Investigation of Pedestrian Accidents Analysis at Signalised Pedestrian Crossings in Edinburgh

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Abstract: Data from STATS19 show that pedestrian accident rates are higher over the pedestrian crossing points than these away from it, or within 50 m of pedestrian crossing facilities. This is contrary to the expectations that accidents should be least over these crossing facilities. This study investigates in more details the factors that affect accidents occurrence at pelican crossing and signalised pedestrian area in Scotland. Accidents data of 14 years (from 1993 until 2006) in selected site, that is 441 pedestrian accidents occurred in or within 50 m on signalised pedestrian crossing area (238 on pedestrian phase at traffic junction and 203 on pelican, puffin and toucan). Grid references of accident locations as well as locations of pedestrian crossings were obtained from STATS19 database and the local city councils. The data was used to identify the locations of accidents relative to the location of pedestrian crossing facilities. The results show an increase in accidents rates decrease as distance increase from the pedestrian crossing facilities. The most risky locations are these at the pedestrian crossings or within 10 m and the distance from 10-30 before the pedestrian crossing facilities. Analysis of pedestrian accidents rates for each of pelican and signalised crossings were discussed. Modelling accidents rates and severities at these pedestrian crossings is also presented in this article. Linear regression and logit modelling are both used to analyse the results. This article is divided into four sections. First, the literature review and background of the work is presented in Section 1. Section 2 discusses the data and the case studies. The results of the work and analysis of the results are presented in Section 3. Finally, Section 4 summarises the results and concludes the work.

Keywords: Pedestrian, Signalised Pedestrian Crossing, Linear Regression, Logit Regression

1 Introduction

Despite all government efforts to protect pedestrians from the risk of accidents, such incidents are still quite pervasive and the severity of which is considered very high because pedestrians are generally unprotected from road accidents. Also, despite an overall positive outlook on road safety in the UK, compared to other European countries such as Austria, Finland, Ireland, Norway, Switzerland, Belgium, Denmark, Germany Netherlands, Sweden, France, Italy and Spain; 'pedestrians form a higher proportion of fatalities in the UK than other countries. For example, the rate of pedestrian fatalities per head of population in the UK is almost three times the level experienced in the Netherlands', (Commission for Integrated Transport, 2007). Figure 1 below shows rate of fatalities per type in the EU countries.

Moreover, Figure 2 below presents the high number of pedestrians killed or seriously injured in road accidents from 1980 to 2006 in the UK. The graph shows that the pedestrians register the second highest number of accident record within the KSI category, next to car users.

On the other hand, other statistics show a reduction in total number of pedestrian accidents in the UK. Statistical analysis of the UK police accident records (STATS19) provides a rich data of pedestrian accident records that includes different variables that characterise pedestrian accidents. In this data set, it appears that number of pedestrian accidents accounted for 13.6% of the total number of accidents. This percentage ranked third place after driver or rider and passenger. Also, although the Transport Statistics Bulletin (2006) records an 18% decrease in road casualties by severity over the 1994-1998 average (Table 1), pedestrian accidents in the UK are still higher than other countries in Europe as discussed earlier.

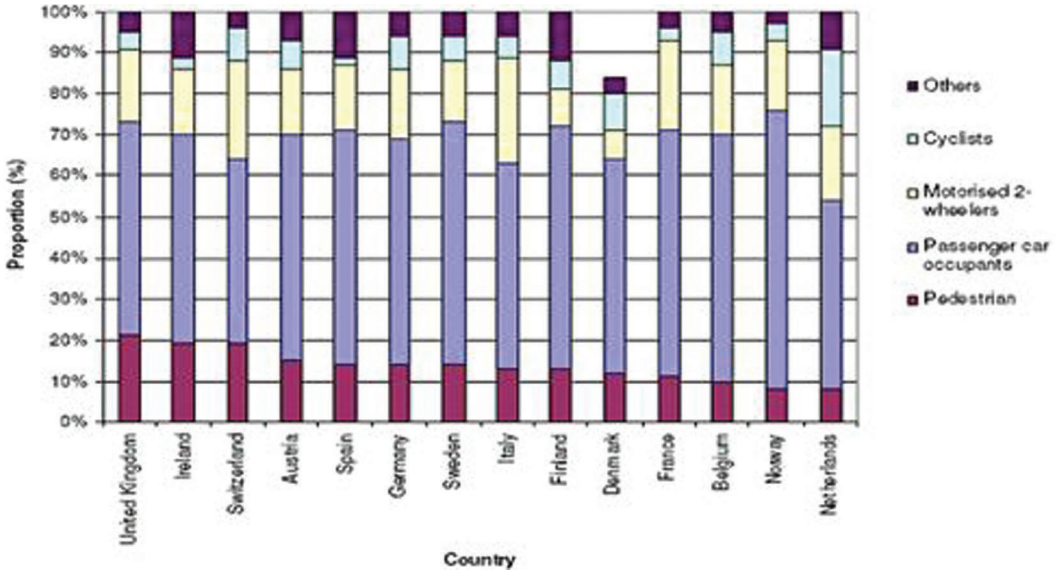

Figure 1 - Rate of fatalities over EU countries

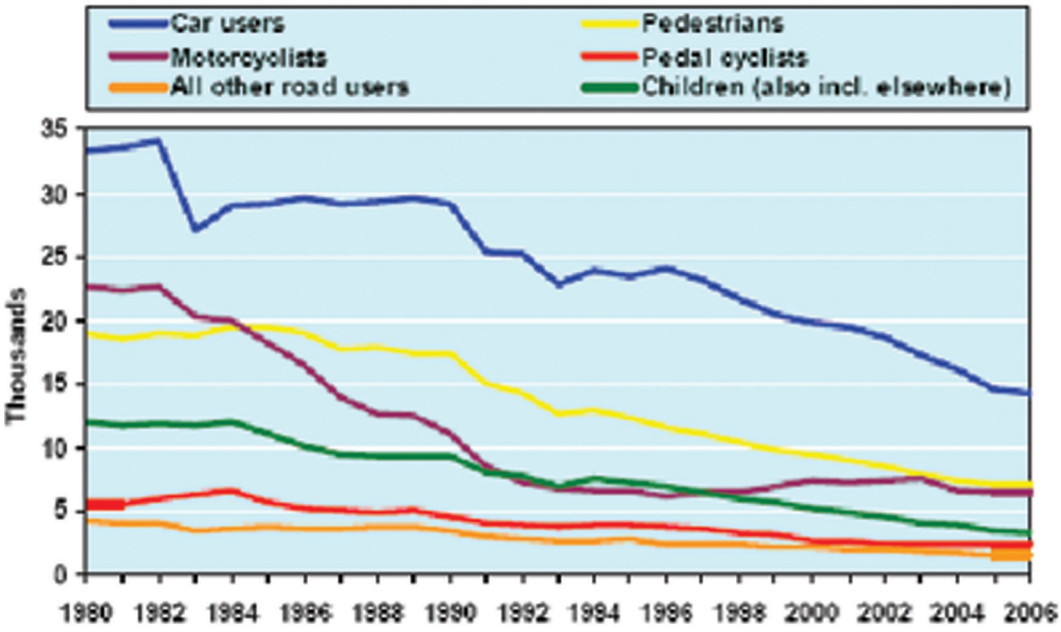

Figure 2 - Killed and serious injury for all type of transport

Moreover, a further decline in the same types of accident was documented in the statistical records of the following year (Transport Statistics Bulletin, 2008). Indeed, the Transport Statistics Bulletin (2008) claims that 'pedestrian casualties were 30,191 in 2007, 3% less than 2006. Pedestrian deaths were 4% lower compared to 2006 at 646 and serious injuries fell by 2% to 6278'.

Table 1 Comparison of pedestrian casualties from 1994-1998 and 2006

	Number / percentage change compared to previous 12 months and 1994-1998 average				
	1994-1998 average A	Jul-04 to Jun-05 B	Jul-05 to Jun-06(P) C	Percentage change over 1994-1998 average *(C-A)/A%*	Percentage change over previous 12 months *(C-B)/B%*
ALL CASUALTIES					
Killed	3,578	3,160	3,190	−11	−1
KSI[1]	47,656	32,633	31,790	−33	−3
Slightly injured	272,272	242,547	231,320	−15	−5
All casualties	319,928	275,180	263,110	−18	−4

Note: P Provisional estimates

[1]Killed or seriously injured

1.1 Importance of This Study

Some previous research and analysis have been conducted in terms of locations of pedestrian accidents. For example, Ward et al. (1994) investigated the location of accidents relative to the road crossing facilities. They noted that pedestrian accidents occurred mainly away from road crossing facilities; the highest number of cases of pedestrian accidents occurred on signalised pedestrian crossing at pedestrian phase at traffic signal and at pelican crossing. However, they have neither further investigated nor modelled this further. There is a lack of papers in this research area.

From STATS19 data (1993-2006), it appears that most pedestrian accidents occur at locations where there are no pedestrian crossing physical facilities; 409,474 accidents (74.6% of total pedestrian accidents) with KSI of 23.34%, while 25.4% of pedestrian accidents happen at physical crossing facilities with KSI of 24.58% (see table 2). With respect to pedestrian crossing physical facilities, the highest number of pedestrian accidents occurred over that 14 years period were at pelican crossings (54,645 or 39%), followed by those were occurred at a traffic signal junction (41,123 or 30%); then those accidents which were at a zebra crossing (28,328 or 20%); (13,214 or 10%) at central refuge while the lowest number of cases of pedestrian accidents were recorded in footbridge or subway (1883 or 1%) (STATS19).

In this article, therefore, a detailed investigation of the factors affect pedestrian accidents at signalised pedestrian crossing is undertaken.

One of the main problems of modelling pedestrian accidents is lack of information on exposure data. For example, hazardous pedestrian behaviour represent by pedestrian volume times vehicular volume, average distance walked per person per day or total aggregate distance of pedestrian travel across an intersection, average number of walking trips made by numbers of population or average time walked per person per day have been used in the literature in a number forms. However, to the knowledge of the author, to date there is no one single measure of pedestrian exposure that has been internationally accepted or used. In this research, one of the main aims is to investigate measures of exposure in modelling pedestrian accidents using pedestrian volumes at pedestrian crossing. Lastly, previous work on modelling pedestrian accidents included factors such as traffic flows, width of road, type of crossing facility and time of crossing and socioeconomic data. Not much work was done to investigate impacts of the distance of the pedestrian accidents from the crossing lines.

Table 2 Percentage of casualties and KSI for pedestrian accidents at physical crossing facilities

Pedestrian crossing-physical facilities	Number of accidents	%	Number of KSI	%
Pelican	54,645	39	13,794	25.24
Pedestrian traffic signal junction	41,123	30	9,631	23.41
Zebra	28,328	20	6,107	21.55
Central refuge	13,214	10	3,922	29.68
Footbridge or subway	1,883	1	712	37.81

2 Literature Review

The statistical data on the various factors related to pedestrian accidents mentioned earlier highlights the importance of pedestrian safety. This section evaluates available literature related to pedestrian motor vehicle crashes. First, it delves on the factors contributing to pedestrian – motor vehicle clashes. Next, it tackles literature related to the frequency of pedestrian – motor vehicle clashes with respect to the distance of pedestrian accidents from pedestrian crossing area or junction. Then, it delves on the influence of pedestrian crossing types on pedestrian accidents. Next, it analyses literature related to the legal instruments being enforced for pedestrians in crossing pedestrian areas. Then, it discusses literature related to pedestrian behaviour. Lastly, literature related to traffic engineering.

Pedestrian–motor vehicle accidents have the highest amount of occurrences in intersections and other areas with the largest amounts of foot and vehicular traffic. However, factors that contribute to pedestrian–motor vehicle accidents are not limited to congestion. The characteristics of the vehicle and drivers, as well as those of the pedestrians, can increase the statistical value of accidents that occur (Campbell et al., 2004). The characteristics of roads and traffic also impact the number of occurrences (Campbell et al., 2004). In particular, the physical features and land use qualities, including crosswalk design and roundabout design in the neighbourhoods, can attribute to higher rates of pedestrian to vehicle accidents (Campbell et al., 2004). These findings were supported by Sideris (2006), who claimed that pedestrian–motor vehicle clashes are influenced by the following: (1) the social and behavioural characteristics of drivers and victims, (2) road design characteristics, (3) vehicular and pedestrian traffic characteristics and (4) area sociodemographic and physical characteristics. Both authors provided an extensive discussion of each factor and the manner by which each influences the prevalence of pedestrian-motor vehicle collisions.

In terms of the distance of pedestrian accidents from pedestrian crossing area or junction, Ward et al. (1994) claimed that: (1) a large number of cases of pedestrian accidents occurred away from road crossing facilities, (2) only few cases occurred at road crossing facilities and (3) the highest number of cases of pedestrian accidents occurred on traffic signals with a pedestrian phase with pelican crossing. Such findings indicate that pedestrians are more at risk to accidents when they decide to cross in places with traffic signals with a pedestrian phase and pelican crossing or when they decide to cross away from road crossing facilities. Such findings were similar to the findings of the Department for Transport (2004), which indicated that 40% of pedestrian collisions in 2003 occurred when pedestrians cross the roads away from a pedestrian crossing. In contrast, only 9% of collisions occurred on pedestrian crossings and only 8% within 50 m of a particular crossing.

With respect to the types of pedestrian crossing, Greenshields et al. (2006) tabulated the different advantages and disadvantages of various types of pedestrian crossing, namely: zebra, pelican, toucan and parallel crossings. However, the study was not empirical and is more on the narrative side, providing guidance on: (1) the legal instruments covering the different crossing types and (2) guidance on the various

design standards of pedestrian crossing facilities. A more comprehensive study of Midblock Pedestrian Crossings in Great Britain was conducted by Hunt (1998) who documented that '80% of pedestrian casualties occurred while pedestrians were crossing the carriageway and, that more than 12% of these pedestrian casualties were at or within 50 m of a Pelican or Zebra crossing'. Moreover, according to Hunt (1998):

- From 1975 to 1985, there had been an increase in the number of pelican crossings and a corresponding increase in the number of pedestrian casualties at or close to pelican crossings.
- From 1975 to 1985, there had been a decrease in pedestrian casualties at or close to zebra crossings where there was a decrease in the number of zebra crossings.
- From 1985 to 1995, there was a decrease in pedestrian casualties at both zebra and pelican crossings.
- In terms of zebra crossings there are fewer accidents 'within 50 m of crossings but not on crossing' than 'on crossing'; this is not the case for pelican crossings.
- From 1990 to 1995, pedestrian casualties at Pelican crossings were 'reduced at a similar rate to the reduction in pedestrian casualties in built up areas; over the same period pedestrian casualties at zebra crossings continued to reduce more rapidly than the reduction for built up areas – this is unlikely to be explained by a reduced number of zebra crossings'.

Similarly, the Department of Transport (2004) claimed that, in 2003, more pedestrian collisions were recorded at mid-block signalised crossings in comparison with other types of pedestrian crossing. The study conducted by the AA Foundation (1994) on pedestrian risk indicated that signalised crossings reduce the pedestrian accident risk by 50% compared with crossings lacking in such facilities. Moreover, the study conducted by Ghee et al. (1998) found that lack of crossing facilities affect 'older women more than anyone else as they were found to have difficulties understanding and monitoring the sequence of traffic movements and a tendency to monitor nearside and far side traffic independently as they cross the road'.

However, because accidents are random events, other non-linear forms of models would be more appropriate to use in for the calibration of accidents prediction models. For example, the Poisson regression, or log-linear model, is a regression analysis method that models counted data in relationship to contingency factors. In this method, the response variable assumes that the expected value is logarithmic and modelled through unknown linear parameters. In its simplest form, Poisson regression uses the form: $\log [E(y)] = a + bx$. Because the Poisson regression model assumes a non-linear function, it is established to be more effective for crash prediction than linear regression (Maher and Summersgill, 1996). Poisson regression models count data, but contains the limitation that predicted outcomes are contingent on the dispersion of data (Maher and Summersgill, 1996). The negative binomial model, also referred to as the Poisson-gamma distribution, allows for accident data to be analysed with a low sample sizes, and mean values that impact the dispersion parameters causing unreliability (Lord, 2006). The Poisson-gamma model overcomes these low dispersion sample variables by acting as a discrete probability distribution. Essentially, this means that the distribution description arises from the sequence of independent variables within multiple constraint factors, where the probability of success (in this research, success can be established as an accident) is constant through a fixed number achieved success factors.

3 Methodology

Data that is used in this research come from different sources such as the city council, STATS19 and data that have been collected from selected sites.

The STATS19 system is a well-established database system, in which accidents involving serious injury are reported by the police (McGrath and Tranter, 2008). STATS19 provides details of personal injury accidents that are presented as three data files (see appendix 1 for the STATS19 form): accident records files which contains, for example, date and time of accident, day of the week, type of road, crossing facility, etc.

Vehicle records files that contain types of vehicle, manoeuvres, vehicle movement, first point of impact, gender and age of driver or rider, and other records related to the vehicle. And, casualty records files that contain casualty class (driver or rider, passenger, pedestrian), gender and age of casualty, severity of injury, pedestrian location, movement and direction and other records which are related to the casualties.

Other data include data from the Edinburgh City Council. These include the map locations of signalised pedestrian crossing facilities and signalised junctions have been provided by Edinburgh City Council. Further, data was acquired by filming the selected locations and counting pedestrians who crossed the road, and an average was reached of how many used the crossing facilities. Filming is one of manual counting methods that used to quantify all types of transportation activity, particularly for study small sample of data such as pedestrian crossing the street at intersection. Filming used to record images of pedestrian cross the street and later reviewed by the researcher. The advantage of filming is helping the researcher to count traffic volume, pedestrian flow, type of vehicle and pedestrian behaviour when crossing the street.

4 Data Analysis and Discussion

The results reveal that for all pedestrian accidents, males under the age of 16 suffered fatality almost twice as much as females in the same age group of pedestrian to vehicle accidents. Males under the age of 16 also have a 63.4% higher occurrence of being seriously injured and are 59% more likely to have a slight injury. Between the ages of 16 and 59, males suffered almost three times more fatalities than females. Also in the same group, twice the number of males suffered serious injuries than females and 59% of male suffered from slight injuries.

However, the KSI percentage for the senior female population are actually higher than that for the male population over 60 (female 35.70% and male 34.68%), where also 57% of females suffered serious injury. This is also the case for slight injuries, where the percentage of female who suffered slight injured was 54.1% and male were 45.9%, in the older population more than 60. These numbers become interesting as the analysis takes into consideration that, through the 1993-2006 period, males have a higher occurrence of fatality and serious injury than females through the age of 60, but after the age of 60 females have a higher rate of fatality and serious injury than males. Although age and gender are important factors when analysing pedestrian accidents, the type of road also impacts on the severity of accidents. Single carriageway has the highest incidence of fatalities during the 1993-2006 period. Accordingly, 75 and 83% of all recorded fatal and serious accidents, respectively, occurred on a single carriageway. The next highest percentages occurred (20% fatal accidents and 10% serious) in dual carriageways. Overall, there are 84 and 11% of KSI accidents occurred on single and dual carriageway, respectively (see Table 3). One way streets, roundabouts and other road types were responsible for 5% of fatalities and serious injuries.

The majority of fatal and serious injuries also occur on roads where the speed limit is between 30 and 39 miles per hour. In term of road surface condition, there is only a 4% difference of KSI in pedestrian accidents occurring in dry and wet road conditions, where dry roads are responsible for 22.73% of KSI and wet roads responsible for 26.36%. Almost 24% of pedestrian to vehicle accidents occur on or near the crosswalk, where pedestrians crossing from the driver's or the passenger's side of the vehicle have more incidence of fatal and serious accidents than other types of pedestrian movements, such as walking along the street or sidewalk. Of all accidents that occur, 75% occur at crossing areas with no signalling. However, this means that 25% of all pedestrian to vehicle accidents occur even when a form of signalling is in place, where the pelican style of signalling has the largest frequency of fatality and serious injury at crosswalks than any other form of signal. Further, modelling of the results will still to be carried out.

Accidents data for 14 years show that there were 442 pedestrian accidents on or within 50 m on signalised pedestrian crossing area. Of these, 16% of these accidents considered as killed and serious injured people and 84% were slight.

Table 3 The summary of pedestrian accidents in the UK from 1993-2006

Variables		Description	Min	Max	Mean	KSI
Age	Child (0-15)	Child = 1; Other = 0	0	1	0.41	0.34
	Adult (15-59)	Adult = 1; Other = 0	0	1	0.43	0.44
	Old (60<)	Old = 1; Other = 0	0	1	0.15	0.22
Gender	Male	Male = 1; Other = 0	0	1	0.58	0.61
	Female	Female = 1; Other = 0	0	1	0.42	0.39
Severity	KSI	KSI = 1; Other = 0	0	1	0.24	
	Slight	Slight = 1; Other = 0	0	1	0.76	
Road Type	Single carriageway	Single cw* = 1; Other = 0	0	1	0.86	0.84
	Dual carriageway	Dual cw* = 1; Other = 0	0	1	0.08	0.11
	One way street	One way = 1; Other = 0	0	1	0.06	0.05
Pedestrian location	On pedestrian	On = 1; Other = 0	0	1	0.11	0.13
	Elsewhere within 50 m	Within 50 m = 1Other = 0	0	1	0.08	0.13
	Elsewhere	Elsewhere = 1; Other = 0	0	1	0.81	0.74
Road surface	Dry	Dry = 1; Other = 0	0	1	0.73	0.70
	Wet	Wet = 1; Other = 0	0	1	0.26	0.29
	Snow	Snow = 1; Other = 0	0	1	0.01	0.01
Light condition	Daylight	Daylight = 1; Other = 0	0	1	0.72	0.65
	Darkness	Darkness = 1; Other = 0	0	1	0.28	0.35
Physical crossing facility	No crossing facility	No facility = 1; Other = 0	0	1	0.81	0.74
	On crossing	On crossing facility = 1; Other = 0	0	1	0.19	0.26

*cw, carriageway.

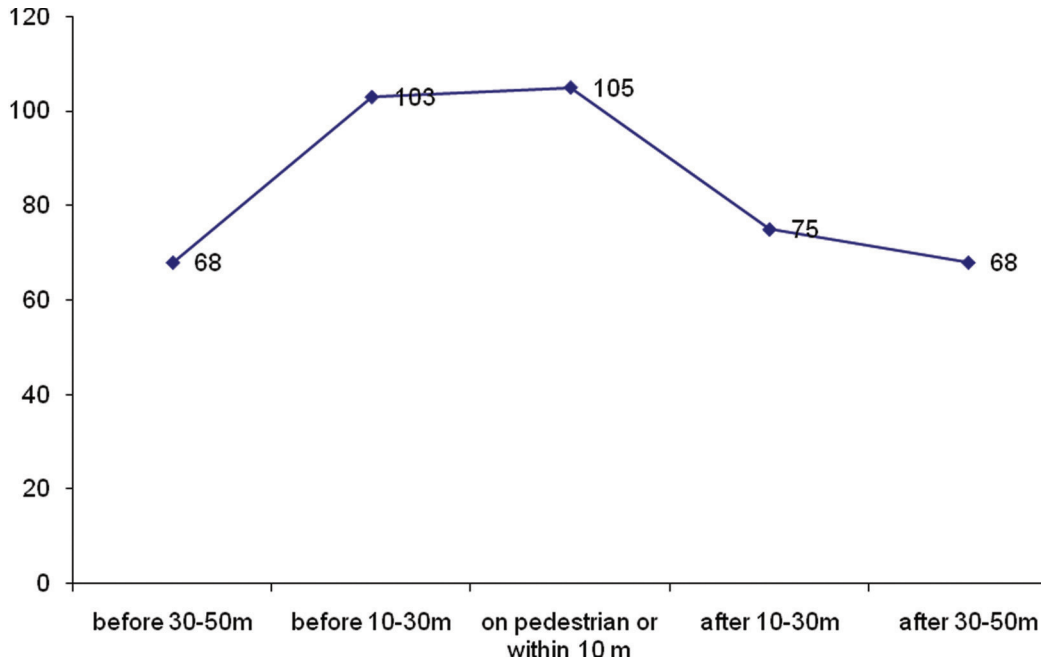

Figure 3 - The most risky distance of pedestrian crossing facilities

The results show that an increase in accidents rate decrease as distance increase from signalised pedestrian crossing area. Figure 3 illustrates the most risky distance of pedestrian accidents from pedestrian crossing point. Figure 3 presents that the most risky location were at the pedestrian crossings or within 10 m of it and the locations before 10-30 m of pedestrian crossing areas.

References

AA Foundation for Road Safety Research. (1994). 'Pedestrian Activity and Accident Risk', University of London and Steer Davies Gleave, London.

Campbell, B.J., Zegeer, C., Huang, H. & Cynecki, M. (2004). 'A Review of Pedestrian Safety Research in the United States and Abroad,' Federal Highway Administration, FHWARD-03-042, McLean VA.

Commission for Integrated Transport. (2007). 'Are We There Yet? A Comparison of Transport in Europe', http://www.cfit.gov.uk/docs/2007/ebp/index.htm#03, accessed on 8 July 2008.

Department for Transport. (2004). 'Road Casualties Great Britain 2003', TSO, London.

Ghee, C.E., Knox, D.J., Selby, T.A., Silcock, D.T., Walker, R.T. & Packer, D.W. (1998). 'Pedestrian Behaviour and Exposure to Risk', Ross Silcock, Limited; available at: http://www.pedestrians-int.org/content/18/222006_p.pdf.

Greenshields, S., York, I. & Paradise, R. (2006). 'Shared Zebra Crossing Study', Cycling Centre of Excellence, Transport for London, London.

Hunt, J. (1998). 'A Review of the Comparative Safety of Uncontrolled and Signal Controlled Midblock Pedestrian Crossings in Great Britain', Swedish National Road and Transport Research; available at: http://www.pedestrians-int.org/content/18/222006_p.pdf

Lord, D. (2006). 'Modeling motor vehicle crashing using Poisson-Gamma models: examining the effects of low sample mean values and small sample size on the estimation of the fixed dispersion parameter', *Accident Analysis and Prevention* Vol. 38, No. 4, pp. 751-766.

Maher, M. & Summersgill, I. (1996). 'A comprehensive methodology for the fitting of predictive accident models', *Accident Analysis and Prevention* Vol. 28, No.3, pp. 281-296.

McGrath, K. & Tranter, M. (2008). Matching UK road traffic accidents as recorded by the police with those from hospital records. http://www.ons.gov.uk/about/newsroom/events/thirteenth-gss-methodology-conference--23-june-2008/programme/matching-uk-road-traffic-accidents-as-recorded-by-the-police-with-those-from-hospital-records.doc. (accessed on 7 July 2008).

Sideris, A.L. (2006). Is it safe to walk? 'Neighborhood safety and security considerations and their effects on walking', *Journal of Planning Literature* Vol. 20, pp. 219-232.

STATS19 Returns. Undated. 'Road Accidents Statistics', http://www.statistics.gov.uk/StatBase, accessed on 26 April 2009.

Transport Statistics Bulletin. (2006). 'Road Casualties in Great Britain Quarterly Provisional Estimates Q3 2008', Transport Statistics, DfT. http://www.dft.gov.uk/pgr/statistics/datatablespublications/accidents/rcgbq32008. (accessed on 26 April 2009).

Transport Statistics Bulletin. (2008). 'Road Casualties in Great Britain Main Results: 2007', www.dft.gov.uk/transtat. (accessed on 26 April 2009)

Ward, H., Cave, J., Morrison, A., Allsop, R. & Evans, A. (1994). '*Pedestrian Activity and Accident Risk*', AA Foundation for Road Safety Research, Basingstoke.