PEDESTRIAN CRASHES AT PRIORITY CONTROLLED JUNCTIONS, ROUNDABOUTS AND SIGNALISED JUNCTIONS: THE UK CASE STUDY

ABSTRACT

Objectives: Over half of pedestrians killed and seriously injured in Great Britain in 2015 were involved in crashes at junctions. This study investigates the nature of these crashes.

Methods: A study was conducted into pedestrian casualty crashes at priority controlled junctions, roundabouts and signalised junctions in England between 2005 and 2015 using information from the UK STATS19 accident database, the UK National Travel Survey and the UK National Census. Consideration was given to coding frequencies of contributory factors, exposure (in terms of miles walked or driven) as well as age, gender and the resident deprivation index of the road users involved.

Results and Conclusions: In terms of indicative blame, the coding frequencies of subjectively determined pedestrian actions and behaviour factors which might have contributed to pedestrian casualty crashes were found to be between 1.6 and 2.8 times the frequencies of driver actions and behavioural factors. Substantial social gradients were found in pedestrian casualty rates per miles walked and in the driver involvement rates per mile driven with those from the most deprived quintile having higher rates. In addition, it was found that female pedestrians, aged 60 years and over, had higher pedestrian casualty rates, per billion miles walked, for all three junction types, when compared with males and females under the age of 60 years, apart from male pedestrians aged 16 years and younger at priority controlled junctions.

Keywords: accident; contributory factors; intersection; pedestrian; social deprivation; crash;

INTRODUCTION

In 2015 there were 23,874 people either killed or seriously injured (KSI) on Great Britain's roads. Of these, 22% were pedestrians (DfT, 2016).

Table 1 International Comparison of Pedestrian Fatality Rates (WHO,2015)

Country	Estimated pedestrian fatality rate per 100,000 population	Country	Estimated pedestrian fatality rate per 100,000 population
Canada	0.95	Spain	0.83
France	0.72	Sweden	0.45
Germany	0.72	United Kingdom	0.66
Netherlands	0.33	United States	1.18

International comparisons of pedestrian fatality rates are shown in Table 1. It may be seen that many developed countries have higher pedestrian fatality rates per head of population than the UK. However, Van den Berghe (2017) reported on a comparative study of road safety developments in Sweden, the

UK, and the Netherlands which found that the UK had a substantial pedestrian casualty problem. Although part of this might have been attributed to a higher number of heavily trafficked roads, the study concluded that a more detailed investigation into pedestrian safety would be desirable.

In 2002, the Department for Transport published UK targets for a 40% reduction in the number of persons killed or seriously injured in road crashes by 2010 when compared with the average for 1994-1998. DfT (2004) highlighted the need to raise awareness of the road safety problem in deprived areas. Subsequently, in England, between 2005 and 2015, the frequency of car occupants being killed or seriously injured has been reduced by 29%. However, for pedestrians, there has been a 1% increase in the frequency of those killed or injured during the same period. An analysis of the 2005 – 2015 data also indicated that 52% of those pedestrians either killed or seriously injured were involved in crashes at either signalised intersections, priority controlled junctions or roundabouts.

In 2015, the UK Department for Transport published a report on an investigation into pedestrian casualties which occurred during 2013 (DfT, 2015). The study considered the age, gender, and resident deprivation quintile of the pedestrian casualties involved, together with exposure in terms of estimated annual miles walked, the vehicle types involved, subjectively assessed contributing factors and urban and rural road types. However, the study did not differentiate between accidents occurring at either road junctions or at mid-block locations. This paper reports an investigation which used the same data sources, as the original Department for Transport study, to gain a further insight into pedestrian crashes at individual junction types.

Different domains of deprivation are prioritised by each country in the UK to produce the overall measure of deprivation for an area. Because of the different weighting systems, it is not possible to compare deprivation data across countries in the UK and the current study has been limited to pedestrian casualties occurring at junctions in England alone.

METHODOLOGY

Outline

The study used the UK STATS19 database to identify individual pedestrian casualty details, including any road user crash causation contributory factors and the postcodes of pedestrians and drivers involved in the pedestrian casualty crashes. These postcodes were then linked both to the UK National Census database to determine resident deprivation quintiles of the road users and to the National Travel Survey to determine the annual miles either walked or driven by the road users. The STATS 19 database was also used to identify the junction types at which the pedestrian casualty crashes were located.

UK STATS19 Road Accident Database

The STATS19 database allows the police to record the attendant circumstances of road casualty crashes, details of the casualties including postcodes, details of the drivers involved, including their postcodes and vehicles and possible crash causation contributory factors. Pedestrians involved in pedestrian casualty crashes were identified from the casualty records together with their age, gender, their location, their direction and resident postcode. Drivers involved in pedestrian casualty crashes were identified from the vehicle records together with details about their age, gender, resident postcode, the type of vehicle they were driving, the vehicle manoeuvre and the junction location of the vehicle. It should be noted that postcode information, within STATS19, is confidential and that, for the current study, permission had to be sought from the Department for Transport to access such data.

Within the STATS 19 database, where appropriate, pedestrians and drivers involved in pedestrian crashes are coded, by investigating police officers, with possible, or probable, crash causation contributory factors such as 'drivers disobeying automatic traffic signals' or pedestrians being 'careless, reckless or in a hurry'. As with postcodes, contributory factors are confidential and permission had to be obtained before accessing the factors. The coding of crash causation contributory factors is a subjective process. However, Broughton (2007) considered that contributory factors can provide a valuable insight into patterns of crash causation.

UK National Census and Social Deprivation

Thirty seven separate UK National Census indicators, including those relating to income, employment, health, education, crime, access to services and the environment, are weighted to produce the English Indicators of Multiple Deprivation for the Lower Layer Super Output Areas (LSOA) (Department for Communities and Local Government (2015). Indices are on a continuous scale but, for the purpose of the study, the LSOAs have been distributed within five deprivation quintiles ranging from the most deprived to the least deprived. The postcodes made it possible to assign individual drivers and pedestrians, involved in pedestrian casualty crashes to an appropriate deprivation quintile.

National Travel Survey

The UK National Travel Survey is a continuous household survey of personal travel by residents in England which involves interviews and one week travel diaries. The data gathered enables estimates to be made of annual distances walked or driven by a particular age group, by gender, and by residents of particular deprivation quintiles for use in assessing the effects of exposure. For the current study annual miles driven were only available for cars and vans drivers on non-business related journeys. As consequence pedestrian crashes involving other vehicle types or car drivers on business related journeys were not considered. The average mileages driven or walked, utilised in the study, are shown in Table 2. As the social deprivation decreases, the drivers' annual miles driven increases and annual miles walked reduces.

Table 2 Average annual miles driven or walked in England (National Travel Survey 2005-2015[1])

Road user	Age group	Most deprived quintile	2nd most deprived quintile	3rd most deprived quintile	4th most deprived quintile	Least deprived quintile

Drivers[2]	17 to 24yrs	1,020	1,956	2,463	3,665	3,937
	25 to 59yrs	3,125	4,630	6,246	7,516	8,634
	60+ yrs	1,722	2,539	3,575	4,262	4,537
Pedestrians	0 to 16yrs	230	208	197	187	183
	17 to 59yrs	220	213	192	178	170
	60+ yrs	138	138	134	139	144

[1]UK Data Service Special Licence (2016) DfT Licence Number (Napier University) 108917
[2]non-business related car and van journeys

Determination of Pedestrian Crash Rates and Drivers involved in Pedestrian Crashes Rates

Pedestrian crash rates for 2005 to 2015 were determined by obtaining the average annual number of pedestrian crashes which occurred between 2005 and 2015, for a particular age group or residence quintile, and dividing this by the average annual miles walked (2005-2015) by that particular age group or deprivation quintile (see Table 2). The driver involvement rates, for pedestrian crashes, were derived in a similar way using the average annual number of drivers involved in pedestrian crashes (2005 – 2015) and the average annual miles driven (2005-2015) by age group and resident deprivation quintile.

Junction Layouts and Operational Characteristics

It may be seen, from Table 3, that 95% of crashes involving pedestrians being Killed or Seriously Injured occurred in built-up areas where the speed limit was 40mph or less. It may also be seen 48% of all crashes involving pedestrians being killed or seriously injured occurred at road junctions with the majority of those occurring at priority controlled junctions.

Table 3 Average annual* frequency of pedestrians KSI in England (2005-2015) by location

Crash location	Speed limit ≤ 40mph (built-up areas)		Speed limit > 40mph (non built-up areas)	
	Frequency	%	Frequency	%
Priority Junction	1,419	39.0%	29	0.8%
Signalised Junction	394	10.8%	7	0.2 %
Roundabout	93	2.5%	4	0.1%
Signalised Roundabout	Not available	Not available	Not available	Not available
Mini Roundabout	29	0.8%	0	0.0%
Grade Separated Junction	Not available	Not available	Not available	Not available
Not at Junction	1,699	46.7%	185	5.1%

*Average annual pedestrian KSI = 3,860

The attendant circumstances fields, within the UK STATS 19 road accident database, allow for the differentiation between mini roundabouts, signalised roundabouts, grade separated roundabouts conventional roundabouts, priority controlled junctions and signalised junctions. Mini roundabouts have no raised island and are often placed within the boundaries of a former priority controlled junction. It may be difficult for the pedestrians to select gaps in the immediate vicinity of such junctions. In such circumstances, offset traffic islands or pedestrian crossings are provided. The provision of such facilities mean that pedestrian KSI crashes at mini roundabouts themselves, are low and, as a consequence, they were not considered in the study. Similarly, pedestrian casualty crash frequencies at grade separated intersections were also very low and so they were also excluded from the study. The layouts and operational characteristics of the remaining conventional roundabouts, signalised junctions and priority controlled junctions are now considered. It should be noted that, when making international comparisons, these may differ from those installed elsewhere in the world.

Conventional Roundabouts: The conventional UK roundabouts, identified within the STATS19 database, will take many different forms and, for the current study, it was not possible to distinguish between them. Some UK layouts will be very different to those utilised in other countries and as a consequence care needs to be taken when making international comparisons. For example, roundabouts installed on the UK road network before 1966 were originally designed to allow entering drivers to merge and then weave with circulating vehicles in order to position themselves for either a downstream exit or to continue on the circulating carriageway. The necessary long weaving lengths resulted in very large layouts and high circulating speeds.

The UK Roundabouts, constructed after the introduction of ‘priority to the right on entry’ in 1966 are more compact because designers have not had to allow for downstream weaving. Designers will also provide approach alignments which limit entry speeds. Furthermore, since 2007, the Design Manual for Roads and Bridges (DMRB, 2007), exit alignments, from smaller roundabouts, are such that exit speeds are also limited for pedestrian safety. The current UK guidelines suggest that additional pedestrian facilities at roundabouts should be considered where appropriate. These include:-

- informal crossings on splitter islands;
- Zebra crossings with or without a central refuge which should be at least 5m from the give way or stop line in accordance with Local Transport Note 2/95 (DfT, 1995);
- Displaced signalised pedestrian crossings at least 20m from the give way or stop line in accordance with Local Transport Note 2/95 (DfT, 1995); and
- Subways or footbridges.

Signalised Junctions: The complex nature of the phase sequences, made available with microprocessor controllers, at signalised junction installations, have the potential to confuse pedestrians. Therefore, there is a strong case for signalised pedestrian control. In the UK, TA 5/05 (DfT, 2005) reinforces this by suggesting that in either the design of new signalised intersection designs or in the upgrading of existing signalised intersections pedestrian signal control should be provided unless site considerations warrant their exclusion. Frequently a full pedestrian stage is provided during which all vehicular approaches are stopped whilst pedestrians are provided with a green pedestrian display on all crosswalks. Alternatively, the pedestrian green may be displayed in parallel with non-conflicting vehicular movements.

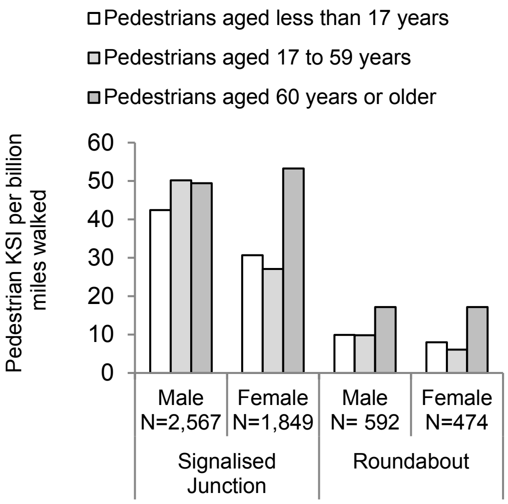
In the US, and some other countries, signalised intersections may be designed to allow right and left turning vehicles to be in conflict with permitted pedestrian movements and in such circumstances turning drivers are required to yield to pedestrians. It should be emphasised that in the UK such conflicts are not permitted and are not present at the signalised junctions considered in the study.

Priority Controlled Junctions: When considering priority controlled junctions, the study did not differentiate between staggered T-junctions and cross roads. In the UK, the DMRB (1995) suggests that, although rarely practical, it is preferable to provide separate pedestrian routes away from priority controlled junctions where road widths are less and traffic movements are more predictable. In practice, pedestrians are often provided with a minor road central refuge away from the mouth of the junction or displaced Zebra and signalised crossings. However, the attendant circumstances recorded within the STATS19 accident database does not include the presence of such features.

RESULTS

Pedestrian Casualty Frequencies and Rates at Junctions

Gender and pedestrian age: It may be seen, from Figure 1, that away from junctions, those pedestrians aged 16 years and younger have the highest pedestrian KSI casualty rates per billion miles walked. However, except for the younger male pedestrians at priority junctions, pedestrians aged sixty years or over have the highest pedestrian casualty rates at priority junctions, signalised junctions and



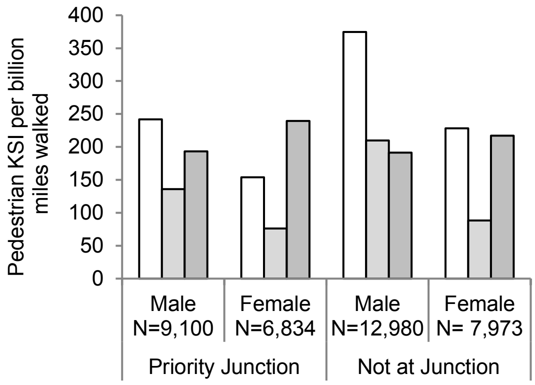


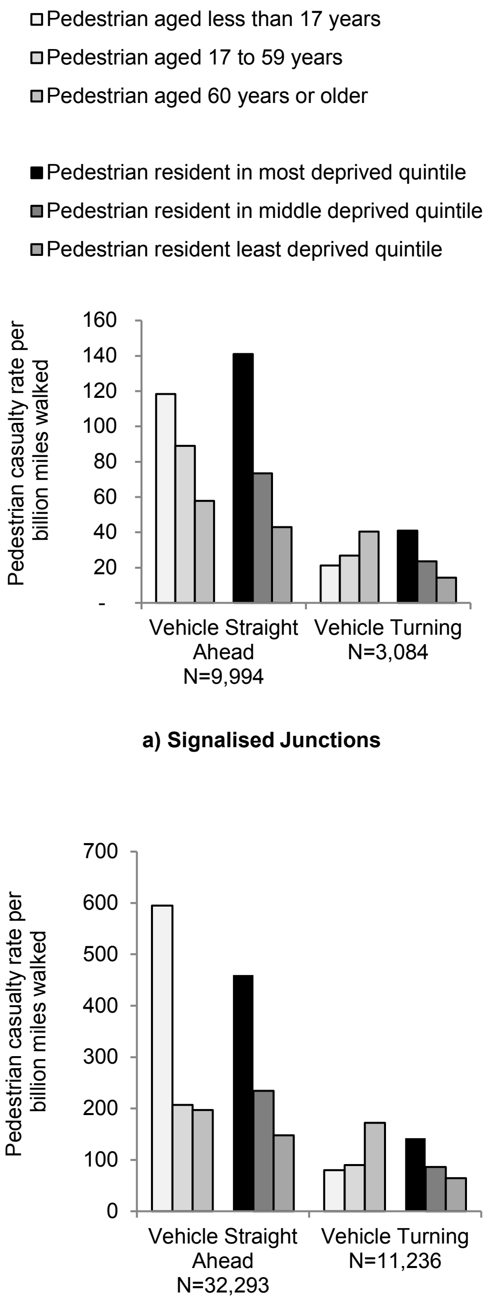
Figure 1 Pedestrian KSI crash rates per billion miles walked by location, pedestrian gender and pedestrian age group for England

The KSI crash frequency for male pedestrians is at least 1.25 times that of females for all three junction types. However, taking into account exposure, the pedestrian KSI crash rates per billion miles walked, at all three junction types, for females aged 60 years and over were higher than that of males of from same age group. Females aged 60 years and over also had higher pedestrian casualty rates than males and females under the age of 60 years apart from males aged 16 years and younger at priority junctions.

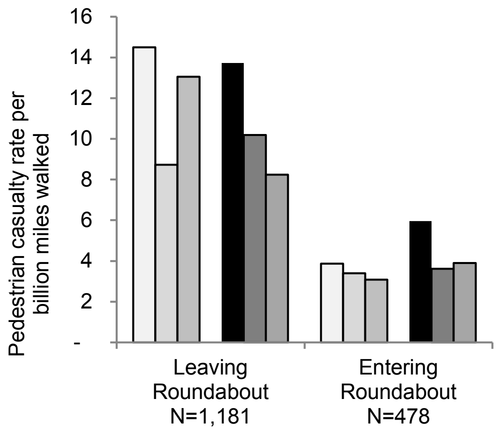
Pedestrians' KSI at junctions based on vehicle movement type

At signalised junctions: The number of pedestrian casualty crashes involving vehicles travelling straight ahead, at signalised junctions was 3.2 times those involving turning vehicles. It may be seen from Figure 2a, the pedestrian casualty rates per billion miles walked, involving vehicles travelling straight ahead, were highest for those aged 17 years or less. In contrast, the pedestrian casualty rates, involving turning vehicles were generally higher for those aged sixty years and over. It may be seen, from Table 4(a), that almost a quarter of pedestrian casualties involved turning vehicles and the frequency of pedestrian casualty crashes involving right turning vehicles was almost double those involving left turning vehicles. Similarly, the Federal Highway Administration (FHWA 2009) found that left turning vehicles at intersections (equivalent to UK right turns)) were more often involved than right turn vehicles.

It may also be seen, from Figure 2(a), that the pedestrian casualty rates at signalised junctions, per billion miles walked, for those resident in the most deprived quintile, were over 2.9 times those from the least deprived quintile.



b) Priority Junctions



c) Roundabouts

Figure 2 Pedestrian casualty rate per miles walked by junction type, vehicle movement and pedestrian age group (England 2005-2015)

Table 4 Pedestrian Casualties at Junctions in England (2005-2015)

(a) Signalized junctions

Conflicting Vehicle Movement	Frequency	Percentage
Vehicle turning right	2,000	16%
Vehicle turning left	1,084	8%
Vehicle travelling straight ahead	9,994	77%

(b) Priority Controlled Junctions

Conflicting Vehicle Movement	Frequency	Percentage
Vehicle turning right from major road	2,112	5%
Vehicle turning right from minor road	1,540	3%
Vehicle turning left from major road	1,070	2%
Vehicle turning left from minor road	775	2%
Vehicle travelling straight ahead	40,457	88%

(c) Roundabouts

Vehicle Movement	Frequency	Percentage
Vehicle leaving roundabout	1,428	54%
Vehicle entering roundabout	604	23%
Vehicle on circulating carriageway	597	23%

At priority controlled junctions: It may be seen, from Figure 2(b), that the pedestrian casualty crash rate involving straight ahead vehicles was lowest for those aged 60 years or over. However, for the same age group, the pedestrian crash rate involving right turning vehicles from the minor road were 2.9 times higher than those aged between 17 years and 59 years for pedestrian. The corresponding figures for crashes involving right turning vehicles from the major road and left turning from the minor road were 1.9 times higher and 1.7 times higher respectively. It may also be seen from Figure 2b, that the pedestrian casualty crash rates, per billion miles walked, for those pedestrians who were resident in the most deprived quintile, were over 2.0 times those from those resident in the least deprived quintile. From Table 4(b), it may be seen that 88% of all pedestrian casualty crashes at priority controlled junctions involved vehicles travelling straight ahead.

At roundabouts: At roundabouts, 54% of pedestrian KSI crashes involved vehicles leaving the roundabout, 23% involved vehicles entering the roundabout and 23% involved vehicles on the circulating carriageway. It may be seen from Figure 2c, that the pedestrian casualty crash rates per billion miles walked involving vehicles leaving the roundabout were at least 2.5 times those involving vehicles entering the roundabout. The pedestrian casualty crash rates per billion miles walked involving vehicles leaving and entering roundabouts were higher for those aged either aged 16 years or less when compared with other age groups. Those aged 60 years or over had a higher pedestrian casualty rate involving vehicles leaving a roundabout when compared with those aged between 17 years and 59 years. From Figure 2c, it may be seen that the pedestrian KSI crash rates, per billion miles walked, were at least 1.2 times higher for pedestrians resident in the most deprived quintile when compared with pedestrians resident in the least deprived quintile.

Car and Van Driver Involvement in Pedestrian Casualty Crashes at Junctions

The frequency of pedestrian KSI crashes involving male car and van drivers was 2.1 times higher than that of female car and van drivers at signalised junctions and roundabouts. The corresponding value for priority controlled junctions was 1.8 times higher for male drivers. Allowing for exposure it may be seen, from Figure 3, that the rate of car and van driver involvement in pedestrian casualty crashes per billion miles driven for male car and van drivers aged between 17 years and 24 years was over 3.5 times that for all other car and van drivers aged 25 years and over for all junction types. The equivalent rates for female car and van drivers aged between 17 years and 24 years was two times higher than that of all other drivers aged 25 years and over for all junction types.

From Figure 4, it may be seen that, for car and van drivers involved in pedestrian casualty crashes at priority controlled junctions and resident in the most deprived quintile the pedestrian KSI crash rate was five times higher than for those drivers from the least deprived quintile. The corresponding rates at signalised junctions and roundabouts were 4.7 times and 3.2 times higher respectively.

Pedestrian Crash Causation Patterns at Junctions

As indicated in Section 3.2, crash causation action/behaviour related contributory factors can provide a valuable insight into patterns of crash causation. In terms of crash causation, it may be seen, from

Figure 5, that the frequency of coding crash causation action/behaviour related factors associated with pedestrians involved in pedestrian casualty crashes at signalised junctions was 2.7 times those associated with car and van drivers involved in such crashes. The corresponding figures for priority controlled junctions and roundabouts were 1.8 times higher and 1.6 times higher respectively.

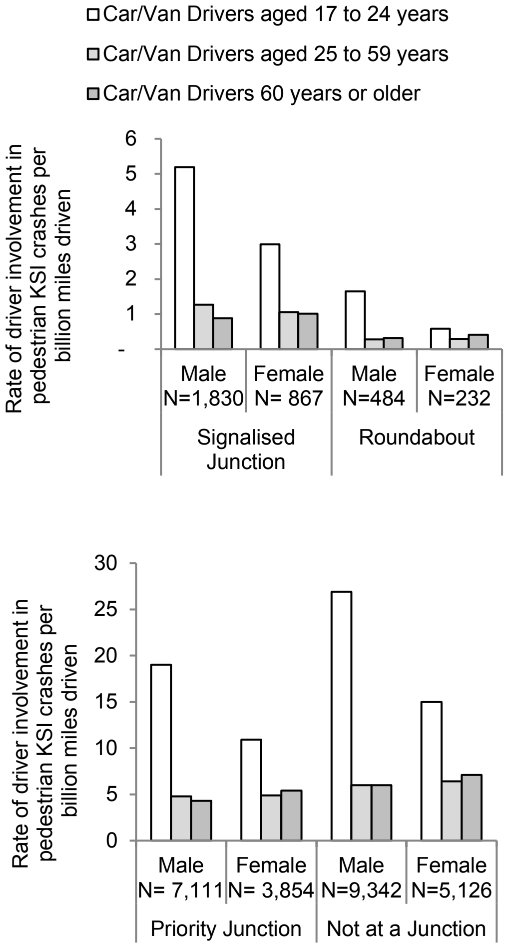


Figure 3 Car and van driver involvement rate in Pedestrian KSI crash per billion miles driven by junction type, driver gender and driver age group for England (2005-2015)

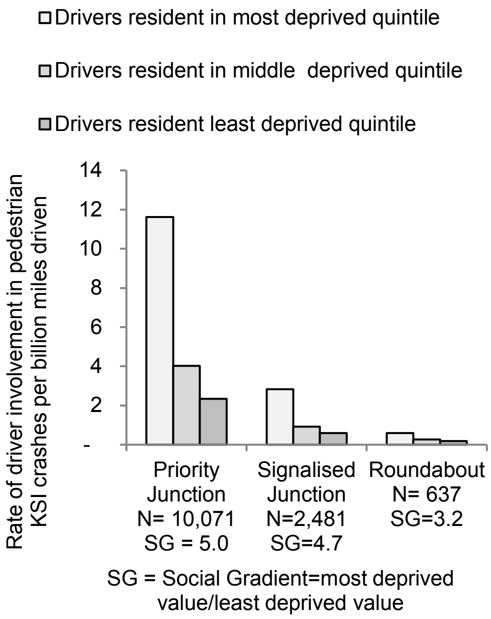


Figure 4 Car and van driver involvement rate in pedestrian casualty crashes per billion miles driven junction type and resident deprivation quintile for England (2005-2015)

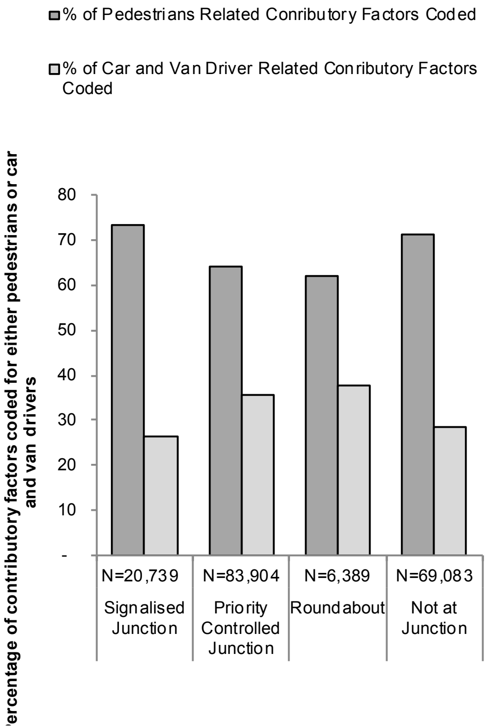


Figure 5 Percentage of pedestrian and car and van related contributory factors coded by junction type for all pedestrian casualty crashes (2005-2015)

Pedestrian Crash Causation Patterns

From Figure 6, it may be seen that the rate of pedestrians, involved in pedestrian KSI crashes at signalised junctions and coded with at least one crash causation action/behaviour related factor per billion miles walked, for those resident in the most deprived quintile was three times higher than that of the residents in the least deprived quintile. The corresponding value for priority junctions and roundabouts was 2.7 times higher and 1.6 times higher, respectively.

The five most frequently coded pedestrian crash causation action or behaviour factors for those pedestrians involved in pedestrian casualty crashes, are presented in Table 5. It may be seen that 'failed to look properly', 'pedestrian careless reckless or in a hurry', and 'failed to judge vehicle's path or speed' are prominent for all junction types. For signalised junctions, the third most frequently coded pedestrian crash causation contributory factor was the 'wrong use of pedestrian crossing facility'. For priority controlled junctions and roundabouts 'pedestrian impaired by alcohol' was also featured in top five causes.

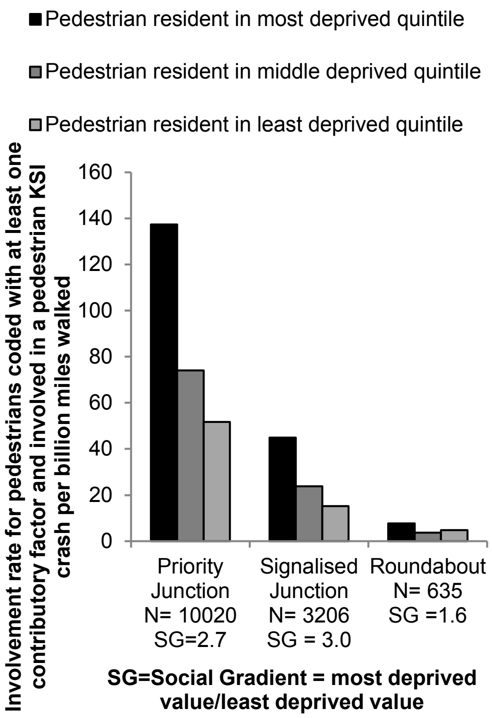


Figure 6 Rate of pedestrians, involved in KSI Crashes and coded with at least one crash causation contributory factor, per billion miles walked, by junction type and resident deprivation quintile (England 2005-2015)

Table 5 Five most frequently coded pedestrian and driver crash action/behaviour related contributory factors by junction type

Pedestrian casualty crashes at priority controlled junctions			
Pedestrian contributory factor	**Frequency**	**Driver contributory factor**	**Frequency**
Failed to look properly	32,577	Failed to look properly	9,228
Pedestrian careless reckless or in a hurry	14,436	Driver careless, reckless or in a hurry	2,445
Failed to judge vehicles path or speed	10,428	Poor turn or manoeuvre	1,702
Crossing road masked by stationary vehicles	8,258	Failed to judge pedestrian's path or speed	1,700
Pedestrian impaired by alcohol	4,523	Too close to pedestrian	1,019
Pedestrian casualty crashes at signalised junctions			
Pedestrian contributory factor	**Frequency**	**Driver contributory factor**	**Frequency**
Failed to look properly	10,190	Failed to look properly	1,473
Pedestrian careless, reckless or in a hurry	4,908	Driver careless, reckless or in a hurry	522
Wrong use of pedestrian crossing facility	3,984	Disobeyed automatic traffic signals	368
Failed to judge other vehicle's path or speed	3,180	Failed to judge other person's path or speed	305
Crossing road masked by stationary vehicles	2,017	Poor turn or manoeuvre	208
Pedestrian casualty crashes at roundabouts			
Pedestrian contributory factor	**Frequency**	**Driver contributory factor**	**Frequency**
Failed to look properly	1,909	Failed to look properly	656
Failed to judge other vehicle's path or speed	765	Driver careless, reckless or in a hurry	219
Pedestrian careless, reckless or in a hurry	744	Failed to judge other person's path or speed	117
Pedestrian impaired by alcohol	396	Disobeyed pedestrian crossing facility	101
Crossing road masked by stationary vehicles	308	Loss of control	90

Car and Van Driver Crash Causation Patterns at Junctions

From Figure 7, it may be seen that the rate per billion miles driven, for car and van drivers from the most deprived quintile who were both coded with a crash causation action or behaviour factor and involved in a pedestrian casualty crash at a priority junction was 4.8 times than that of car and van drivers from the least deprived quintile. The corresponding values for signalised junctions and roundabouts were 7.2 times and 3.1 times higher respectively.

The five most frequently coded driver crash causation action or behaviour factors for each junction type are also presented in Table 5. It may be seen that 'failed to look properly', 'driver careless reckless or in a hurry', and 'failed to judge vehicles path or speed' were prominent for all junction types. For priority controlled junctions, 'poor turn or manoeuvre' and 'too close to pedestrian' were also featured. For signalised junctions, the third most frequently coded contributory factor was 'disobeyed automatic traffic signal'. In addition, the 'Poor turn or manoeuvre' contributory factor also featured. For roundabouts, 'loss of control' and 'disobeyed adjacent pedestrian crossing facility' were also featured.

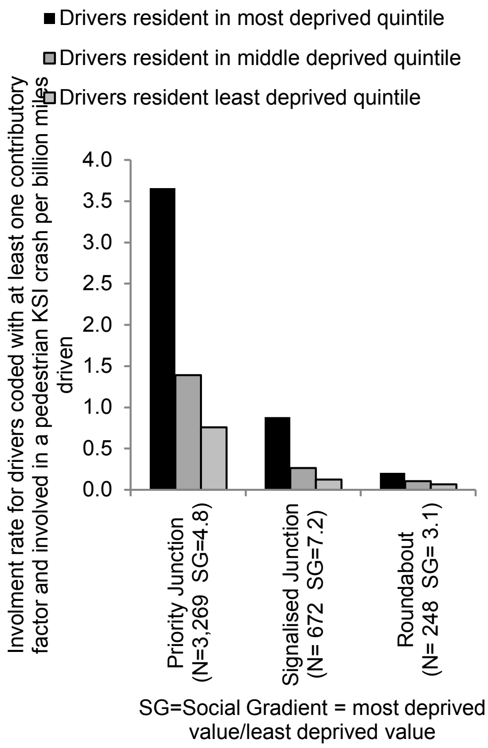


Figure 7 Rate of car and van drivers involved in pedestrian KSI crashes and coded with at least one Crash Causation Contributory Factor per billion miles driven by Junction Type and Resident Deprivation Quintile for England (2005-2015)

Vehicle Types involved in Pedestrian Casualty Crashes at Junctions

The pedestrian KSI crash frequency and involvement rates shown in Table 5 were derived from frequencies and estimated annual miles driven for different vehicle types within the Road Casualties Great Britain, Annual Report 2015 (DfT, 2016). It may be seen that, for all junction types, the frequency of car and van drivers involved in KSI crashes with pedestrians was more than seven times that of other vehicle types. Taking into account exposure, the pedestrian KSI casualty rates, per billion miles driven, are similar for both cars and vans and Heavy Goods Vehicles (HGV). However, for buses and coaches, the pedestrian KSI crash rate was more than five times that for cars and vans at priority junctions, and roundabouts. For signalised junctions, this rate was thirteen times.

From Figure 8 it may be seen that the percentage of buses and coaches involved in pedestrian KSI crashes and turning left at signalised junctions was 1.9 times that for other vehicles. This rate was 1.1 times more when travelling straight ahead at priority junctions. It may also be seen that the rate of KSI crashes involving ‘other vehicles’ turning right at priority junctions was 2.3 times more than that of buses and coaches.

Considering crash causation patterns, the frequency crash causation action/behaviour related factors associated with pedestrians involved in pedestrian casualty crashes, at signalised junctions, was four times higher than those associated with bus and coach drivers involved in such crashes. For pedestrians’ contributory factors at roundabouts and priority controlled junctions, the frequency was three times higher than that for bus and coach drivers.

Table 6 Pedestrian KSI crash frequency and involvement rate, per million miles driven, by vehicle type and junction type for Great Britain 2005-2015

	Pedestrian average annual KSI crash frequency by vehicle type involved			**Pedestrian KSI crash rate per billion miles driven**		
Junction Type	**Car or van**	**Bus or coach**	**Heavy goods vehicle**	**Car or van**	**Bus or coach**	**Heavy goods vehicle**
Signalised Junction	424	59	22	1.48	19.64	1.28
Priority Junction	1,592	87	46	5.57	29.00	2.74
Roundabout	107	6	5	0.38	2.00	0.27

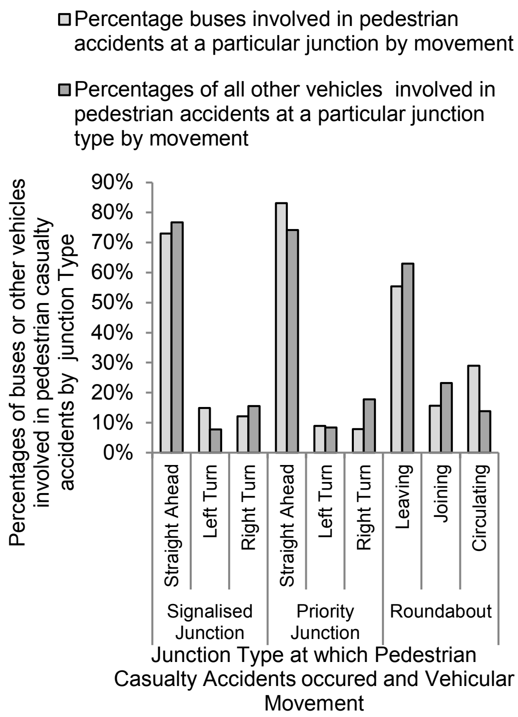


Figure 8 Percentage of buses and other vehicles involved in pedestrian casualty crashes by junction type and vehicular manoeuvre

DISCUSSION AND CONCLUSIONS

Contributing Factor Analysis

As indicated earlier, Broughton (2007) suggested that although there are possible limitations with contributory factor data because of its subjective nature, being based on the opinions of police investigating officers, it can provide a useful insight into patterns of accident causation. Knowles et al (2012) investigated pedestrian fatalities, at both junctions and mid-block locations, in London between 2006 and 2010 and used detailed fatal crash records to assign contributory factors to pedestrians and drivers involved in pedestrian fatalities. During the analysis, they coded 74% of pedestrians and 63% of drivers, involved in fatal pedestrian crashes, with contributory factors. They noted that although the coding of contributory factors gives an indication of the actions or behaviours which contributed to an individual collision it does not necessarily imply who was to blame.

In contrast to the Knowles et all (2012) study, the current investigation found that the percentage of pedestrians, involved in fatal and serious injury accidents, coded with at least one contributory factors were much higher than the percentage of drivers coded with at least one contributory factor for all junction types. Possible reasons for these larger percentages of pedestrians coded may include:-

- The earlier study involved pedestrian fatalities and did not include pedestrian crashes involving serious injury, the nature of which may be different; and
- The earlier study included pedestrian crashes at mid-block locations.

Social Deprivation

Pedestrians: The Department for Transport (DfT, 2015a), found that, for the whole of the road network, the casualty rate for people in the most deprived quintile was 0.58 KSI casualties per million miles walked, which was more than double the 0.28 KSI casualties per million miles rate in the least deprived quintile. Graham et al (2005) found that pedestrian casualty rate for adults in the most deprived areas was 2.3 times greater than the rate in the least deprived areas. Futher, Lyons et al (2003) found that, for people over 75 years, there was a substantial socio-economic gradient for pedestrian injuries. Laflamme and Engström (2002) found that young people belonging to a low social class and living in deprived socioeconomic areas are consistently at greater risk than others.

The current study found that the results for pedestrian casualty accidents at signalised junctions, priority controlled junctions, and roundabouts were similar to those found by the Department for Transport (DfT, 2015a) and Graham et al (2005) with casualty crash rates per billion miles walked for pedestrians residing in the most deprived quintile being between 1.6 times and 2.7 times higher than those pedestrians who were residing in the least deprived quintile areas.

Factors involved might include the fact that they may be resident in densely populated heavily trafficked areas with little open space, they are less likely to belong to car owning families and they are less likely to receive or respond to road safety education when compared with those from the least deprived quintile.

Drivers: Ward et al (2007) found that, for car drivers and occupants in the UK, 20% of the road fatalities came from the lowest socioeconomic group, whilst they constituted only 13% of the population. Clarke et al (2007) determined that, for older drivers and passengers, the frequency of fatalities was higher for the drivers from the least deprived quintiles. Murray (1998) found that over-representation of low-educated men and women among drivers involved in car crashes could not be explained by a higher risk exposure. In Australia, Chen et al (2010) found that the risk of crash-related hospitalization for 17 to 24 year old young drivers from the most deprived areas was about twice that of young drivers from the least deprived areas.

The current study which, in contrast to the other studies, only considered pedestrian accidents at signalised junctions, roundabouts and priority junctions found that the social gradients for drivers involved in pedestrian casualty crashes at junctions were very high ranging from 3.2 at roundabouts to five at priority junctions. Lowe et al (2011) found that some residents, in deprived areas, felt that the lack of enforcement of traffic regulations generated a general perception that ‘the rules of the road’ did not apply. This is supported by Clarke et al (2007) which found that drivers and passengers involved in fatal accidents who were resident in the more deprived quintiles were more likely to be not wearing seat belts, more likely to be under the influence of alcohol, more likely be travelling while unlicensed and uninsured and more likely to be involved in multiple fatality collisions.

Age and Gender

Pedestrians: In the United States, Laurie et al (2007) found that the pedestrian fatality rates per trip increased with age. They also found that that using time spent walking, as the exposure measure, also showed increased risks for older pedestrians. The DfT (2015a) also found that proportion of both male and female pedestrians aged 70 years and over who were killed and seriously injured were much higher than the proportion of distances each group walked per year. The current study found that the pedestrian KSI crash rates, per distance walked, for those aged 60 years and over, were higher than those aged between 25 years and 59 years at priority junctions and roundabouts. The rates were also higher for female pedestrians aged 60 years or over at traffic signals. However, for males pedestrian aged 60 years and over the KSI crash rate per distance walked, for signalised junctions, was slightly lower than for those aged between 25 years and 59 years. A partial explanation for this difference at traffic signals might be the differences in the age groups used in the studies. In the DfT (2015a) study it was found that males aged between 60 years and 69 years were involved 7% of all KSI pedestrian accidents but made up 10% of the distance walked whilst females were involved in 10% of the KSI pedestrian accidents but only made up 9% of the miles walked.

The study identified that the pedestrian KSI accident rates, for those aged 60 years and over, were higher than those aged 25 years to 59 years for pedestrians involved in crashes with turning vehicles at signalised junctions, turning vehicles at priority junctions and exiting vehicles at roundabouts. This may be associated with difficulties in detecting approaching turning vehicles or identifying which vehicles, on a roundabout, are going to exit or going to continue to circulate. Oxley et al (2004) noted sensory, perceptual, cognitive and physical abilities decline with age and that this can result in problems coping with traffic. They also noted that current road systems, for the most part, seems to be unforgiving for older vulnerable road users and few facilities are designed specifically for the special needs and capabilities of older adults. Issues to be addressed might include improved pedestrian conspicuity and driver education in terms reinforcing pedestrian priority on the minor arms of priority controlled junctions.

Drivers: The Department for Transport (DfT, 2009) found that 26% of all casualty accidents involved at least one driver aged between 17 years and 24 years. In the current study, the rate of involvement in pedestrian KSI crashes at signalised junctions, priority junctions and roundabouts, per billion miles driven, for those car and van drivers aged between 17 years to 24 years, was at least four times higher than for car and van drivers aged 25 years and over.

Many studies have found similar results. For example, Feleke et al (2018) also used estimated annual mileages driven derived from the UK National Travel Survey in a study which found that the UK fatality rates of a male driver aged 17–20 were between 14 to 18 times higher than of middle aged male drivers. McCartt et al (2009), in a study which reviewed eleven studies undertaken since 1990, found that that teenage drivers had dramatically higher crash rates than older drivers. They advocated a graduated licensing system that ‘phased in’ unsupervised driving during high-risk situations as teenagers gain independent driving experience. Similarly, in the UK context, Kinnear et al (2014) suggested that the introduction of a graduated driver licensing (GDL) system in Great Britain could considerably reduce the number of young novice-driver collisions and the associated casualties.

Buses and Coaches

The Department of Transport (DfT, 2015b) found that although buses were involved in seven percent of all pedestrian fatalities, they only accounted for one percent of the traffic. Similarly in the US, Paulozzi (2005) reported that when compared with cars, the fatality rate of pedestrian crashes, per mile driven by buses was 7.9.

In the current study the pedestrian casualty rate per billion miles driven by buses was 5.2 times that of cars both at priority junctions and roundabouts. These lower values may be because junctions are usually some distance from bus stops. However, for signalised junctions the pedestrian casualty rate per billion miles driven by buses was 13.2 times that of cars. Possible contributing factors to this higher rate may be fact that the British bus fleet is largely rear engine (lower audible warning) and limited driver visibility. Knowles et al (2012) found that, in 33 fatal pedestrian crashes involving buses which occurred in London, over a quarter of the pedestrians involved were impaired by alcohol and, in a third of the cases, the bus driver's line of vision was obscured.

Summary

The most important findings of the investigation may be summarised as follows:-

- With regard to indicative blame, the coding frequencies of subjectively determined pedestrian actions and behaviour which might have contributed to pedestrian casualty crashes were between 1.6 and 2.8 times the coding frequencies of driver actions and behaviour.

- Substantial social gradients were found in pedestrian casualty rates per miles walked and in the driver involvement rates per mile driven. In particular the driver involvement rate in pedestrian casualty crashes for those resident in the most deprived quintile, per mile driven, was over 4.5 times that for those resident in the least deprived quintile at signalised intersection, and priority controlled junctions

- Females aged 60 years and over had higher pedestrian casualty rates per billion miles walked, at all types of junctions, than those males and females under the age of 60 years apart from males aged 16 years and younger at priority controlled junctions.

- For male car and van drivers, aged between 17 years and 24 years, the rate of driver involvement in pedestrian casualty crashes at junctions per billion miles driven, was over 3.5 times that of drivers aged 25 years and over. The equivalent value, for female drivers aged between 17 years and 24 years, was two times higher.

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REFERENCES

Beck, L. F., Paulozzi, L. J., Davidson, S. C. Pedestrian fatalities, Atlanta metropolitan statistical area and United States, 2000–2004. Journal of safety research. 2007. 38(6), 613–616.

Broughton, J. Contributory factors in road accidents. Transport Research Laboratory (TRL) Staff Paper. PA/TRS/5756/07. Wokingham. Berkshire. 2007.

Chen H. Y., Ivers R. Q., Martiniuk, L. C., Boufous, S., Senserrick, T. , Woodward, M., Norton, R. Socioeconomic status and risk of car crash injury, independent of place of residence and driving exposure: results from the DRIVE Study. Journal of Epidemiology and Community Health. 2010;, 64 (11), 998–1003.

Clarke, D., Ward, P., Truman, W., Bartle, C. Fatal vehicle-occupant collisions: An in-depth study. Department for Transport, Road Safety Research Report 75. London. 2007.

Department for Communities and Local Government. The English Indices of Deprivation 2015. Research Report. 2015.

Department for Transport (DfT). The design of pedestrian crossings. Local transport note 2/95 London. 1995.

Department for Transport (DfT). Pedestrian facilities at signal controlled junctions. Traffic advisory leaflet 5/05. 2005.

Department for Transport (DfT). Reported road accidents involving young car drivers: Great Britain 2009. Road Accident Statistics Factsheet No. 6, Department for Transport, London. 2009.

Department for Transport (DfT). Facts on pedestrian casualties. London. 2015a.

Department for Transport (DfT). Facts: young car drivers. National Statistics. London. 2015b.

Department for Transport. Tomorrow's roads – safer for everyone. The first three years. London, 2004.

Department for Transport (DfT) Reported road casualties Great Britain: 2015 Annual Report, Moving Britain Ahead. 2016.

Design Manual for Roads and Bridges (DMRB). Geometric design of major/minor priority junctions. TD 42/95 Volume 6, Section 2, Part 6, 1995.

Design Manual for Roads and Bridges (DMRB). Geometric design of roundabouts TD 16/07, Volume 6, Section 2, Part 3, 2007.

Federal Highway Administration (FHWA). Pedestrian Safety at intersections. FHWA-SA-10-005. 2009.

Feleke, R., Scholes, S., Wardlaw, M., Mindell, S. Comparative fatality risk for different travel modes by age, sex and deprivation Journal of Transport & Health. 2017.

Graham, D., Glaister, S., Anderson, R. The effects of area deprivation on the incidence of child and adult pedestrian casualties in England. Accident Analysis and Prevention. 2005;. 37 (1), 125–135.

Kinnear, N, Lloyd, L., Scoons, J., Helman, S. Graduated Driver Licensing. A regional analysis of potential casualty savings in Great Britain. RAC Foundation TRL May 2014.

Knowles, J., Smith, L., Cuerden, R., Delmonte, E. Analysis of police collision files for pedestrian fatalities in London. 2006-10. Published Project Report PPR620. 2012. Transport Research Laboratory, Crowthorne.

Lowe, C., Whitfield, G., Sutton, L., Hardin, J., RSRR 123 Road User Safety and Disadvantage – Main Report , DfT London. 2011.

Laflamme, L., Engström, K. Socioeconomic differences in Swedish children and adolescents injured in road traffic accidents: cross sectional study. British Medical Journal. 2002. 324 (7334), 396–397.

Lyons, R. A., Jones, S. J., Deacon, T., Heaven, M. Socioeconomic variation in injury in children and older people: a population based study. Accident Injury Prevention. 2003;. 9 (1), 33–37.

McCartt, A. T., Mayhew, D. R., Braitman, K. A., Ferguson, S. A., Simpson, H. M., Effects of age and experience on young driver crashes, Traffic Injury Prevention. 2009;. 10(3), 209–219.

Murray, A. The home and school background of young drivers involved in traffic accidents. Accident Analysis and Prevention. 1998;. 30 (2), 169–182.

National Travel Survey 2005 to 2015, UK Data Service Special Licence (2016). DfT Licence Number 108917.

Paulozzi, L. J. United States pedestrian fatality rates by vehicle type, Injury Prevention 2005;11:232–236.

Van den Berghe, W. The association between road safety and socioeconomic situation (SES), An international literature review. Brussels, Belgium: Vias institute – Knowledge Centre Road Safety. 2017.

World Health Organization. Global status report on road safety. Switzerland. 2015. ISBN 978 92 4 156506 6

Ward, H., Lyons, R., Christie, N., Thoreau, R., & Macey, S., Fatal injuries to car occupants: Analysis of health and population data. Department for Transport, Road Safety Research Report 77. London. 2007.