new road safety strategy and is expecting to publish the final document towards the end of this year. In support of this work, DOE has prepared challenging but achievable road safety casualty targets, and has undertaken to aim to identify a suitable comparator against which performance can be measured.

1.2   Project objectives

The overall objectives of this project, as defined by DOE, are:

- To conduct a literature review of key research applicable to the benchmarking process, from UK, Irish and international sources

- To design an appropriate benchmarking approach for Northern Ireland based on the findings of the literature review

- To carry out a benchmarking exercise for Northern Ireland using this approach, identifying a suitable set of comparators from within GB

- To critically assess the effectiveness and outcome of this benchmarking exercise, identifying the extent and likely causes of the differences in road safety records of Northern Ireland and GB

1.3   Report structure

Following this introduction, Chapter 2 contains the literature review carried out for the project. Chapter 3 compares Northern Ireland with other areas in the UK in terms of the factors contributing to road safety; it also compares the road safety performances of each nation and how these have changed over time. The relationships between the background factors and road safety performances in England, Scotland and Wales are modelled in Chapter 4; this enables road safety in Northern Ireland to be compared with what would be expected having controlled for the background factors.

2   Literature Review

This Chapter provides a literature review of previous studies from the UK, Ireland and international sources that have evaluated the road safety performance of countries or sub-national areas. The purpose was to collect information about previous work on benchmarking exercises, their design, effectiveness and relevance to Northern Ireland.

The methodology for the literature review is described, then the concept of benchmarking is explained. The main body of the literature review examines different approaches to benchmarking, initially reviewing benchmarking methodologies and then considering the various approaches used to understand the reasons for differences in road safety performance. A previous road safety benchmarking exercise in Northern Ireland is then reported.

2.1   Literature review methodology

Published data were searched using the following methods:

- Searches using databases held by TRL (The International Transport Research Database (ITRD) and Science Direct)

- Web-based search tools (e.g. Google and Google Scholar)

- Browsing the reference lists of relevant articles to identify additional relevant pieces of work (whose reference lists were examined etc.)

- Consulting TRL colleagues and other contacts about relevant TRL projects and other research

The searches were conducted using a systematic approach, with the following search terms:

- Road safety, Road accident/collision/crash

- Benchmark(ing), comparisons, regional differences

- SUNflower (the SUN countries are Sweden, the United Kingdom and the Netherlands)

The grading of literature found in the searches was undertaken to select only those articles which were: directly relevant to the project; of a suitable quality, robustness, and academic rigour; and sufficiently recent to still be relevant. This grading was based on an analysis of the abstract text contained in the search results; if no abstract was present then the article title was used.

A 'filtering' methodology was therefore set up as a consistent and quick means of selecting the search results based on three criteria:

- Relevance

- Quality

- Timeliness

Relevance was interpreted to mean: 'Does the publication present any evidence, and is it likely to be relevant?' Quality was interpreted to mean: 'Is the publication peer reviewed or from a trusted source, does its methodology appear robust?' Timeliness refers to when the article was published.

The findings are grouped under the following headings:

- What is benchmarking?

- Benchmarking approaches

- Explaining the differences in road safety risk between different countries and regions

- Previous benchmarking in Northern Ireland

2.2 What is benchmarking?

Benchmarking is a process in which countries or regions evaluate various aspects of their performance in relation to that of other countries or areas. In assessing road safety, different benchmarks can be used:

2.2.1 Comparing collision statistics

One way to benchmark is to compare collision statistics for the study area with the corresponding statistics for areas which are judged to be comparable. It can be challenging to find areas that are truly comparable or that can be adjusted to be comparable, and the more areas differ, the harder it becomes to interpret the comparisons.

The SUNflowerNext project (Wegman, Commandeur, Doveh, Eksler, Gitelman, Hakkert, Lynam and Oppe, 2008) aimed to develop a knowledge-based framework for comprehensive benchmarking of road safety performances and developments of a country. They noted that benchmarking consists of the following core activities: identifying the key components of a road safety performance, identifying with whom to compare, constructing indicators for meaningful comparisons, determining and understanding gaps in performance and identifying potential improvements.

PACTS (2009), the Parliamentary Advisory Council for Transport Safety, in its response to the DfT's consultation document 'A safer way – consultation on making Britain's roads the safest in the world', stated that to compare a road safety record with that of another country is overly dependent on the performance, achievements, frameworks and deliveries of that country. For example, this approach might suggest that one country is performing better when, in fact, it is actually because another is performing worse.

2.2.2 Trend analysis

Another way to benchmark is to compare collision statistics for the study area over successive years to judge whether the number of casualties is developing satisfactorily, though it can be challenging to define 'satisfactory development'.

Provided the forecasts are reasonably reliable, predicting the trend in road safety allows the ongoing benchmarking of a country's road safety efforts. In March 2000, the British Government announced a new national casualty reduction target for 2010 for Great Britain (DfT, 2000, or DETR at the time of publication). TRL has been monitoring progress towards the target and has produced an annual series of reports that analyse casualty trends and review the implications of the latest casualty and traffic statistics in achieving the target, the latest being Broughton and Knowles (2009). The annual number of casualties is compared to a baseline/benchmark average of 1994 to 1998 data.

2.3 Benchmarking approaches

The literature reviewed considered ways of understanding differences in road safety performance as well as methodologies for benchmarking itself. In this Section, the literature that specifically refers to benchmarking a country's performance is reviewed.

2.3.1 General approach

Road safety researchers have traditionally evaluated road safety performance of a country by comparing its road safety risk indicators with those of other countries and by the analysis of their development over time. In an international context, three risk

indicators are generally used (Breen, 2000, Australian Transport Safety Bureau, 2000). These indicators are the ratios between the number of persons killed in road traffic collisions (numerator) and their exposure to traffic risk (denominator):

- Fatalities per 100 million people (how road collisions affect the safety and health of the population - the mortality rate)

- Fatalities per 10,000 registered vehicles (the degree of traffic safety)

- Fatalities per 100 million vehicle kilometres travelled

Using the size of the population to calculate the road safety risk is appealing since population figures are normally easily available. However, using this measure takes no account of the degree to which a country is motorised and, even if the road safety risks in two countries are similar, a country with more vehicles is likely to have more collisions per head of the population. Using the number of vehicles is also inadequate since this measure takes no account of the distances travelled by those vehicles: even if two countries have similar number of vehicles and similar levels of safety, the one with the higher average mileage is likely to experience more road collisions per head of the population. When it is available, therefore, using traffic volume as the exposure factor provides the fairest comparison when comparing road safety records.

However, comparing any of these indicators for different countries may be misleading. For example they do not take into account that the road safety record of a region or area is influenced by local conditions such as population density, age and sex distributions, numbers of the different types of road users, the composition of the road network (proportions of different road types), size of the area and traffic flow on the different types of road.

2.3.2   SUNflower

The SUNflower project (Morsink, Oppe, Reurings and Wegman, 2005) developed a methodology to produce a 'road safety footprint' for a country which represents the road safety status and development over time. This can be used for benchmarking. It calculates key indicators, standardising them as appropriate, so that they can be compared meaningfully with reference data, considering a particular moment in time or period of time. Reference data may be from a single country, averages for a range of countries, or road safety targets. The footprint allows for all aspects of road traffic collisions and extracts the most prominent underlying elements which are proven to contribute to those collisions. It contains several graphs: bar charts and star-shaped graphs which allows aspects of a country's performance to be visually compared to the 'benchmark' data. The detailed footprint scheme is shown in Appendix A. Although this approach enables gives a pictorial overview of road safety factors and performance, not all differences can be explained by the footprint and further analysis is often required.

The follow-on project SUNflowerNEXT (Wegman *et al.*, 2008) aimed to develop a knowledge-based framework based on the footprint methodology for the comprehensive benchmarking of the safety performance of countries. The team developed a comprehensive set of indicators to measure the road safety performance of a country and explored combining these indicators to create a composite index. The composite index enabled a ranking of countries according to their safety performance. However, the authors emphasised that it is the factors behind the composite index that enable an understanding of how improvements to road safety might be brought about.

2.3.3   Data envelopment

Hermans, Brijs, Wets and Vanhoof (2008) conducted a data envelopment analysis to evaluate the relative road safety performance of 21 countries. This analysis provided some insight into the good and bad aspects of road safety for each country and indicated which countries could be used as suitable benchmarks. The relative efficiency of a

country was defined as the ratio of the weighted sum of outputs to the weighted sum of inputs so that a score of one indicated an efficient country. The two outputs were the numbers of injury crashes and fatal crashes per 100,000 people. The six input indicators were:

- Alcohol (% of road users below the blood alcohol concentration limit, or BAC limit) as the risk of crash involvement increases with an increased BAC level

- Speed (% of drivers with a driving speed below the maximum speed limit on country roads)

- Use of protective systems (% of persons wearing a seatbelt in the front seat)

- Vehicle age since newer cars are equipped with better safety systems (% of cars less than six years old)

- Infrastructure (total length of motorways divided by area of country)

- Spending on trauma management since better medical service can increase the chance of survival (% of Gross Domestic Product spent on healthcare)

This method has a number of limitations. In particular, the conclusions are very sensitive to the input and output data and specifications. Also, the country specific results are dependent on the countries in the data set and different results would be achieved with a different choice of countries.

2.3.4   EuroRAP

In 2001 the European motoring organisations and some road authorities started the European Road Assessment Programme (EuroRAP) which aims to increase road safety by high level benchmarking of European roads. The EuroRAP consortium has developed three different assessment protocols to benchmark European roads.

The Risk Mapping protocol shows the individual risk to the road user per billion vehicle kilometres travelled (normally based on three years of collision data), presenting findings cartographically for ease of interpretation. This methodology allows direct comparison across European countries participating in the programme. However, EuroRAP Risk Maps include a specific road network (e.g. motorways and 'A' roads) and thus exclude some roads in a country; therefore direct comparisons should be interpreted with caution due to incomparable network compositions.

The Performance Tracking protocol compares performance over time, identifying overall trends in safety. This approach allows identification of the most improved roads over time.

The Star Rating protocol compares performance of the road design. The Road Protection Score (RPS) reflects the safety of the road according to key characteristics of design. These characteristics reflect the passive (forgiving) and active (self-explaining) nature of the road. Direct comparisons can be made between the results of this exercise providing exactly the same protocol has been used. Due to the continuing evolution and improvement of this protocol some results are not directly comparable across Europe.

The Risk Mapping indicates where the individual risk to drivers has been high retrospectively; the Star Ratings identify safety deficits that may impact on crash outcomes in the future.

2.4   Explaining the differences in road safety risk between different countries and regions

Much of the literature reviewed refers not to benchmarking a country/region's performance but instead investigates methods of how to explain the differences in the road safety record of a region or area in terms of population density, the age and sex

distribution, numbers and types of road users, the road network, the size of the area and traffic flow. In this Section, the literature that investigates differences in collision risk between areas is reported.

A number of studies reviewed modelled collisions and / or casualties assuming a Poisson or Negative Binomial distribution. Results from Harland, Bryan-Brown and Christie (1996), Eksler, Lassarre and Thomas (2008) and Noland and Quddus (2004), for example, are discussed below.

Harland, Bryan-Brown and Christie (1996) developed a model to investigate the high pedestrian casualty rate in Scotland compared with the rate in the English regions. Data from national collision statistics (STATS19), the National Travel Survey and the Census of Population were used in the development of a statistical method for predicting casualty rates at District levels. The hypothesis used in developing the prediction was that the number of pedestrian casualties in a given period of time in a District depended on a measure of exposure - pedestrian traffic, vehicle traffic and the space available for collisions. Proxy variables were used to represent these three factors: population, car ownership, and area.

The results showed that when these variables were taken into account, the Scottish pedestrian rate was similar to that obtained by applying the model to the English regions. Further analysis showed that casualty numbers increase as car ownership decreases. Scotland's higher pedestrian casualty rate was explained by the level of car ownership in Scotland being lower than in England and Wales. The same effect was shown in similar equations developed to predict casualty numbers for four subgroups of the population; children aged 0-11, children aged 12-15, males aged 18-44 and injured between 2000 hours and 0500 (which includes most drinking pedestrians), and other adults. The car ownership effect was strongest for the younger group of children, then for the males at night, and weakest for other adults.

Harland (1999) also carried out similar work to determine if casualty levels in Districts of the North West Region of England were unusually high compared with similar Districts outside the Region. The analysis assessed risk by using regression analysis to model the relation between casualty numbers and a small range of explanatory variables. Equations were developed to predict casualty numbers (all severities) in Districts from the 1991 census data on population, cars owned by households, journey to work by bicycle or motorbike and road length in each District. The difference between the expected and observed casualty levels for five road user groups indicated whether a District had unexpectedly high casualty levels or not. The ratios of observed to expected casualties were found to be reasonable measures for comparing the Districts of the North West Region with Districts in the rest of England and Wales except for the City of London and possibly the City of Westminster.

Other authors have also explored whether differences in fatality rates between countries/regions can be explained using various exposure data. Eksler (2007) investigated the effect of the differing demographic structures of 23 European countries and their regions on road mortality rates (fatalities per head of population). Eksler (2007) found that the mortality risk faced by people in road traffic is not equal for men and women and the degree of risk also varies significantly with age. He found that the demographic structure at the national level, defined as the distribution of age and sex in aggregated age groups, had only a minor effect on mortality ratios but had a large effect when comparisons were made between regions, accounting for up to 12% of the variation in mortality rates.

Eksler, Lassarre and Thomas (2008) showed that population density has a significant influence on road mortality at the regional level. Based on data from 1,089 regions of 25 European countries they used a Bayesian spatial multi-level regression model and concluded that a 10% increase in population density was linked with a 3.2% decrease in road fatalities per head of population. The higher level of road safety in densely populated regions was attributed to lower travelling speed, availability of public transport

services, better access and quality of emergency services, more developed infrastructure and proportionally more new vehicles. They concluded that taking account of differences in population density of countries produces a different ranking according to their road safety level than is generally quoted (fatalities per head of population). Such ranking allows the identification of countries with significantly better or worse road safety records than should be expected. Population density stands for a wide range of explanatory factors that influence the occurrence of fatal injuries in road traffic. Further analysis performed by Eksler (Wegman *et al.*, 2008) suggested that vehicle kilometres travelled accounted for half of the explanatory value of fatal injuries (the average annual kilometres driven per rural inhabitant is generally higher than per urban citizen) and road environment and travelling speeds accounted for 20%. The remaining 30% was related to demographic, deprivation, economic and other factors.

Wegman *et al.* (2008) states that an urban/rural variable could also be used as a proxy for a range of explanatory factors that influence collision risk. In fact population density and an urban/rural variable are strongly correlated. Mortality in rural areas is much higher than in urban areas possibly due to higher driving speeds, the availability and efficiency of emergency services, drink driving prevalence, lower use of protective systems and an older vehicle fleet. Less populated areas are also often characterized by a different age structure and social deprivation leading to additional risk factors. Rural residents travel more kilometres by road and may therefore be more likely to be involved in serious collisions. Annual household income could also be a possible explanatory variable of collision risk at the regional level. Research quoted in Wegman *et al.* (2008) showed that a 10% increase in annual income per person was associated with a 2.4% reduction in fatality risk in Belgium.

Several authors have suggested there are distinct effects on casualty rates from characteristics associated with deprivation affecting the incidence of pedestrian and child casualties. The fatality rates per population in these areas are 30% higher for adult fatalities and 60% higher for child fatalities than in other local authority areas. This is likely to be due to the higher exposure to traffic as well as social factors (Broughton and Buckle, 2006).

Jones *et al.* (2008) explored data on road traffic fatalities, serious casualties and slight casualties in each local authority district in England and Wales for 1995–2000. District-level data were assembled for a large number of potential explanatory variables relating to population numbers and characteristics, traffic exposure, road length, curvature and junction density, land use, elevation and hilliness, and climate. Multi-level negative binomial regression models were used to identify combinations of risk factors that would cause variations in mortality and morbidity. Statistically significant explanatory variables were the expected number of casualties derived from the size and age structure of the resident population, road length and traffic counts in the district, the percentage of roads classed as minor, average cars per capita, material deprivation, the percentage of roads through urban areas and the average curvature of roads.

Noland and Quddus (2004) used a spatial analysis approach to evaluate road casualties in each ward of England. This was achieved using geographic UK ordnance survey data on road lengths and other infrastructure features, overlaid with land use data on percent urban and rural populations, population data, and data on economic deprivation. The level of aggregation was over 8,414 wards for England. Casualty data were derived from the STATS19 national road collision data and aggregated to the ward level. Negative binomial models were used to analyze the associations between these factors with traffic fatalities, serious injuries and slight injuries. The results showed that land use and area deprivation were both associated with traffic casualties. Wholly urban wards experienced a lower level of fatalities compared to wholly rural wards whereas wards with higher employment density and lower population density were associated with increased fatalities. More deprived areas tended to have higher levels of casualties, though not of motorized casualties (except slight injuries). The effect of road characteristics (e.g. number of roundabouts and length of motorway per square metre of ward) were less

significant but there were some positive associations with the density of A and B class roads.

Various other authors have also looked at comparing numbers of road traffic crashes between small areas and exploring whether observed differences can be accounted for by various explanatory factors. For example, Amoros, Martin and Laumon (2003) used a negative binominal regression model to compare counties in France, MacNab (2004) applied Bayesian modelling techniques to study small area variation in British Columbia, Aguero-Valverde and Jovanis (2006) used full Bayes hierarchical models and negative binomial models to explain county-level crash data in Pennsylvania and Eksler and Lassarre (2008) used a Bayesian approach to model the disparities in collision risk at a small scale level in Belgium.

Archermann (2009) investigated the regional disparities of traffic collisions and data on driving behaviour and attitudes between the three main language areas in Switzerland. She investigated three risk taking behaviours: driving under the influence of alcohol, speeding and not wearing the seat-belt. She found them to be more common in the regions with higher rates of road traffic injuries. For some regions there was an imbalance between the deaths of non-residents ("imports") and the deaths of residents outside the district ("exports"). This occurs if risk indicators are calculated using police-registered collision data (number of injured persons at the place of collision in the numerator) and annual population statistics (residents in the denominator) because the numerator and denominator do not refer to the same population. This was also found in a study comparing the geographical distribution of road traffic deaths in England and Wales (Haynes, Jones, Harvey, Jewell and Lee, 2005) where the total numbers of road traffic deaths registered in a district, once as place of collision and once as place of residence, differed considerably. In the majority of the districts, the two numbers diverged by more than 25%.

Hindle, Hindle and Souli (2009) considered the role Local Authorities have to play in contributing to governmental targets for road casualty reductions in England. The research explored the relationships between road casualties and local authority characteristics such as population, road networks, traffic, and geography. Regression models were identified for types of road casualty to provide local area expectations against which observed numbers could be compared. A number of issues were identified that raise concerns about the current methods adopted for assessing road safety performances and about the implementation of this approach at local levels. These issues include the large impact on judgments of casualty severity and of estimates of baseline casualties when estimating reductions over time. This study led to recommendations for ways in which current approaches to road casualty appraisal might be improved, including the use of modelling to set performance standards and increased clarity in measuring performance.

2.5   Previous benchmarking in Northern Ireland

Broughton and Simpson (1995) carried out a study to determine whether differences between Northern Ireland and Great Britain were a direct consequence of the local conditions or whether there were any specific road safety problems in Northern Ireland.

This was achieved by establishing whether the differences seen in the casualty distributions over the period from 1988-1992 could be explained by the available exposure data. The following exposure data were investigated for the English regions, Wales, Scotland, GB and Northern Ireland:

- Road length: the distribution by road type and speed limit and also in relation to population and area

- Traffic volumes (disaggregated by road type and speed limit where available)

- Population size and age distribution

- Vehicle stock by age and size of car fleet

- Information on road traffic regulation differences

- Drink/drive data: police breath test rates for collision involved drivers and the percentage of post-mortem alcohol levels exceeding the legal limit

Broughton and Simpson found that conditions in Northern Ireland did not match any region found in Great Britain. Northern Ireland was found to be highly rural, with a young population and relatively low vehicle ownership, so it could not be compared directly with any single region. In addition, a study of hospital collision and emergency information suggested that injured car occupants in Northern Ireland were more likely to report a minor injury to the police than those in GB.

Broughton and Simpson also explored the use of a statistical modelling approach with the objective of finding a model which explained the number of collisions in an area in terms of exposure data such as road length or traffic volume. If satisfactory models could be found then the model would calculate the number of collisions that would be expected in an area and this expected value could be compared with the actual number. In order to achieve satisfactory models for the number of collisions of each severity, it was necessary to fit separate models for each class of road and for urban and rural roads. Unfortunately the traffic flow data were not available for minor roads and it was not possible to develop satisfactory substitute models within the resources of the study.

2.6   Summary and conclusions

Previous studies have used various approaches to make more appropriate and meaningful comparisons between different countries or areas. The complexity of these approaches varies considerably from the simplistic approach of deriving rates per head of the population to the very complex approach of fitting multivariate Bayesian spatial and ecological models which attempt to control for a raft of potentially influential factors. Taking account of factors such as the age distribution of the population, the proportions of roads of different types and traffic speeds, enables fairer comparisons to be made and contributes to an understanding of the reasons for differences in road safety risks.

Where rates are employed alone, it is preferable to use rates based on vehicle kilometres if available, rather than those based merely on the size of the population or the number of vehicles, since the amount of traffic is a key explanatory variable in road traffic collisions and casualties. These rates need to be considered separately by different road types and populations, for example, since differences in such factors may well explain differences in these rates.

Previous work in Northern Ireland indicated that it was more rural overall, that vehicle ownership was lower and that the population was younger than any region in Great Britain. Subsequently, a modelling approach taking into consideration some or all of these differences was recommended by Broughton and Simpson. These differences are amongst the key determinants investigated in Chapter 3 and modelling is explored in Chapter 4.

3 Benchmarking

The similarities and differences between Northern Ireland and Government Office Regions (GORs) in England, as well as Scotland and Wales, are considered in this Chapter. Section 3.1 analyses exposure data with a view to finding a suitable comparator for Northern Ireland, and to determine whether or not the differences in background conditions are still such that it is not possible to compare the road safety record of Northern Ireland directly with that of other regions of the UK.

As identified within the literature review, it is useful to derive and compare road safety performance indicators. The following collision rates are therefore compared in Section 3.2:

- Rate per 100 million vehicles kilometres
- Rate per 1,000 people
- Rate per 1,000 kilometres of road
- Rate per 10,000 registered vehicles

These rates were derived for collisions and casualties at various levels of severity. They were then compared across different types of roads, by urban/rural areas, by age distributions etc. since they are influenced by such factors. They were also compared between LA areas (of which there are 26 in NI) as well as for all of NI and GB (England, Wales, Scotland as well as GORs within England). There were marked differences between LA areas and it was valuable to compare them where possible though, for some sub-sets, there were not sufficient (or available) data to make meaningful comparisons.

Finally in this Chapter, consideration is given to the different casualty trends in each constituent part of the United Kingdom in Section 3.3, to understand how improvements in Northern Ireland's road safety compare with those in other 'countries' in the UK.

3.1 Exposure factors

3.1.1 Road length by type

Road lengths for different types of road are published for NI (DRDNI, 2009) and GB (DfT, 2009c) and illustrate that NI has a relatively high proportion of non-major roads (B, C and Unclassified), and very few dual-carriageway A-roads. Importantly, NI also has a relatively high percentage of single carriageway A-roads compared to the other countries in the UK. Figure 3.1 shows that there are differences in the relative percentages of different types of road in England, Wales and Scotland and that there are no GORs which have a similar distribution of road types as NI.

Figure 3.1 Distribution of road types (% by length)
NI figures from DRDNI (2009), GB figures from DfT (2009c)
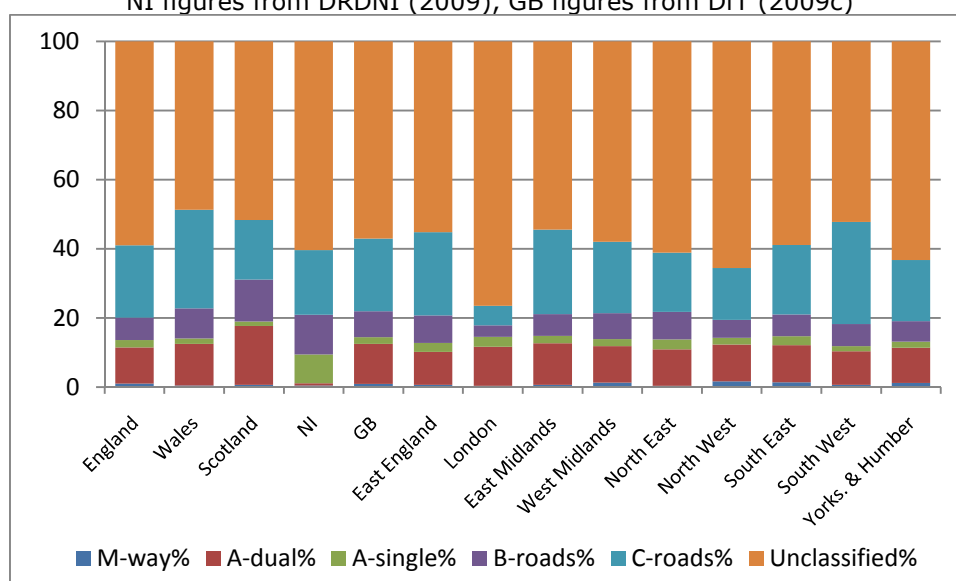
Nearly 9.5% of NI roads are either an A-road or motorway, as compared to nearly 19% in Scotland, and around 14% in Wales and England. Only approximately 1% of NI roads are either a dual-carriageway A-road or a motorway; at least ten times the proportion of the road network is separated in other UK countries.

Figure 3.2 shows the distribution of Local Authority (LA) areas within NI, and illustrates the high percentage of non-major roads especially for Cookstown, Omagh and Strabane. There are some areas with a higher percentage of major roads such as Ards and Fermanagh, and overall Figure 3.2 illustrates the variability in road mix between Local Authorities.

Figure 3.2 Distribution of roads types by LAs within NI
Figures from DRDNI (2009)
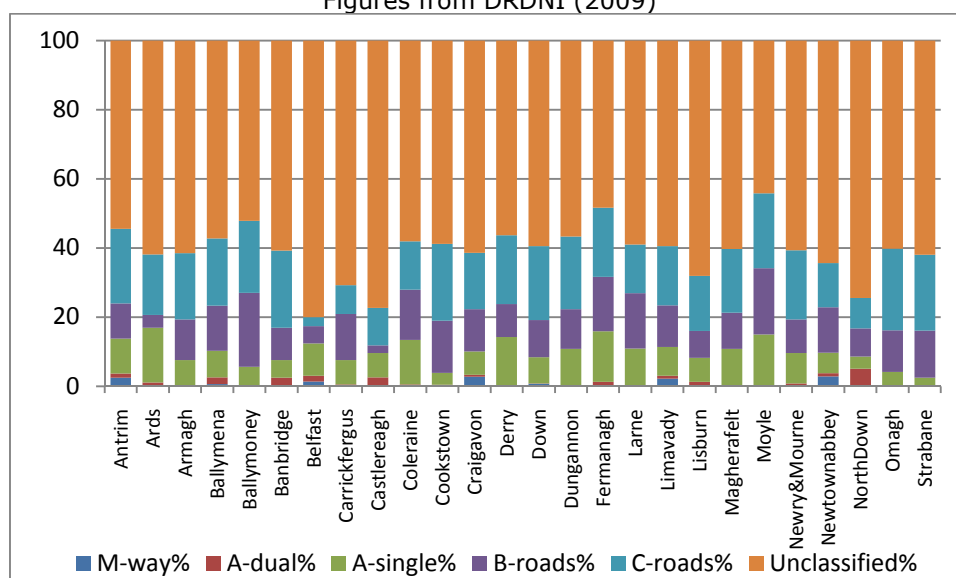
NI has approximately 14.3 kilometres of roads per thousand people which is much higher than England with 5.9 kilometres per thousand people, and somewhat higher than Wales and Scotland with approximately 11.5 kilometres per thousand people. However, relative to area, Northern Ireland has a less dense network than England (17.8 kilometres per thousand compared to 23.1 kilometres per thousand hectares), a slightly

denser network than Wales (16.3 kilometres per thousand hectares) and a considerably denser network than Scotland (7.6 kilometres per thousand hectares).

3.1.2 Traffic flows

The historical traffic flow figures for NI and GB from 1994 to 2008 have been indexed to the average figures for 1996-2000 and are shown in Figure 3.3. The figure shows that traffic growth has been markedly higher in NI than in GB. The traffic flow in 1994 for NI was approximately 13,771 vehicle-kilometres which increased to 19,683 vehicle-kilometres in 2008, an increase of 43%. These compare to GB figures of 421,500 vehicle-kilometres in 1994 which increased to 508,906 vehicle-kilometres in 2008, an increase of only 21%.

Figure 3.3 Traffic flow figures (Indexed to 1996-2000 average = 100)
NI figures from DOENI personal communication, GB figures from DfT (2009a)
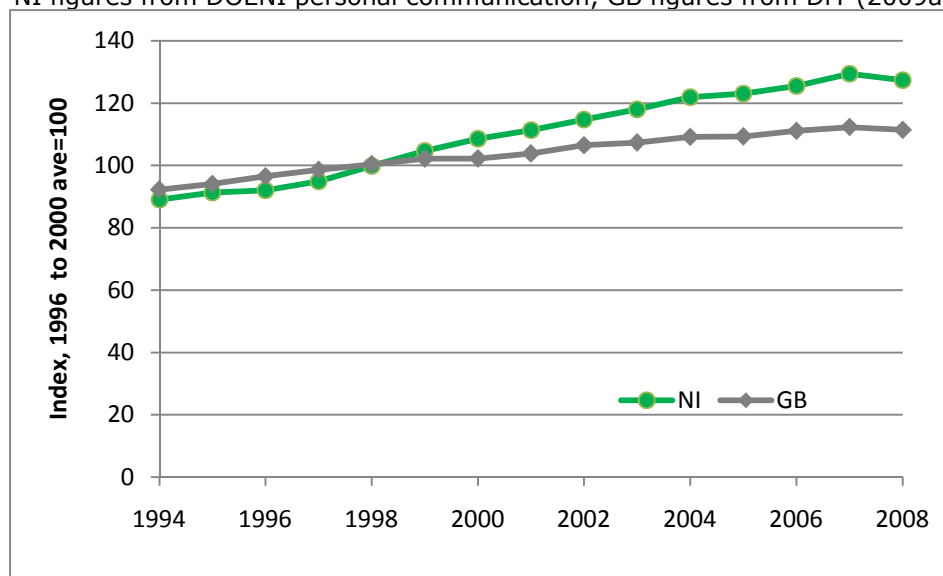
Given the increase in traffic over this 14 year period, an increase in collisions and casualties might be expected unless there were also very significant improvements in road safety. As noted earlier, casualty rates based on traffic volume (vehicle-kilometres) should provide an index which is most informative since they take exposure into account. They do not necessarily allow for different types of road, but do allow for vehicle use on the roads. However, obtaining reliable traffic flow data is expensive since traffic counters are needed across the network to cover all types of road. Vehicle flow data (vehicle-kilometres) for types of road are available from the Roads Service (2008). Table 3.1 shows the distribution of road lengths and of traffic (vehicle-kilometres) by type of road for NI and GB.

Table 3.1 Road length and traffic flow by road type
NI figures from The Roads Service (2008), GB figures from DfT (2009a)

Road Type Description	NI		GB	
	% km	% traffic	% km	% traffic
Motorway	0.5%	6.7%	0.9%	19.7%
A-road Rural	6.9%	28.9%	9.0%	28.1%
A-road Urban	2.2%	17.2%	2.8%	15.7%
Minor rural	71.8%	39.1%	54.1%	14.2%
Minor urban	18.7%	8.1%	33.2%	22.3%

There are clearly very different patterns of road use between NI and GB, with 39% of traffic in NI being on rural minor roads as compared to 14% for the GB equivalent. In

contrast only 8% of NI traffic is on minor urban roads compared to 22% in GB. These differences in the proportions of roads of each type and the amount of traffic on each type are very likely to contribute to differences in overall collision and casualty rates; therefore, GB is not a good comparator for Northern Ireland. The change in casualties relative to traffic flow is explored in Section 3.3.2.

3.1.3 Population

Northern Ireland has only approximately 2.9% of the UK population (2007 figures) which consists of just fewer than 1.8 million people, as illustrated in Figure 3.4. Of these approximately 51% are female which is similar to Wales (51.2%), Scotland (51.6%) and England (50.8%).

Figure 3.4 Distribution of UK population by country
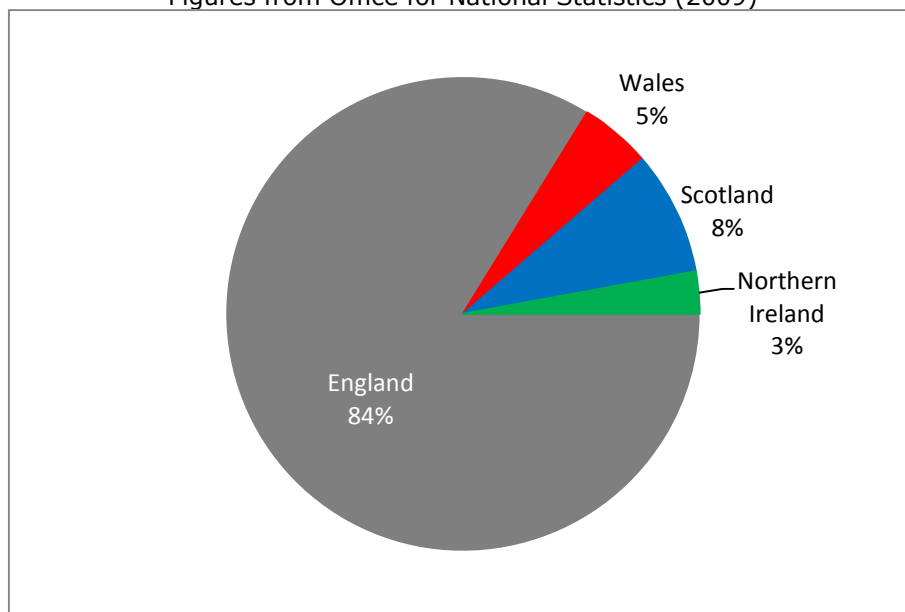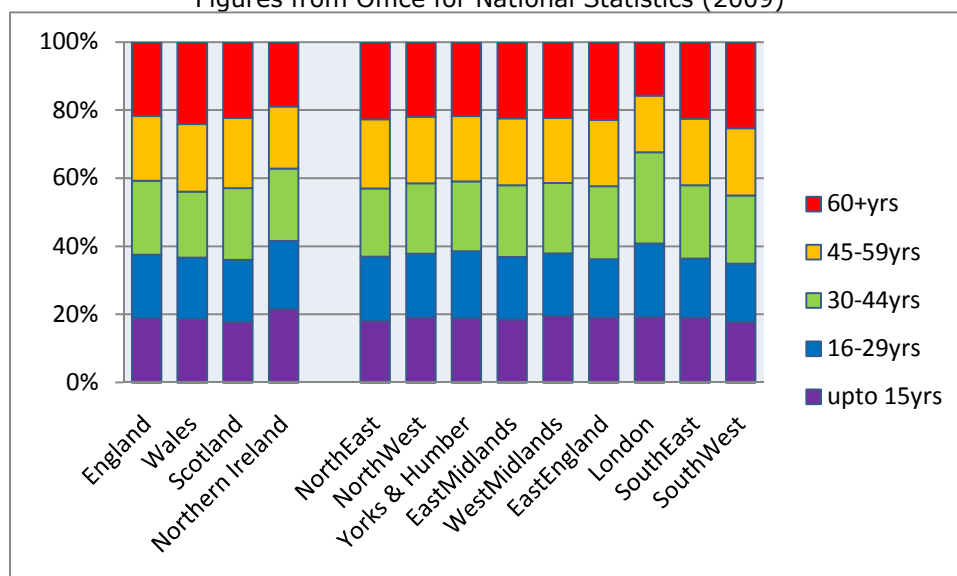Figures from Office for National Statistics (2009)

Figure 3.5 shows the distribution of the 2007 population by age group, and Figure 3.7 shows the same distribution but excluding those under 16 thus focussing on the driving population.

Figure 3.5 Distribution of 2007 population by age group
Figures from Office for National Statistics (2009)

Northern Ireland has a slightly younger population than the rest of the UK, with 21.6% being under 15 years of age, compared to Wales with 18.7%, Scotland with 17.8% and England with 18.9%; indeed every GOR in England has a lower proportion of its population under 15.

Figure 3.6 Distribution of 2007 population by age group (excluding under 16s)
Figures from Office for National Statistics (2009)
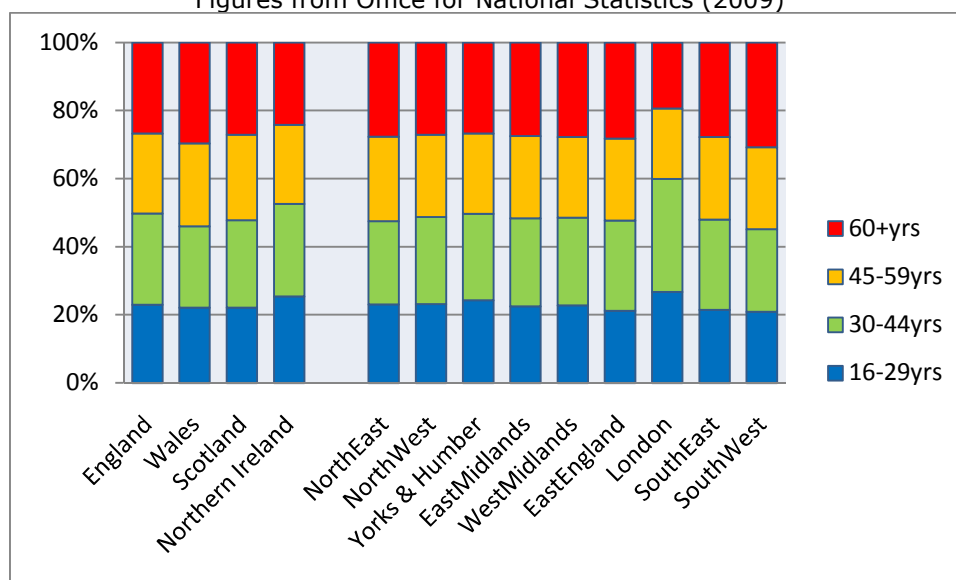
Excluding London, a lower percentage of the population in NI is aged over 60 years and a higher proportion of Northern Ireland's population is under 30. The only GOR comparable to Northern Ireland in age distribution is London, which is clearly dissimilar to Northern Ireland in many other ways such as its high level of urbanisation. Road safety casualty rates will inevitably reflect these variations since young drivers are less experienced and at particularly high risk, and there appears to be no GOR that is a suitable comparator for Northern Ireland.

3.1.4   Vehicle stock

The numbers of registered vehicles per thousand people are shown in Figure 3.7. It shows that the rate is very similar in NI to that for Wales and England, but somewhat higher than Scotland.

Figure 3.7 Registered vehicles per thousand people (2008)
Population figures from Office for National Statistics (2009), NI vehicle figures from DRDNI (2009),
GB vehicle figures from DfT (2009b)
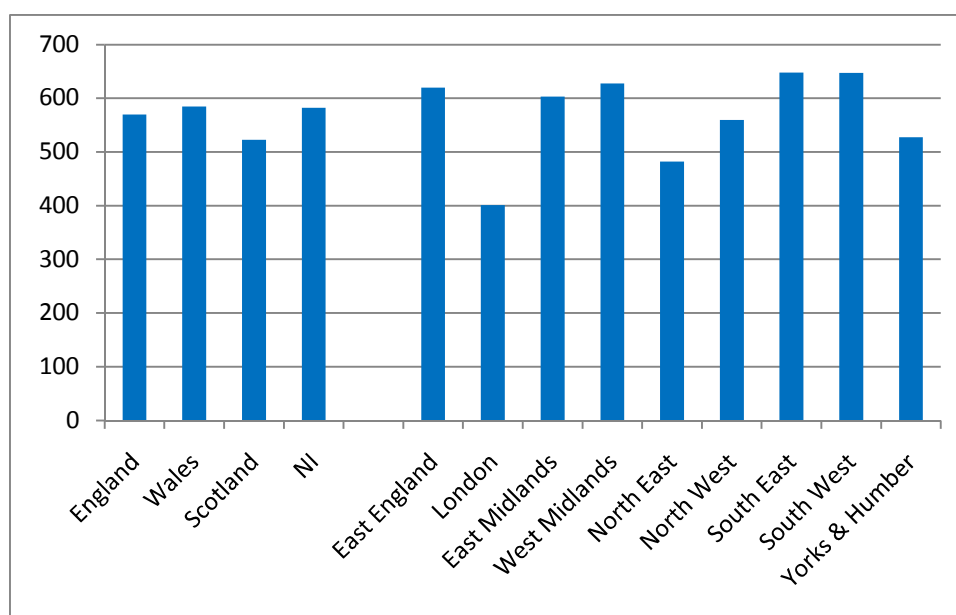
The overall average for GB is 566 vehicles per thousand people, i.e. a vehicle for every 1.77 people. The figure for NI is 582 per thousand people which corresponds to a vehicle for every 1.72 people.

The average distances travelled per person are shown in Figure 3.8; it is evident that people drive further in NI than in any other country or GOR in the rest of the UK. People drive an average of 11,200 kilometres per person in NI as compared to 10,500 kilometres per person in the South East and just 4,300 kilometres per person in London.

Figure 3.8 Vehicle kilometres per person (2008)
Population figures from Office for National Statistics (2009), NI traffic figures from The Roads Service (2008), GB traffic figures from DfT (2009c)
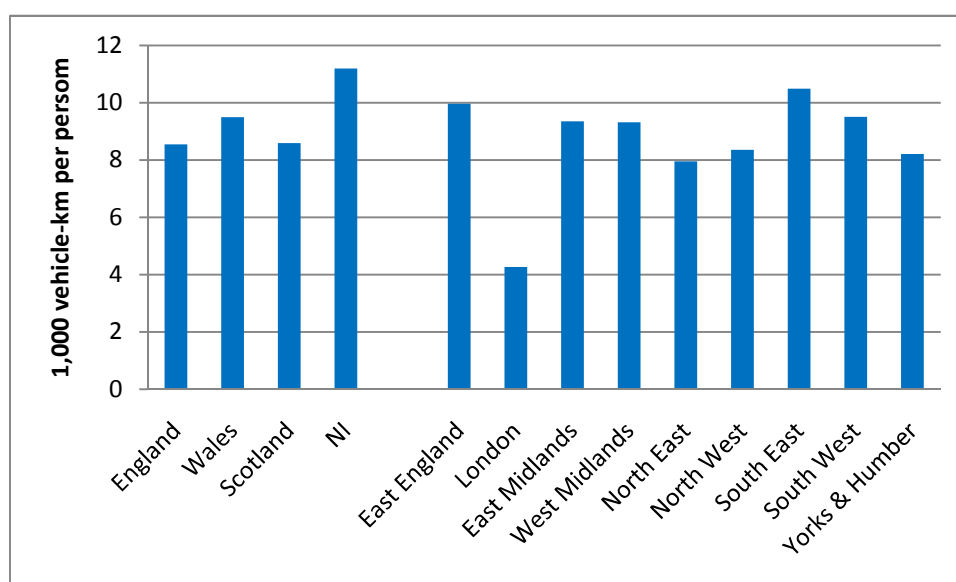
The numbers of vehicle-kilometres per registered vehicle are shown in Figure 3.9; it is evident that the average vehicle is driven further in NI than elsewhere. This is again a reflection of the fact that more of the roads are rural in NI and hence there are generally higher levels of driving. There are 19,200 kilometres driven per vehicle in NI as compared to London with 10,600 kilometres per vehicle.

Figure 3.9 Vehicle kilometres per vehicle (2008)
NI figures from DRDNI (2009) and The Roads Service (2008), GB figures from DfT (2009b) and DfT (2009c)
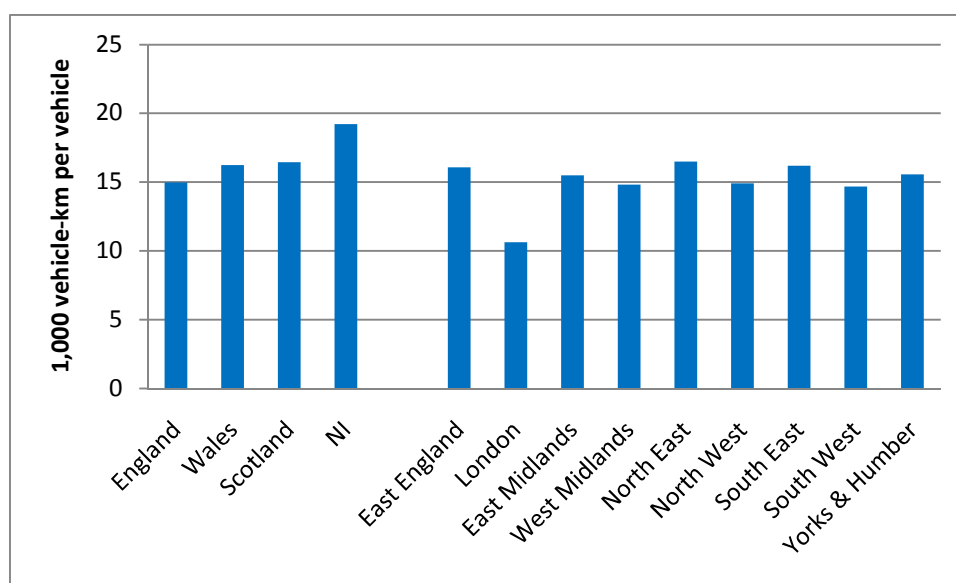
While the South East has a similar average number of vehicle kilometres per person, for example, it has quite a different average number of vehicle kilometres per vehicle. Therefore, it appears that no GOR is an appropriate comparator on variables such as the distances travelled.

3.1.5 Section summary

In summary:

- There is no GOR or country in the rest of the UK with a similar balance of road types as Northern Ireland, or any NI Local Authority:

  - The proportion of roads that are dual carriageways is lower in NI than in every GOR and country in the rest of the United Kingdom.

  - There are more kilometres of road per head of the population in NI than in other parts of the UK.

  - There are more kilometres of road per unit area in NI than in Wales or Scotland, though fewer than in England.

- In the last fifteen years, traffic volume has grown by 43% in Northern Ireland – more than double the increase in Great Britain.

- Well over twice the proportion of traffic in Northern Ireland is on minor rural roads compared to the rest of the UK, while there is far less on motorways or minor urban roads.

- Northern Ireland has a younger population than in any other part of the UK. This is particularly significant given that young drivers are inexperienced drivers and, on average, the most at risk.

- While the number of vehicles per head in Northern Ireland is similar to elsewhere in the UK, the number of vehicle-kilometres per person and per vehicle in Northern Ireland is higher than in any other part of the UK.

These differences between NI and the rest of the UK will inevitably affect the frequencies, types and severities of collisions. It is clear that no other country or GOR is comparable to Northern Ireland in terms of all of the critical exposure factors such as road types, vehicle kilometres and age distribution of the population. In particular, if

roads of the same type are of comparable safety across the UK, overall collision and casualty rates in Northern Ireland are likely to be higher than elsewhere given the combination of:

- more single carriageway roads

- more traffic on minor rural roads

- a younger population and

- greater distances travelled per person and per vehicle.

3.2 Analysis of collision and casualty data

This Section considers the distribution of casualties. The differences in population, registered vehicles, road class distribution and the fact that NI has a higher proportion of rural roads and a slightly younger population than GB are considered.

3.2.1 Distribution of casualties

The distribution of fatalities and serious injuries (KSIs) and all casualties in 2008 for NI and GB are compared in the following tables: Table 3.2 considers the road user type, Table 3.3 the time of day, Table 3.4 the age of casualty and Table 3.6 the type of road. Given the relatively small number of fatalities in Northern Ireland – 107 in 2008 – differences should be interpreted with caution.

Table 3.2 Distribution of 2008 casualties by road user type
NI figures from Northern Ireland casualty data, GB figures from DfT (2009a)

	Fatal		KSI		All	
	NI	GB	NI	GB	NI	GB
Motor vehicle driver	43%	36%	43%	30%	52%	47%
Pillion passenger	1%	1%	1%	1%	0%	0%
Vehicle passenger	22%	16%	22%	15%	32%	22%
Pedestrian	18%	23%	19%	24%	9%	13%
Motorcyclist	14%	19%	13%	21%	5%	10%
Pedal cyclist	2%	5%	3%	9%	2%	8%

It is evident from these distributions of casualties that a proportionally higher number of drivers and passengers are killed or injured in NI than in GB. In contrast, a proportionally higher number of pedestrians and motorcyclists are killed or injured in GB. These differences in distribution in casualties are likely to be due to differences in road use, i.e. that the average mileage of motorised vehicles in NI is higher than in GB. In addition, differences in occupancy rates may partly account for the higher proportion of passenger casualties in Northern Ireland.

Table 3.3 Distribution of 2008 casualties by time of day
NI figures from Northern Ireland casualty data, GB figures from DfT (2009a)

	Fatal		KSI		All	
	NI	GB	NI	GB	NI	GB
4-10 am	23%	17%	15%	17%	17%	19%
10 am - 2 pm	13%	17%	20%	18%	21%	21%
2-6 pm	22%	25%	26%	29%	32%	30%
6-10 pm	21%	20%	21%	21%	19%	19%
10 pm - 4 am	20%	22%	18%	15%	11%	10%

There is not a substantial difference between the distribution of casualties by 'time of day', suggesting that collisions (and hence casualties) occur in similar time periods in both NI and GB, probably due to similar distributions of traffic flows by time of day.

Table 3.4 Distribution of 2008 casualties by age of casualty

NI figures from Northern Ireland casualty data, GB figures from DfT (2009a)

	Fatal		KSI		All	
	NI	GB	NI	GB	NI	GB
0-15yrs	7%	5%	9%	10%	10%	10%
16-19yrs	19%	12%	14%	14%	13%	13%
20-29yrs	25%	21%	24%	22%	25%	24%
30-49yrs	21%	29%	30%	30%	33%	33%
50+yrs	28%	32%	22%	24%	19%	20%

Higher percentages of fatal casualties are aged between 0 and 15, 16 and 19 and 20 and 29 in NI when compared to GB; in contrast, a higher percentage of older fatal casualties occur in GB. However, there are not similar differences with lower severity casualties and the difference with fatalities is likely to be due to natural statistical variation in the main. For example, there were seven fatalities in Northern Ireland in the 0-15 year old age group in 2008; in statistical terms, this is little different from the five that there would have been had the distribution in Northern Ireland been the same as that in GB. To understand the differences in severity by age group further, Table 3.5 shows the percentages of KSIs that were fatal, by age group, in 2008.

Table 3.5 Severity of 2008 casualties by age of casualty

NI figures from Northern Ireland casualty data, GB figures from DfT (2009a)

	% of all KSIs which were Fatal	
	NI	GB
0-15yrs	7%	4%
16-19yrs	13%	8%
20-29yrs	10%	9%
30-49yrs	7%	9%
50+yrs	12%	12%

Again these differences need to be interpreted with caution given the relatively small numbers in Northern Ireland. However, they indicate that when a vehicle occupant under the age of 20 is killed or seriously injured in a road collision, they are more likely to be killed in Northern Ireland than in GB.

Further research might investigate this in more detail and, if this finding does hold, possible explanations considered. For example, unlike in GB, learner drivers and those within a year of having passed their test in Northern Ireland are restricted to 45mph. There may, therefore, be a possibility that young, inexperienced drivers in Northern Ireland are less well prepared for driving at higher speeds than are those in GB.

Table 3.6 Distribution of 2008 casualties by type of road

NI figures from Northern Ireland casualty data, GB figures from DfT (2009a)

|	Fatal		KSI		All	
	NI	GB	NI	GB	NI	GB
Roundabout	0%	1%	1%	3%	5%	6%
One way street	1%	1%	2%	2%	2%	2%
Dual carriageway	4%	20%	4%	14%	4%	16%
Motorway	2%	6%	2%	3%	3%	5%
Single carriageway	93%	71%	91%	76%	84%	71%
Slip road	0%	0%	0%	1%	1%	1%

There are differences between the distributions of casualties by type of road in NI as compared to GB. This is a reflection of the road networks, for example NI only has approximately 0.7% of dual-carriageway A-roads whereas GB has 11.6%. Further, most of NI's A-roads are single carriageway (8.4% of the network) and so it is not surprising

that over 90% of fatal or KSI casualties occur on single carriageway roads, whereas in GB just 2% of the network consists of single carriageway A-roads.

Figure 3.10 shows the distribution of KSI collisions by speed limit. It illustrates that most KSI collisions in GB occur on 30mph speed limit roads whereas in NI most occur on 60mph roads. This reflects differences between NI and GB since NI has far fewer urban roads (with speed limits of 30mph and 40mph) compared to GB, and NI has most casualties on single carriageway A-roads which are likely to have a 60mph speed limit. This suggests that collisions in Northern Ireland are, on average, likely to be of a higher severity; it also suggests that, for benchmarking purposes, it is important to control for the road class and speed limit when making comparisons between NI and GB.

Figure 3.10 Distribution of KSI collisions by speed limit (2008)
NI figures from Northern Ireland casualty data, GB figures from DfT (2009a)
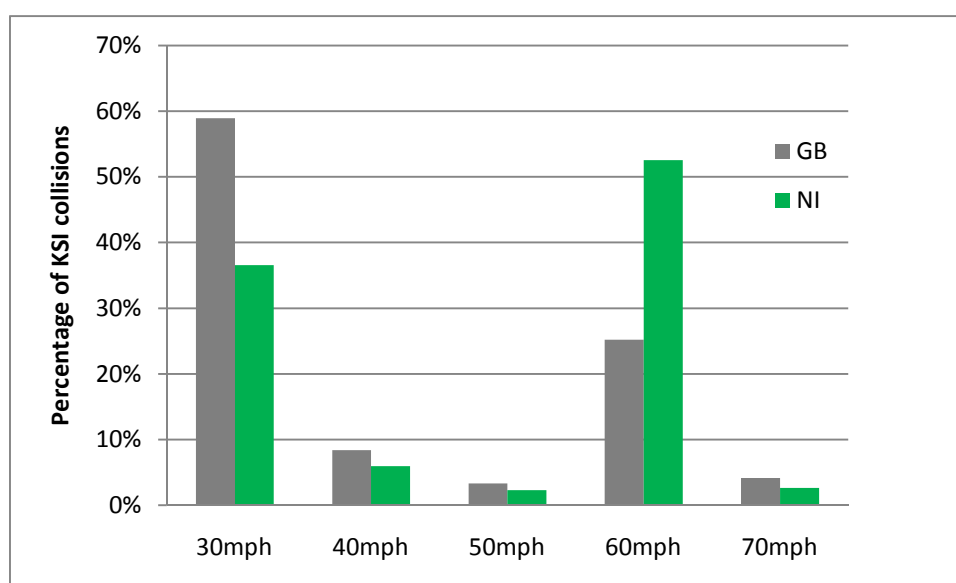

3.2.2   *Casualties and population*

The numbers of fatal and KSI (killed or seriously injured) casualties by size of population are shown in Figure 3.11, fatalities per million people and KSIs per 100,000 people. The rates are higher for NI than for other UK countries; this is likely to be a result, at least in part, of the substantially increased frequency of collisions on roads with 60mph speed limits. On these roads, traffic is likely to travel faster without corresponding improvements in road design, and thus collisions are likely to be more severe.

Figure 3.11 Casualties by population (2008)

Population figures from Office for National Statistics (2009), NI casualty figures from Northern Ireland casualty data, GB casualty figures from DfT (2009a)
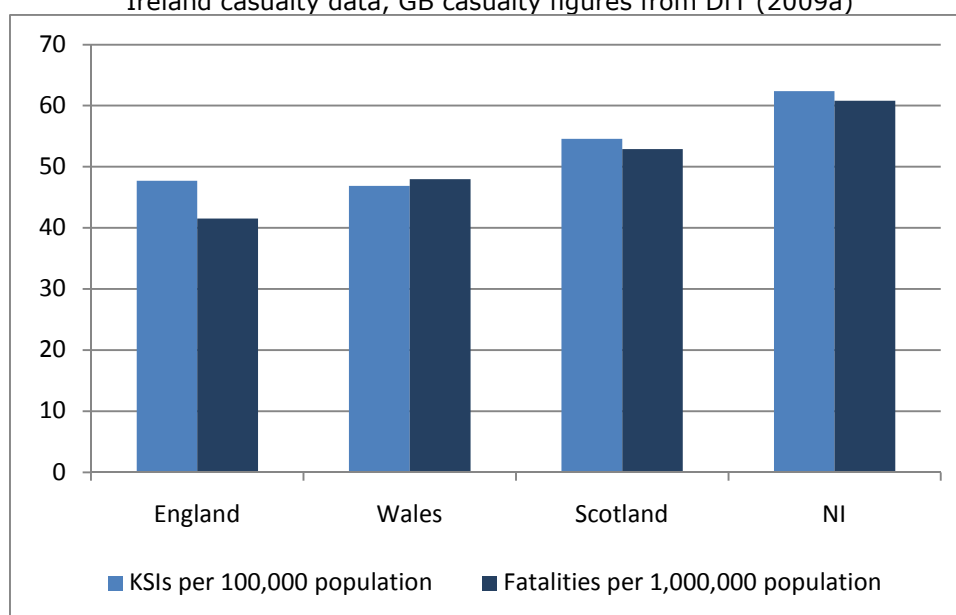
The numbers of KSI casualties per 10,000 people for the UK and for the Government Office Regions (GOR) in England are shown in Figure 3.12. The NI rate is higher than it is for any of the other countries or GORs; this is likely to be a reflection of the factors considered in the previous section, such as the higher proportion of travel on rural, single carriageway roads, and the younger population.

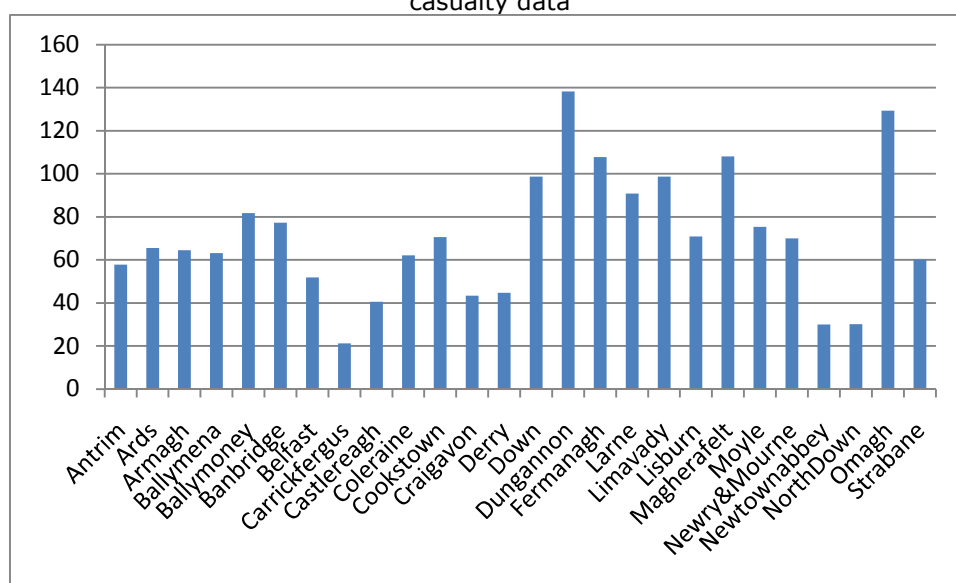**Figure 3.12 KSI casualties per 100,000 people, UK and England Regions (2008)**

Population figures from Office for National Statistics (2009), NI casualty figures from Northern Ireland casualty data, GB casualty figures from DfT (2009a)
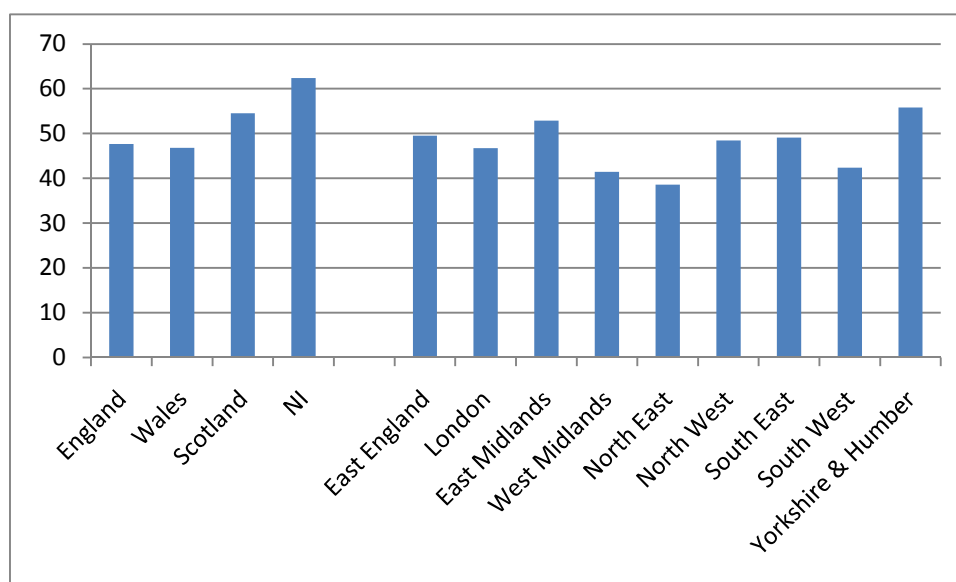
The numbers of KSI casualties per 100,000 people for the NI Local Authority (LA) areas are shown in Figure 3.13. The figure shows the considerable variability in KSI population rates within NI. The KSI rate per 100,000 people varies from 21 in Carrickfergus to 138 in Dungannon, which is likely to be a reflection of the lengths of road, types of roads and traffic speeds within each LA area.

**Figure 3.13 KSI casualties per 100,000 people - NI LA areas**

Population figures from Northern Ireland census 2001, casualty figures from Northern Ireland casualty data

NI has a slightly younger population than GB and, given that younger adults tend to have a higher casualty risk, higher numbers of casualties per head of the population may be expected in NI than in GB, i.e. as seen in Table 3.4. Calculating the casualty rate per thousand people within age group adjusts for differences in population age distribution; the fatal and KSI casualties rates per thousand people are shown in Figure 3.14.

Figure 3.14 Casualties per thousand people (2008)

Population figures from Office for National Statistics (2009), NI casualty figures from Northern Ireland casualty data, GB casualty figures from DfT (2009a)
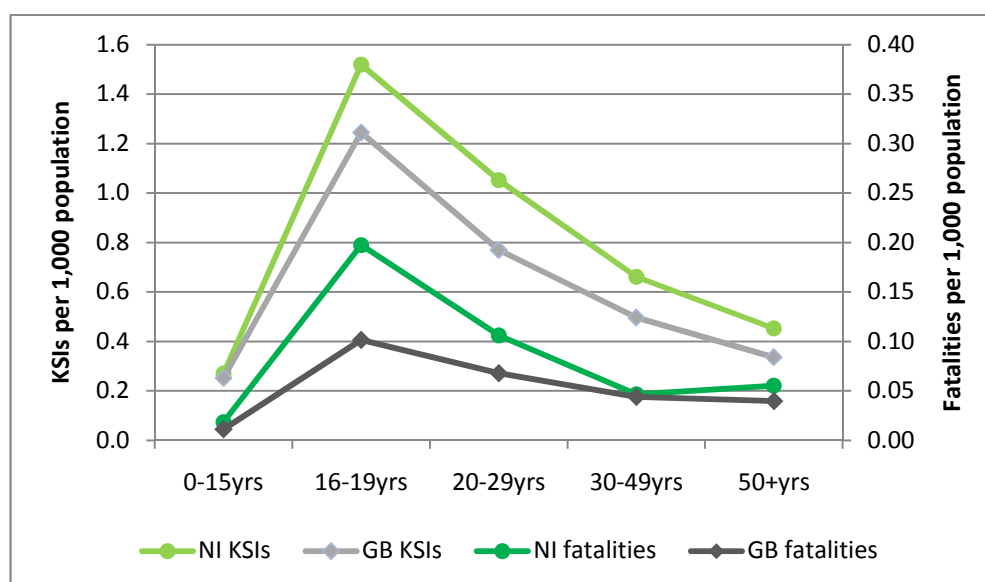
It can be seen that the fatal and KSI rates for those aged under 15 years are very similar for NI and GB. However there are large differences between the rates for the 16-19 year old and 20-29 year old age groups. The rates for both fatal and KSI casualties per thousand people are considerably higher for NI casualties, the fatal rate for NI 16-19 year olds (0.197 fatal casualties per thousand) being nearly twice the rate of that for GB (0.101 fatal casualties per thousand).

In general it is clear that the casualty rates per thousand people are higher in NI than those for GB; the large difference in rates for 16-19 year olds between NI and GB is

most concerning. This may partly be a reflection of the higher severities of casualties in this age group, as seen in Table 3.5. However, some of the differences may be attributable to other factors, such as the larger proportion of single carriageway A-roads in NI and the larger proportion of rural roads in general; without detailed exposure data, i.e. the number of vehicle-kilometres split by driver age as well as road type, these differences cannot be fully understood.

3.2.3   Casualties and vehicle stock

The numbers of fatal and KSI casualties by vehicle stock are shown in Figure 3.15, fatalities per 100,000 and KSIs per 10,000 registered vehicles. The rates are higher for NI than for other UK countries but very similar to those for Scotland; again, this is likely to be a reflection of factors such as the greater distances travelled in Northern Ireland.

Figure 3.15 Casualties by vehicle stock (2008)
NI casualty figures from Northern Ireland casualty data, GB casualty figures from DfT (2009a), NI vehicle figures from DRDNI (2009), GB vehicle figures from DfT (2009b)
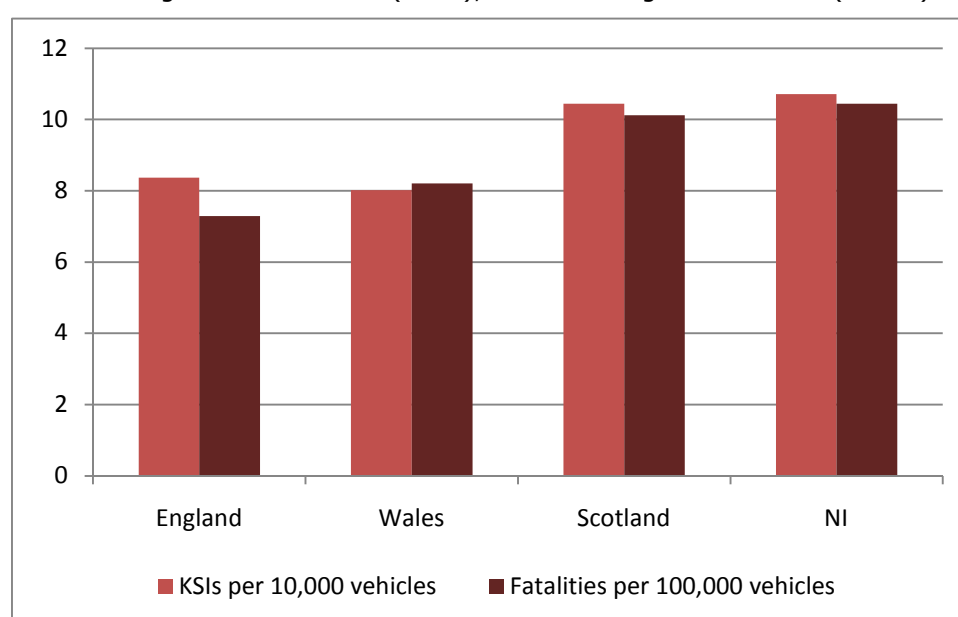
The numbers of KSI casualties per 10,000 vehicles for the UK and for the Government Office Regions (GOR) in England are shown in Figure 3.16. The NI rate (10.7) is similar to those of Scotland (10.4) and to Yorkshire & Humberside GOR (10.6).

Figure 3.16 KSI casualties per 10,000 vehicles, UK and England Regions (2008)
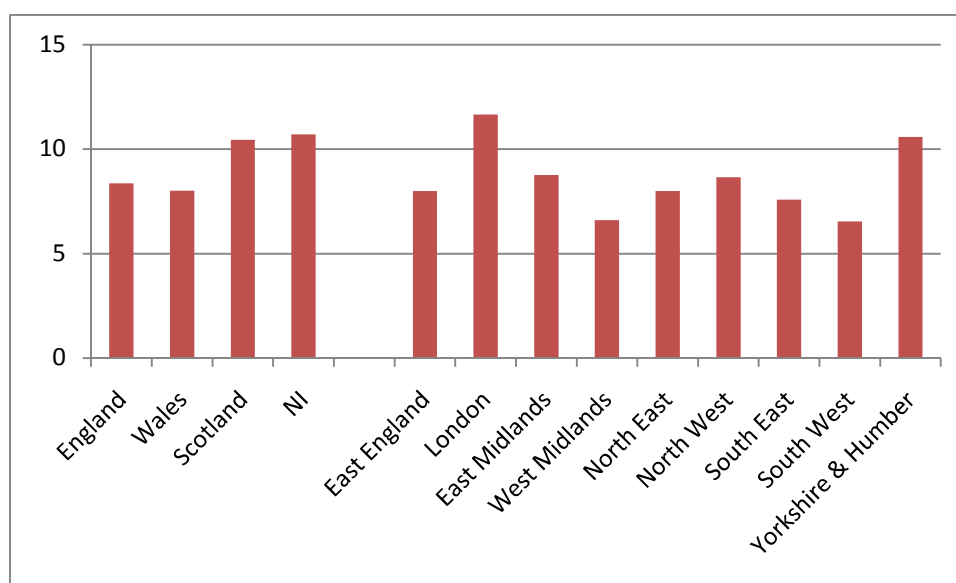
NI casualty figures from Northern Ireland casualty data, GB casualty figures from DfT (2009a), NI vehicle figures from DRDNI (2009), GB vehicle figures from DfT (2009b)

3.2.4 Casualties and road length

The numbers of fatal and KSI casualties by total road length are shown in Figure 3.17, fatalities per 10,000 kilometres and KSI per thousand kilometres. The rates are somewhat higher for England but for NI the rate is quite similar to those of Wales and Scotland.

Figure 3.17 Casualties by road length (2008)

NI casualty figures from Northern Ireland casualty data, GB casualty figures from DfT (2009a), NI road length figures from DRDNI (2009), GB road length figures from DfT (2009c)

The numbers of KSI casualties per thousand kilometres for the UK and for the Government Office Regions (GOR) in England are shown in Figure 3.18. The NI rate (43.6) is similar to those of Wales (41.2), Scotland (47.1) and the South West GOR (43.9).

Figure 3.18 KSI casualties per 1,000 km road for UK and England areas (2008)
NI casualty figures from Northern Ireland casualty data, GB casualty figures from DfT (2009a), NI road length figures from DRDNI (2009), GB road length figures from DfT (2009c)
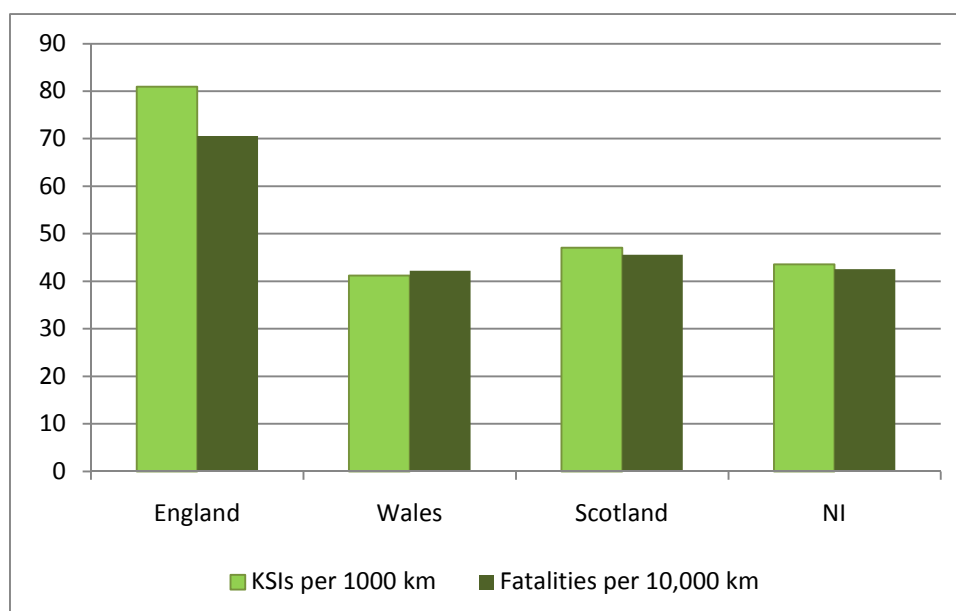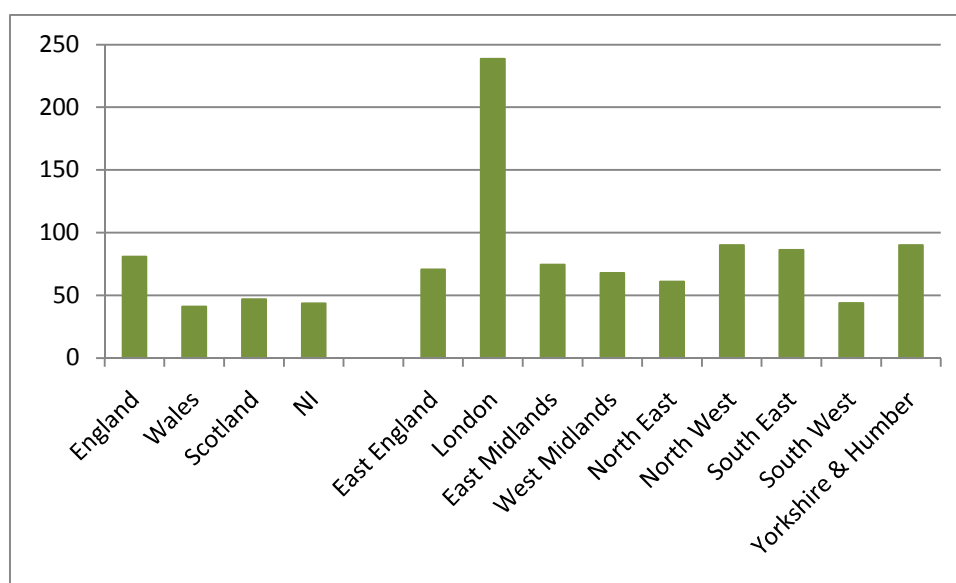

The numbers of KSI casualties per thousand kilometres of road for the NI LA areas are shown in Figure 3.19. The figure shows the considerable variability in KSI rates per thousand kilometres of road within NI LA areas. These vary from 17 in Strabane to 165 in Belfast, which is likely to be a reflection of the population, traffic speeds and road types within each of these LA areas.

Figure 3.19 KSI casualties per 1,000 km road - NI LA areas
Casualty figures from Northern Ireland casualty data, road length figures from DRDNI (2009)
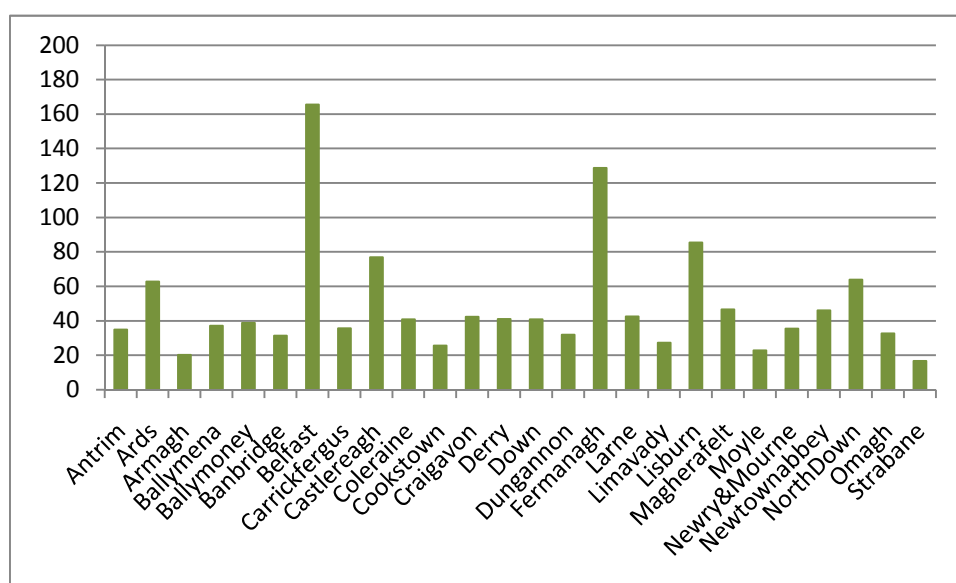
3.2.5   Casualties and traffic

The fatal and KSI casualty rates in terms of traffic (vehicle-kilometres) are shown in Figure 3.20, fatalities per 100 million vehicle-kilometres and KSIs per billion vehicle-kilometres. Note that, for Northern Ireland, the traffic figures used were actually those for 2007 as these were the most recent that were available. The rates are highest for Scotland and NI is very similar to England, though NI has slightly more fatal casualties.

Figure 3.20 Casualties by traffic (2008*)
*For NI, 2007 traffic figures were used
NI casualty figures from Northern Ireland casualty data, GB casualty figures from DfT (2009a), NI traffic figures from The Roads Service (2008), GB traffic figures from DfT (2009c)
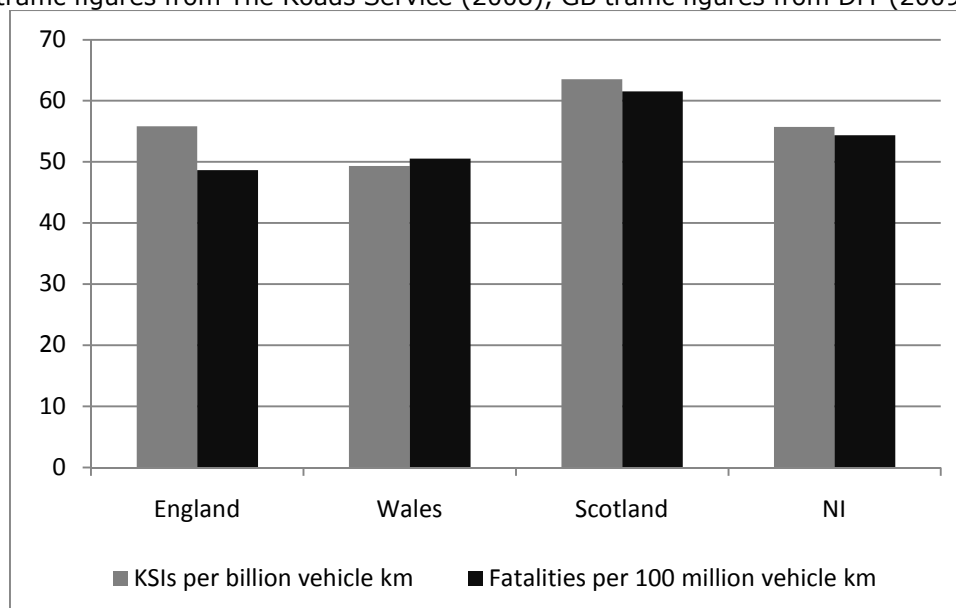
The numbers of KSI casualties per billion vehicle-kilometres for the UK and for the Government Office Regions (GORs) in England are shown in Figure 3.21. The NI rate (56) is the same as England (56), as the East Midlands (57) and as the North West (58).

Figure 3.21 KSI casualties per billion vehicle kilometres for UK and England areas (2008*)
*For NI, 2007 traffic figures were used
NI casualty figures from Northern Ireland casualty data, GB casualty figures from DfT (2009a), NI traffic figures from The Roads Service (2008), GB traffic figures from DfT (2009c)
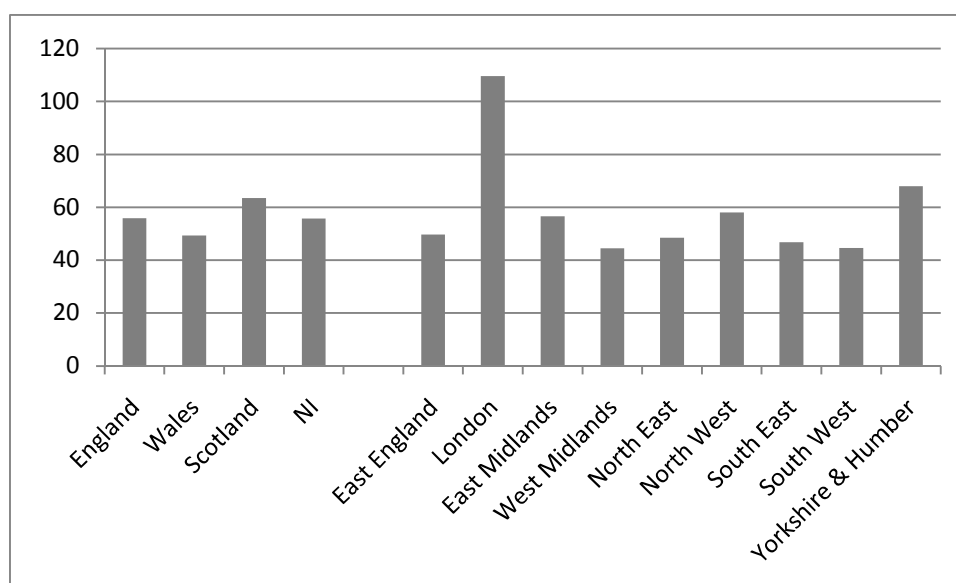
In GB, 'urban roads' are defined as roads within an urban area with a population of ten thousand or more; this differs from 'built-up roads' in that the latter refers to roads with speed limits less than or equal to 40mph. Some roads in rural areas may therefore be built-up roads while some in urban areas may be non built-up roads, though the majority of urban roads are built-up roads and the majority of rural roads are non built-up roads. In Northern Ireland the 'urban roads' definition as set out above does not apply and so 'urban roads' are defined as 'built-up' roads, i.e. those with speed limits of

less than or equal to 40mph. These differences of definition mean that the comparisons made between road types in GB and NI are not perfect.

In order to use the available vehicle flow data, it was necessary to group the data into motorway, urban and rural roads. Table 3.7 shows the casualty rates per billion vehicle-kilometres for fatal, KSI and all casualty severities. Note that, while the numbers of casualties used were the figures for 2008, the NI vehicle flows used were those for 2007, the latest year for which such figures were available.

Table 3.7 Casualty rate per billion vehicle-kilometres
NI casualty figures from Northern Ireland casualty data, GB casualty figures from DfT (2009a), NI traffic figures from The Roads Service (2008), GB traffic figures from DfT (2009c)

Rate per billion vehicle-kilometres	Fatal		KSI		All	
	NI	GB	NI	GB	NI	GB
Motorway	1.50	1.58	12.8	10.3	170.6	114.6
Urban	5.34	5.45	86.6	92.3	983.6	830.5
Rural	5.73	6.15	47.2	45.0	238.8	272.0

Table 3.7 shows that NI fatal casualty rates per billion vehicle-kilometres are lower than the most comparable figures for GB across all road classifications. However the NI KSI rates for motorways and rural roads are slightly higher than those for GB, as are the 'all severity' rates for motorway and urban roads in NI. This suggests that the higher casualty rates by population and by vehicle stock for NI seen earlier are misleading because the more appropriate road safety indicators based on traffic flow (i.e. exposure) and disaggregated by road type suggests that NI is safer in many respects.

3.2.6   Section summary

- A greater proportion of casualties in NI are drivers and passengers compared to GB, as may be expected given the proportions of road types and traffic flows; equally, a smaller proportion of casualties in NI pedestrians and motorcyclists.

- The casualty distributions are similar in NI and GB in terms of time of day.

- Those under 30 who are killed or seriously injured are substantially more likely to be killed in NI than in GB.

- A greater proportion of casualties are injured on single carriageways in NI compared with GB, as may be expected given the higher proportion of the network that is single carriageway in NI.

- The majority of KSI collisions are on roads with 60mph speed limits in NI in contrast to GB where the majority are on roads with 30mph speed limits, as may be expected given the proportions of road types and traffic flows.

- Northern Ireland has higher KSI and fatal casualty rates per head of the population than anywhere else in the UK, as may be expected given that higher proportions of KSI collisions are on roads with higher speed limits. The differences in rates vary by age and are largest for people aged between 16 and 19 when they are most at risk in any case.

- If it is assumed that urban roads have speed limits no higher than 40mph and rural roads have speed limits of higher than 40mph, Northern Ireland's casualty rates per billion vehicle-kilometres compare quite favourably with those of GB: many of the apparent differences in road safety between NI and the rest of the UK appear to be attributable to the mix of traffic flows.

3.3   Casualty trends

The numbers of casualties by country within the UK vary considerably which makes them difficult to compare; in addition, levels of under-reporting may differ in each area of the UK. However the rate of change can be computed using an index to a base year and the long-term changes can then more easily be compared between different countries (or regions). Under-reporting is not an issue when considering such indices unless the level of under-reporting in an area changes substantially; in GB, there has been some concern that the under-reporting of collisions involving only slight injuries is increasing – see, for example, DfT (2009a); this is less of an issue with serious injuries and no such concern exists with collisions involving fatal casualties and therefore such an approach remains viable.

3.3.1   All casualties

Casualties were indexed to the average for the period 1996-2000 (=100) for NI, England, Wales and Scotland. The 'all' casualty indices are shown in Figure 3.22.

Figure 3.22 All casualties (Indexed to 1996-2000=100)

NI casualty figures from Northern Ireland casualty data, GB casualty figures from DfT (2009a)
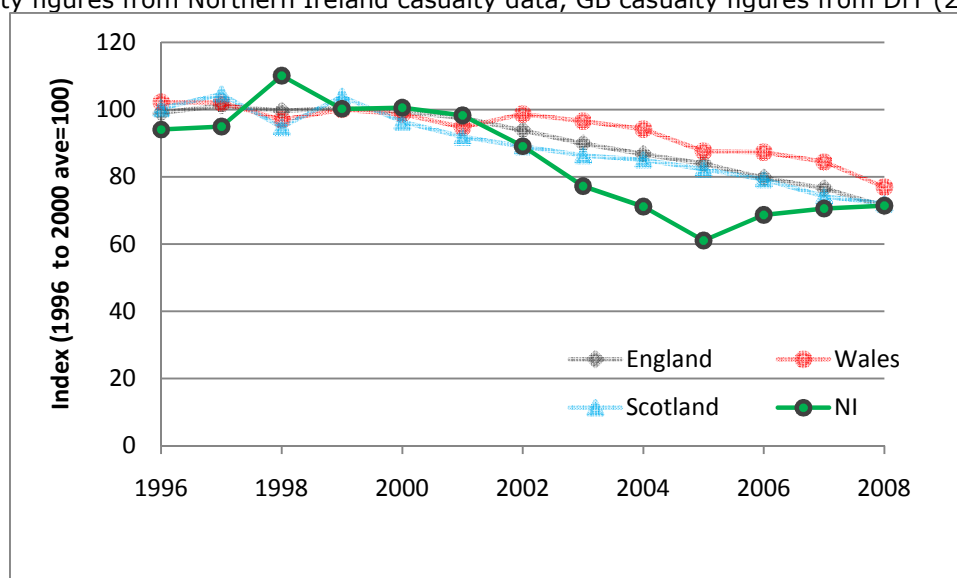
The numbers of casualties have reduced since 1999 in all countries. NI experienced a greater decrease than the rest of the UK until 2005 when the index was reduced to a value of 61, but this then increased to a value that was very similar to the other UK countries in 2008. At the end of this 10-year period the index reduced to a value of 71 for NI and England in 2008, i.e. there was a 29% reduction in the numbers of casualties from the baseline figures. Wales had an index of 77 in 2008 and Scotland an index of 72 at the end of the period. The 'fatal' casualty indices are shown in Figure 3.23.

Figure 3.23 Fatal casualties (Indexed to 1996-2000=100)

NI casualty figures from Northern Ireland casualty data, GB casualty figures from DfT (2009a)
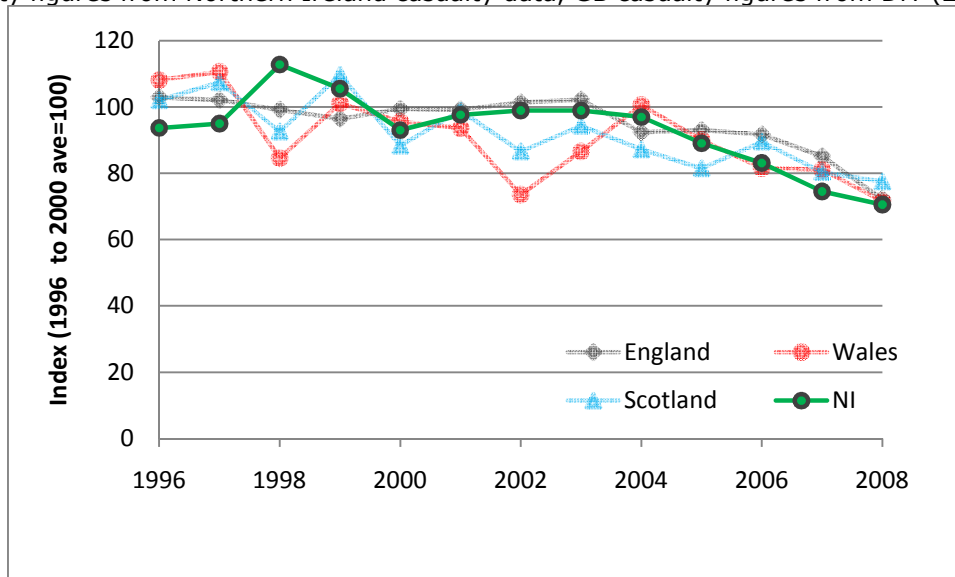
All countries experienced a decrease by similar proportions during the 10-year period from 1999 to 2008. NI's index decreased to a value of 71, i.e. a 29% reduction over 10 years. Scotland's index reduced to 77 and Wales' and England's indices both reduced to 72. There is some variation between the ways the rates decrease over this 10-year period. For example, the fatal index for England did not drop until 2004 whereas in NI the index dropped in 2000 and then did not change a great deal for four years thereafter.

The 'KSI' casualty indices are shown in Figure 3.24.

Figure 3.24 KSI casualties (Indexed to 1996-2000=100)

NI casualty figures from Northern Ireland casualty data, GB casualty figures from DfT (2009a)
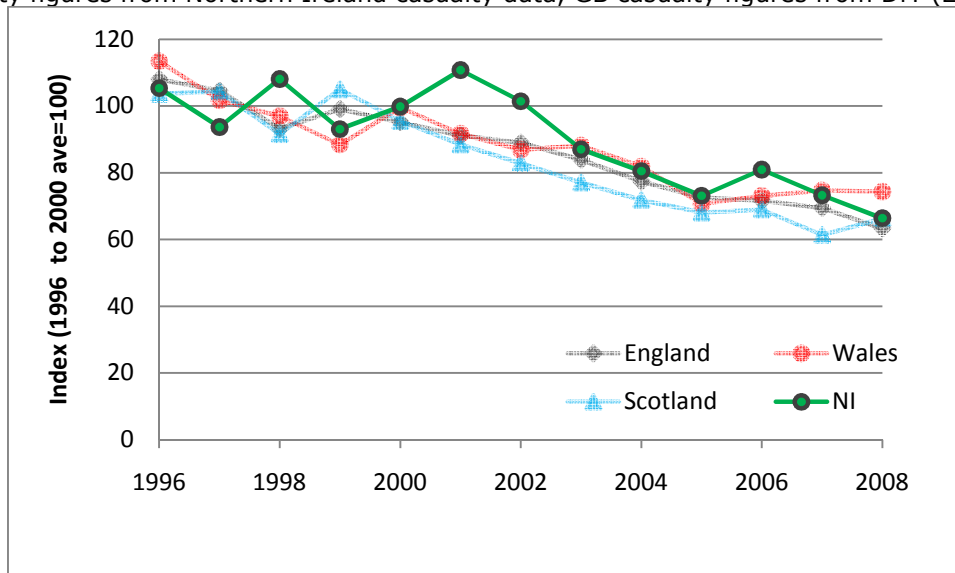
All countries experienced a decrease relative to the baseline in the period to 2008. NI's index and England's index both decreased to 63, a 37% reduction; Wales' decreased to 74 and Scotland's to 66.

3.3.2 KSI casualties

Figure 3.3 showed how traffic (vehicle-kilometres) increased in NI compared to that in GB. The figures in NI rose at a steady rate until 2004 and the rate reduced slightly thereafter. During this 15-year period the number of KSI casualties decreased as shown in Figure 3.25 (indexed to the average for 1996 to 2000).

Figure 3.25 KSI casualties (Indexed to 1996-2000=100)

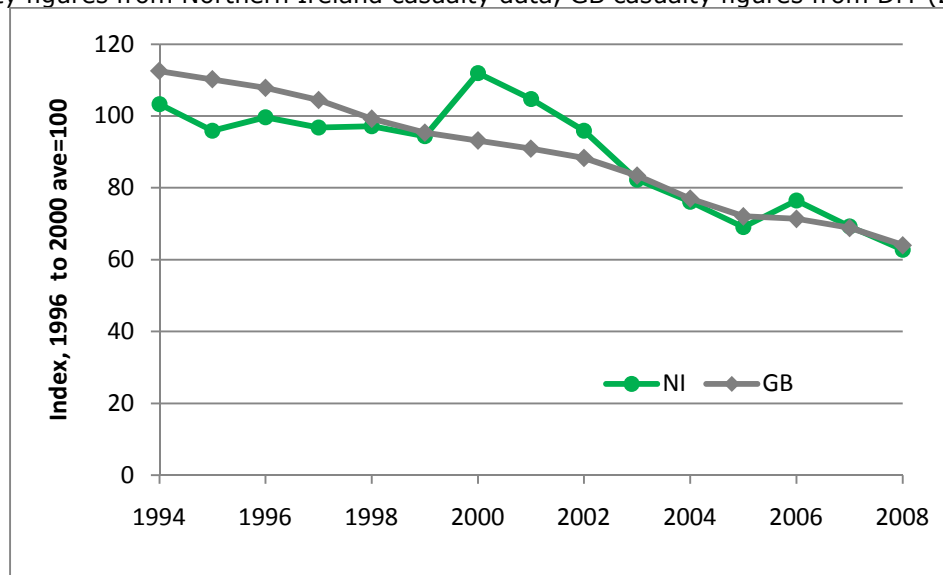NI casualty figures from Northern Ireland casualty data, GB casualty figures from DfT (2009a)

The GB index varied less than that for NI, as would be expected given that the numbers are bigger. Apart from a period between 1999 and 2003, both indices decreased at similar rates throughout this period and over the period as a whole, GB's index reducing to 64 and NI's to 63.

Combining the traffic data with KSI casualty numbers generates a KSI casualty rate per billion vehicle-kilometres. This takes into account exposure and provides a performance indicator of risk of being killed or seriously injured in absolute, as opposed to relative, terms. Figure 3.26 shows the KSI casualty rate per billion vehicle-kilometres for the past 15-years.

Figure 3.26 KSIs per billion vehicle-kilometres

NI casualty figures from Northern Ireland casualty data, GB casualty figures from DfT (2009a), NI traffic figures from The Roads Service (2008), GB traffic figures from DfT (2009c)
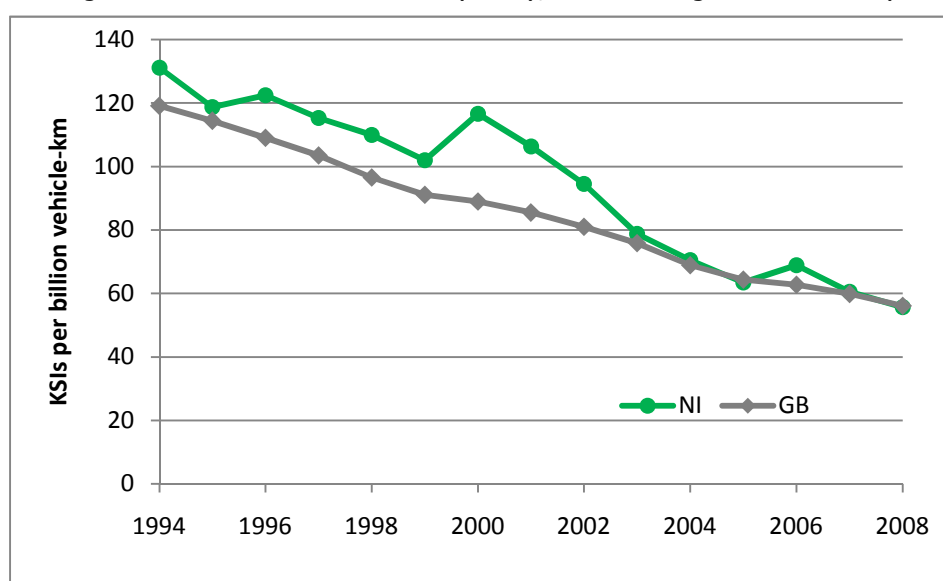
Whereas NI had a higher rate than GB in 1994 – 131 as opposed to 119 - it decreased more quickly in NI than in GB – to the same value of 56 in 2008. Hence NI has experienced a faster reduction in the KSI rate per billion vehicle-kilometres than has GB.

3.3.3 Section summary

It is notable that comparisons between UK countries and regions based on casualties per billion vehicle-kilometres, disaggregated by road type, are more similar than when using other road safety measures. By allowing for exposure, this measure is necessarily a good indicator of collision risk, as discussed in Section 2.3.1.

In terms of the reduction in KSIs per billion vehicle-kilometres, Northern Ireland has made better progress than GB over the last fifteen years.

Unfortunately, detailed traffic flow data are not available by the same disaggregated variables as the casualty and collision data; for example, the collision data do not include the urban/rural split whereas the traffic flow data do not include the speed limit; the speed limit in the collision data can be used as a proxy for urban/rural, but this inevitably results in a lack of accuracy.

3.4 Implications for benchmarking

In order to make fair comparisons between road safety performance in NI and GB, it is necessary either to find a comparable region or to take into account the differences. The analyses in this Chapter suggest that no GOR or country has the same mix of road types, traffic composition and age distribution as NI.

Where meaningful comparisons have been made, the road safety record in NI seems to be quite favourable compared with the rest of UK. The apparent differences are attributable to the different age distributions and the different balances of road types and traffic flows.

Chapter 4 takes these factors into account more fully in order to provide a meaningful set of comparator data.

4 Modelling

Earlier Chapters found that conditions in Northern Ireland do not match those found in any region of Great Britain, as was the case in a previous study, so it still cannot be compared directly with any single region. It was therefore necessary to adjust for different elements of the road safety records of different regions/areas in Great Britain in order to produce a hypothetical comparator region with which to compare Northern Ireland's road safety data. This Chapter presents the modelling of collision data which controls for many factors affecting road safety. Estimates for the expected numbers of collisions/casualties were made, taking into account the road environment and population characteristics, and these were compared with the observed numbers. This enabled meaningful comparisons to be made between road safety in Northern Ireland and that in a hypothetical appropriate comparator from Great Britain.

Data from NI and GB Government Office Regions (GORs) were compared as were overall estimates for NI, England, Wales and Scotland. Assuming that the model developed using GB data was applicable to Northern Ireland, this approach estimated the casualty numbers that would be expected if NI matched those in GB, allowing for adjustments to be made for differences in road types, road lengths and population size.

In order to ensure performance was compared on an appropriate basis, it was necessary to control for as many variables as possible. A primary factor that had to be controlled was vehicle flow. Therefore the benchmarking approach was based on comparable rates determined by vehicle flows or, where appropriate flow data were not available, road lengths. In addition, factors such as the distributions of road types (e.g. urban / rural, speed limits) were included in the modelling exercise.

4.1 Methodology

Modelling requires collision and/or casualty data plus potential explanatory measures disaggregated to an appropriate level, for example to a Government Office Region. It is necessary that the basic data record includes a sufficient number of collisions and is of a size such that the data are reliable, i.e. too small an area could have considerable variation and any explanatory power from the measures may be hidden by random fluctuations within the data.

The literature review found that it is generally assumed that collisions (and casualties) are distributed as Poisson or Negative Binomial variables. When fitting a model, therefore, the distributional forms of the dependent measures must be taken into account. This is achieved using a generalised linear model (GLM) and fitting a $\log_e$ link function with the following functional form:

$$\log_e(\text{casualties}) = \text{constant} + b1.x1 + b2.x2 + b3.x3 + \ldots.$$

In this case, the casualty numbers were modelled, and b1, b2 etc. were parameters to be estimated and were associated with explanatory measures x1, x2, etc. The explanatory measures may be categorical measures such as type of road, or continuous variables such as vehicle flow and road length.

Once a model has been derived it can be used to estimate the expected number of collisions (or casualties). The estimated values could be compared with the observed values to determine how well the model represented the observed data in GB. It could also be used to estimate the number of collisions for another area, e.g. to compare different areas having taken into account influential factors. If data are available on traffic growth, for example, the model could also be used to forecast the likely numbers of future collisions or casualties, though it is unlikely that any model will take all possible variables into account.

4.2 Modelling GB data for NI collisions

The main challenge in modelling is to obtain the necessary data, especially in terms of vehicle flows. This is because vehicle flows are obtained from survey points on the road network and are not necessarily disaggregated to the level required.

The approach used in this project was to model at the level of Government Office Regions in England, plus Wales and Scotland. This gave a total of eleven areas for which traffic flow data were available by type of road. The model used explanatory data on the numbers of registered vehicles, on the size of population, and on vehicle flows and road lengths, for the following five road types:

- Motorway

- Rural A-roads

- Urban A-roads

- Rural other roads (i.e. minor roads in rural areas)

- Urban other roads (i.e. minor roads in urban areas)

Using five types of road and eleven areas generated 55 data records which were used to derive estimates of the parameters in the model. Each record contained the numbers of casualties by severity as well as the data referred to above, and models were therefore derived separately for fatal and KSI severities.

Ideally, the model would have included time as an explanatory variable since there may be background changes in road traffic risk over time. However, doing this is reliant upon having access to annual data for each of the other variables i.e. collision numbers, population, road lengths and, crucially, traffic flows and therefore was not possible.

The initial model used all the explanatory measures, though non-statistically significant measures were excluded from the final model. The final model was then used to derive the expected number of casualties for NI. The casualty numbers were compared with the observed numbers (for 2008) which were grouped by urban/rural, since casualties disaggregated by both road class ('A-road' or 'other road') and road type (urban or rural) were not available. It was necessary to assume that the parameters as estimated from GB data would be applicable to NI and as such provided meaningful expected values for NI.

4.3 Results from modelling

Generalised linear models were fitted to the data records from 2008 for the nine Government Office Regions plus Wales and Scotland data. The initial model included a categorical parameter for the road type (as described above), plus vehicle flow data (billions vehicle-kilometres), population numbers, registered vehicles and road length (km). The population and registered vehicle variables were not found to be statistically significant and so were excluded from the final model.

Given that traffic flow was not available disaggregated by driver age, and that the size of the population itself was not found to be an explanatory factor, measures of the population distribution were not included as a factor within the model. The inclusion of such a variable could be considered in future work; however, without the exposure data disaggregated by driver age, this would require assumptions to be made that may compromise the integrity of the model.

The models thus had the form:

$$\log_e(\text{casualties}) = \text{constant} + b_1.\text{traffic} + b_2.\text{length} + b_i.\text{road-type} \quad i=3....7$$

Casualties were either fatal or KSI – there was one model for each severity. The estimated parameters, which were all statistically significant at the 95% level (i.e. there

is less than a five per cent probability that each estimated parameter was zero), are shown in Table 4.1.

Table 4.1 Estimated model parameters from England GORs, Wales & Scotland data

		Casualty severity	
Parameter		KSI	Fatal
	Constant	5.5380	2.9690
b_1	Traffic flow (billion vehicle-kilometres)	0.10670	0.09393
b_2	Road length (km)	0.000024	0.000026
b_3	Motorway	-2.21800	-1.34600
b_4	Rural A-road	-0.80700	0.02523
b_5	Urban A-road	0.00000	0.00000
b_6	Rural other roads	-1.06100	-0.61680
b_7	Urban other roads	-0.12170	-0.35130

These values indicate that, for example, every ten per cent increase in traffic flow would result in an increase of approximately 1% in the natural log of the number of casualties.

The model for KSI casualties predicted the observed casualty values with a coefficient of determination[1] of 78%, and the fatal model with a coefficient of determination of 79%. The models thus provided a good level of explanatory power, i.e. nearly 80% of the variability in the data was explained by the traffic-flow, road-length and road-type variables. The model 'predicted' nearly 4% more KSI casualties and 3% more fatalities than there actually were; this is the result of using a $\log_e$ model – the natural logarithms of the disaggregated figures sum to the same figure whether using the observed values or those predicted by the model. This 'over-prediction' needs to be borne in mind and any small differences between the predicted and actual NI figures should be interpreted with caution.

The derived models were used to predict casualty numbers for NI. The traffic flows and road lengths applicable to each road type, together with the expected casualty numbers, are given in Table 4.2.

Table 4.2 Background data and expected casualty numbers for NI
Background figures from DRDNI (2009) and The Roads Service (2008)

Road Type Description	Background data		Casualties	
	Road length	Traffic flow Billion	Expected	Expected
	Km	vehicle-kilometres	KSI	Fatal
Motorway	114.8	1.331	32.0	5.8
A-road Rural	1729.9	5.783	219.3	35.9
A-road Urban	543.2	3.446	372.0	27.3
Minor rural	18045.5	7.829	315.5	34.9
Minor urban	4685.7	1.615	299.9	18.0
Total	25119.1	20.002	1238.7	121.9

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[1] This is a measure of the variation explained by the model; 100% would be fully explanatory.

For example, using the equation above, the parameters from Table 4.1 and the background data from Table 4.2, the natural log of the number of KSI casualties on rural A-roads is calculated as follows:

$$5.5380 + 0.10670 * 5.783 + 0.000024 * 1729.9 - 0.80700 = 5.39$$

In this case, therefore, the number of expected casualties is $\exp(5.39) \approx 219$. If the traffic flow were to increase by 10%, the natural log of the number of casualties would become 5.45, i.e. increase by slightly more than 1%, and the actual number of casualties would increase to $\exp(5.45) \approx 233$, i.e. increase by approximately 6%. Note that the predicted risk by road type using the estimated model parameters from GB is stated relative to the risk associated with urban A-roads; motorways aside, 'rural other' roads were found to be the safest in GB.

Observed casualty numbers for NI were not available for each of the road types used in the model. However, road types can be combined to provide figures for motorways, urban roads and rural roads; these are given in Table 4.3. The actual numbers of casualties recorded in NI in 2008 were 1,097 KSI and 107 fatalities, i.e. the model expected approximately 13% more casualties than were actually recorded.

The comparisons presented here are more meaningful than those presented in Table 3.7: whereas the earlier comparisons simply considered casualty rates, the model allowed for the different background factors that apply to Northern Ireland including the proportions of 'A' roads and non 'A' roads.

Table 4.3 Comparison between 2008 expected and observed casualty numbers
Observed numbers from Northern Ireland casualty data

	NI KSI			NI fatal		
	Observed	Expected	% difference	Observed	Expected	% difference
Motorway	17	32.0	-88%	2	5.8	-188%
Urban	438	671.9	-53%	27	45.3	-68%
Rural	642	534.8	17%	78	70.8	9%
Total	1097	1238.7	-13%	107	121.9	-14%

The model expected higher numbers of motorway and urban casualties than were actually recorded. Even when allowing for the slight over-prediction effect of the models, the actual numbers were somewhat lower than those expected. This suggests that, once traffic flow and road length have been taken into account, there were fewer motorway and urban road casualties in NI than would have been expected if its road safety was comparable with that of GB.

On the other hand, the model expected lower numbers of rural casualties than were recorded. Further, given that the model over-predicted to a degree, the actual numbers were clearly higher than the expected casualty numbers. This suggests that there were relatively more rural road casualties in NI as compared to GB even after traffic flow and road length have been taken into account. However, the higher number of rural road casualties was not enough to offset the lower numbers of motorway and urban road casualties: overall, there were fewer road casualties in Northern Ireland in 2008 than would have been expected had Northern Ireland's road safety been comparable with that of GB. When the observed casualty numbers for NI become available for each road type, Table 4.3 could be expanded using the expected values presented in Table 4.2 to make more detailed comparisons.

It should be noted that the models took into account only some of the measures which influence the collision and casualty risk to motorists and, as such, are not perfect. It would be desirable to include other potentially influential measures and/or to disaggregate further those being used. For example, the model used only five levels in

the road type variable and, given the different proportions of single carriageway A-roads and dual-carriageway roads between GB and NI, 'better' models could probably be produced if these types of roads were identified. It would also be useful if the data were further split by speed limit and/or by B, C and unclassified road types. However, further disaggregation would require traffic-flow data and road length data within road type (and class) which are not readily available. Further it would also be potentially valuable to have data for several years such that a greater understanding could be obtained of how numbers of collisions have been changing by types of road and over time.

4.4   Summary and Conclusions

It was established in the previous Chapter that there are some major differences between NI and GB in terms of road types and use. Modelling can be used to adjust for these differences, but is clearly reliant on data being available at a sufficiently disaggregated level.

The models derived were used to predict fatal and KSI casualties in NI based on parameters derived from GB regions. The models indicated that NI had a better road safety record in 2008 for motorways and urban roads than GB; however, they also indicated that NI has a worse safety record on rural roads. That is, NI had a worse road safety record on its rural roads even after allowing for the fact that two-thirds of the traffic-flow is on these roads compared to less than half of the traffic-flow in GB.

The net effect across all road types – motorways, urban and rural roads – is that, had performance been comparable, Northern Ireland had a better road safety record in 2008 than Great Britain.

5   Summary and Conclusions

The project described in this report benchmarked Northern Ireland's road safety performance against appropriate comparator data.

A literature review of relevant research identified the standard approaches taken in benchmarking road safety. The results of this review informed the subsequent analyses.

An examination of the similarities and differences in road safety exposure factors in Northern Ireland and Great Britain concluded that no single country or region of Great Britain was appropriate as a comparator for Northern Ireland. The analyses demonstrated that collision and casualty rates are likely to be higher in Northern Ireland than elsewhere in the UK given the combination of:

- more single carriageway roads

- more traffic on minor rural roads

- a younger population and

- greater distances travelled per person and per vehicle.

Comparing road safety performance in Northern Ireland with that of other countries and Government Office Regions in the United Kingdom confirmed that there are more collisions on single carriageway roads and roads with higher speed limits in Northern Ireland. Given their locations on faster rural roads, collisions are inevitably more severe on average in Northern Ireland, but are less likely to involve vulnerable road users such as motorcyclists, cyclists and pedestrians. The differences in severity between Great Britain and Northern Ireland are greatest for people aged between 16 and 19, which is particularly concerning given that this is the age group when drivers are already at the greatest risk.

When the differences in the proportions of traffic on different road types are accounted for (as far as possible with the available data), Northern Ireland's casualty rates compare quite favourably with those of Great Britain; for example, the likelihood of a fatality on any particular road type (motorway, urban or rural) appears to be lower in Northern Ireland than in Great Britain.

Trend analyses found that the numbers of casualties in Northern Ireland have decreased by approximately the same proportions as those in other parts of the United Kingdom in the last fifteen years. Traffic has grown proportionally more in Northern Ireland in this time period; therefore road safety performance in Northern Ireland has improved more per vehicle kilometre than in the United Kingdom.

The lack of an appropriate comparator region makes it difficult to make reasonable, sustainable and, indeed, fair comparisons between road safety in Northern Ireland and that of other parts of the United Kingdom. Therefore, it was necessary to use statistical modelling to 'build' a hypothetical comparator. The hypothetical comparator was created using data from Great Britain, but adjusted for variables such as traffic flow and road type. This model showed that safety on motorways and on urban roads is substantially better in Northern Ireland than on the same road types in Great Britain once traffic flow and road length have been taken into account. However, even allowing for the exposure factors, safety on rural roads is worse in Northern Ireland than on rural roads in Great Britain; this is particularly concerning given the higher proportion of traffic on rural roads in Northern Ireland. Nonetheless, overall, the net effect across all road types is that there were fewer road casualties in Northern Ireland in 2008 than there would have been had road safety performance been comparable with that in Great Britain.

Improvements to road safety in Northern Ireland need to be directed at young drivers and at rural, single carriageway roads in particular. Further investigation into these issues would enable resources to be prioritised and targeted most effectively.

For future modelling work, it would be useful to have consistency in the way that different datasets are disaggregated in GB and NI. For example, traffic flow, road length and casualty data would ideally be disaggregated by the same variables in GB and NI, including: road classification (e.g. motorway, 'A', 'B', 'C' and unclassified), urban / rural classification and speed limit.

From a modelling perspective, it would also be desirable to have consistent definitions. That is, urban and rural definitions would ideally be the same in GB and NI, and speed limits would ideally be set using the same criteria.

In order to perfectly support this type of modelling work, it would be necessary to adopt precisely the same definitions and categorisations in NI as in GB. However, it is accepted that this is unrealistic and so appropriate proxies will continue to be necessary.

Ideally, traffic flow data would be disaggregated by driver age to allow greater insight into the exposure factors pertaining to young drivers. It is unlikely that traditional traffic flow measurement methods would be able to provide such data; however, it may be possible to combine data from driver surveys with traffic flow counts to estimate this information. Alternatively, future technological developments such as the use of black boxes in vehicles may enable representative data to be gathered.

Given the findings of this project, future modelling work might focus on further disaggregation of factors affecting safety on rural roads and of young drivers in order to identify the precise nature of these road safety challenges.

For example, the modelling could be extended to consider collision types (i.e. single vehicle collisions, head-on collisions, run-off collisions and collisions at intersections) on rural roads in particular.

The relative severity of collisions involving young drivers might also be investigated further; for example, this could be looked at over several years to see how the severity of collisions involving people of different age groups has varied over time. Investigations into the collision risk of young drivers would include a consideration of the advantages and disadvantages of learner and recently passed drivers being limited to a speed of 45mph, for example.

Finally, additional modelling work could take account of developments over time. The modelling undertaken in this project used data from just one year in GB and NI: by using data from several years it would be possible to build time into the model. Subsequently, it would be possible to forecast appropriate benchmarks with which to compare NI collision and casualty data in the future.

Acknowledgements

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Appendix A   Detailed footprint scheme

Transport background			
Road traffic fatalities Population Area Public paved road length Motorway length Number of motor vehicles Motor vehicle kilometres Motor vehicle kilometres on motorways		Percentage of vehicle kilometres per road type	

Final outcomes - fatalities

Collision matrix

Modes	Fat./km (pkm and vkm)		Fat./veh.		Fat./pop.
Age groups	0-14	15-17	18-24	25-64	65+
	Fat./km per mode	idem	idem	idem	idem

	Fat./population per age group		% Fatalities per age group		
	0-14	15-17	18-24	25-64	65+
	% Fatalities per mode	idem	idem	idem	idem

Behaviour	• Percentage of on-the-spot fatalities resulting from crashes involving at least one impaired active road user • Impaired killed drivers/all killed drivers • Percentage of fatalities due to excessive speeds • Percentage of fatalities due to car occupants not wearing a seatbelt • Percentage of fatalities of riders of powered two-wheelers not wearing a safety helmet

Roads	Motorways	A-level roads	Other rural roads	Urban roads
	Fat./vkm per mode	idem	idem	idem
	Fat./vkm per road type		% Fatalities per road type	

Safety Performance Indicators

Modes		Crashworthiness	• Compatibility ratio • Fleet composition	• Fleet age

Behaviour	Speeding	Motorways	A-level roads	Other rural roads	Urban roads
		Drivers over the limit	idem	idem	idem
		Mean speed *and* standard deviation per road type			
	Daytime running lights (DRL)	Motorways	A-level roads	Other rural roads	Urban roads
		DRL rate per vehicle type	idem	idem	idem
		DRL rate per road type			
	Other	• Percentage of impaired road user population • Seatbelt wearing rates (front, rear, child restraint systems) • Helmet wearing rates (motorcycles, mopeds)			
Roads		Percentage length of road types			
		Per road type: • Percentage of intersection types • Intersection density • Percentage of road length with a wide median or median barrier • Percentage of road length with a wide obstacle-free zone or roadside barrier • Percentage of road length with facilities to separate vulnerable road users from motorized traffic			
Trauma management		• Arrival time of emergency services • Quality of medical treatment			

Fat. = fatalities; pop. = population; veh. = vehicles; pkm = person kilometres; vkm = vehicle kilometres.

Detailed footprint scheme (continued)

Policy output		
Types and number of measures		Types and number of measures that have been taken (e.g. regarding drinking & driving, seatbelts and helmets, speed, vehicle fleet characteristics, infrastructure, young drivers, vulnerable road users)
National road safety policy documents		• The political support of the document • The precision of the definition of goals/objects/targets • The use of valid causal theory (problem – solution) • The available means (implementation + monitoring) • The reduced necessity of inter-organizational decisions • The sanctions/incentives for co-producers and target audience • The implementation priority for all stakeholders • The active support of stakeholders
Implemen-tation	Organization	• National government support and funding • Linkages between central and local government
	Modes	• Existence and quality of periodical vehicle inspection • Percentage of cars completely equipped with seatbelts • Percentage of bicycles with side reflectors/lighting
	Behaviour/ enforcement	• The legal BAC limit • The speed limit system (limits per road type) • The chance of getting caught (violations/population); too high BAC, not wearing a seatbelt/helmet, speeding • The penalty level; violation of BAC, seatbelt/helmet, speed • Attitude/awareness of the public
	Behaviour/ education	• Training programmes and access age per mode • Existence/quality annual test (e.g. an eye test) for elderly drivers • The quality of the education for powered two-wheelers • The type of driver's licence for powered two-wheelers
	Roads	• The quality of road design standards • The percentage of all residential areas designed as a '30 km/h zone' • Traffic calming schemes application

Fat. = fatalities; pop. = population; veh. = vehicles; pkm = person kilometres; vkm = vehicle kilometres.