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Collisions involving pedal cyclists on Britain's roads: establishing the causes

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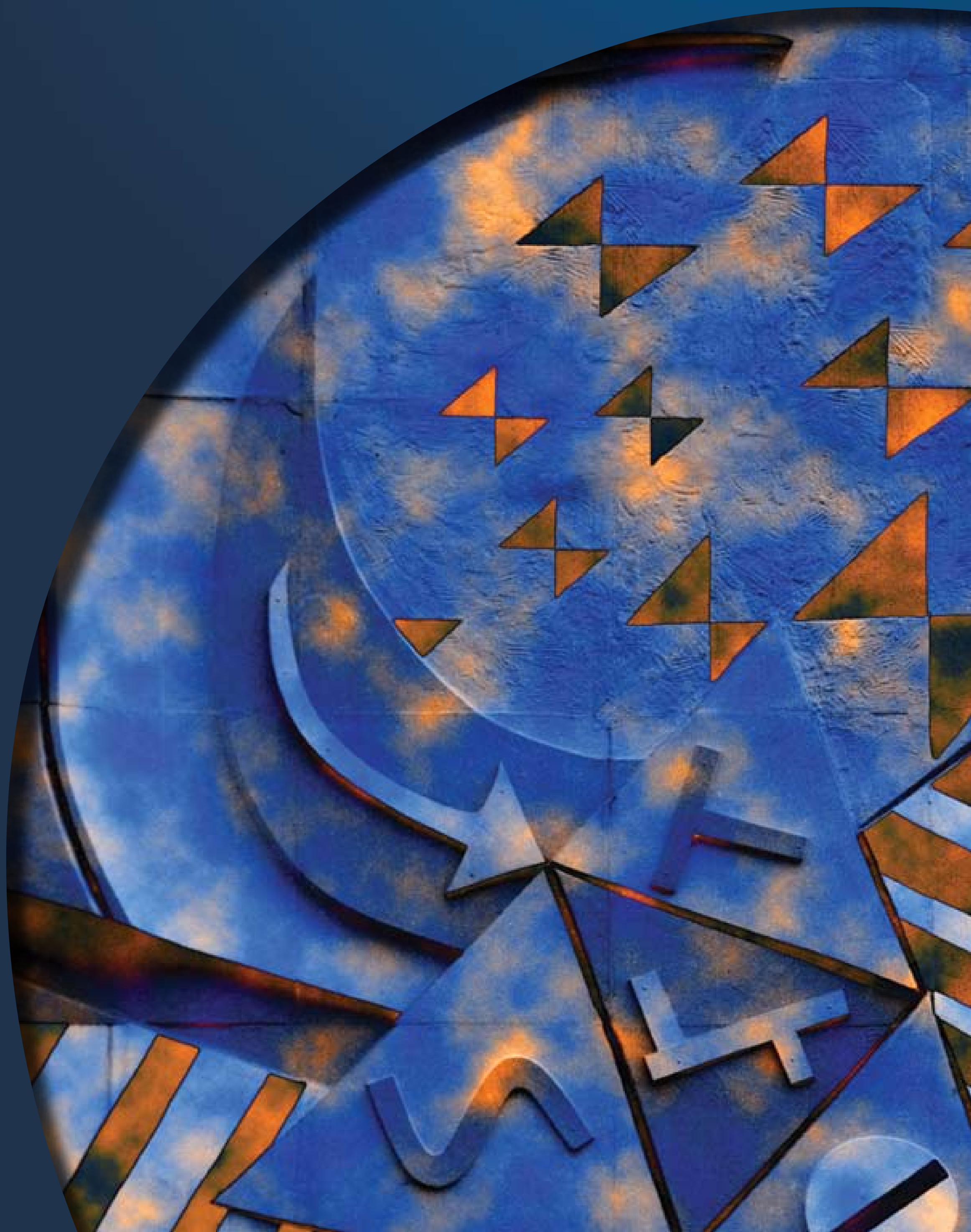

Transport Research Laboratory

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Collisions involving cyclists on Britain's roads: establishing the causes

by Knowles J, Adams S, Cuerden R, , Savill T, Reid S and Tight M

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Executive summary

Introduction

In 2008, 115 pedal cyclists were killed and 2,450 reported as seriously injured on Britain's roads, accounting for 9% of all killed or seriously injured (KSI) road casualties (Department for Transport, 2009). The number of cyclists KSI has steadily increased in recent years, with the figure for 2008[1] being 11% higher than for 2004. However, the number of cyclists killed and injured makes no allowance for the number of people cycling or the distance travelled. The number of KSI per 100 million KM travelled (as measured by the National Road Traffic Survey) was fairly constant between 2002 and 2006 but increased in 2007.

The Government is committed to increasing the amount of cycling in Great Britain and reducing road casualties for all road users, including cyclists. To support this aim the Department for Transport has commissioned a wide-ranging research programme looking into the safety of cyclists that is designed to inform policy on reducing the risk of cycling casualties.

This report provides an in-depth assessment of the key risk factors relating to cycling. The work involved an international literature review and a detailed analysis of cyclist casualties in Great Britain, drawing on both national and in-depth databases of road collisions and cycling. The main source of the casualty data was the national STATS19 injury accident data for 1994-2007. Contributory factors have been recorded nationally as part of the STATS19 system from 2005 and analyses of these data are also reported. The main source of cycling activity data was the National Travel Survey (NTS) of 2006 (the most recent data available at the time of analysis).

Who is being injured[2]?

- 82% of cyclist KSI were male, although males were only slightly more vulnerable than females when exposure (number of KM cycled from the NTS) was taken into account.
- Children accounted for almost a quarter of cyclist KSI casualties, with the majority being between 10 and 15 years old.
- Cyclists aged 10 to 15 years were more at risk of injury (per km cycled based on the NTS) than any other age group.
- Cyclists aged 16 to 29 years were more at risk of injury per KM cycled (based on the NTS) than any other adult group.
- KSI have increased sharply for the 30-49 year age group since the year 2000.
- Collisions involving cyclists aged 50 years old or more tended to have more serious outcomes than the younger age groups.

Where do these collisions happen?

- STATS19 data from 2005-07 show that 97% of bicycles involved in collisions resulting in a serious injury or fatality were on the main carriageway at the time of the collision. Two per cent were coded as being on a cycle lane on the main

[1] At the time the analyses were undertaken, the 2008 data was unavailable and so the majority of the report refers to data up to 2007
[2] The main source of collision data for this study was the national STATS19 injury accident database.

carriageway and one per cent were coded as being on a cycleway/shared footway. It should be noted that STATS19 includes only collisions that occur on the public highway and which were reported to the police.

- Almost three quarters of all cyclist KSI in Great Britain were injured on urban roads, while almost half of cyclist fatalities occurred on rural roads. This indicates that, while the frequency of injuries is greater on urban roads, their severity tends to be greater on rural roads.

- Casualty severity was found to increase with the posted speed limit.

- Almost two-thirds of cyclist KSI were at or near junctions where the risk of conflict is greater.

- A high proportion of child casualties were injured on minor roads in urban areas while the proportion of cyclists KSI on rural roads increases with age for the over 30s.

- Exposure data for people cycling to work were compared with the numbers of collisions involving cyclists. This analysis suggests that there is not a straightforward relationship between levels of cycling to work and collision risk. For example, several areas (Cumbria, Northumberland, Durham, Lancashire, West and South Yorkshire, parts of Wales and London) had higher numbers of casualties relative to the numbers of people cycling to work, whereas some areas with relatively high levels of cycle commuting had lower casualty rates.

When are cyclists injured?

- 80% of cyclist KSI were injured in fine conditions on dry roads.

- 78% of cyclist casualties were injured in daylight.

- Collisions at night/in the dark were more likely to result in a fatality. Rural roads present particular difficulties as not only are the speed limits generally higher but the roads are often unlit. The literature showed that children have a tendency to under-estimate the dangers of cycling at night (Lim and Vigilante, 2007).

- In Britain, a high proportion of cyclist KSI occurred in the summer, with a particularly strong peak for child cyclists between May and September.

- A higher proportion of adults were injured on their bicycles during the working week rather than at the weekend and there were peaks in the morning (6am to 9am) and late afternoon (3pm to 6pm).

- Children were injured predominately in the afternoon (42% between 3 and 6pm). The daily proportions of child cyclists KSI were roughly equal on Monday through to Saturday with a lower proportion on Sunday.

Circumstances and causes of the collision

- Most reported cyclist KSI casualties (83%) in 2005-07 were involved a collision with another vehicle, usually a car or taxi (69%).

- The bicycle was generally hit by the front of the other vehicle. Over a quarter of fatal collisions involved the front of the vehicle hitting the back of the bike.

- Half of the cyclist fatalities involved a car or taxi and these collisions were divided almost equally between urban and rural locations.

- The main collision configurations involving a bicycle and car were the car turning right or left while the cyclist was going straight ahead and the cyclist making a right turn while the car was going straight ahead.

- When a cyclist was involved in a collision with a large goods vehicle, they were more likely to be killed (18% of fatal cycle accidents involved a HGV compared with 4% of serious accidents). Almost half of these fatal accidents in Britain occurred at an urban junction.

- When an HGV was involved, the main collision configuration was the HGV driver making a left turn while the cyclist was going ahead.

- Single cycle accidents (without a preceding collision with another vehicle) are less likely to be reported to the police. Nevertheless, 16% of cyclist KSI casualties for the period 2005-07 in the STATS19 database did not involve a collision with another vehicle. The majority of non-collision cycle accidents occurred away from junctions and a higher proportion of non-collision fatalities occurred in rural locations.

- Contributory factors are assigned by the police reporting officer and provide their view on the likely cause(s) of the collision. It should therefore be borne in mind that, as they are based on the subjective view of a police officer who was not present at the time of the collision, they may not necessarily represent the true cause(s). They should therefore be seen as giving an indication of likely causes.

- In over three-quarters of collisions where a child cyclist was seriously injured, the child's behaviour was reported as the primary contributory factor for the collision. It is not clear whether this means children are more likely than adults to behave in ways that result in a collision or whether the police are simply more likely to attribute contributory factors to a child.

- Where contributory factors were assigned to the driver, 'failed to look properly' was by far the most commonly reported factor (56% of serious collisions), followed by 'poor turn or manoeuvre' (17%) and 'careless, reckless, in a hurry' (17%).

- Cyclist injury severity was greater when the following contributory factors were assigned to the driver: 'impaired by alcohol', 'exceeding the speed limit', 'travelling too fast for conditions' and 'vehicle blind spot' for HGVs.

- 'Passing too close to the cyclist' was judged to be a contributory factor in a quarter of accidents resulting in a serious injury involving HGVs, buses and coaches.

- The main contributory factors attributed to the cyclist included: 'cyclist failed to look properly' (43% of serious collisions) and 'cyclist entering the road from the pavement' (20% of serious collisions). 'Cyclist entering the road from the pavement' was most likely to be attributed to a child (34% of fatal and serious collisions involving children). 'Loss of control', 'dark clothing being worn at night' and 'travelling too fast for conditions' were more common factors in fatal collisions, being reported in twice as many fatal collisions as serious collisions.

- The prime contributory factors for single cycle accidents were judged to be 'loss of control' (reported in 67% of fatal cases), 'travelling too fast for conditions', 'careless, reckless or in a hurry'' and 'impaired by alcohol'.

- Cyclists who were killed at the weekend and in the evening were more likely to be over the legal drink drive limit (13% at the weekend compared with 9% on weekdays, 24% in the 6pm-6am period compared with 4% in the 6am-6pm period).

- Weather was not found to be a key contributory factor in cyclist casualties.

What types of injuries are sustained by cyclists admitted to hospital?

- An analysis of hospital in-patient data found that the head was most likely to sustain injuries, especially for children (45% of children in the database), closely followed by the arms (41% of casualties in the database). Hynd et al (2009) looks at the types of injury in more detail.

- The most serious or life threatening injuries were those to the head, closely followed by the thorax. Cyclists killed in urban areas sustained proportionally more injuries to the lower extremity and abdomen than those in rural areas. This is principally due to the higher percentage of lower speed accidents involving HGVs turning across the cyclist path and running them over. The rural accidents more commonly involved blunt trauma due to higher speed impacts with vehicles and the ground.

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1 Introduction

In 2008, 115 pedal cyclists were killed and 2,450 seriously injured, on British roads, accounting for 9% of all KSI road casualties (Department for Transport, 2009). The Government is committed to reduce road casualties for all road users, including cyclists and has a national casualty target of reducing by 40% the number of people KSI in road collisions by 2010, compared with the baseline average for 1994-98 (DETR, 2000). Whilst there is no specific target relating to cyclists, in 2004 the number of KSI had fallen to 38% below the baseline average. The number of KSI has increased steadily since then, however, and in 2007 and 2008 was only 31% below the baseline average. In order to assess the causes of collisions involving cyclists, the Department for Transport commissioned this research which is designed to inform policy on reducing casualties.

This report covers the key causes of collisions involving cyclists. The work involved an international literature review and a detailed analysis of cyclist casualties in Great Britain, drawing on both national and in-depth databases of road collisions and cycling. The technical details of the research are presented in a separate document (Technical Annex - Knowles et al 2009) and these Annexes are referenced throughout this report.

2 Sources of data on cycling

2.1 Cycling Activity levels

At a national level there is one main source of information about levels of cycling – the National Travel Survey (NTS). There is also limited information on cycling activity levels from the National Road Traffic Survey (NRTS) and the Census of Population.

2.1.1 National Travel Survey (NTS)

The main source of cycling activity data for this study was the 2006 NTS[3]. The NTS is a continuous survey on personal travel based on an interview and a one-week travel diary (completed by all members of the household). In 2006, just under 8,300 households provided details of their personal travel. The survey is intended to establish long term trends rather than short term changes.

The interview is used to record personal information such as age, gender, working status and driving licence holding, and details of the cars available for their use. The travel diary is used to record respondents' trips within Britain over a seven day period. Travel details provided by respondents include trip purpose, method of travel, time of day and trip length. This is available by mode of travel including bicycle.

As with all sample surveys the NTS is subject to sampling error (i.e. estimates made from a sample survey depend on the particular sample chosen and generally differ from the true values of the population). This is not usually a problem when considering large samples (such as car trips of all types in GB) but may give misleading information when considering data from small samples, such as cyclists in a particular age band or from small local authority areas. Five years of data were combined (2002-2006) in this report to make the results more robust for cyclists.

The NTS cycle data, while of interest at a national level, cannot be reliably disaggregated to explore trends at a local level nor to establish variations in casualty rate. A source for more information about the NTS is the User Guide available on the UK Data Archive[4].

2.1.2 National Road traffic survey (NRTS)

A second source of cycling activity data is the NRTS which provides an annual estimate of the cycle traffic (in million vehicle kilometres). The road traffic estimates are calculated by combining data collected by some 180 Automatic Traffic Counters (ATCs) and 12-hour manual counts at approximately ten thousand sites per annum with road lengths. The figures that relate to traffic are measured in terms of vehicle kilometres. Pedal cycle estimates need to be treated with caution however as they are based on small sample sizes.

2.1.3 Population Census

The Population Census is undertaken nationally every 10 years by the Office for National Statistics (ONS) covering all people and households in the country. It provides essential information from national to neighbourhood level for government, business and the

[3] Data from the 2007 survey were not available at the time the analysis was undertaken. The 2007 results were delayed and were not published until August 2009.

[4] UK Data Archive Study Number 5340 - National Travel Survey, 2002-2006:
http://www.data-archive.ac.uk/doc/5340/mrdoc/pdf/5340userguide1.pdf
NTS technical report 2008:
http://www.dft.gov.uk/pgr/statistics/datatablespublications/personal/methodology/ntstechreports/ntstechrep2008

community. The most recent population census was on 29 April 2001. The key Statistics dataset is a series of 33 tables which provide a summary of the complete results of the Census. Table 15 from this dataset provides information, in numbers, on the method of travel to work of the population of England and Wales. It covers the population 'all people aged 16-74 in employment', and contains data at a Local Authority level.

As the Census was last undertaken in 2001, it is a relatively old dataset. It is possible to make some estimation of variations and trends in cycle trips to work but it is not possible to establish a detailed understanding of how much cycling is taking place, where and why. In the case of cycling this is exacerbated by the bicycle's dual role as both a mode of transport and a leisure activity, both of which can take place on and/or off the public highway.

2.2 Collision data for Great Britain

The following data sources were interrogated to gain a detailed picture of cyclist casualties in Great Britain.

2.2.1 Collision data – STATS19 and contributory factors

The main source of collision data for this study is the national STATS19 injury accident data for 1994 to 2007[5]. STATS19 is the national database of records of road accidents that occur on the highway involving personal injury reported to and by the police. The highway[6] does not include cycle paths or tracks with no access for motor vehicles and therefore does not include activities such as off-road mountain biking. Thus the majority of the collisions considered in this report are those where the rider is likely to come into contact with a vehicle. A number of variables are recorded for each collision, including details of the collision circumstances, vehicles involved and the resulting casualties (details of what information is recorded is given in STATS20, DfT, 2004). Driver/rider and passenger casualties are linked to the vehicle they were in/on at the time of the collision so it is possible to analyse those collisions where a pedal cyclist was injured.

Contributory factor data has been recorded nationally as part of the STATS19 system since 2005. Contributory factors are reported by the police officer and represent their view of the key factors leading to the collision. Whilst they give a good indication of the causal factors, they should be treated with caution: many rely on a subjective assessment rather than hard facts and they are inevitably determined after the accident occurred. This data has been used in the present study to indicate possible causes of the collision, and therefore provides useful information on what could have been done to potentially prevent it. There are 77 different factors, and each collision can have up to six factors attributed to it. Contributory factors can be either related to the road environment, behaviour or actions of a driver, rider or pedestrian. All contributory factors relating to collisions involving a pedal cyclist were looked at in detail for this report and the full analysis is contained in Annex H (Knowles et al, 2009).

2.2.2 Hospital data

The Scottish Hospital In-Patient System[7] (SHIPS) has been in operation for over two decades, and in England the Hospital Episodes Statistics (HES)[8] has operated for over

[5] At the time the analyses were carried out, the 2008 data were not available. Since completing the work, the data have been released and updated trend information is available in Annex A.

[6] Includes A, B, C and unclassified roads, bus lanes, cycle lanes, shared access footways, footways and pavements

[7] The hospital in-patient data is supplied by the Information Services Division of the NHS National Services Scotland. It is released to TRL under conditions agreed with the Privacy Committee of the Scottish Health Service and the British Medical Association (Scottish Joint Consultants Committee), as described by Keigan et al. (1999).

ten years. These sources provide a source of information on the medical outcome of more serious road collisions[9]. They cover patients admitted to hospital and so exclude attendance at A & E or visits to a GP, but do include collisions not reported to the police. This data source contains very detailed coverage of medical diagnoses using the International Classification of Diseases codes (ICD codes). However they contain few details of the collision and the most that was known was whether the patient was riding a pedal cycle.

2.2.2.1 Under-reporting of cyclist collisions to the police

The collisions recorded in the STATS19 database form a sample of the national population of road collisions involving personal injury. In Great Britain there is no legal obligation to report collisions, providing the parties concerned exchange details at the scene; an appreciable number of non-fatal collisions are thus not reported to the police and therefore do not appear in the STATS19 database (Tranter, 2008). In addition, the police may on occasion underestimate the severity of a collision because of the difficulty in distinguishing severity at the scene of the collision (Tranter, 2008).

Simpson (1996) showed that the number of seriously injured casualties in the sample should be increased by a factor of 2.76 and the number of slight casualties should be increased by 1.70. Moreover, pedal cyclists form the user group that is least well represented in the STATS19 database. The corresponding factors found for pedal cyclists were 5.73 and 2.35 respectively. The Simpson study analysed data from 1993, however, so these factors may no longer be applicable.

A wide-ranging literature review undertaken as part of the current study found that under-reporting was particularly acute when no motor vehicle was involved (Stutts *et al*, 1990).

Medical records for hospital in-patients can be used to make comparisons with the STATS19 sample. However, they only include those casualties that require medical treatment and are admitted to hospital, i.e. they exclude those treated in hospital A&E departments or doctors' surgeries. They also exclude those casualties that require no medical treatment (the formal STATS19 definition of slight injury includes "injuries not requiring medical treatment").

Whilst the adjustment factors calculated using these data are the best measures of STATS19 reporting levels that can be prepared at present, they are not perfect.. The fact that only in-patient data are available means that the calculated factors may be lower than they would be if hospital A&E casualties and those treated in doctors surgeries were also included especially for slight casualties. In spite of these limitations, however, the method of using medical records to check the levels of under-reporting of police-reported casualty data for cyclists has been used in a number of other studies (e.g. DfT 2008, Meuleners, *et al*., 2003).

TRL has linked data from the Scottish Hospital In-Patient System (SHIPS) with Scottish STATS19 data for many years. Analysis of the SHIPS/STATS19 data for this study suggests that for each serious STATS19 cyclist casualty recorded between 2001 and 2005 there were actually 2.95 serious casualties, while the factor for slight casualties was 1.25 (see Annex B; Knowles et al, 2009); the corresponding factors for all road users were 1.25 and 1.06.

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[8] Tranner (2008)

[9] Each patient record contains clinical details of the patient's condition, coded to the International Classification of Diseases (ICD). The ICD codes allow the identification of patients whose injuries have been caused by a road traffic accident.

In principle, the STATS19 casualty data presented in this report could be adjusted (increased) using these factors to compensate for the fact that many SHIPS casualties are not recorded in the STATS19 data. This was not done, however, because of the limitations of the approach using only in-patient data.

2.2.3 Coroners data

A principal source of information on the role of alcohol in road collisions is the DfT commissioned database of blood alcohol concentration (BAC) of fatally injured casualties aged 16 and over who die within 12 hours of a collision. These data, supplied by the Coroners in England and Wales and the Procurators Fiscal in Scotland, are linked to the national STATS19 road accident database as part of another project carried out by TRL on behalf of DfT (TRL leaflet LF2104, 2008). This study was able to make use of this database to study the BAC of cyclist fatalities. It was not possible to study the BAC of drivers involved in cyclist collisions using this data as it is very rare that the driver dies in these types of collisions.

About 80% of all fatally injured road collision casualties aged 16 and over dies within 12 hours of the collision and the blood alcohol level is known for about 78% of them (TRL, 2008). The BAC was known for 66% of cyclist fatalities aged 16 or over who died within 12 hours for 2002-2006.

2.2.4 Police Fatal Files

Police reports on fatal collisions provide detailed information on the events leading up to a collision. These reports are comprehensive, including witness statements, reports by collision investigation and vehicle examination specialists, sketch plans showing pre-impact trajectories and post-impact positions of vehicles and photographs.

In 1992, TRL was commissioned by DfT to set up a scheme whereby police forces in England and Wales would routinely send fatal road collision reports to TRL when they were no longer of use for legal purposes. These fatal reports provide a unique insight into how and why fatal collisions occur and much of the detailed information contained within them is not available from any other source. The current archive contains over 36,000 police fatal collision reports.

There were 810 cyclist fatalities between 2001 and 2006 in Great Britain. TRL has recently undertaken a project for TfL (Keigan et al, 2009) which investigated all the fatal cyclist collisions in London over this period and coded the results into a database (92 cases).

The TfL project provided an insight into London collisions but did not cover cyclist collisions in *rural* locations. Therefore, for this project the research team reviewed 50 fatal files from *rural* locations (see Annex C: Knowles et al, 2009).Ideally the 50 files should have been selected to represent the national picture but in practice this was not possible.

2.2.5 On the Spot study

In 1999, the UK's Department for Transport and Highways Agency (HA) commissioned the 'On the Spot' (OTS) research project to collect detailed information at the scene of a sample of road collisions, covering all severities. In-depth collision investigations have been, and continue to be, carried out to study their causes and injury mechanisms, human involvement, highway and vehicle design.

Two investigation teams, the Vehicle Safety Research Centre (VSRC) at Loughborough University and the Transport Research Laboratory (TRL), work in close co-operation to produce a joint dataset. The teams work in the Nottinghamshire and Thames Valley Police Force areas respectively, and each investigate around 250 crashes per year. A comprehensive description of the methodology and investigations achieved during Phases I and II (currently the project is in its third phase) is provided in Cuerden *et al*, 2008.

There have been 149 OTS cyclist related collisions investigated to date. These include 4 fatalities, 36 seriously injured, 101 slightly injured and 8 uninjured cyclists. These cases were reviewed as part of this project, concentrating on the extra detailed information that the OTS can provide to complement the STATS19 analysis (see Annex D: Knowles et al, 2009).

2.3 International Literature

An international review of the literature was undertaken to establish what is already known about casualties involving cyclists (For more detail on the methodological approach see Annex E : Knowles et al, 2009).

Much of the literature relates to research carried out overseas – primarily Australia, New Zealand, Western Europe and Scandinavia. It is important to recognise that there may be important differences between countries which should be taken into account when making comparisons with the UK situation. Variations that may be significant in causing different casualty outcomes are numerous and can include:

- More or less emphasis on leisure cycling;
- Different age profile among cycle users;
- Different climate;
- Different cultural, legal and regulatory context;
- Different methodologies for collection of data;
- Different sub-national political structures and responsibilities; and
- Different patterns and densities of road networks and vehicle use.

3 Numbers of Cyclist Casualties

3.1 Trends in Britain[10].

In 2008, 115 pedal cyclists were killed and 2,450 seriously injured, accounting for 9% of all KSI road casualties (Figure 3-1). This proportion has slowly increased from 6% in 2003 to its current level of 9% in 2008 as the number of casualties for the other road users has fallen more quickly.

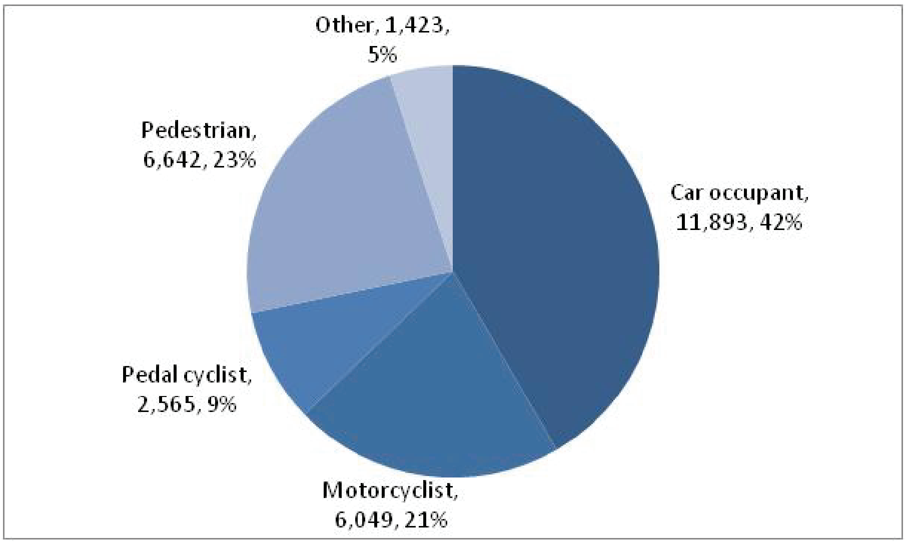

Figure 3-1 Distribution of KSI by road user group, 2008

Figure 3-2 shows how the number of pedal cyclists killed and KSI have changed since 1994: the number of cyclist KSI fell until 2004 but since then the trend has started to rise. The number of cyclists killed also increased in 2004 and 2005 but has been falling since 2005 and continues to fall in 2008, returning to the levels seen in 2003. Compared to the 1994-98 annual average that was adopted as the basis for the national casualty reduction target for 2010 (DETR, 2000), the number of cyclist casualties KSI had decreased by almost a third (31%) by 2008 and the number killed had fallen by just over a third (38%).

[10] The analyses for this report were carried out in the autumn of 2008 hence the 2008 data was not available to include. Since completing the work, the data has been released and so the trend information has been updated and more detail is available in Annex A

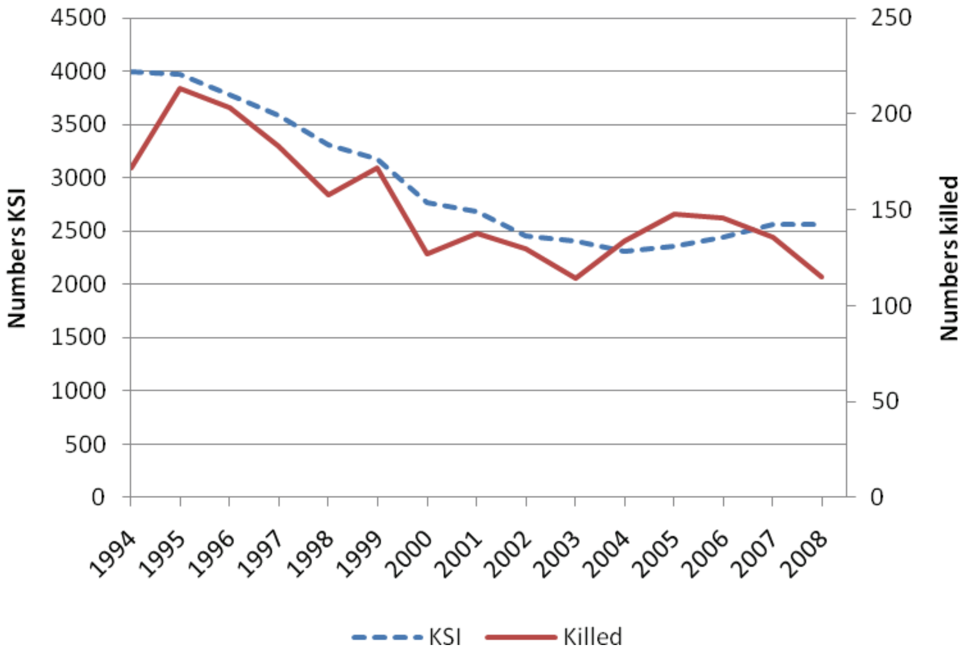

Figure 3-2 Pedal cyclist casualty trends, 1994-2008

The number of cyclists killed and injured makes no allowance for the number of people cycling or the distance travelled. Cycling has been in long term decline in Britain, falling from about 23 billion passenger kilometres in the early 1940s to under 5 billion passenger kilometres in 2007 (as measured by the National Road Traffic Survey- NRTS). The amount of cycling has remained fairly constant since about 2002 (apparent from both the National Travel Survey and NRTS) varying from 4.2 to 4.6 billion passenger kilometres. Figure 3-3 shows the KSI cyclist casualty rate per 100 million cyclist kilometres travelled. The number of KSI per 100 million KM travelled was fairly constant between 2002 and 2006 but increased in 2007, falling again in 2008.

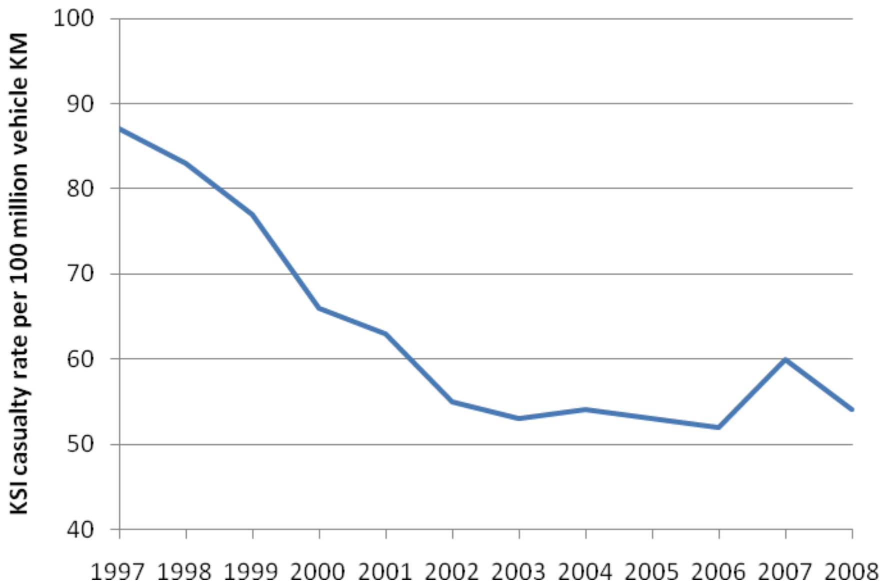

Figure 3-3 Pedal cyclist KSI casualty rate per 100 million vehicle km, 1997-2008

The number of pedal cyclist casualties varies by region, with Greater London and the South East having the highest proportion of KSI cyclists in 2005-07 and the North East and Wales having the lowest (Table 3-1). To be meaningful these variations need to be related to the amount of cycling in the areas, but the current data sources (NTS and NRTS) are unable to provide this level of detail. Although some local authority data is collected on trends in cycle use, with one or two exceptions this is not adequate to determine an absolute level of cycling at a local level nor to compare levels of activity between different regions. The best source available was the 2001 Census of Population which showed that within England and Wales there was wide divergence in the use of cycles for travel to work. Detailed geographical data are presented in Annex F (Knowles et al, 2009).

Table 3-1 Cyclist KSI (aged 16-74) by region, 2005-07

Region	Regional distribution of cyclist KSI 2005-07
East Midlands	8%
East of England	11%
Greater London	18%
North East	4%
North West	13%
South East	17%
South West	8%
West Midlands	7%
Yorkshire & Humberside	11%
Wales	3%
England and Wales	100%

3.1.1 Relationship between perceptions of safety and modal choice

Concerns about safety have an impact on whether people choose to cycle or not, although there are clearly other factors that people take into consideration (e.g. Bergstrom & Magnusson, 2003; McKenna & Whatling, 2007). The choice of route is also partly dependent on safety considerations along with, for example, perceived convenience and ease of access.

The National Cycle Network and Cycling Demonstration Towns have aimed to address perceived safety, convenience and ease of access to their infrastructure with longer term increases in cycling levels expected as a result. Whether these expected increases result from perceived (rather than actual) safety improvements, from more active promotion of cycling, through enhanced convenience or some combination of these (and other) factors is not yet fully understood. In the case of the National Cycle Network, schools linked to it have experienced higher levels of participation in cycling (DfT, 2008).

Increasing perceived safety is also likely to play a role in bringing cyclists onto the road system. For example Leden, *et al*. (2006) showed that various calming measures on a main road through a small town increased levels of cycling, improved cyclists' perceptions of safety and reduced casualties, although not uniformly. In addition to road safety, personal security is widely known to affect modal choice. Stone & Gosling (2008) showed that around half of 1,002 cyclists surveyed felt safe in terms of their personal security when cycling during the day, while only one fifth said they felt safe at night.

3.1.2 Relationship between risk and modal choice

Safety in Numbers (SiN) is a theory that the risk of injury for any given cyclist in a road collision decreases as the overall volume of cyclist activity increases. For example the theory assumes that if cycling activity doubles then the number of cyclists injured would be less than double. Although research assessed as part of this study is strongly suggestive that a safety in numbers effect exists for cyclists, the available research is not conclusive.

It is also not clear how large the SiN effect is or what causes it. The evidence does suggest however that higher levels of cycling and lower levels of risk to cyclists can co-exist. Thus the objectives of increasing cycle use while reducing the risk of casualties are compatible and complementary. The SiN effect is considered in more detail in Annex G (Knowles et al, 2009), where a number of issues are highlighted with regard to the current available research.

4 Who is being injured?

The only personal details recorded in STATS19 are the age and gender of the casualties involved. There is a question which records journey purpose but in three-quarters of cases this was unknown and so has not been analysed.

4.1 Age

Analyses relating to age have been produced for Great Britain using STATS19 casualty data, combined with an estimate of the total cycle mileage per year split by age group calculated from the NTS[11]. The risk calculated in these terms shown in

Table 4-1 suggests that:

- Children aged 10-15 are more at risk from being injured on a pedal cycle than the other age groups;
- The risk of a child being injured tends to increase with age;
- The risk of an adult being injured tends to decrease with age (with the exception of those over 60 years).

Table 4-1 shows that a child aged 10-15 has double the risk of KSI than an adult aged 40-49. Although the casualty numbers for both these age groups were similar at 16% (Figure 4-2) the levels of cycling activity were different, the 40-49 age group accounted for 20% of the cycle km travelled while the 10-15 year olds accounted for only 9%.

Table 4-1 also shows that the risk of an adult being involved in a collision tends to decrease with age, with the exception of those over 60 years.

Table 4-1 Pedal cyclist casualty rates per million KM travelled by age, 2005-07

Age	Killed	KSI	Slight	All
0-4	0.02	0.3	1.6	1.9
5-9	0.04	1.0	6.6	7.6
10-15	0.05	1.3	8.0	9.3
16-19	0.03	1.0	6.3	7.3
20-29	0.03	0.7	4.7	5.4
30-39	0.03	0.6	3.3	3.9
40-49	0.03	0.6	2.6	3.2
50-59	0.05	0.5	2.2	2.8
60-69	0.05	0.6	2.2	2.9
70+	0.15	0.9	2.3	3.3

Figure 4-1 presents the pedal cyclist casualty data by age since 1994. The main feature to note is the increase in the proportion of 30-49 year old cyclists who were KSI since 2000. In contrast, the proportion of cyclist KSI who were children has been falling in recent years. Similar patterns were observed for the distribution of cyclist fatalities (see Annex A: Knowles et al, 2009).

[11] The exposure data used to calculate these rates were extracted from the NTS. The casualty rate differs from Figure 3-3 in section 3.1 which was calculated using data from the NRTS. These two sources give different annual mileage totals as well as different trends (Broughton and Buckle, 2008). The NTS was the preferred source as it allows the mileage estimates to be split by age group.

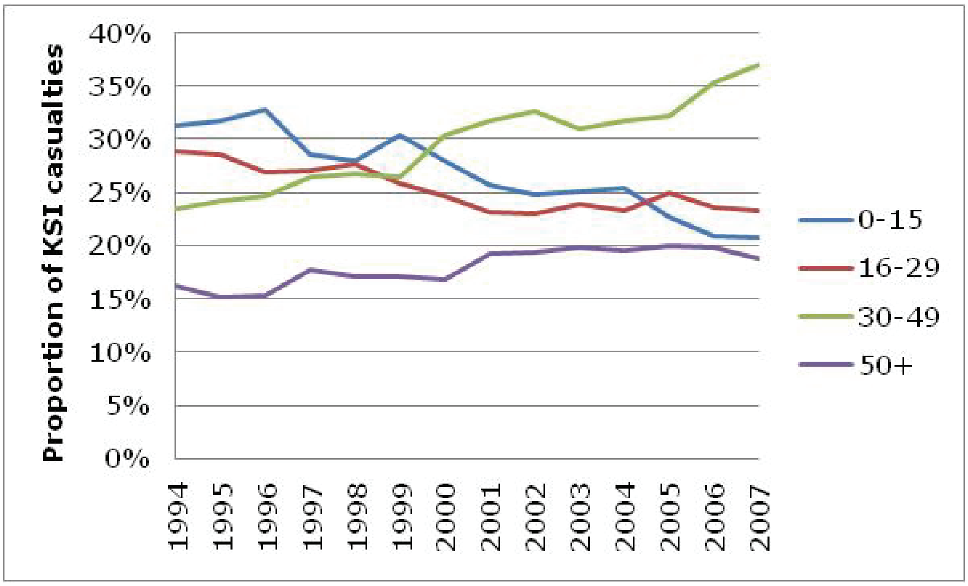

Figure 4-1 Pedal Cyclists KSI by age, 1994-2007

Figure 4-2 shows the age distribution of pedal cyclist casualties by severity for the period 2005 to 2007. There is a clear peak of KSI pedal cyclist casualties for the 10-15 year age group and a smaller proportion of pedal cyclists KSI aged over 60. The age distribution of pedal cyclists that were killed differs from the KSI and slight distributions, with the injuries for those aged over 50 years tending to be more severe while the injuries of those aged less than 30 tending to be less severe. Kim, *et al*. (2007) found that if a cyclist is aged 55 years or older then they have more than double the probability of suffering a fatal injury in an collision, all other items being kept constant. Other studies have reached similar conclusions (e.g. Eilert-Petersson and Schelp, 1997; Stone and Broughton, 2003). There is a peak of cyclists killed aged 55-59; this is most probably due to statistical chance as the annual numbers killed are very small.

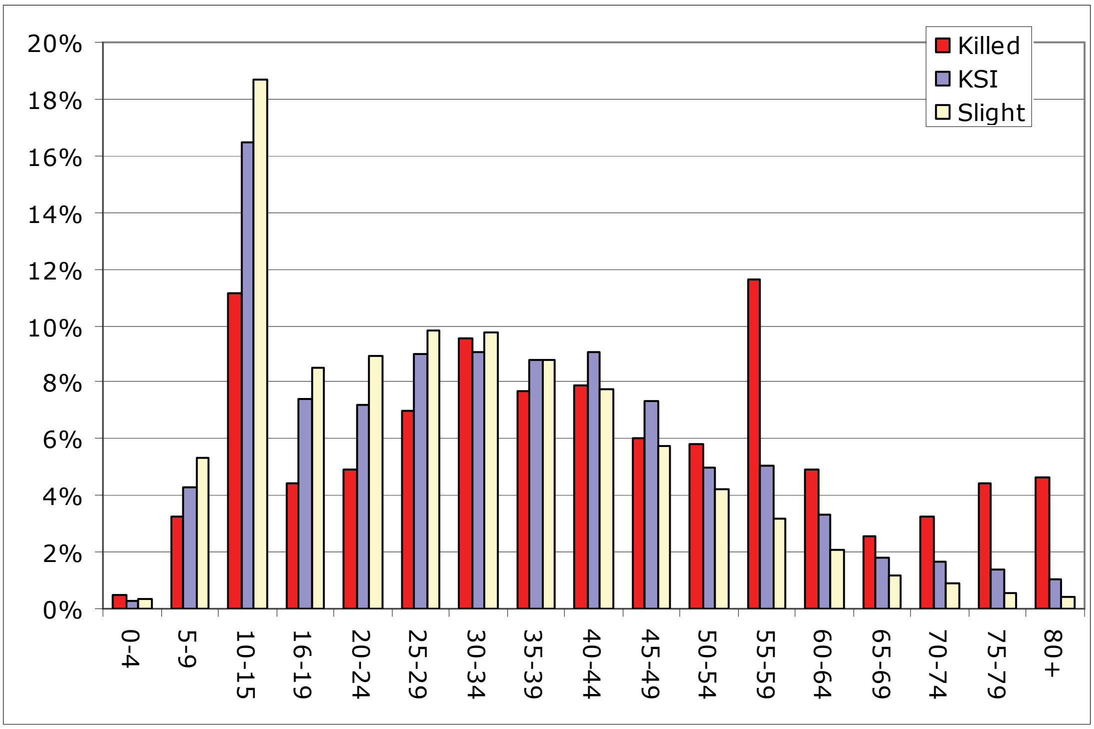

Figure 4-2 Age distribution of pedal cyclist casualties (2005-07)

Other studies in both the UK and abroad have also found that children are over-represented in bicycle-related injuries (e.g. Stone & Broughton, 2003; Rodgers, 2000; Eilert-Petersson and Schelp, 1997; Maring and van Schagen, 1990), although

Table 4-1 suggests that the risk increases as the age of the child increases and so the term 'children' needs to be defined by age group. Possible explanations given in the literature for the increased risk of injury for children included the following:

- Less developed perceptual-motor speed and cognitive skills of children are related to collision involvement (Maring et al., 1990; Kim, et al., 2007; and Tutert, 2004. Tutert (2004) notes that until the age of 10 years most children still underestimate the speed of approaching cars whilst boys between 10 and 14 years old tend to overestimate the speed.
- Older children may be at increased risk because of changing patterns of exposure, such as increasing levels of cycling with less supervision. Older children/young adults may also tend to take greater risks when cycling (Rodgers, 1997; Hodgdon et al., 1981), although this may interact with issues of cognitive development.
- A tendency for children to be less mindful of traffic rules than adults, responding instead to immediate traffic conflicts (Brezina & Kramer, 1970);
- Maring and Van Schagen (1990) found children possessed the lowest levels of knowledge regarding road priority rules of cyclists interacting with cars.
- A review of the relationship between children's psychological characteristics and their involvement in traffic collisions identified that traffic collision risk amongst children was directly linked to a *'low adherence to responsible social values'*, sensation seeking, impulsiveness and hyperactivity (DfT, 1999).
- Children from deprived areas have higher collision involvement when cycling (Epperson, 1995). DfT's data (2008) show that the risk associated with deprivation (measured by Indices of Multiple Deprivation IMD[12]) is more acute for children than for all age groups taken together. The number of casualties per 100,000 population for cyclists aged 0-16 declines directly with deprivation, from the most deprived areas to the least.
- Although children can appear to be competent in making road-safety related judgements they may have less awareness of their own abilities (e.g. slower to start moving and slower acceleration when crossing a line of traffic)(Plumert et al., 2004). Research for the Department for Transport (1996b) considered the skills and abilities needed by pedestrians, particularly children, and concluded that training can be effective in improving children's skills in negotiating trafficked environments but that such training is only likely to be effective if it is practical (rather than theoretical) in nature.

It is clear that age can to some extent predict cycling risk although this is not a straightforward relationship. The exact mechanisms underlying that risk are complex and interacting but are likely to include attitude to risk, cognition, impulsiveness and vulnerability to collisions.

[12] The Index of Multiple Deprivation combines a number of indicators (economic, social and housing) into a single deprivation score for each small area in England. This allows each area to be ranked relative to one another according to their level of deprivation.

4.2 Gender

Table 4-2 shows that the majority of pedal cyclist casualties are male. This proportion varies with injury severity, with the proportion of male casualties being greater for fatal casualties than for serious or slight. This result is partly reflected in the cycling activity data, with the majority of the cycle mileage being done by males (77% of the total NTS cycle mileage). The data suggest that, even when allowing for greater exposure, males are somewhat over-represented, particularly among fatal casualties, with males being 1.7 times more likely to be killed and 1.4 times more likely to be KSI than females.

Williams et al (2002) showed that children with Attention Deficit Hyperactivity Disorder (ADHD) or classified as being especially 'impulsive' or 'hyperactive' by their parents are over-represented in pedestrian and cycling collisions. ADHD is believed to affect three to five per cent of all children (Williams et al., 2002) and is two to three times more prevalent among boys than girls. A greater proportion of children may be expected to be 'impulsive' whilst not being diagnosed as actually suffering from ADHD.

Table 4-2 The gender distribution of pedal cyclist casualties, 2005-07

	Male	**Female**	**Total (100 %)**
Killed	85%	15%	430
KSI	82%	18%	7,366
Slight	80%	20%	41,586

4.3 Age and Gender

Table 4-3 presents the age distribution of male and female injured cyclists. The distributions follow similar patterns although higher proportions of KSI male casualties are aged between 10-15 years compared to females.

Table 4-3 Age and gender distribution of KSI pedal cyclist casualties, 2005-07

	Age												
	0-9	10-15	16-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60+	All (100%)
Male	5%	17%	8%	7%	9%	9%	9%	9%	7%	5%	5%	9%	6,052
Female	5%	13%	6%	8%	11%	10%	8%	8%	8%	5%	6%	11%	1,312
All	5%	17%	8%	7%	9%	9%	9%	9%	8%	5%	5%	9%	7,364

STATS19 records the age and gender of the driver of the other vehicle (i.e. the vehicle that collided with the cycle) and Table 4-4 presents this by vehicle type. This shows that overall two thirds of collisions with cyclists involve a driver aged 20-49 years.

Table 4-4 Pedal cyclist KSI from a collision with another vehicle by age and gender of other driver, 2005-07

Age	Car/ taxi	Van	HGV	Bus/ coach/ minibus	Other	All
16-19	6%	1%	0%	0%	19%	6%
20-29	22%	25%	11%	13%	23%	21%
30-39	22%	24%	32%	23%	23%	22%
40-49	22%	26%	29%	20%	19%	22%
50-59	14%	18%	21%	31%	9%	15%
60+	15%	6%	8%	12%	5%	13%
All (=100%)	5,050	404	295	178	187	6,114

5 Where are cyclists being injured?

The STATS19 database covers all police-reported injury road collisions that occur on the highway. The highway[13] does not include cycle paths or tracks with no access for motor vehicles and therefore does not include activities such as off-road mountain biking. Thus the majority of the collisions considered in this report are those where the rider is likely to come into contact with a vehicle (84% of the KSI cycle collisions recorded in STATS19 were as a result of an impact with another vehicle). The main exception to this is in Section 8, where the cyclist injuries discussed come from hospital inpatient data (SHIPS and HES), and almost two-thirds of these collisions did not involve an impact with another vehicle.

It should be noted that because STATS19 systematically excludes off-road injuries they are not well represented in the available data. Nevertheless there is some evidence from the literature that a significant proportion of injured cyclists sustain their injuries off-road (e.g. in car parks and on off-road trails). These studies were based on hospital admission data and data from emergency departments (e.g. Turner, et al. 2006, Meuleners, et al. 2003, Jacobson et al. 1998).

Of those casualties represented in the STATS19 data, the majority of cyclists were injured on roads in urban areas and this was also the case for those KSI (Figure 5-1). In contrast, the pattern differs for fatalities, with almost half being killed in rural areas. This suggests that rural roads represent a high level of risk for the cyclist, possibly because of traffic travelling at faster speeds and lower levels of lighting. The DfT traffic census is unable to provide reliable cycle traffic data by road type to calculate this risk due to small sample size. However, Broughton and Buckle (2008) found that the number killed per KM cycled on roads with a speed limit over 40mph was about 10 times the overall rate and the KSI rate was 3.2 times the overall rate.

Figure 5-1 presents the KSI pedal cyclist casualty data by road type for 2005-07. A composite road type has been used based on the GIS based urban/rural classification and the STATS19 road class. The major roads are taken to be motorways and A-class roads, while the minor roads are B and C class roads and unclassified roads. The table highlights the differences between cyclists that are killed and KSI. Roughly an equal proportion of cyclists killed are cycling on all four road types while the majority of the cyclists KSI are cycling on minor roads (59%). This proportion has remained fairly constant since 1994.

[13] Includes A, B, C and unclassified roads, bus lanes, cycle lanes, shared access footways, footways and pavements

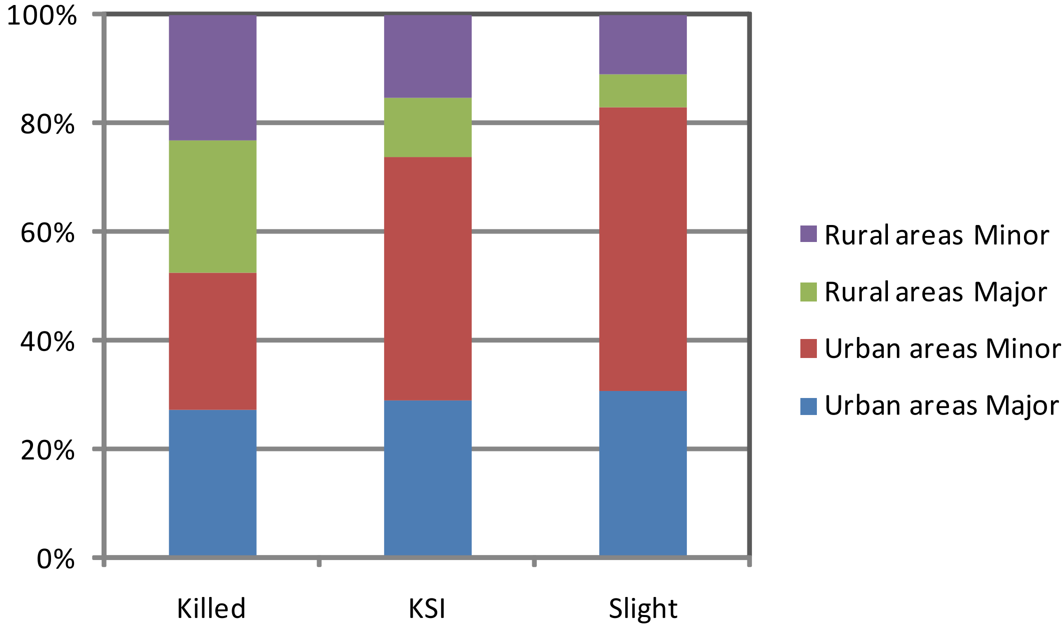

Figure 5-1 Pedal cyclists casualties by road type 2005-2007

Table 5-1 shows that casualty severity increases with the speed limit. 45% of all fatalities are on roads with a speed limit of 40mph or more compared with 21% of KSI cyclists and 13% of slightly injured cyclists.

Several studies from the literature review emphasised that cyclist fatality rates are directly related to vehicle speed (e.g. Garder, 1994; Garder *et al*., 1998; Fernandez de Cieza *et al*., 1999; Stone & Broughton, 2003). According to Kim, *et al*. (2007) the probability of injury or fatality in a collision is greatly increased as the speed prior to impact increases beyond 32.2 km/h (20mph). This research is supported by Stone & Broughton (2003), who also found that fatality rate rises markedly with the posted speed limit.

Table 5-1 Pedal cyclist casualties by speed limit, 2005-07

	Killed	KSI	Slight
20	1%	1%	1%
30	53%	78%	87%
40	10%	7%	6%
50	3%	1%	1%
60	25%	11%	5%
70	8%	2%	1%
All speed limits (100%)	430	7,366	41,586

The age distribution of cyclist casualties by road type is of interest, as shown in Figure 5-2. A higher proportion of child casualties are on minor roads in urban locations (presumably because these are the types of road they tend to cycle on) while the proportion of cyclists KSI on rural roads increases with age for the over 30s. Almost 40% of cyclists KSI aged 20-39 were injured on major roads in urban areas.

The casualty data may be divided into three broad age groups of cyclists:

- Children tend to be injured in urban areas on minor roads (presumably while riding close to home);
- Cyclists aged 20-39 tend to be injured while riding on major and minor roads in urban areas (possibly commuting, see section 6.1); and
- Those aged 40+ are more likely than younger cyclists to be injured while riding in rural locations.

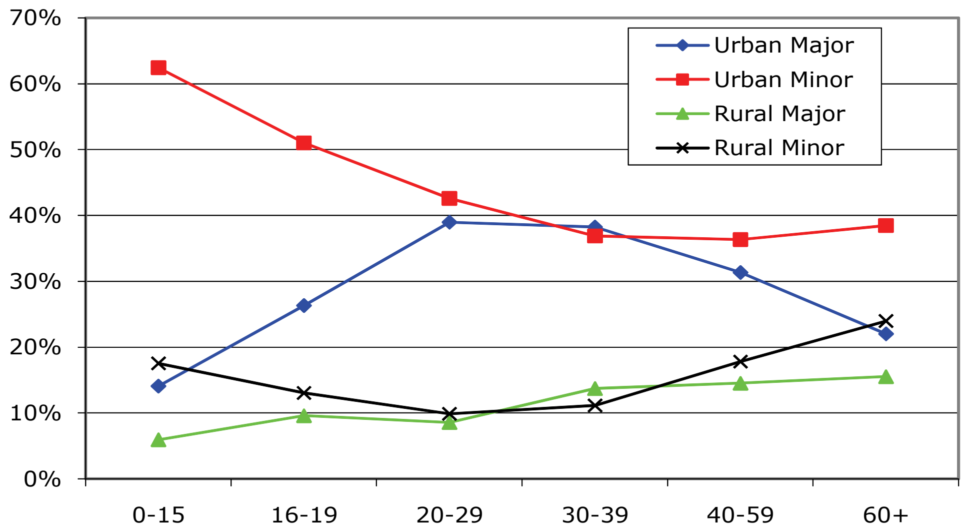

Figure 5-2 Age distribution of pedal cyclist KSI by road type (2005-07)

Contributory factors in a road collision are the key actions and failures that the police officer judges to have led to the actual impact (see annex H). The pattern of reported contributory factors (CFs) was found to vary by road type. *'Loss of control'* and *'road layout'* were reported as contributing to the collision more often on minor rural roads than the other road types. *'Passing too close to the cyclist'* was more common on major roads for serious collisions and also minor rural roads for fatal collisions. Drivers and cyclists *'Impaired by alcohol'* were more likely on rural roads in fatal collisions.

STATS19 records the vehicle location at the time of the collision if it is in a restricted lane away from the main carriageway, e.g. if the vehicle was in a bus lane, cycle lane, cycleway or shared use footway or on the pavement. This variable was examined for those collisions involving a cyclist and a motorised vehicle. For collisions where the cyclist was KSI, 97% of the bicycles were on the main carriageway at the time of the collision, 2% were in a cycle lane (on the main carriageway) and 1% was on a cycleway/shared footway which was not part of the main carriageway. A similar proportion was found for the other severities. As previously discussed, the lack of fine-grained exposure data makes it impossible to compare those with the relative time, or distance, spent by cyclists in these different types of location.

The literature review identified a range of socio-economic and area-wide demographic characteristics related to cycle casualty rates. Kim, *et al*. (2007) reported that socioeconomic factors, particularly the percentage of poor households within a neighbourhood, were related to cycle collision rates. Pless *et al*. (1989) reported that family and neighbourhood characteristics were stronger risk factors for bicycle injuries than children's personality and behaviour; higher risk of injury was related to fewer years of parental education, a history of collisions in the family, an environment judged as unsafe, and poor parental supervision.

These findings are supported by research from the DfT (2008) which showed the casualty rate for cyclists in the 10% most deprived areas is greater than in the 10% least deprived areas. For example, there were 29 cycle casualties per 100,000 population in the most deprived areas (as categorised by the Index of Multiple Deprivation), compared with 20 per 100,000 population for the least deprived. The pattern is the same for all other road user types except car drivers. There is, however, variation between rural and urban areas and age.

The safety of cyclists at road works has also been studied. Davies et al (1998) analysed STATS19 collision data and found that 0.8% of collisions involving cyclists occurred at road works between 1992 and 1996. The average injury severity for collisions at road works was higher than the overall average. A survey observing cyclists and other road users at road works reported some 'non standard' behaviour. Drivers were seen passing cyclists very closely, driving on the footway to pass cyclists and following very close behind cyclists. Cyclists, meanwhile, were observed riding on the footway to avoid narrow lanes or delays and also ignoring road closure signs to gain access.

6 When the collision occurred, lighting and weather conditions

Figure 6-1 shows the distribution of pedal cyclists killed or seriously injured by month of year. A higher proportion of pedal cyclists are KSI during the summer months while fewer cyclists are KSI from December to March. The fatal and slight distributions also follow this pattern. The pattern varies with age, with the biggest seasonal differences seen among children (child cyclist casualties had a very pronounced peak in the summer months) and less pronounced seasonal differences among older cyclists.

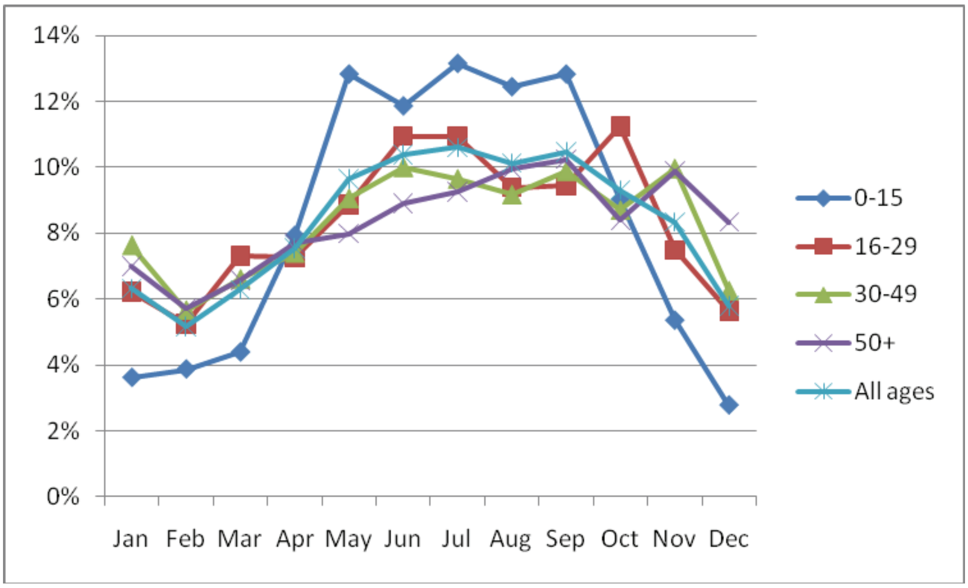

Figure 6-1 Pedal cyclist KSI by month of collision and age, 2005-07

The proportion of KSI injured on urban roads varies slightly by month of year. The proportion is slightly higher in the winter months than in the summer months (77% in February compared with 72% in June).

Figure 6-2 shows the proportion of pedal cyclists killed or seriously injured by the day of week. Overall, each weekday (Monday-Friday) has an average of 16% of the cycling KSI compared with 11% per day at the weekend. This is reflected in the cycling activity data from the NTS, with each weekday having on average 15% of the overall mileage compared with 12% on Saturdays and Sundays.

The KSI casualty pattern by day of week varies by age, with almost an equal proportion of children KSI from Monday to Saturday (15% per day) and a less pronounced peak for the 50+ age group. This may be a reflection of cycle usage, with larger numbers of 30-49 year olds using their bicycle to commute to work. This assumption is also reflected in the time of day distribution shown in Figure 6-3, with peaks of pedal cyclist casualties between 6-9am and 3-6pm.

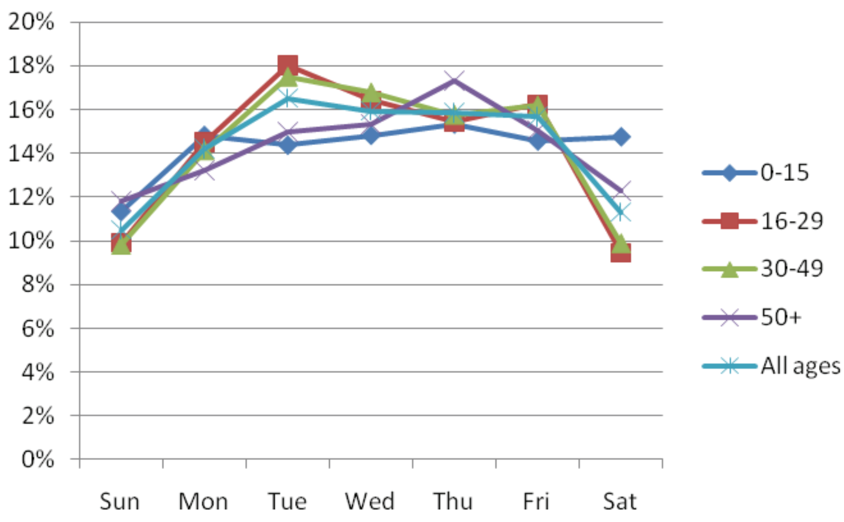

Figure 6-2 Pedal cyclist KSI by day of week, 2005-07

During the working week the majority of the cyclists killed are travelling on urban roads (approximately 60%). This pattern reverses at the weekend, however, with the majority (approximately 60%) travelling on rural roads. A similar change is seen for KSI and slight casualties although not as marked. The Contributory factors reported in collisions by day of week were examined. There were some slight differences, the only noteworthy one being that 'loss of control' was more likely to be reported at the weekend than in the week.

The main peak for cyclist casualties was between 3pm and 6pm; there was also a morning peak between 6am and 9am, Figure 6-3. Relatively few cyclists were injured during the night (9pm-6am), but collisions are more likely to be fatal at night than during the day (severity ratio of 9.4 compared with 5.6). The Contributory factors were analysed by time of day and a higher incidence of the factor '*cyclist or driver impaired by alcohol*' (especially in fatal collisions), the '*cyclist wearing dark clothing'* and '*cyclist failure to display lights'* was found between 9pm and 6am. The CF '*cyclist entering the road from the pavement'* occurred most often between 3-6pm. This is perhaps not surprising as this factor was more often attributed to children than to adults (see section 7.1.2) and relatively many of the cyclists injured at this time were children (Figure 6-4).

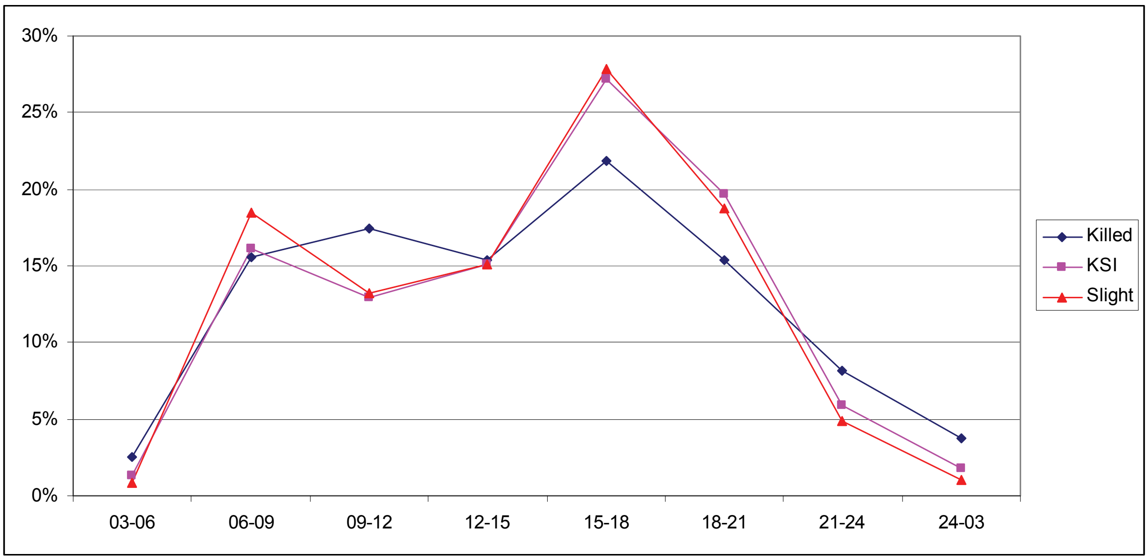

Figure 6-3 Distribution of pedal cyclist casualties by time of day, 2005-07

The distribution of pedal cyclist casualties by time of day varies with cyclist age. Figure 6-4 shows clearly that relatively many child cyclists are KSI between 3 and 6pm (42% of all KSI compared to 27% for all ages) while a higher proportion of 30-49 year old KSI were injured during the morning and evening commuting time periods (21% between 6 and 9am, 23% between 3 and 6pm). In contrast, two-thirds of KSI aged 50+ are injured during the day between 9am and 6pm. Fourteen percent of the cyclist KSI aged 16-29 years were injured between 9pm and 3am compared with an average of 8% for all age groups.

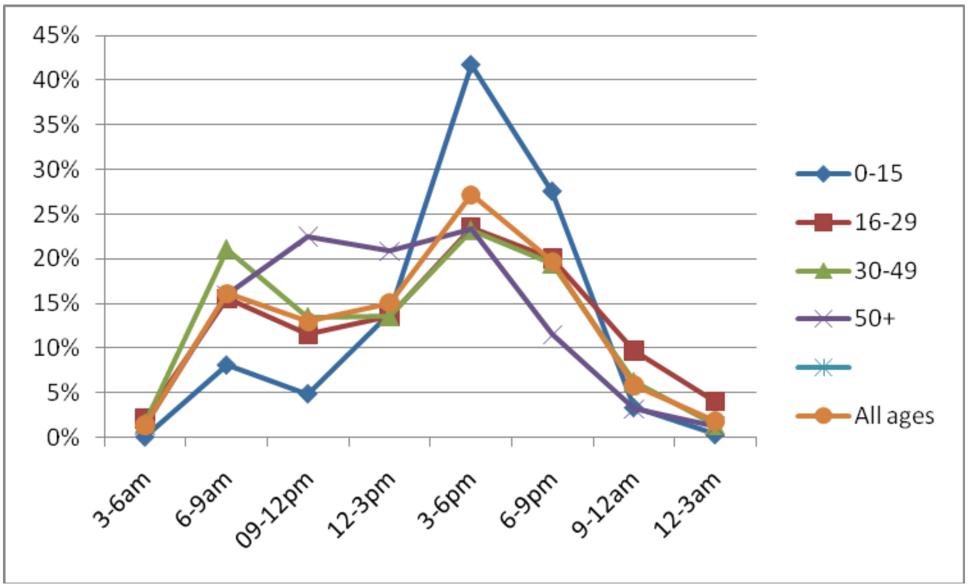

Figure 6-4 Distribution of pedal cyclist KSI by time of day and age group, 2005-07

The seven STATS19 'light conditions' codes have been combined into 3 groups for analysis: daylight, dark with street lighting and dark without street lighting. Table 6-1 shows that the majority of cyclist KSI (78% of KSI cyclists) took place in daylight. However, the severity of the collision was greater when the collision occurred in the dark with no street lighting (11% of fatalities occurred in the dark with no street lighting). This is a particular problem on rural roads as these roads generally have no street lights and the speed limit is also often higher. A detailed examination of these accidents found that the bicycle was commonly impacted in the rear by the other vehicle. The use of lights and wearing high-visibility/reflective clothing may help reduce the risk of such collisions in the dark. Kim, et al. (2007) also found that darkness without streetlights increases the probability of a fatal injury.

The analysis of contributory factors reported by the police found that serious collisions in the dark with no street lighting have a very different distribution to collisions in the daylight and in the dark with street lighting. The CFs relating to dark clothing and not displaying lights were attributed to 28% and 19% of serious collisions in the dark with no street lighting compared with 10% and 8% of serious collisions in the dark with street lighting. The vehicle passing too close to the cyclist was also a common factor on roads with no street lighting in serious (16%) and to a greater extent slight collisions (22%) but not fatal collisions (6%). The CF analysis for fatal collisions emphasises the role of alcohol impairment in cycle collisions that occurred in the dark (CF reported three times more for fatal than for serious collisions). Annex I (Knowles et al, 2009) includes more information on the role of alcohol in road collisions using the Coroners database of blood alcohol concentration (BAC).

Table 6-1 KSI pedal cyclist casualties by lighting conditions and road type, 2005-07

	Urban	**Rural**	**All**
Killed			
Daylight	77%	68%	73%
Darkness – with street lights lit	22%	9%	16%
Darkness – no street lighting	1%	21%	11%
Total (=100%)	225	204	430
KSI			
Daylight	77%	81%	78%
Darkness – with street lights lit	21%	9%	18%
Darkness – no street lighting	1%	9%	3%
Total (=100%)	5,412	1,954	7,366

The majority of cyclists KSI were injured in fine conditions on dry roads (80%) and only 8% were in the rain. This was also found to be true for several international studies which cited lower exposure in wet conditions (Doherty et al 2000) and faster motorist speeds during dry weather (Lapparent, 2005) as being partly responsible.

6.1 Commuters

The involvement of commuters in cycle casualties is evident in the data. Cyclist KSI aged 20-40 are injured predominantly on major and minor roads in urban areas (see Section 5). This age group are also more likely to be injured on a weekday, with peaks of KSI between 6-9am and 3-6pm (section 6)

7 Circumstances of collision involvement and the key Contributory Factors

There are four scenarios in which a pedal cyclist is injured:

- The pedal cyclist in a collision with another vehicle;
- The pedal cyclist in a collision with another pedal cycle;
- The pedal cyclist in a collision with a pedestrian; and
- The pedal cyclist being injured in a non-collision accident[14]

Table 7-1 shows the distribution of cyclist casualties between these scenarios as recorded in Stats19.

Table 7-1 Pedal cyclist casualties by collision scenario, 2005-07

	Percentages		
	Killed	**KSI**	**Slight**
In a collision with another vehicle	82%	83%	87%
In a collision with another pedal cycle	0.0%	0.2%	0.4%
In a collision with a pedestrian	0.7%	0.7%	0.6%
Non collision accidents	17%	16%	12%
All pedal cyclist casualties	430	7,366	41,586

As would be expected, the vast majority of the collisions reported to the police where a cyclist is injured involve an impact between the bike and vehicle (over 82% for all severities) and a much smaller proportion are when there is no impact with another vehicle (although these types of single-cycle accidents are generally considered to be especially poorly reported in the STATS19 data). Nevertheless, single cycle non-collision accidents account for 17% of reported cyclist fatalities and an approximately equal proportion of KSI. Figure 7-1 shows how the collision and non-collision scenarios for KSI have changed over time. Pedal cyclist KSI resulting from a collision with another vehicle fell until 2004 but since then they have begun to rise.

Single-cycle non-collision accidents resulting in a pedal cyclist injury vary more erratically from year to year but have also stopped falling in recent years. The proportion of these accidents that are recorded in the STATS19 data is likely to be low, however, no strong conclusions can be drawn about changes in the reported numbers of such cases.

Figure 7-2 and Figure 7-3 show the types of cyclist KSI and fatal collisions.

[14] These accidents may involve two or more vehicles but the cyclist and vehicle do not collide. Several examples were found in the OTS cases: "car emerged from drive into path of cyclist, cyclist braked and went over handlebars", "cyclist saw stationary bus ahead, tried to get onto nearside footway and lost control" (Annex D)

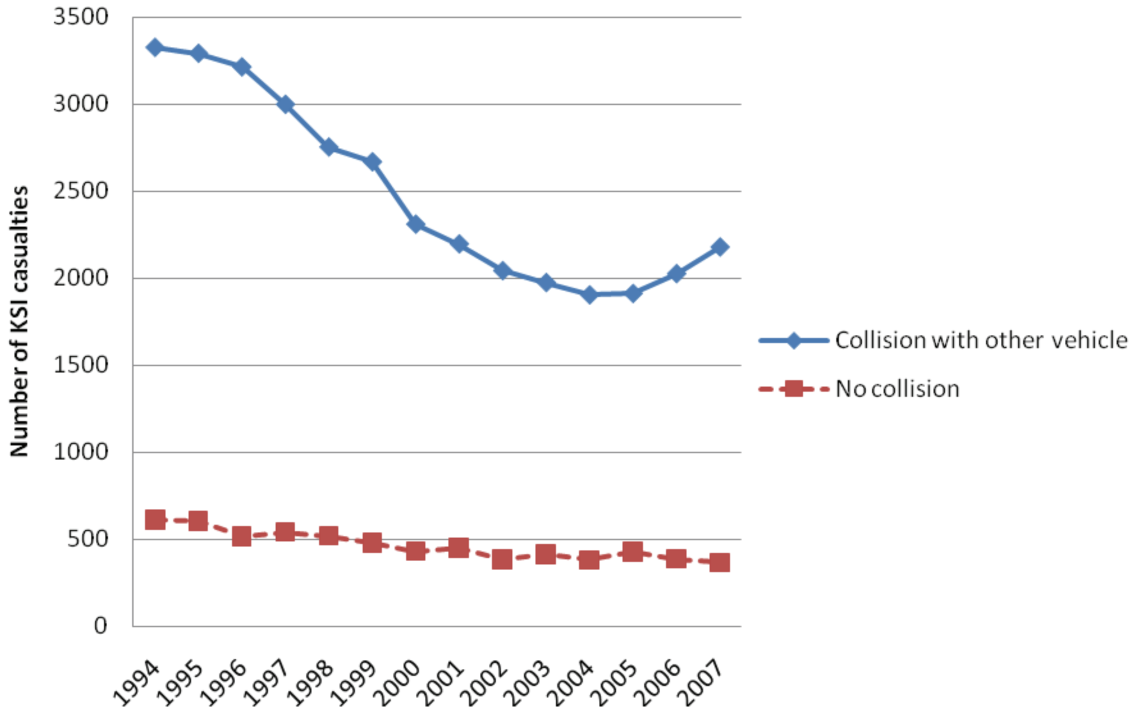

Figure 7-1 Pedal cyclist KSI by main collision scenario

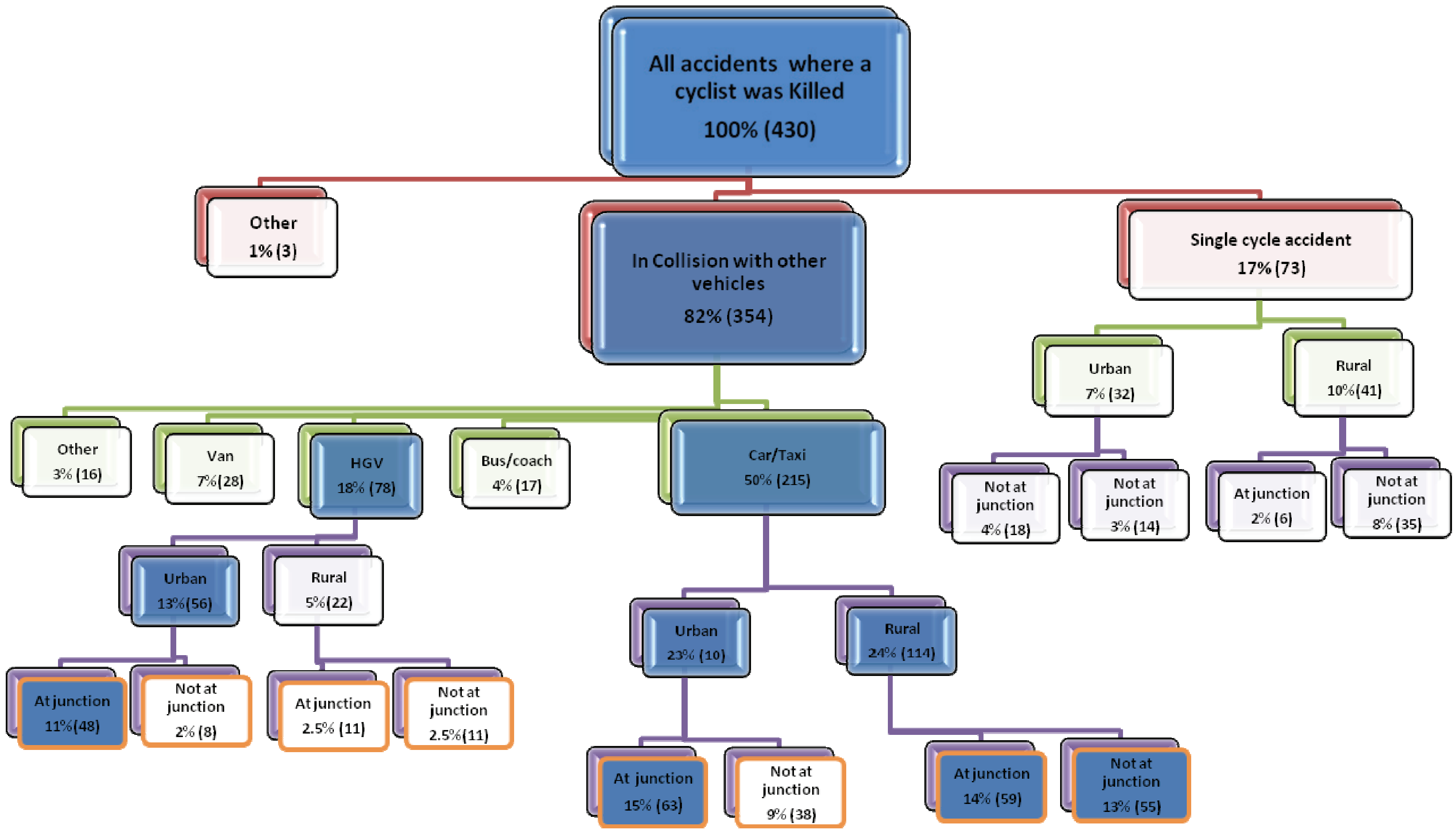

Figure 7-2 Pedal cyclist fatalities, 2005-07

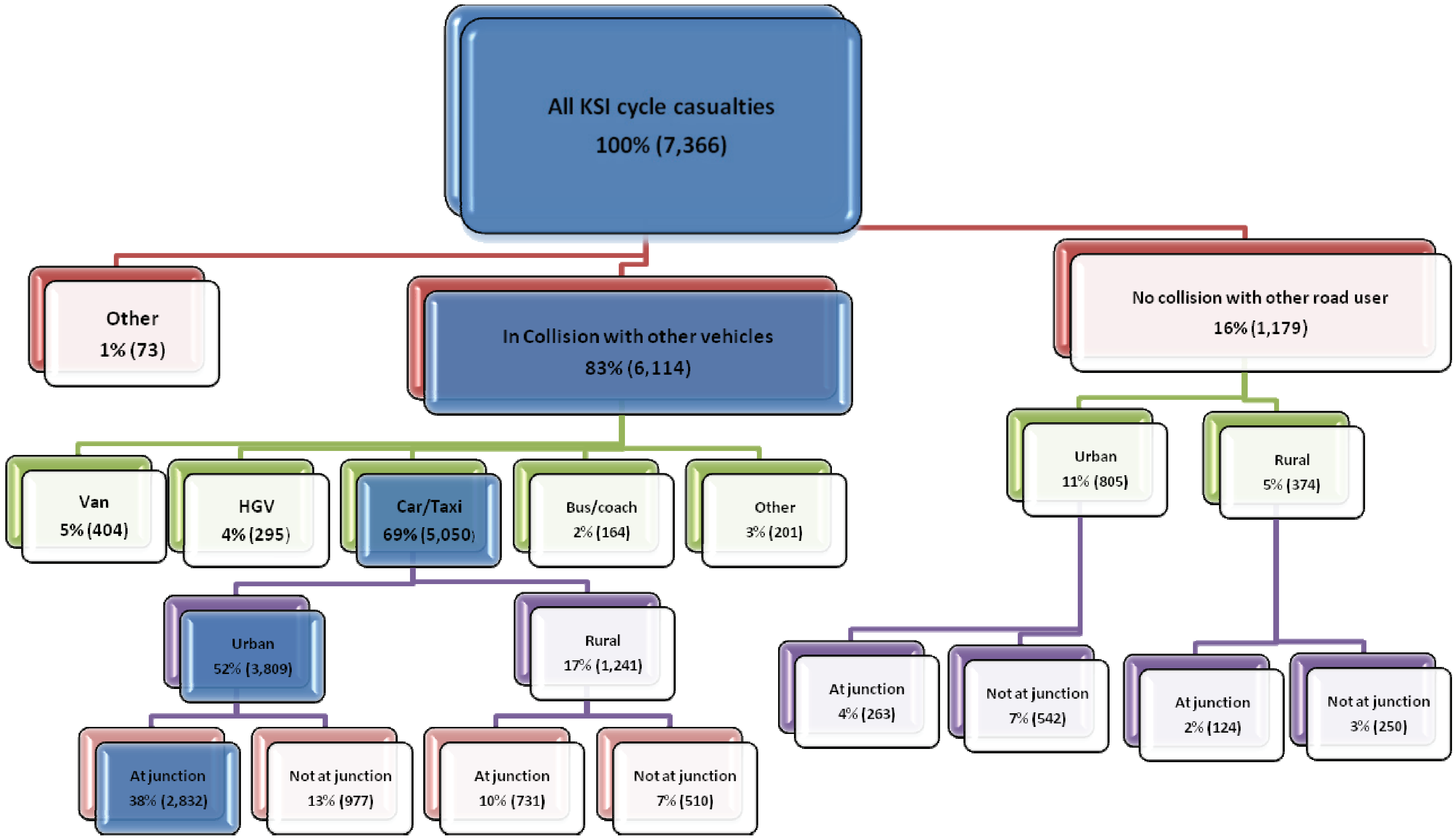

Figure 7-3 Pedal cyclists killed or seriously injured in collisions, 2005-07

7.1 Pedal cyclist casualties resulting from a collision with a motorised vehicle

The STATS19 analysis found that the majority of KSI cycle casualties involved a collision with a car or taxi (69% of all KSI). These casualties occurred mainly in urban areas (three times as many casualties than in rural areas) and at junctions. In fact 38% of all cyclist KSI involved a car/taxi in an urban area at a junction (Figure 7-3).

Cyclist fatalities involving a motorised vehicle differ from the collisions where the cyclist was KSI, with a smaller proportion involving a car/taxi (50% of all fatalities) and a larger proportion involving an HGV (18%). Collisions involving a large vehicle such as an HGV were more likely to result in a fatality than a slight injury, because of their size, the potential for direct impact with the head and upper body and the possibility of crushing the cyclist (Keigan, 2009). Collisions between HGVs and cyclists occurred mainly in urban areas at junctions; they were more common on A roads than minor roads, which probably reflects the more common use of large vehicles on these roads. The literature also provided evidence that, while most cycle collisions involve a passenger car, the most serious and fatal collisions often involve large goods vehicles (Keigan, 2009; Kim, et al. 2007). Robinson (2005) found that most of the collisions occur when large goods vehicles are travelling at less than 10mph. This was because most collisions occurred during manoeuvres, in particular left turns and at roundabouts. It has also been shown that vehicles with a higher bonnet, i.e. where the grill section hits the middle or upper body, cause greater injuries (e.g. Maki *et al*., 2003, who explored mini-vans).

Cyclist fatalities involving a car/taxi occurred in roughly equal proportions on rural and urban roads (27% and 23% of all fatalities). This differs from the KSI distribution where the majority were on urban roads, suggesting that collisions on rural roads are more likely to result in a fatality (presumably due to the higher speeds of the other vehicles on these roads, Figure 5-1 and Table 5-1). It may also be that the population of cyclists on rural roads is different from those on urban roads in either their demography or behaviour, however there is little statistical evidence against which to test these hypotheses. In urban areas the collisions were twice as likely to be at a junction (the most common type being a T-junction) but in rural areas the collisions were equally split between junction and non-junction locations.

The most common manoeuvres cyclists made prior to the collision were 'g*oing ahead'* and *'turning right'*. These two manoeuvres accounted for 87% of the cyclist KSI involving a car/taxi;*'Going ahead'* accounted for the majority (79%) and turning right accounted for 9% of the recorded cyclist manoeuvres. Turning right was a particularly risky manoeuvre for cyclists especially on rural roads, perhaps due to the higher speed of the other traffic.

Figure 7-4 shows the manoeuvre the car/taxi prior to the collision for the two main cyclist manoeuvres. The figure shows that the most common combination of manoeuvres was that both car and cyclist were *'going ahead'* (39%). The figure also shows that a large proportion of cyclist KSI were as a result of the car turning right (15%), the car turning left (8%) and the car moving off/slowing down (6%) while the cyclist was going ahead. The car turning right or left were particularly common manoeuvres in urban areas at junctions. Three percent of cyclist KSI involved a car overtaking the bicycle on its offside while the cyclist was going ahead. This manoeuvre was particularly common in rural areas, accounting for twice as many KSI in urban areas. The cyclist *'going ahead'* and colliding with a parked car accounted for 5% of cyclist KSI.

An analysis of Contributory factors found that the CF *'failed to look properly'* was reported more frequently at junctions than away from junctions (60% of serious collisions compared with 38%). Conversely, passing too close to the cyclist, loss of control and vehicle door opened or closed negligently were reported far more frequently away from junctions than at junctions (Annex H: Knowles et al, 2009).

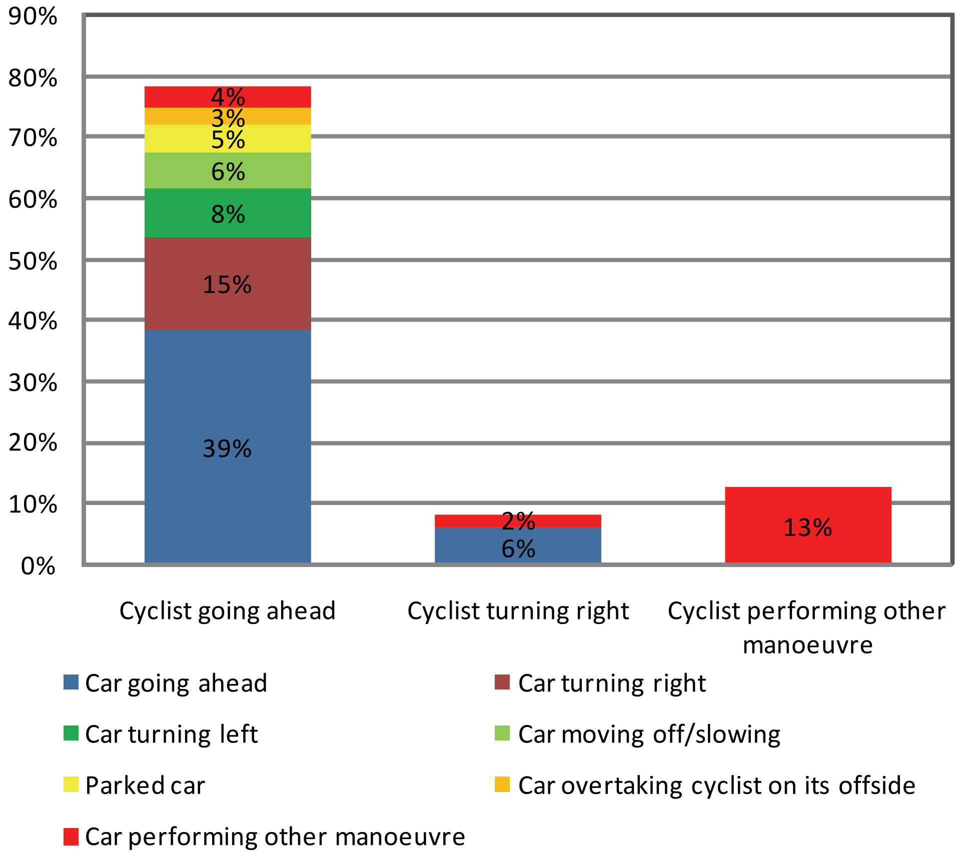

Figure 7-4 Pedal cyclist KSI from a collision with a car/taxi by main cyclist manoeuvre

It was of interest to determine whether the vehicle manoeuvre differed by vehicle type. Table 7-2 shows that going ahead was less common for vans and HGVs. A quarter of HGVs were turning left prior to the collision and this proportion rose to more than a third when the cyclist was killed. Figure 7-5 shows the manoeuvre the HGV was doing prior to the collision for the main cyclist manoeuvres. The most commonly reported contributory factors in fatal collisions involving goods vehicles were *'poor turn or manoeuvre'* (13%) and *'vehicle blind spot'* (14%). Large vehicles were also more likely to be overtaking the cyclist than cars, particularly buses/coaches. '*Passing too close to the cyclist'* was the contributory factor reported in 25% of the serious collisions involving large vehicles (goods vehicles and buses and coaches).

Table 7-2 KSI pedal cyclist casualties from a collision with another vehicle by most common other vehicle manoeuvre and vehicle type, 2005-07

	Car/taxi	Van	HGV	Bus/coach	All
Going ahead	51%	38%	40%	57%	50%
Turning left	8%	10%	25%	7%	9%
Turning right	17%	17%	8%	6%	16%
Overtaking bicycle on its offside	3%	7%	6%	12%	4%
Moving off	4%	4%	7%	4%	5%
Parked	6%	10%	4%	2%	6%
Other	10%	13%	9%	12%	10%

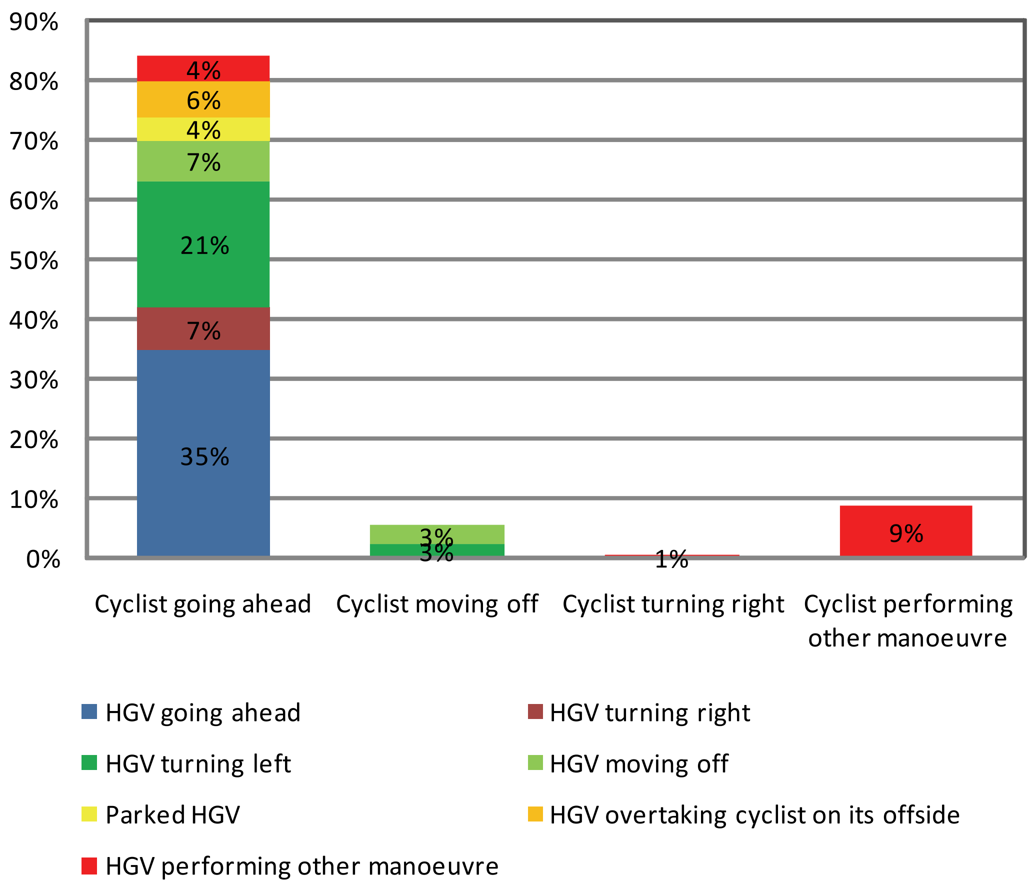

Figure 7-5 Pedal cyclist KSI from a collision with an HGV by main cyclist manoeuvre

The fatal accident database compiled as part of this research contained 23 cases that were classified as involving an HGV at an urban junction. Collisions where the HGV was turning left into a side road with the cyclist travelling on the inside were the most frequent sub-group of this collision type (18 out of the 23 cases). Thirteen of the collisions occurred at traffic light controlled junctions, three of which had advanced stop lines. Further details of these collisions are in Annex C: Knowles et al, 2009 and Keigan et al, 2009.

The first point of contact can have a significant impact on severity of injury caused. Table 7-3 presents the first point of impact for the bicycle (B) and other vehicle (V) for those cyclists killed and KSI. In the majority of cyclist collisions, in particular when the cyclist was killed, the bicycle was hit by the front of the other vehicle. Over a quarter of the fatal collisions reviewed involved the front of the vehicle hitting the back of the bike. This was found to be particularly high in rural areas (rising to 35%) and away from junctions (rising to 40%). This particular fatal collision type was most common in the dark on unlit rural roads (Annex C:Knowles et al, 2009 and Stone & Broughton, 2003).

For those cyclists who were KSI, it was less common for the bicycle to be hit in the rear by the other vehicle and more common for the front of the bicycle to impact the offside or nearside of the vehicle (11% and 14% respectively). This was more common in urban areas and at junctions.

The first point of impact was looked at by the type of vehicle that collided with the bicycle. For large vehicles, the offside of the bicycle colliding with the nearside of the large vehicle accounted for almost a third of KSI pedal cycle collisions with HGVs and almost a quarter of KSI collisions with buses/coaches.

Table 7-3 Pedal cyclist casualties from a collision with another vehicle by first point of impact, 2005-07

		Front/V	Back/V	Offside/V	Nearside/V	All
Killed	Front/B	14%	2%	5%	6%	27%
	Back/B	27%	0%	1%	2%	29%
	Offside/B	14%	0%	1%	13%	28%
	Nearside/B	9%	0%	1%	1%	11%
	All[15]	64%	2%	8%	21%	100%
KSI	Front/B	19%	4%	11%	14%	49%
	Back/B	12%	0%	0%	1%	14%
	Offside/B	12%	0%	1%	9%	22%
	Nearside/B	9%	0%	3%	1%	13%
	All[2]	52%	5%	16%	25%	100%

The OTS and fatal files were able to provide a more detailed insight into the main collision configurations involving a bicycle and a motorised vehicle. Frequent collision types involving a car and a bicycle were found to be *'car turning out of and into side road', 'cyclist crossing or entering road into path of vehicle'* (particularly for child cyclists), *'vehicle failing to stop at a junction'*, and '*cyclist failing to stop at a junction'* (Annex C and D: Knowles et al, 2009).

The literature agrees with the STATS19, OTS and fatal file findings. Räsänen & Summala (1998) and Preusser et al. (1982) found the most frequent type of bicycle-motor vehicle collisions related to a driver turning right and a bicycle coming from the driver's right. A Department for Transport study (DfT, 2003) noted research from the Netherlands (Breithaupt, 1999) which found that a common crash manoeuvre involving child cyclists was when they crossed the road or went straight ahead while crossing other traffic flows.

7.1.1 What is judged as being the primary contributory factor for the collision

The Contributory factors in a road collision are the key actions and failures that the police officer judges to have led directly to the actual impact and, as mentioned earlier, should be viewed as indicative only as they result from a subjective view of the accident. Under the STATS19 system, factors can be attributed to any of the vehicles or casualties involved. This provides the opportunity in the case of cycle collisions to investigate the extent to which the police reporting officers judged that primary contributory factors were related to the cyclist or to others involved in the collision (this does not necessarily mean that the cyclist or other road user was in fact responsible).

Figure 7-6 groups the cycle collisions according to whether factors were attributed only to the cyclist, only to the driver/non-cyclist or to both the cyclist and to the driver/rider of the other vehicle. It can be seen that attribution is split fairly equally between the cyclist and driver/rider of the motorised vehicle. However, a strong variation with cyclist age can be seen at each severity.

[15] The rows and columns may not add up as the totals include some unknowns

For children, contributory factors were more likely to be attributed to the cyclist (in over three-quarters of serious collisions). This proportion decreases with age, with cyclist casualties aged over 30 being more likely to have the contributory factor assigned to the driver. It is not clear whether this means children are more likely than adults to behave in ways that result in a collision or whether the police are simply more likely to attribute contributory factors to a child. The attribution of Contributory factors also varies with gender. Between the ages of 16 and 54, contributory factors were less likely to be attributed to the cyclist and more likely to be attributed to the driver if the cyclist was female. Among children and adults at least 55 years old, there was little difference between gender.

Research quoted in Turner, *et al*. (2006) found that the extent of error on the part of the cyclist varies considerably with age. The crash circumstances of approximately 2,000 injured cyclists were examined and, for children aged under 12 years, a high proportion was judged to be due to cyclist error. Furthermore, the 8 to 12 year old cyclists were judged twice as likely to have caused a crash if they had had no formal training. In contrast, for cyclists over the age of 18 years, less than half of collisions were considered to be due to the actions of another road user.

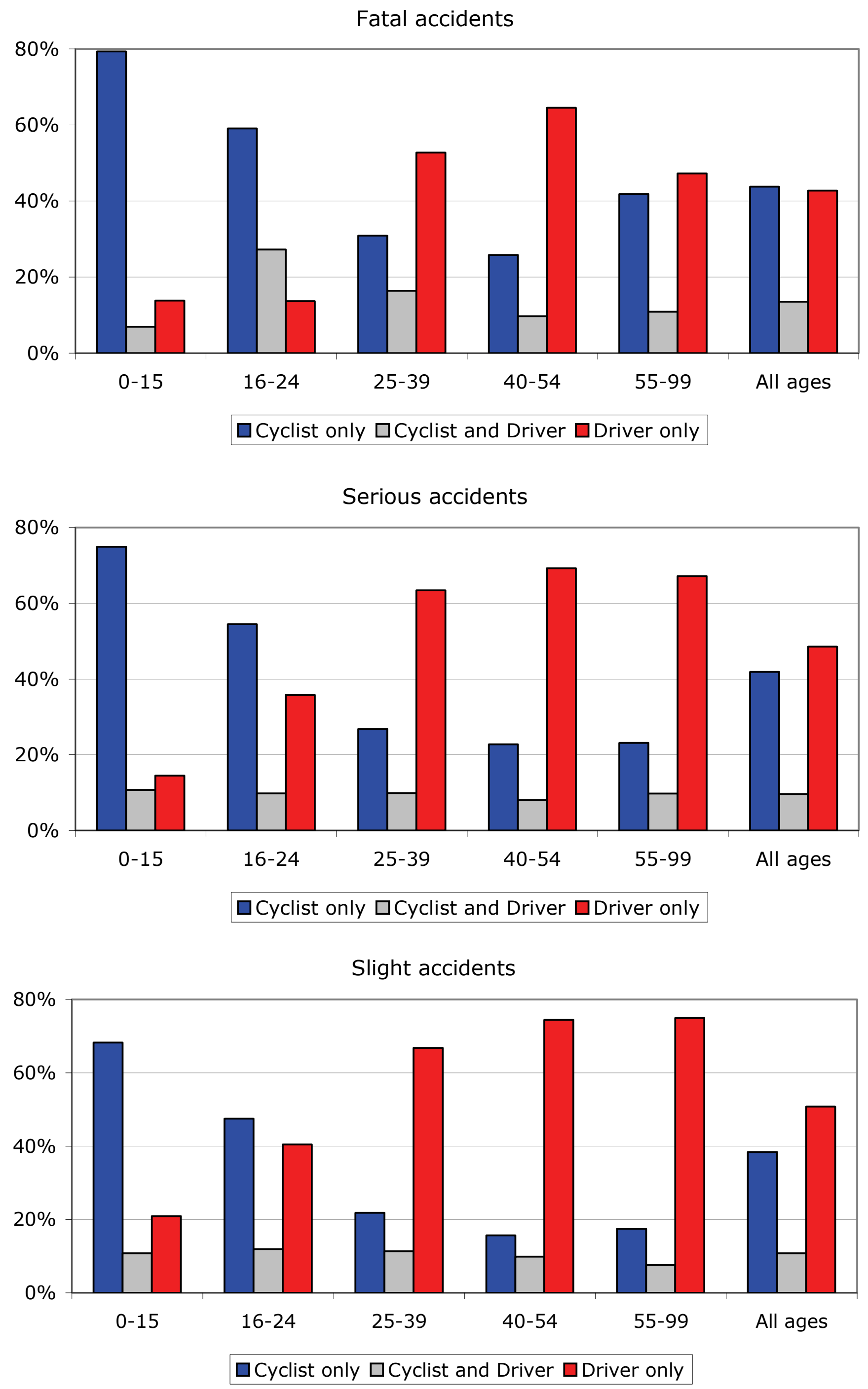

Figure 7-6 Distribution of Contributory Factor(s) in 2-vehicle collisions involving 1 pedal cycle, by age of cyclist

7.1.2 What Contributory Factors are attributed to pedal cyclists

Table 7-4 lists the 10 CFs reported most frequently as being attributed to pedal cyclists. The top 10 ranking was based on serious collisions and any 'top 10' factors that did not appear in this list for fatal or slight collisions are noted separately. The proportion of collisions where the CF was reported is shown in the table. *'Cyclist failed to look properly'* was by far the most commonly reported factor for all severities but *'cyclist entering the road from the pavement'* was reported as contributing to the accident in

20% of serious collisions. *'Cyclist wearing dark clothing at night'* was a factor that appeared more often in fatal collisions.

Table 7-4 Frequency of Contributory Factors attributed to pedal cyclists, 2005-07

CF code	Contributory Factors	Proportion of CFs attributed to cyclists in fatal collisions	serious collisions	slight collisions
	Number of cyclists with CFs	183	2,801	14,432
	Average number of CFs per cyclist	1.82	1.75	1.74
405	Failed to look properly	31%	43%	47%
310	Cyclist entering road from pavement	17%	20%	22%
602	Careless, reckless or in a hurry	9%	13%	14%
406	Failed to judge other person's path or speed	15%	12%	12%
403	Poor turn or manoeuvre	11%	11%	10%
410	Loss of control	17%	9%	7%
507	Cyclist wearing dark clothing at night	10%	5%	4%
401	Junction overshoot	4%	4%	4%
506	Not displaying lights at night or in poor visibility	5%	4%	3%
302	Disobeyed "Give Way" or "Stop" sign or markings[16]	5%	4%	3%
Top 10 factors that do not appear in top 10 for serious collisions				
307	Travelling too fast for conditions	5%		
309	Vehicle travelling along pavement			4%

Table 7-5 Frequency of Contributory Factors attributed to pedal cyclists KSI, by age of cyclist

CF code	Contributory Factors	0-15	16-24	25-39	40-54	55-99
	Number of cyclists with CFs	1087	542	605	421	313
	Average number of CFs per cyclist	1.86	1.81	1.74	1.61	1.55
405	Failed to look properly	55%	38%	36%	33%	33%
310	Cyclist entering road from pavement	34%	18%	10%	9%	10%
602	Careless, reckless or in a hurry	15%	17%	13%	8%	5%
406	Failed to judge other person's path or speed	10%	10%	16%	13%	12%
403	Poor turn or manoeuvre	9%	9%	13%	11%	15%
410	Loss of control	7%	10%	11%	10%	17%
507	Cyclist wearing dark clothing at night	2%	9%	6%	9%	4%
401	Junction overshoot	7%	4%	3%	0%	2%
302	Disobeyed "Give Way" or "Stop" sign or markings[7]	5%	5%	3%	2%	4%
506	Not displaying lights at night or in poor visibility	2%	8%	4%	6%	3%

Age and gender are the only personal details of cyclist casualties recorded in STATS19. Table 7-5 compares the Contributory factors attributed to cyclists who were killed or seriously injured, by age of cyclist. There are several differences by age: for example, children are more likely to fail to look and to enter a road from the pavement than older cyclists. There are relatively few female cyclist casualties, so it is difficult to know

[16] This factor does not include the rider disobeying automatic traffic signals, that is a separate factor

whether differences in the CFs between males and females of the same age are significant. The main differences are for children and young adults; females are more likely than males to enter the road from the pavement (40% compared with 33%) and young male adults aged 16-24 are twice as likely as females to be '*careless, reckless or in a hurry*' (18% compared with 9%) and may be more likely to *'disobey Give way or stop signs'* (5% compared with 1%).

The literature review found some evidence of cyclists exhibiting risk-taking behaviours. An often-cited anecdote regarding evidence of cyclists' attitudes to risk taking is running red lights. Evidence of this does exist in the literature reviewed; Allen, et al. (2007) showed that around 60% of cyclists in an observational study of advanced stop lines in London violated red lights (defined as crossing the stop line whilst the traffic light is red and proceeding to cross the junction). However it should be noted that 30% of car drivers also ran red lights in this study, according to the same criterion. Studies by Kim, et al. (2007), Garder (1994) and Kim & Li (1996) concluded that cyclists were more likely than drivers to violate traffic laws.

A number of other studies have found that cyclists exhibit risk-taking behaviours. For example Nekomoto, *et al*. (1997) studied collisions involving cycle couriers, and found that most of the couriers reported exhibiting illegal or risky behaviour. Thompson, *et al*. (1986) showed that central lanes on roundabouts, although used properly by most cyclists, were used by a number of cyclists to make illegal turns. Li, *et al*. (2000) found that cyclists who had consumed alcohol were more likely than those who had not to have previously had their vehicle driving licence revoked or had a conviction for driving under the influence of alcohol.

A significant amount of evidence reviewed suggests that cyclists have a reasonably accurate appreciation of the level of risk they experience whilst cycling, and that they change their riding behaviour appropriately as their perceived risk levels rise and fall. Harvey & Krizek (2007) approached this issue by fitting GPS equipment to a number of cyclists to follow their behaviour and route choice through their normal riding. The results showed that, in general, as perceived safety decreased riders appeared to be more cautious and move more slowly. However, in cases of substantial perceived danger cyclists would sometimes speed up so as to spend less time in the undesirable section of road. It is also interesting that cyclists reported sometimes choosing these sections of road (despite the high perceived danger) to save travel time. This again shows, not unsurprisingly, that perceived safety is just one consideration affecting cyclist's decisions about when and where to cycle. Another study that shows cyclists' behaviours changing with perceived risk is Davies, *et al*. (1997). This study reported that cyclists experience feelings of risk at road narrowings (due to close-passing cars and cars following close behind and 'urging them on') and report that they 'ride defensively' in such conditions.

7.1.3 What Contributory Factors are attributed to the drivers

The same approach is now taken with the Contributory factors attributed to other people involved in these cycle collisions. These are mainly drivers of cars and taxis, but there are also appreciable numbers of drivers of Goods Vehicles, buses and coaches. The factors are listed according to their ranking for all drivers in serious collisions, and this matches exactly the ranking for all drivers in slight collisions. There are, however, some interesting top 10 factors in fatal collisions that do not appear in the top 10 for serious collisions: the car driver being impaired by alcohol, exceeding the speed limit and driving too fast for conditions and, for drivers of large vehicles, the vehicle blind spot was a common factor.

Table 7-6 shows that *'failed to look properly'* was by far the most common reported factor for drivers of the other vehicles. *'Passing too close to the cyclist'* was reported in 25% of the serious collisions involving Goods Vehicles and buses and coaches, rising to 29% for fatal collisions.

Table 7-6 Frequency of Contributory Factors attributed to non-cyclists, 2005-07

		Fatal collisions			**Serious collisions**			**Slight collisions**		
	Drivers of	**Cars[1]**	**GVs[2]**	**All**	**Cars**	**GVs**	**All**	**Cars**	**GVs**	**All**
	Number of drivers with CFs	71	56	131	2146	358	2587	14218	1816	16410
	Average CFs per driver	1.62	1.52	1.60	1.69	1.75	1.71	1.71	1.86	1.73
405	Failed to look properly	38%	50%	44%	57%	51%	56%	59%	57%	58%
403	Poor turn or manoeuvre	10%	13%	11%	17%	22%	17%	18%	23%	19%
602	Careless, reckless or in a hurry	17%	7%	12%	16%	18%	17%	16%	21%	17%
406	Failed to judge other person's path or speed	8%	14%	11%	15%	16%	15%	15%	18%	16%
407	Passing too close to cyclist, horse rider or pedestrian	13%	29%	19%	11%	25%	13%	11%	27%	13%
904	Vehicle door opened or closed negligently	4%	0%	2%	5%	5%	5%	6%	4%	6%
302	Disobeyed "Give Way" or "Stop" sign or markings	3%	4%	4%	5%	4%	5%	6%	4%	6%
706	Dazzling sun	1%	0%	1%	4%	2%	4%	4%	2%	4%
701	Stationary or parked vehicle(s)	4%	0%	3%	3%	2%	3%	4%	3%	4%
601	Aggressive driving	6%	2%	4%	2%	2%	3%	3%	3%	3%
Top 10 factors that do not appear in top 10 for serious collisions										
501	Impaired by alcohol	15%	2%	9%						
710	Vehicle blind spot	0%	14%	6%						
306	Exceeding speed limit	8%	2%	5%						
307	Travelling too fast for conditions	8%	2%	5%						

[1]Cars includes Taxis,
[2]GVs includes Goods Vehicles, Buses and Coaches

The literature review found little research on the role of other road users in cycle collisions, particularly in terms of their behaviour; the main focus of most papers was on the cyclist. More research is needed to explore the behaviour of drivers in relation to cyclists on the road, especially as the outcomes of some driver behaviours, such as speed choice, are associated with higher levels of risk and injury severity for cyclists. Moreover Basford & Reid (2002) also showed motorists perceive that there is a 'social norm' for motorists to pass cyclists even if they do not think it is safe to do so, presumably related to a pressure from motorists behind to 'make progress'.

Interestingly cyclists do not always realise that motorists may fail to see them and give way. For example, Rasanen & Summala (1998) concluded that cyclists are often hit by cars turning across their cycle path when turning from a main road onto a minor road because drivers are looking for oncoming cars rather than bicycles on the main road during the critical phase of the manoeuvre. However, although the majority of cyclists had noticed the cars before impact, almost all of them had believed that the car driver would give way as required by law. Allen, *et al*. (2007) showed that cyclists in advanced stop line feeder lanes experience motorist encroachment—thus car drivers also need to be encouraged to remain outside of those areas of the road reserved for cyclists.

The literature suggests that motorists sometimes have problems seeing cyclists or judging their trajectory. For example Herslund & Jorgensen (2003) examined car drivers' behaviour when accepting gaps in front of other cars, cycles, or both. Cyclists rode in the middle of the road (i.e. in the same position as cars) and the time gaps accepted by emerging motorists were measured. Drivers chose smaller gaps in front of cycles than in front of cars. This may be because people tend to overestimate the time-to-arrival of smaller vehicles compared to larger vehicles by around half a second (e.g. Horswill, *et al*., 2005).

7.2 Non-collision pedal cyclist casualties

Whilst the presence of other motor vehicles certainly increases the risk of collisions, it should be noted that some injuries to cyclists occur when there is no collision with another vehicle. These are less likely to be recorded, unless the cyclist requires hospital treatment. In the Stats19 data, there were no collisions with other road users for 16% of the cyclist KSI.

Table 7-7 shows the cyclist age distribution of non-collision KSI cycle casualties compared with casualties which involved a collision with a motorised vehicle. Cyclists with injuries from non-collision accidents were more likely than those involved in a collision to be in the older age groups (44% aged over 40 compared with 35%) and less likely to be children (16% compared with 23%). 81% of the cyclists were male (a similar proportion was found for collisions with a motorised vehicle).

Table 7-7 KSI Pedal cyclist casualties by age, 2005-07

	Collision with vehicle	No collision	All
0-15	23%	16%	22%
16-29	25%	21%	24%
30-39	18%	19%	18%
40-59	26%	31%	27%
60+	9%	13%	9%
Total (=100%)	6,114	1,179	7,293

Table 7-8 shows the characteristics of non-collision KSI cycle casualties compared with casualties which involved a collision with a motorised vehicle. Non-collision casualties were more likely than casualties resulting from a collision to be in rural areas (32% compared to 25%) away from junctions (44% compared with 30%) where the cyclist was going straight ahead (86% compared with 78%). A slightly higher proportion of non-collision casualties were at the weekend compared with collisions with another vehicle, and this proportion was found to be higher during the daytime rather than the evening. This is perhaps surprising given the higher incidence of alcohol impairment as a contributory factor for this group of cyclists (see section 7.2.1).

Table 7-8 Characteristics of non-collision KSI pedal cyclist casualties, 2005-07

	Collision with vehicle	**No collision**	**All**
Road Type			
Urban	75%	68%	74%
A roads	29%	29%	29%
Minor roads	45%	40%	44%
Rural	25%	32%	26%
A roads	11%	10%	11%
Minor roads	14%	21%	15%
At a junction?			
No	30%	44%	32%
Yes	70%	56%	68%
Pedal cyclist manoeuvre			
Going ahead	78%	86%	79%
Turning right	8%	4%	7%
Turning left	3%	2%	3%
Other	10%	8%	11%
Day of week			
Monday	15%	13%	14%
Tuesday	17%	15%	17%
Wednesday	16%	15%	16%
Thursday	16%	15%	16%
Friday	16%	15%	16%
Saturday	11%	13%	11%
Sunday	10%	15%	10%
Total 100%	6,059	1,225	7,284

In 10% of KSI non-collision casualties, the pedal cyclist hit an object in the carriage way. This was predominantly due to the cyclists hitting the kerb (6% of KSI non-collision casualties).

7.2.1 The Contributory Factors in non-collision accidents

There are relatively few accidents recorded in STATS19 that result in a pedal cyclist casualty when there is no collision with another vehicle, and it is of interest to understand how they occur. Table 7-9 lists the 10 factors reported most frequently in non-collision cycle accidents.

Table 7-9 Contributory Factors in non-collision cycle accidents, 2005-07

		Fatal	Serious	Slight
	Number of cyclists with CFs	27	257	518
	Average number of CFs per cyclist	1.85	1.44	1.48
410	Loss of control	67%	44%	40%
501	Impaired by alcohol	15%	9%	13%
999	Other - please specify below	19%	9%	9%
103	Slippery road (due to weather)	0%	8%	9%
408	Sudden braking	7%	7%	8%
101	Poor or defective road surface	4%	6%	6%
307	Travelling too fast for conditions	19%	5%	4%
409	Swerved	0%	5%	6%
403	Poor turn or manoeuvre	0%	5%	6%
602	Careless, reckless or in a hurry	11%	5%	6%
Top 10 factors that do not appear in top 10 for serious accidents				
405	Failed to look properly			10%

The reported CFs for non-collision single-cycle accidents differ from collisions with another vehicle with the most frequently reported factor being *'loss of control'*, a factor reported in 67% of fatal accidents. *'Travelling too fast for the conditions' and 'careless, reckless or in a hurry'* were also reported frequently in fatal accidents. *'Impaired by alcohol'* is a factor that affects non-collision single-cycle accidents for all severities of accident and yet did not appear in the top 10 factors for 2-vehicle collisions.

For the period 2002-2006, the majority of cyclists with a known BAC had not been drinking (78%) which is probably why *'impaired by alcohol'* did not appear in the top 10 factors for 2-vehicle collisions. However, the cyclists that were killed in the evening were more likely to be over the legal drink drive limit (24% killed between 6pm and 6am, compared with 4% between 6am and 6pm). The CF analysis found that alcohol was a common factor in non-collision fatal cycle accidents. There were very few single-cycle fatalities with known BAC level, but of these just over a third had consumed some alcohol compared with just under a quarter of two vehicle cycle collisions.

Intoxication of road users (driver and cyclist) has been found by others to increase injury severity (Meuleners, *et al*., 2003; Li, *et al*., 2001). A study in Helsinki (Olkkonen and Honkanen, 1990) found the injury risk of an inebriated cyclist was at least 10 times that of a sober cyclist. Alcohol was found to increase the cyclist's risk of injury from falling more than collision involvement. This seems to replicate the finding from the analysis of STATS19 contributory factors. Kim *et al* (2007) argue that intoxication increases injury severity in cyclists because it is more likely to lead to careless behaviour, which appears to lead to more severe injuries if an accident occurs. They also note that intoxicated cyclists were unlikely to wear helmets. Their sample of intoxicated cyclists (174 people) contained only one person wearing a helmet (0.6% wearing rate); the helmet wearing rate for the complete sample was 6.0% (176 out of 2758).

8 Cyclist injuries

8.1 HES database

The Hospital Episode Statistics (HES) database analysed here contains details of 37,504 pedal cyclists injured in traffic collisions in England between 1999 and 2005. This database has also been used by the DfT to investigate the differences between STATS19 and HES data sources on road accidents, the results of which can be found in two articles in two reports (DfT, 2007 and DfT, 2008).

The majority (67%) of the casualties were involved in a non-collision accident which includes falling from a pedal cycle or overturning. An additional 24% were injured when they were involved in a collision with a car or HGV. Half of the injured cyclists (50%) in the HES database were children (aged 0-16 years), and of these, 70% were involved in a non-collision accident.

Injury information is recorded in HES using ICD-10 codes. These give detailed information on region and type of injury, and other illnesses and diseases. Other illnesses and disease are excluded from this analysis. Figure 8-1 shows the distribution of injuries to different body regions for all pedal cyclists with at least one injury, pedal cyclists involved in non collisions and injured child pedal cyclists. Around 1 in 10 pedal cyclists (9% of all, 11% of non-collision and 13% of children) had an injury to more than one body region. The body regions that were most commonly recorded in the HES database were injuries to the arms and head. In non-collision accidents the proportion of injured cyclists with head injuries decreases. Children were proportionately more likely to have a head or arm injury than adults in the database. Hynd et al (2009) looks at injuries to the head in more detail.

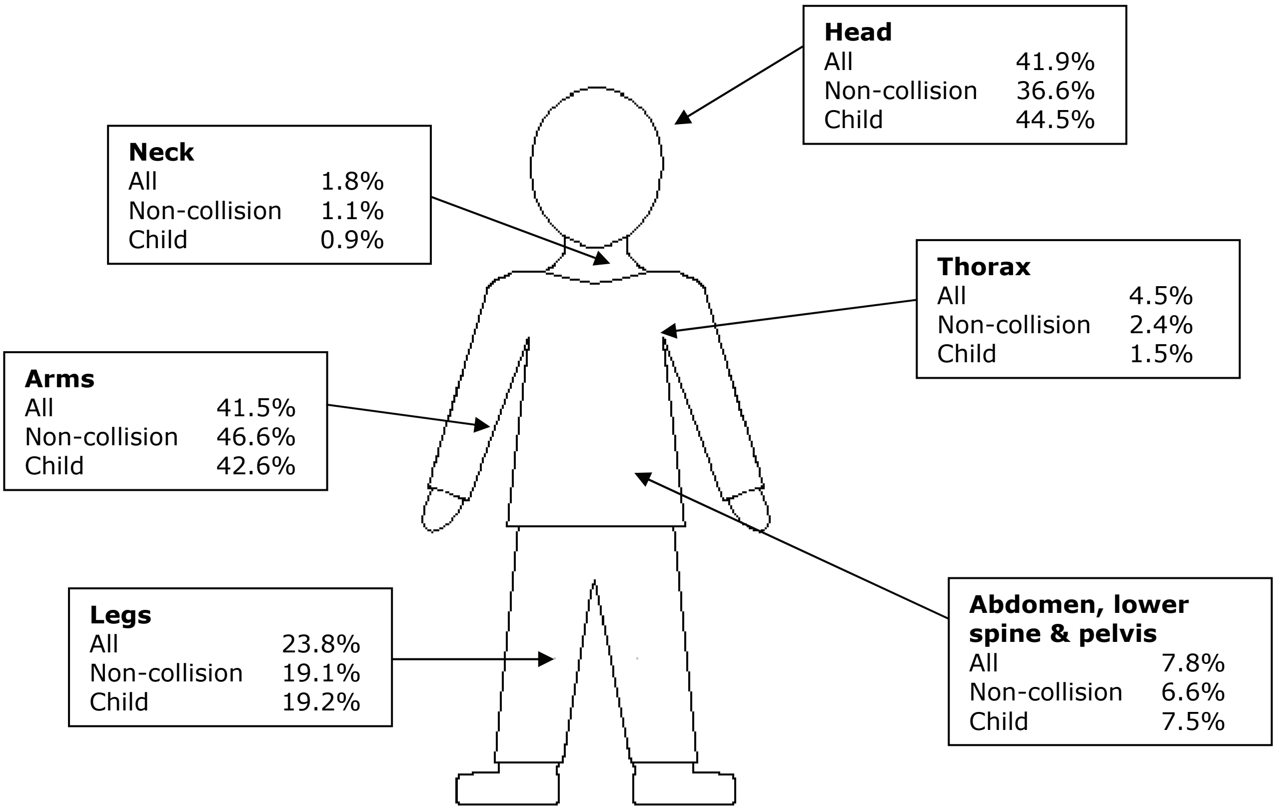

Figure 8-1:: Distribution of injury regions (all injured cyclist casualties involved in traffic collisions in HES data, 1999-2005)

8.2 Fatals database

The fatal accident database compiled as part of this research has the post mortem results for 116 cyclist accidents (66 London collisions and 50 rural collisions). Injuries were classified using the Abbreviated Injury Scale (AIS) (Gennarelli and Wodzin, 2005), which is an internationally recognised method of measuring injury severity. The AIS is based on threat to life, ranging from AIS 1 (minor) to AIS 5 (critical) and AIS 6 (currently untreatable). The proportion of moderate and greater (AIS 2+) and serious and greater (AIS 3+) injuries by body region are highlighted in Figure 8-2 urban (labelled U) and rural (labelled R) collisions.

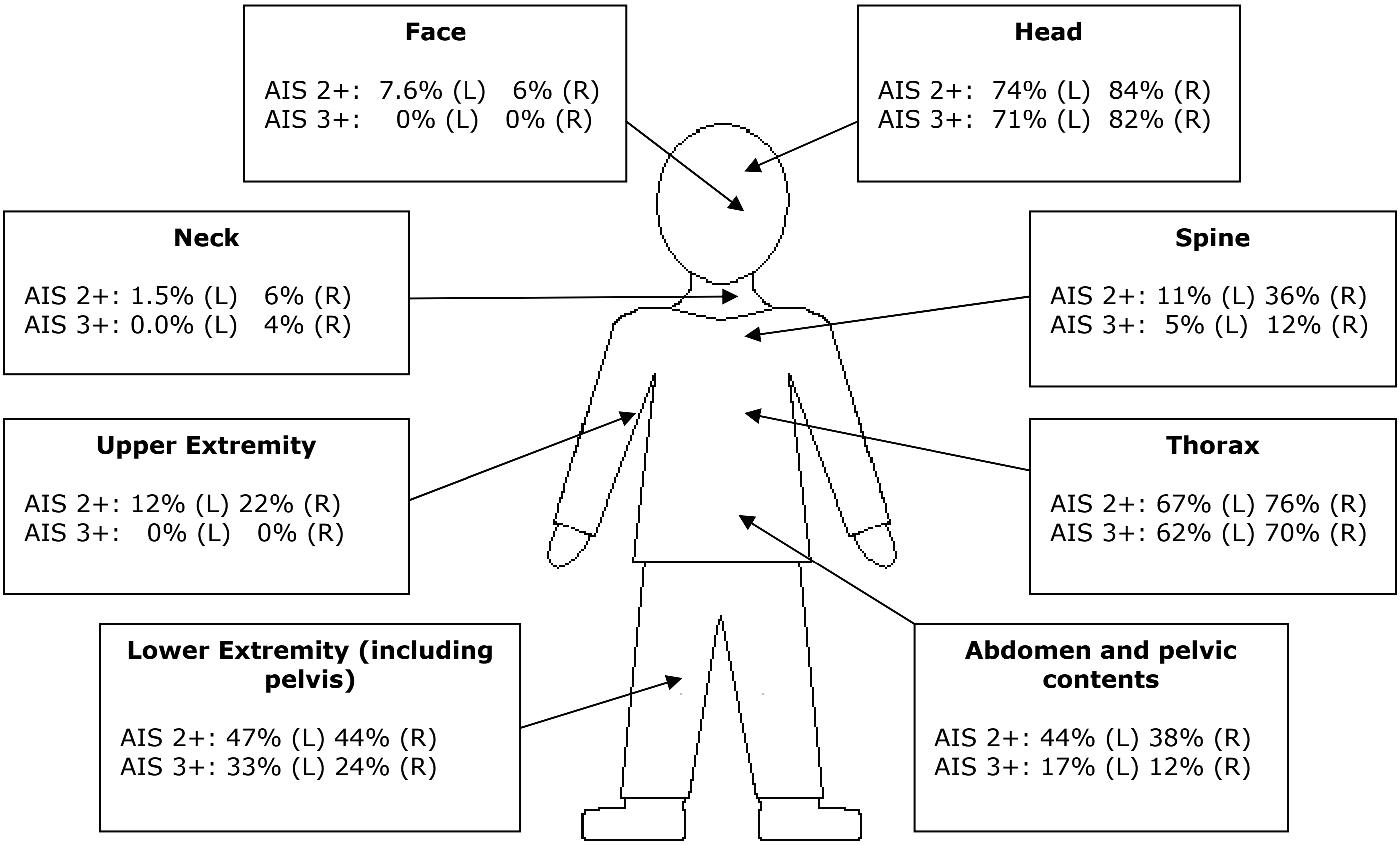

Figure 8-2: Distribution of injury regions for cyclists who died in collisions in London(L) and rural areas (R)

For pedal cyclist fatalities the most serious or 'life threatening' injuries are those with severity scores of AIS 3+. The head most frequently suffered AIS 3+ injury, with 82% and 71% of pedal cyclists involved in rural and London collisions respectively. Seventy percent of the rural pedal cyclists sustained AIS 3+ thorax injury and 62% of the London group. The London cyclists sustained proportionally more 'lower extremity' and abdominal injury (including pelvic fractures). This was principally due to the higher percentage of lower speed accidents involving HGVs or larger vehicles turning across the cyclists' path and running them over, which were particularly common in London. Keigan (2009) compared cyclist fatalities in London with other built-up[17] areas in GB and found that London had a higher proportion of cyclist fatalities arising from a collision with an HGV compared to other built-up areas (39% compared to 23%). Sixty percent of London's pedal cyclist fatalities had a collision with a goods vehicle or large passenger vehicle (bus or coach), compared with 40% for Great Britain. This resulted more often in crushing injuries, whereas the rural accidents more commonly involved blunt trauma due to higher speed impacts with vehicles and the ground.

The majority of the pedal cyclists who died (62% London, 76% rural) sustained severe injury (AIS 3+) to more than one body region, the most common combination being 'head and thorax' (20% London, 34% rural). The head was the only body region seriously injured (AIS 3+) in 27% of fatal injuries of the London sample and 20% in the rural sample. A table of all combinations is in Annex J: Knowles et al, 2009).

The collision circumstances were investigated for each range of injuries to determine patterns. Given the small numbers, patterns were not clear. However, of those collisions where the cyclist died of a head injury only, a quarter were from the cyclist being hit in the rear by a vehicle (either the other vehicle drove into them or the cyclist moved into the path of the vehicle) and 15% were single-cycle non-collision accidents. The London pedal cyclist fatalities who sustained 'head and thorax' at AIS 3+ typically were involved in collisions where either a larger goods or passenger vehicle turned left across their path and ran them over or the cyclist lost control and fell into the path of the other vehicle. The rural pedal cyclist fatalities who sustained 'head and thorax' at AIS 3+ were struck from the rear in two thirds of cases and the vehicle passed too close causing them to lose control in one third.

[17] Built-up roads have a speed limit of 40mph or less

9 Conclusions

The number of cyclists killed or seriously injured (KSI) has steadily increased in recent years, with the figure for 2008 being 11% higher than for 2004. The Department of Transport is committed to improving the safety of cycling and so commissioned this study to assess the key causal factors relating to collisions involving cyclists with the aim of informing policy on reducing casualties.

Whilst this report has identified areas where the casualty numbers appear high, in many cases the risk (i.e. number of casualties relative to amount of cycling) cannot be reliably quantified. Unfortunately, the exposure data is not available to the same level of detail as the collision data from the STATS19 accident database and therefore it was not always possible to calculate an estimate of risk given for a given set of circumstances. The best available measures of distance travelled by cyclists is the National Travel Survey (NTS) and the National Road Traffic Survey (NRTS), although both have the problem of small sample sizes and also the two sources give different annual totals and different trends. The advantage of using the National Travel Survey (NTS) was the availability of distance travelled by various personal characteristics such as age and sex, although this was limited by small samples. Overall, taking exposure into account using the NRTS, the number of KSI per 100 million KM travelled was fairly constant between 2002 and 2006 but increased in 2007.

The report has identified four distinct groups of cyclists that have different collision characteristics:

<u>Children (0-15 years old)</u>

- Children accounted for almost a quarter of KSI with the majority aged between 10-15 years old. They were injured predominantly between 3-6pm on minor roads in urban areas.
- Cyclists aged 10-15 years were more at risk (per KM cycled) than other age groups. The reasons for this increased risk are unclear, and could relate to a number of factors such as risk taking, lack of skills in particular areas or inexperience. Older children may be at increased risk because of changing patterns of exposure, such as increasing levels of cycling with less supervision**.** There is some evidence that children may not fully understand their own capabilities (Plumert *et al*. 2004).
- Children from deprived areas have higher collision involvement when cycling (Epperson, 1995; DfT, 2008).
- The police are required to assign 'contributory factors' to road collisions, i.e. the main reasons, in their judgement for the collision. In over three-quarters of collisions in which a child cyclist was seriously injured, the child's behaviour was reported as the primary contributory factor for the collision. It is not clear whether this means children are more likely than adults to behave in ways that result in a collision or whether the police are simply more likely to attribute contributory factors to a child. The main contributory factors assigned to child cyclists involved in collisions were that the child 'failed to look properly' and 'entered the road from the pavement'.
- The in-depth databases[18] were able to provide a more detailed insight into the main collision configurations involving children on a bicycle and a motorised vehicle. *'Cyclist crossing or entering road into path of vehicle'* was a frequent collision type for children. This was also supported by evidence from the literature which found that a common crash manoeuvre by child cyclists in the Netherlands was 'crossing the road' or when a child cyclist went straight ahead while crossing other traffic flows (DfT 2003).

[18] The in-depth databases include the 'on-the-spot' study (Cuerden R et al, 2008) and the police fatal files archived at TRL.

Younger adults (age 16 to 29 years)

- Cyclists aged 16 to 29 years were more at risk of injury per KM cycled than any other adult group. This is a large age group and so the reasons for the increased risk are likely to vary.
- Young male adults in this age group were two times more likely than females to be judged by the police to have been '*careless, reckless or in a hurry'* and more likely to '*disobey Give Way or stop signs'*.
- This age group was almost twice as likely as the other age groups to be KSI at night (9pm-3am) when the risk of a fatality is higher.

Adults aged 30-49

- KSI have increasing sharply for the 30-49 year age group since the year 2000.
- The 30-49 year age group were injured predominately on roads in urban areas, on week days between 6-9am and 3-6pm. KSI for this group also had a less pronounced summer peak compared with the other age groups. This suggests that a large proportion of this age group are likely to be commuters.
- Exposure data on people cycling to work was compared with the numbers of collisions involving cyclists. This analysis suggested that there is not a straightforward relationship between levels of cycling to work and collision risk.

50+ year olds

- Collisions involving cyclists aged 50 years or more tended to have more serious outcomes. This may be due to the circumstances of where and when they cycle or that older people are more susceptible to injury. Kim, *et al*. (2007) found that cyclists aged 55 years or older have more than double the probability of suffering a fatal injury in a collision, all other items being kept constant.
- This group had the highest proportion of casualties on rural roads (40% compared with the average of 27%), where the risk of a more serious injury is greater.
- Almost half of KSI casualties for this age group occurred between 9am-3pm and there was a less pronounced weekday/weekend difference.
- People in this age group were least likely to have been judged by the police to have been '*careless, reckless or in a hurry*' (5% of KSI accidents compared to 17% for the 16-24 year age group) and were more likely to have '*loss of control'* prior to the accident (17% of KSI accidents compared to 10%).

Whilst there has been some research into the attitudes and motivations of cyclists, there is very little known about the specific areas of apparent increased risk (accepting the lack of fine-grained exposure data) compared to other cyclists highlighted for the age groups above. Further research is required to better understand the attitudes and motivations of all cyclists in particular: children aged 10-15, young adults (late teens and early 20s), commuters and older/possibly retired cyclists who cycle on rural roads so that, if necessary, appropriate remedial actions may be found.

The remainder of this section discusses the other areas that the authors consider warrant further attention.

Rural Roads

The study found that rural roads present particular challenges for cyclists and the risk of being killed is much higher than for other roads. Almost half of cyclist fatalities occurred on rural roads and the proportion of collisions on rural roads increases for those aged 40+ years. Casualty severity was found to increase with the posted speed limit and so measures to reduce traffic speeds in rural areas may benefit cyclists.

Collisions at night/in the dark were more likely to result in a fatality and rural roads present particular difficulties as not only are the speed limits generally higher but the roads are often unlit. A detailed examination of these accidents found that the bicycle was commonly impacted in the rear by the vehicle. Increased promotion of the use of cycle lights and wearing high-visibility/reflective clothing may help reduce the risk of such collisions in the dark.

<u>Junctions</u>

A high proportion of collisions occur at junctions; almost two-thirds of cyclist KSI were injured at or near junctions, which is perhaps not surprising given the relatively high frequency of junctions on urban roads. The main collision configurations involving a bicycle and car were the car turning right or left while the cyclist was going straight ahead and the cyclist making a right turn while the car was going straight ahead. The factors that lead to these collisions, however, are not clear. In collisions involving a bicycle and another vehicle, '*failed to look properly'* was found to be a key contributory factor at junctions for drivers and riders (reported in 60% of serious collisions at junctions). '*Failed to look properly*' was attributed to the car driver in 57% of serious collisions. Available sources fail to show whether drivers are looking but failing to see the cyclist or failing to look for them. Equally, the strategies adopted by cyclists at junctions are also not well understood; '*cyclist failed to look properly'* was attributed to the cyclist in 43% of all serious collisions.

'<u>*Cyclist entering road from the pavement'*</u>

The second most common contributory factor attributed to cyclists was 'cyclist entering the road from the pavement'. This was assigned in a fifth of serious collisions and was especially common for children (over a third of serious collisions). This contributory factor includes crossing the road at a pedestrian crossing and the in-depth (OTS) analysis also found that 'cyclist crossing or entering road into path of vehicle' was a frequent collision type for children. More research is required to identify why cyclists are making this manoeuvre, whether it is related to infrastructure, and what can be done to reduce such collisions.

<u>HGVs</u>

HGVs present particular challenges for cyclists and are over-represented in cyclist fatalities (18% of fatal cycle accidents involved a HGV compared with 4% of serious accidents). These accidents were more common at junctions where the main collision configuration was the HGV driver making a left turn while the cyclist was going ahead. '*Vehicle blind spot'* and '*passing too close to the cyclist'* were judged by the police to be key contributory factors. From the data, it appears that this is a particular issue for London and it has been the subject of recent research for Transport for London (Keigan et al 2009). Ongoing work being carried out here will provide important lessons for other Authorities.

<u>Single-cycle non-collision accidents</u>

Hospital data suggest that many 'non-collision' single-cycle accidents (without a preceding collision with another vehicle) are not reported to or by the police. Nevertheless, 16% of cyclist KSI casualties for the period 2005-07 recorded in the STATS19 database did not involve a collision with another vehicle, which is unexpectedly high. The contributory factor most frequently attributed by the police in such accidents was '*loss of control'* (67% of fatal single-cycle accidents and 44% of serious). Whether such events result from rider error, lack of skill or defects in the design or maintenance of infrastructure is not clear. After '*loss of control', 'travelling too fast for conditions', 'careless, reckless or in a hurry*' and '*impaired by alcohol'* were judged to be the main causes of the accidents. This group of accidents warrants further consideration.

In summary, this report has identified a wide range of factors relating to cyclist safety. Taking measures to reduce vehicle speeds and collisions with HGVs (particularly in cities) will clearly be important in reducing the number of cyclists who are killed and seriously injured. It is clear from the report that further work is required to better understand how cyclists and other road users interact on the road, as it is likely for example that a lack of shared perspective may be limiting the benefits of the measures that have been implemented.

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Collisions involving pedal cyclists on Britain's roads: establishing the causes

In 2008, 115 pedal cyclists were killed and 2,450 reported as seriously injured on Britain's roads, accounting for 9% of all killed or seriously injured (KSI) road casualties. The Government is committed to reducing road casualties for all road users, including cyclists, and has a national casualty target of reducing by 40% the number of people KSI in road collisions by 2010, compared with the baseline average for 1994-98. Whilst there is no specific target relating to cyclists, in 2004 the number of KSI had fallen to 38% below the baseline average. However, the number of KSI has increased steadily since then and in 2007 and 2008 was 31% below the baseline average. The Department for Transport commissioned research to assess the causes of collisions involving cyclists. This report investigates the key causal factors relating to accidents involving cyclists. The work involved an international literature review and a detailed analysis of cyclist casualties in Great Britain, drawing on both national and in-depth databases of road collisions and cycling. The main source of the casualty data was the national STATS19 injury accident data for 1994-2007. Contributory factor data has been recorded nationally as part of the STATS19 system from 2005 and is also reported. The main source of cycling activity data was the National Travel Survey (NTS).

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