Modelling The Relationship Between Pilgrims' Pedestrian Casualties and Land Use Type: A Case Study of Al Madinah Al Monawarah

By

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Abstract

The growing fatality of road traffic accidents in most cities constitutes a public health challenge. Annually, about 1.24 million people are killed from road accidents, among which more than one fifth of these deaths occur among pedestrians. Pedestrian collisions are even more prevalent in cities that host mass gathering events such as the Hajj. Yet this phenomenon has been neglected within the existing literature. Correspondingly, this research examines the relationship between pilgrims' pedestrian casualties and the land use type in Madinah. The relationship between the land use and pedestrian casualty was determined from pilgrims pedestrian casualty data (N=2204) from 2001 to 2005 supplied by the Madinah Police Department. The accident data is characterized by the personal and socio-demographic attributes of the victims as well as the land use type of the accident.

The significant findings from this study show that male pilgrims were over represented in pedestrian casualty in Madinah. This is consistent with other road accident studies in Arab-Muslim countries which also recorded higher male casualty compared to female. Again, more men embark on pilgrimage than their female counterpart. Young pilgrim (12-20's) pedestrians suffer the most casualties; while the least casualty was recorded for child pilgrim pedestrians (<12). In terms of day of the week, the high casualty occurs on Friday which is an important day for prayer that usually cause high incident of traffic and over-crowdedness. Though almost three-quarter of the pilgrim pedestrians sustained their casualties during high season months as most Moslem pilgrims embarks on pilgrimage during this period. However, most pilgrims' pedestrians suffer casualty during non-praying time because during prayer time, most of them would either be in the Mosque or residence fulfilling their obligation to pray, thereby, making them less exposed to pedestrian-vehicle collisions.

In modelling the relationship between pilgrims' pedestrians and land use type, quasi-Poisson regression models fitted the accident data better than Negative Binomial regression models. Most of the models developed indicate strong association between pilgrims' pedestrian casualties and commercial and religious land use types. For the major land use types, fatalities were more prevalent in the commercial and religious land use types. In terms of road type, the highest casualties occurred on single carriageway-2 lanes and mostly on roads around the Holy site. Whilst the results indicate that there is a greater number of accidents occurring in proximity to junctions or close to T,Y or staggered junctions categories taken together, the large single category of accidents occurred ‘not at junction or within 20metres of junction.. Nevertheless, majority of coefficients for road type and junction details variables were insignificant. Main findings from this research are discussed and suitable recommendations are made to assist policy makers in proffering countermeasures to will help improve safety and reduce accidents. One of the main findings of this research is that the serious accident pattern indicates the need for improved pedestrian facilities for pilgrims. This is the major outcome of the modelling and the analysis in general.

Keywords: Pedestrians, Land use, Road accidents, traffic safety, Madinah and Pilgrims.

Declaration

I hereby declare that this thesis was composed by myself

and that the work herein is mine

unless otherwise stated.

Sign…………………………………………………………………….

Date: ……………………………………………………………………..

Dedication

Say: "Truly, my prayer and my service of sacrifice, my life and my death, are (all) for Allah, the Cherisher of the Worlds; No partner hath He: this am I commanded, and I am the first of those who bow to His Will."

— **The holy Quran (6:162-163)**

This thesis is dedicated to my parents, Mr. Nayif Awad Alahmadi and Mrs Khadijah Ahmad Alahmadi, for their constant prayers and effort in guiding me to the path of knowledge. Their encouragement and loving support has strengthened me throughout this research. And also to my lovely son, Master Nayif Raed Alahmadi, who endured my absence during the period of this research.

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First and foremost, I would like to express my profound gratitude to the Almighty God for His providence and guidance throughout this research. God is truly the ultimate source of inspiration and strength in accomplishing this research.

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The kindness, encouragement and support from my parents and colleagues at the School of Engineering & the Built Environment (Civil & Transportation Engineering Subject Group) are also acknowledged. The successful completion of this research could not have been achieved without the contributions of these people.

Finally, I am indebted to the government of the Kingdom of Saudi Arabia for the financial support given to me throughout the study period. My thanks also goes to the local authority of Madinah and its residents for their support and generosity in supplying us with useful pilgrims' pedestrian casualty data for this research. We are also grateful for the permission given to us to use maps, photographs and other information relevant to this research.

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Definitions

There are several ambiguous terminologies (or words) that are often used in traffic road accident studies that need to be defined for clarity purposes. Hence, the following definitions as applicable to this research are given below:

Adults – These are persons aged 16 years and over (except otherwise stated).

Casualty – These are persons killed or injured in an accident. Casualties are usually categorized as follows: fatal injury (killed); serious injury; and slight injury.

Children – These are persons considered to be less than 16 years of age.

Degree of Freedom – Number of independent dimensions of variation. For example, in the N cells of a table of probabilities only N-1 can be arbitrarily filled, the last being determined by the requirement that probabilities must add to 1, hence there are N-1 degree of freedom.

Deviance – Essentially error (residual) of prediction (model).

Drivers – These are persons mechanically controlling the vehicles, excluding pedal cycles and two-wheeled motor vehicles.

Exposure – The number of opportunities for a certain type of accident to occur in a given time in a given area.

Fatal injury – This refers to injuries which caused death less than 30 days after the accident.

Over-dispersion – Ratio of variance to mean is equal or greater than 1

Passengers – These are occupants of vehicles excluding the driver.

Pedestrians – These are persons travelling on foot. Pedestrians comprise a broad range of persons including those travelling on tiny wheels such as roller skates, skateboards, scooters and wheelchair users.

Proportion – The ratio of a quantified part to a corresponding quantified whole.

Road Traffic Accidents – These are unforeseen and unplanned events that occur on the public highways (including footpaths) which often result in casualty (or personal injury) and sometimes culminated in death. It usually involves at least one road vehicle or a vehicle in collision with pedestrians which has been reported to the police within 30 days of occurrence. The vehicles involved in traffic road accidents may be in motion or stationary and may give rise to several casualties that often affect the occupants of the vehicle(s) and pedestrians. This thesis focuses on accidents resulting in pedestrian casualties.

Serious injury – These are injuries sustained by accident victims which result to hospitalization (i.e. in-patient) or any of the following injuries (regardless whether or not the accident victims are hospitalized):, internal injuries, fractures, concussion, crushings, burns (excluding friction burns), severe cuts and lacerations, severe shock which require medical treatment and other injuries that result to death of the victim in 30 or more days after the accident.

Slight injury – These are injury of that are not severe such as a sprain (including neck whiplash injury), minor bruise or cut (considered not to be severe), slight shock and other minor injuries which require roadside medical attention.

Under-dispersion Ratio of variance to mean is equal or less than 1

Variance A measure of the spread of data.

List of Abbreviations

AAA	American Automobile Association
CNN	Cable News Network
IRF	International Road Federation
MoC	Ministry of Communications
MoI	Ministry of Interior
NHTSA	National Highway Traffic safety Administration
OECD	Organization for Economic Co-operation and Development
RTA	Road Traffic Authority
SAPTCO	Saudi Arabia Public Transport Company
SPSS	Statistical Package for the Social Sciences
SR	Saudi Riyal
TRL	Transport Research Laboratory

Chapter One: Research Introduction

“Transportation is the center of the world! It is the glue of our daily lives. When it goes well, we don't see it. When it goes wrong, it negatively colors our day, makes us feel angry and impotent, curtails our possibilities” – **Robin Chase**

Chapter One: Research Introduction

1.1 Introduction

There is growing concern about the public health risks associated with mass gathering events. Mass gathering events are organized or spontaneous public events held at a specific location for a specified period and involves sufficient number of people capable of straining the planning and response resources of the community, state or nation hosting the events (WHO, 2008). The number of attendees that characterized a mass gathering events is a subject of debate, but it is typically taken to be more than 1000, although much of the literature suggests more than 25000 attendees (Milsten et al., 2002; Arbon et al., 2001; Mitchell and Barbera, 1997). Mass gathering events may be sporting events (e.g. Olympic Games and FIFA World Football Competition), musical concerts (e.g. Rock Concerts), political campaigns (or demonstrations), and religious gatherings (e.g. the Hajj, Vatican and Hindu festivals). Since mass gathering events are usually attended by people of common interest, the nature of the crowd will mainly determine the potential health challenges experienced in such events. For instance, participants at a religious mass gathering event such as the Hajj are likely to be very different from those attending the Olympic Games or a rock concert. The abuse of recreational drugs and sexual promiscuity are more prevalent in sporting and musical concerts (Tsouros and Efstanthiou, 2007). Therefore, mass gathering events such as the Hajj (i.e. pilgrimage to Makkah) and the subsequent visit of the pilgrims to Madinah for religious tourism may present unique public health challenges that needs to be tackled by concerted effort of various stakeholders such as both the central and local government authorities. This may include inter-Ministry collaboration involving the Ministry of Health, the Ministry of Hajj, the Ministry of Interior, the Saudi Red Crescent and other government and non-government establishments (Memish, 2013).

The large number of people and the diversity of the population attending mass gathering events could lead to high rates of morbidity and mortality from infectious and non-infectious diseases, road accident casualties and terrorist attacks (Memish, 2013; Memish and Al-Rabeeah, 2013; Elliot et al., 2013; Steffen et al., 2012; Tam et al., 2012; Heggie, 2009; Shafi et al., 2008; Memish et al., 2003). Hence, mass gathering events poses a complex public health challenges that needs urgent attention. Consequently, extensive scientific researches and the advent of emergency medicine have been dedicated to tackling these problems. Most studies on mass gatherings are descriptive and focused on non-religious events such as rock concerts and sports (Milsten et al., 2002; Michell and Barbera, 1997). Moreover, most of these researches have also focused on infectious and non-infectious (Elliot et al., 2013; Memish, 2013; Memish and Al-Rabeeah, 2013; Tam et al., 2012; Shafi et al., 2008). Nevertheless, road accidents also deserve more attention considering the potential of an increased number of casualties of overcrowding streets during mass gathering events. In fact, the high fatality rate among pedestrians from human stampede and pedestrian-vehicle collision during mass gathering events makes it imperative for road accidents to be given more consideration. For instance, the most deadliest human stampede in the world over the past decades are the stampedes in Baghdad during a religious procession in 2005 (965 fatalities), Mina Valley during the annual Hajj in 2006 (380 fatalities) and the 2010 Phnom Penh black Friday shopping stampede that claimed the lives of 347 persons in Cambodia (Illiyas et al., 2013; Hsu, 2011). Furthermore, road accidents have been identified as the most common cause of casualty to tourists (Rosselló and Saenz-de-Miera, 2011; Heggie and Heggie, 2004; McInnes et al., 2002; Wilks, 1999). Hence, the enormous number of pilgrims attending the Hajj or visiting Holy city like Madinah for religious tourism are prone to road accidents, especially, pedestrian casualty which deserves thorough investigation and possible remedies. Therefore, the modelling of the relationship between pilgrims' pedestrian casualty and land use type in the Holy city of Madinah will be the focus of this research and to the best of our knowledge it has never been investigated prior to now.

1.2 Background of Road Accidents

The growing fatalities from road traffic accidents are becoming a major public health problem worldwide (Peden et al., 2004). Globally, over 1.27 million deaths and as many as 50 million injuries are annually caused by road traffic accidents. The statistics of those killed as a result of road traffic accident is very alarming and comparable to those caused by communicable diseases as shown in Table 1.1. Although road traffic accidents affect all age groups, but its fatality rate is conspicuously highest among young people. In fact, it is consistently one of the top three causes of death for people between the ages of 5 and 44 years (WHO, 2009). These unprecedented fatality rates has prompted the World health Organization (WHO) to call for urgent action to be taken to curb this menace or else the fatalities could rise to become the fifth leading cause of death by 2030 (WHO, 2009).

Table 1.1: Leading causes of death, 2004 and 2030 compared (Source: Peden et al., 2004)

TOTAL 2004

RANK	LEADING CAUSE	%
1	Ischaemic heart disease	12.2
2	Cerebrovascular disease	9.7
3	Lower respiratory infections	7.0
4	Chronic obstructive pulmonary disease	5.1
5	Diarrhoeal diseases	3.6
6	HIV/AIDS	3.5
7	Tuberculosis	2.5
8	Trachea, bronchus, lung cancers	2.3
9	Road traffic injuries	2.2
10	Prematurity and low birth weight	2.0
11	Neonatal infections and other[a]	1.9
12	Diabetes mellitus	1.9
13	Malaria	1.7
14	Hypertensive heart disease	1.7
15	Birth asphyxia and birth trauma	1.5
16	Self-inflicted injuries	1.4
17	Stomach cancer	1.4
18	Cirrhosis of the liver	1.3
19	Nephritis and nephrosis	1.3
20	Colon and rectum cancers	1.1

TOTAL 2030

RANK	LEADING CAUSE	%
1	Ischaemic heart disease	14.2
2	Cerebrovascular disease	12.1
3	Chronic obstructive pulmonary disease	8.6
4	Lower respiratory infections	3.8
5	Road traffic injuries	3.6
6	Trachea, bronchus, lung cancers	3.4
7	Diabetes mellitus	3.3
8	Hypertensive heart disease	2.1
9	Stomach cancer	1.9
10	HIV/AIDS	1.8
11	Nephritis and nephrosis	1.6
12	Self-inflicted injuries	1.5
13	Liver cancer	1.4
14	Colon and rectum cancer	1.4
15	Oesophagus cancer	1.3
16	Violence	1.2
17	Alzheimer and other dementias	1.2
18	Cirrhosis of the liver	1.2
19	Breast cancer	1.1
20	Tuberculosis	1.0

The fatality rate of road traffic accidents vary geographically depending on several factors which may include: the population of the place (i.e. level of crowdedness); the development of the region (e.g. its quality of road networks); economy of the region (e.g. income of the people); government policies of implementing road safety regulations etc. For instance, road traffic accidents have claimed more lives in North America than any other geographic region. Whereas, the lowest death rates in terms of population was recorded in Sub-Saharan Africa as shown in Figure 1.1.

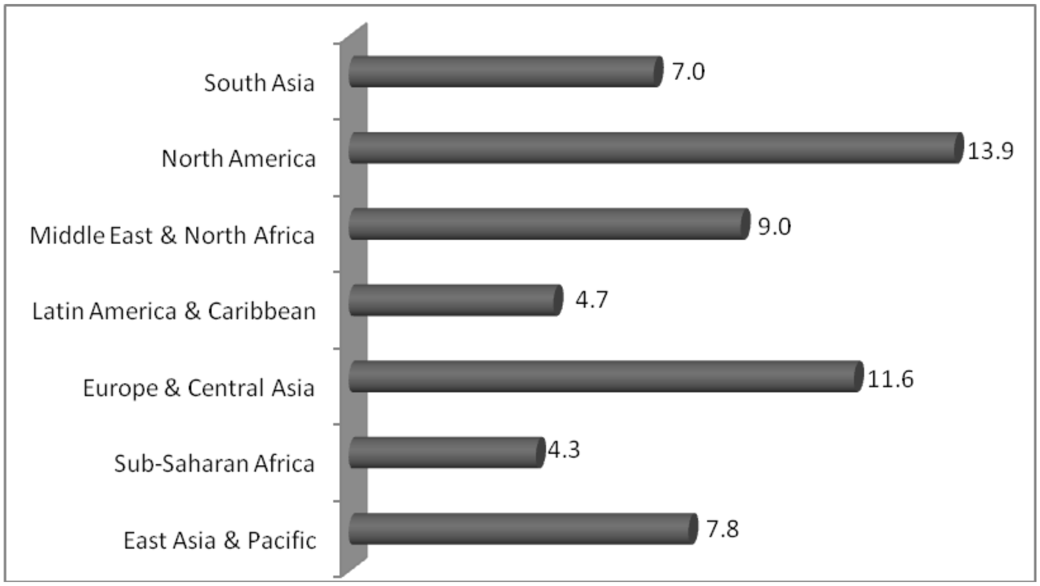
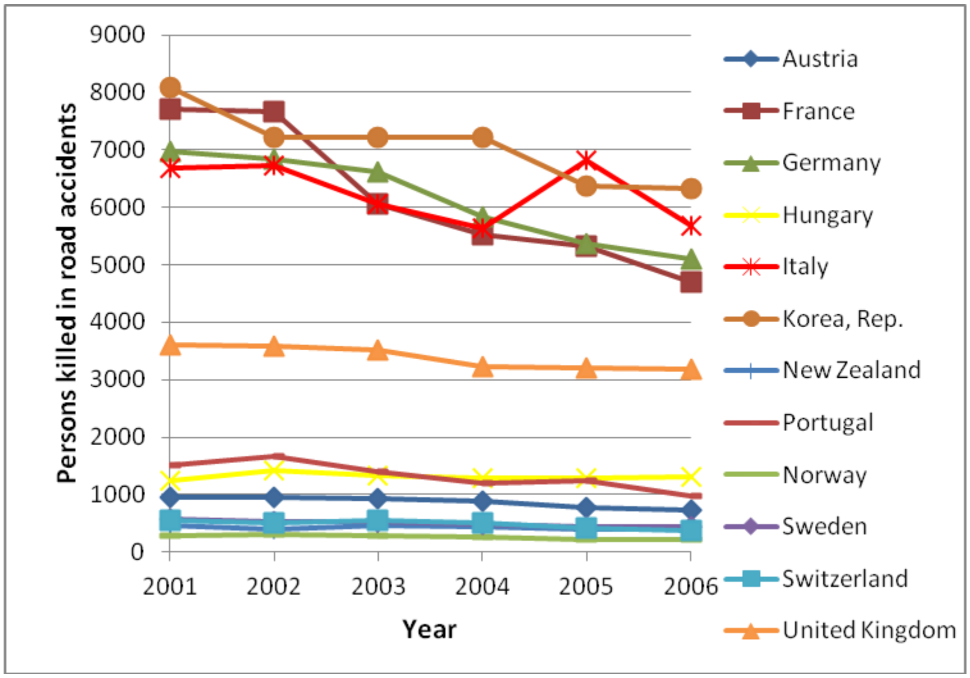


Figure 1.1: Persons killed / 100'000 people *per geographic regions* (*IRF World Road Statistics 2008*).

Despite the great efforts exerted by the government of the United States of America (USA) to curb road traffic fatalities by improving road safety, they are still causing considerable damage to the country. According to the report by the National Highway Traffic Safety Administration (NHTSA), every year more than 40,000 people are killed and more than 3 million people are injured in road traffic accidents in the United States. Furthermore, motor vehicles crashes have been reported to be the 9th and 11th leading cause of death in the US for the year 2008 and 2009, respectively. The majority of the victims belong to the 6 – 27 years old category (NHTSA, 2012).

In recent decades, there has been an alarming rise in the death rates from road traffic accidents in most geographical regions, but the fatalities are becoming stable or declining in many high-income countries. For instance, the road accident fatalities in the United States have declined by about 25 percent since 2005 and fell to its lowest levels in 2010 after several decades (NHTSA, 2012). Similar trends have been reported for most industrialized countries with high-income as shown in Figure 1.2 (IRS, 2008). These trends could be attributed to the availability of better infrastructures such as good roads and strict implementation of road safety regulations in these high-income countries. Furthermore, people in these high-income countries are exposed to outstanding medical facilities and could afford the exorbitant cost of such treatments.



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(**Source of data:** IRF World Road Statistics, 2008).

Regardless of the economic status of any given country, people from poor backgrounds are disproportionately affected by road traffic fatalities. According to the *IRF World Road Statistics 2008*, persons that are in the low income category suffer the highest fatalities (Figure 1.3). Again, studies have shown that children from lower socio-economic status were at highest risk of a road traffic injury (WHO, 2009). In addition to the increased risk, people in this category lack the financial resources needed to mitigate the adverse effect resulting from motor vehicle crashes. Similarly, road accident fatalities are conspicuously prevalent in developing and poorer nations (Appendices A).

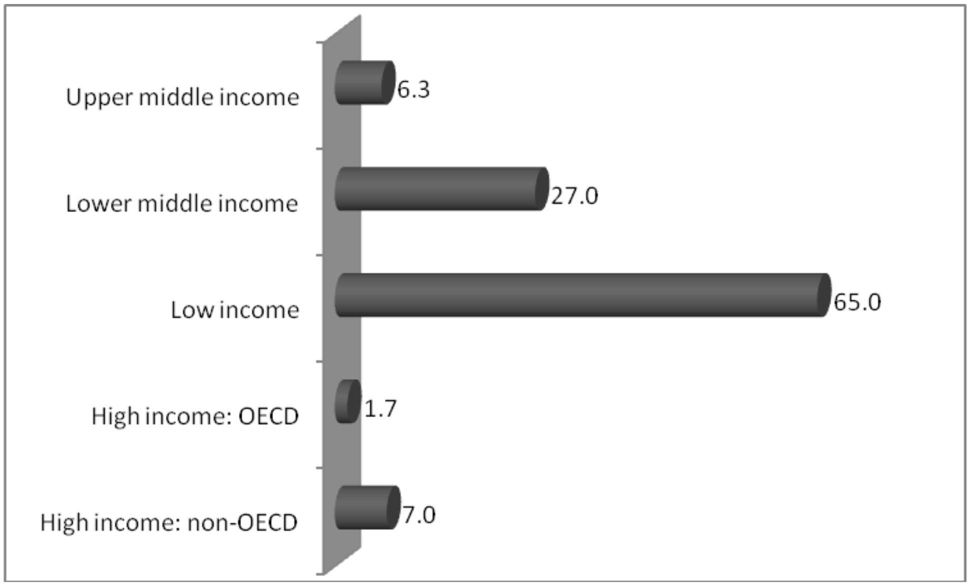

Figure 1.3: Persons killed / 10'000 registered vehicles *per income groups* (IRF, 2008).

In fact, the developing countries are the most affected with over 90% of the death due to several factors which may include: lack of good infrastructures (e.g. bad roads and unavailability of good medical facilities); poor implementation of road safety regulations; unprecedented poverty of the people preventing them from affording good medical treatment etc. Besides the colossal loss of lives and serious injuries inflicted on victims of road traffic accidents, the families of crash survivors and other bereaved persons could also suffer long-term consequences of such tragedies which may plunge them into poverty due to the expensive medical care and rehabilitation and costly funeral arrangements and the loss of the family breadwinner. Many of the injured or disabled victims of road traffic accidents are cared for by people who are supposed to be contributing to national development. Hence, earnings are lost by these persons who often forgo their jobs to care for the injured or disabled. Furthermore, the injuries sustained during road traffic accidents placed an enormous strain on national health services and other resources that could be used for national development (WHO, 2009).

There is an enormous economic cost resulting from traffic road accidents due to loss of productivity, repair of damaged vehicles and road infrastructure and effective management of the incidents by the relevant authorities such as the police and health care services. Globally, the total economic cost of traffic road accidents has been estimated to exceed US$518 billion (Peden et al 2004). In most countries, the cost of road traffic accidents is rapidly rising. According the motorist advocacy group AAA (American Automobile Association), road traffic accidents cost the US economy US$164.2 billion annually (CNN World Report, 2008). Developing countries also suffer enormous economic losses as a result of road traffic accidents. The economic burden of road traffic accidents in most developing countries have been estimated to surpass the annual amount received as developmental aid by these countries (Peden et al 2004; Jacobs et al., 2000). The economic cost of road traffic accidents depends on several factors and varies from country to country. It has been estimated that traffic road accidents cost countries between 1–3% of their gross national product. It has been estimated that approximately 1% of the gross national product (GNP) in low-income countries, 1.5% in middle-income countries and 2% in high-income countries are spent annually to tackle this menace (Jacobs et al., 2000). According to the International Road Federation (IRF, 2008), billions of dollars are spent annually by most countries to tackle this problem. It was also acknowledged that many countries lack the "political will" to tackle the menace.

1.3 Overview of road accidents in Saudi Arabia

Despite effort by the Saudi government to improve road safety regulations, road traffic accidents are becoming increasingly prevalent in Saudi Arabia, thereby, constituting a serious public health problem (Barrimah et al., 2012; Ansari et al., 2000; Bener & Jadaan, 1992; Ofosu et al., 1988). In fact, researches have shown that road traffic accidents are the major cause of morbidity and mortality at a rate that is comparable to heart diseases and cancer (WHO, 2009; Al Ghamdi, 1998). In Saudi Arabia, road traffic accidents have been found to be second major health problem, after infectious diseases (Mufti, 1983). Since the oil boom in 1973, the Kingdom of Saudi Arabia has experience a rapid expansion of its economy and urban development of most of its cities (Ofosu et al., 1988). Again, there has been rapid population growth triggered by its economic prosperity causing an influx of foreign workers (Ansari et al., 2000; Ofosu et al., 1988). Saudi Arabia is also an attractive destination to most Muslims across the globe due to its utmost significance to Islam. For instance, the cities of Makkah and Madinah are custodians of the two Holy Mosques of the Prophet and other Islamic heritages. Hence, many Muslims worldwide embark on Holy pilgrimage to these cities to perform religious rituals and for the purpose of religious tourism, especially, during Hajj and other religious festivals. The over-crowdedness of these cities caused by the influx of Muslim pilgrims from around the world impact on road traffic accidents in Saudi Arabia (Al Jazeera, 2009; BBC News, 2006; The Guardian, 2006). Again, there have been an increased motorization of the highways and rapid expansion of road networks in Saudi Arabia (Ansari et al., 2000; Ofosu et al., 1988). This is because motor vehicles are the principal means of transportation in Saudi Arabia due to the convenience and speed they offer in facilitating the movement of people and goods to their various destinations (Ansari et al., 2000). Road transportation also has positive impacts on both the nations and individuals by enabling increased access to economic activities, job opportunities, education, recreation and health care service.

Table 1.2: Population and road accident statistics of Saudi Arabia from 2000 to 2012.

Accident Year	Population of Saudi Arabia	Number of Accidents	Total Fatality	†Estimated Fatality/Day	†Fatality/1000 Traffic Accidents	†Fatality/100,000 Persons
2000	20,474,000	280,401	4,419	12	16	22
2001	20,976,000	305,649	3,913	11	13	19
2002	21,491,000	223,816	4,161	11	19	19
2003	22,019,000	261,872	4,293	12	16	20
2004	22,529,000	293,281	5,168	14	18	23
2005	23,119,000	296,051	5,982	16	20	26
2006	24,122,000	283,648	5,883	16	21	24
2007	24,941,000	435,264	6,358	17	15	25
2008	25,787,000	485,931	6,458	18	13	25
2009	26,660,000	484,805	6,142	17	13	23
2010	27,563,000	498,203	6,596	18	13	24
2011	28,082,000	544,179	7,153	20	13	25
2012	29,600,000	589,258	7,638	21	13	26
Total	**N/A**	**4,982,358**	**74,164**	**N/A**	**N/A**	**N/A**

Sources: National Statistical Office (2011); General Directory of Traffic in Saudi Arabia (2013).

† Calculated values were rounded up to the nearest persons for easy interpretation, since fatality refers to a whole person and not fraction.

N/A – Not Applicable.

Despite these advantages, road transportation has also impacted adversely on the economic, social and health of humans. For instance, emissions from the exhaust of vehicles have contributed to environmental pollution which could lead to serious health issues e.g. respiratory illnesses etc. It has also brought increasing noise and the depletion of finite resources such as petroleum products. Furthermore, vehicles are susceptible to mechanical failure; misuse by reckless drivers and non-compliance to road safety regulations by both drivers and pedestrians may culminate in road traffic accident (RTAs) which often leads to human casualties. The steady increase of Saudi population and the progressive motorization of its highways over the decades have resulted to an increased exposure of road users to the risk of road accidents. Consequently, Saudi Arabia has experienced corresponding increases in road traffic violations which have reached 9 million in recent years (SAHER, 2012). The number of reported road traffic accidents and its corresponding fatality has also drastically increased throughout Saudi Arabia as shown in Table 1.2.

The road accident statistics of Saudi Arabia as shown in Table 1.2 was subsequently converted to graphical depiction of the values for easy interpretation as shown in Figures 1.4A to 1.4F. These road accident statistics provides insight on the exposure of road users to the risk of road accidents in Saudi Arabia by relating the annual population to the number of road accidents for that given year. Although population is not the only factor that affects exposure of road users to the risk of road accidents; but it is evidently clear that an increase in the population in Saudi Arabia as shown in Figure 1.4A, generally results in the increase in the exposure of road users to road accidents as reflected by the corresponding increase in the accident rates and fatalities. The trend of the road accidents and the corresponding fatalities from 2000 to 2012 in Saudi Arabia are illustrated in Figures 1.4B and 14C, respectively. Furthermore, the accident statistics were also presented in the context of the estimated fatality per day (Figure 1.4D); fatality per 1000 traffic accidents (Figure 1.4E) and fatality per 100,000 persons in Saudi Arabia (Figure 1.4F).

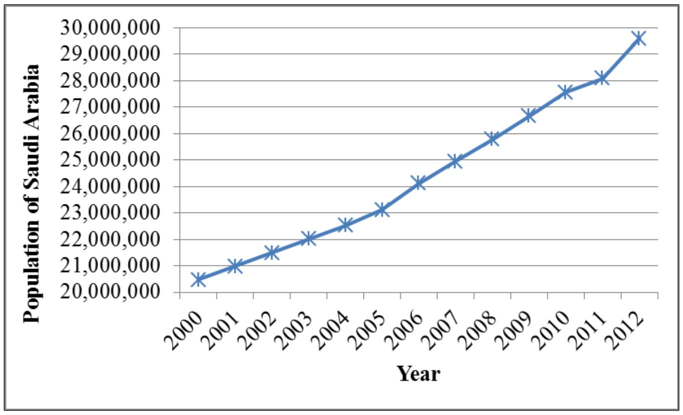

Figure 1.4A: Trend of Saudi Population from 2000 to 2012.

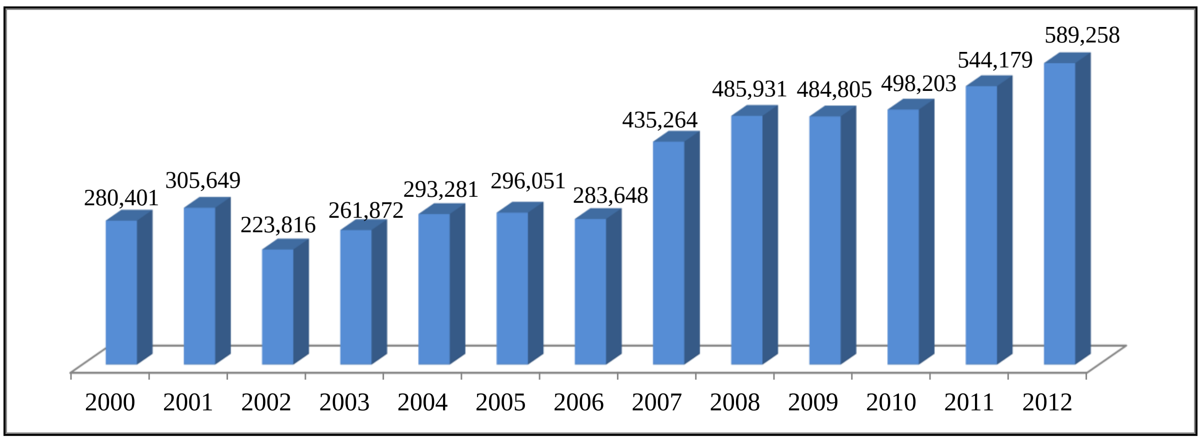

Figure 1.4B: Trend of road accidents in Saudi Arabia from 2000 to 2012.

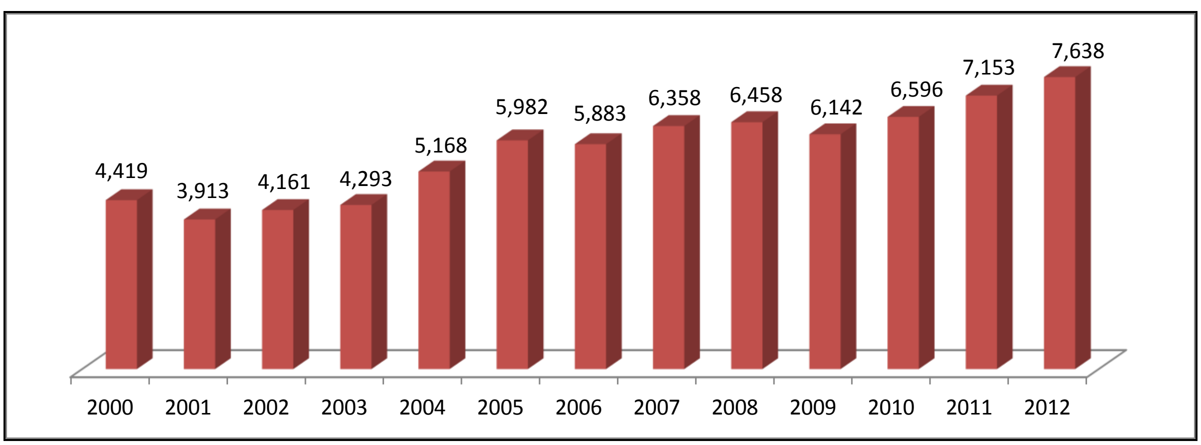

Figure 1.4C: Trend of total fatality from road accidents in Saudi Arabia from 2000 to 2012.

Over the years, the total population of Saudi Arabia have steadily increased leading to increased number of registered vehicles. In general, as the Saudi population increases, the accident rate and its corresponding fatality have also increases in an alarming rate (Figures 1.4A – 1.4C); although there were sudden decline in the annual accident rates and fatality in 2002, 2006 and 2009 as illustrated in Figures 1.4B and 1.4C. The total number of accidents and fatality recorded in Saudi Arabia from the year 2000 to 2012 were 4,982,358 and 74,164, respectively. According to General Directory of Traffic in Saudi Arabia (2013) road traffic accidents has increased from 280,401 in the year 2000 to 589,258 in 2012 as shown in Figures 1.4B. This represents 110% increase in road accidents during the twelve years period considered in this study (i.e. from 2000 to 2012). The corresponding fatality rate also follow similar trend as illustrated in Figure 14C. In this case, the recorded deaths from road traffic accidents increased from 4,419 in 2000 to 7,638 in 2012, which represents an increase of 73% over the twelve years period.

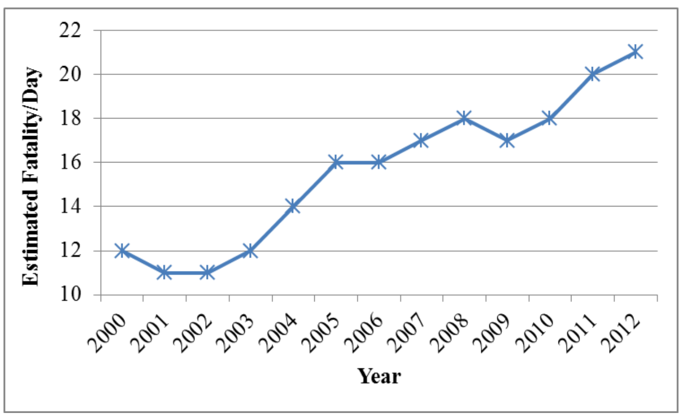

Figure 1.4D: Trend of estimated fatality per day in Saudi Arabia.

In general, the estimated fatality per day (i.e. number of deaths in a given year divided by 365 days) increases over the period considered (Figure 1.4D). The trend was similar to those observed in Figures 1.4B and 1.4C. The estimated fatality per day ranged from 11 to 21; with an estimated minimum of 11 deaths per day which occurred in 2001 and 2002. In contrast, the estimated maximum of 21 deaths per day occurred in 2012 as shown in Table 1.2. In other words, road accident claimed the lives of 3,913 victims in Saudi Arabia in 2001, which corresponds to an average of 11 persons killed per day in that year. Again, 4,161 persons died from road accidents in 2002, which also translated to an average of 11 persons killed per day in 2002 (even though the fatality rate in 2002 was slightly higher that of 2001). While the fatalities recorded were 7,638 in 2012 corresponding to 21 persons killed every day.

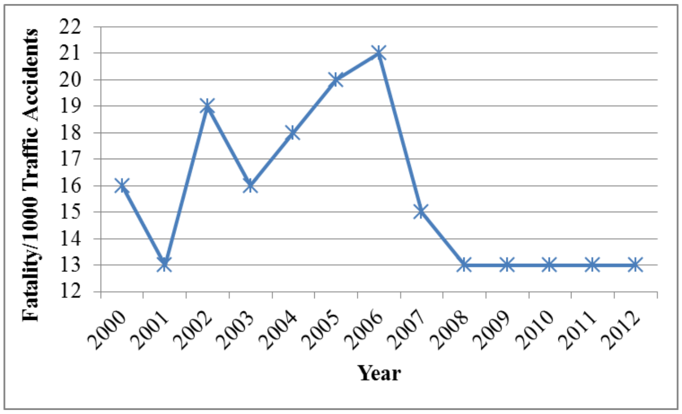

Figure 1.4E: Trend of fatality per 1000 traffic accidents in Saudi Arabia.

Nevertheless, the number of fatalities per 1000 traffic accidents did not follow a particular trend from 2000 to 2012 (Figures 1.4E). In this case, the trend of fatality per 1000 traffic accidents in Saudi Arabia has been steady in recent years (i.e. from 2008 to 2012) as shown in Figure 1.4E. The number of fatalities ranged from 13 to 21 persons for every 1000 traffic accidents that occurred in Saudi Arabia from 2000 to 2012. According to the statistics, at least 13 persons were killed for every 1000 road traffic accidents every year in Saudi Arabia between 2000 and 2012. While the highest number of persons killed were 21 for every 1000 road traffic accidents in Saudi Arabia and occurred in 2006. While expressing the fatality per 100,000 Saudi population did not also show a clear pattern (Figure 1.4F). It occasionally increases and then declines suddenly. However, it has steadily increased in recent years (i.e. from 2009 to 2012). In this case, at least 19 persons were killed for every 100,000 persons in Saudi Arabia from 2000 to 2012 (Figure 1.4F). The lowest fatalities per Saudi population were found to occur in 2001 and 2002. But peaked at 26 persons killed for every 100,000 Saudi population in 2005 and 2012 as shown in Figure 1.4F.

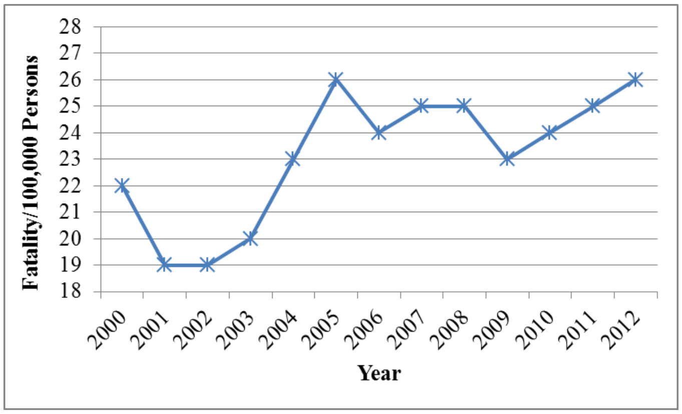

Figure 1.4F: Trend of fatality per 100,000 Saudi population from 2000 to 2012.

Considering the worst case scenario, it can be deduced that 21 persons were killed per day in road traffic accidents in Saudi Arabia in recent years; which translates to an average of one death recorded for everyone and half hours (SAHER, 2012). While 21 were killed for every 1000 road traffic accidents that occurred and 26 persons lost their lives for every 100,000 Saudi population annually. These road accident statistics shows that Saudi Arabia has one of the highest fatalities in road accidents all over the world as illustrated in Appendix A. The alarming increase of road accident fatalities constitutes a public health burden and it is worrisome to the Saudi Government, which has spent enormous amount of valuable resources to tackle this menace over the years. In fact, the material loss caused by road traffic accidents in Saudi Arabia has been estimated at 13 billion SR (Saudi Riyal), which was about US $3.47 billion (SAHER, 2012). These valuable resources could have been utilized in developmental projects that would improve the lives of the people of Saudi Arabia. Hence, it is imperative for thorough investigation of road accidents to be undertaken to obtain reliable and comprehensive accident data that would assist the government monitor the problem and proffer countermeasures that will curb the problem. The absolute accident values (or statistics) will serve as indices to evaluate the extent of the problem and for comparison as exemplify in Appendix A. It will also help the government to assess the effectiveness of its countermeasures and to estimate the cost of resources needed to tackle the problem. Hence, proper budgeting is necessary for the planning and execution of countermeasures such as the construction and repair of vehicular roads, pedestrian lanes and street lights to forestall preventable accidents. It is also needed to fund hospitals and other medical services that may help minimize the adverse effects of road accidents.

The scourge of road accidents is even worse in the populated Saudi cities like Riyadh and Jeddah (Bener and Jadaan, 1992; Ofosu et al., 1988). Similarly, cities such as Makkah and Madinah also have high fatality rate because of the increasing exposure measures of their residents to the risks of road accidents. The case of Madinah including relevant accident statistics are presented in subsequent Chapters. Nevertheless, the exposure measures that may contribute to the greater accident risk in these cities may include high population density (i.e. over-crowdedness) caused by the influx of Moslem pilgrims due to their religious significance, especially, during Hajj (Holy pilgrimage). These cities have also witnessed increased motorisation and expansion of road networks to accommodate the growing population. Furthermore, these cities are not only of religious significance; but also commercial centres that routinley generates trips. Hence, these cities are very busy with road users that are exposed to the daily risks of road accidents. For instance, these cities are likely to have increased pedestrian activities as most Moslems, especially, pilgrims will be walking to the Mosques for their prayers and possibly visit other religious sites. Consequently, these vulnerable road users (i.e. pilgrims' pedestrians) are likely to suffer the most in these over-crowded cities. Nevertheless, the increase in population of a given city (or country) may not necessarily lead to an increase in exposure to road accidents due to the interplay of other factors (Elvik et al., 2009; Jacobsen, 2003) For instance, the progressive increase of Saudi population over the period considered (i.e. from 2000 to 2012) may not necessarily suggest that the accident risk increased nearly so significant during the same period. Occasionally, the increase in population may not lead to increase in road accidents; instead it could decrease as exemplified in 2002, 2006 and 2009 (Table 1.2). The effectiveness of government's countermeasures such as the separation of vulnerable road users (e.g. pedestrians) from vehicular roads through pedestrian lanes (or either underground tunnels or over-head crossing bridges etc.), enhanced road and safety regulations could reduce the exposure of these road users significantly despite increasing population. A similar argument was also asserted by Cowley and Solomon (1976) that increasing motorization may lead to a decline in pedestrian fatality probably due to a decrease in exposure rather than a decrease in risk. In such a case, the risks to pedestrians may actually be increasing due to traffic density increases because most people tend to drive rather than walk. This scenario is usually found in most high income European countries. Nevertheless, the pedestrian exposure measures are discussed more fully in Chapter 3.

1.3.1 Pedestrian/ motor vehicle collisions Crashes in Saudi Arabia

Pedestrian/ motor vehicle collisions are also a global problem and one of the leading causes of road traffic casualty in most countries (Damsere-Derry et al., 2010). Several factors have been associated with pedestrian casualties. These factors may include rapid motorization; over-crowdedness or population density, land use (Peden et al., 2004). Despite greater proportion of the world's vehicles are owned by people residing in developed countries, the burden of road traffic accidents is disproportionately suffered by people in developing countries. For example, over 85% of global fatalities and 90% of global disability caused by road accident has been reported as occurring in developing countries (Peden et al., 2004; Nantulya and Reich, 2002; Mock et al., 2003; Mock et al., 2005; Asiamah et al., 2002). Consequently, pedestrian casualties are considerably higher in developing countries than developed countries (Damsere-Derry et al., 2010; Jadaan and Bener, 1993). The higher pedestrian fatalities in these countries may be attributed to many factors which include lack of enforcement of road safety regulations, poor maintenance of vehicles, lack of good roads and absence of pedestrian facilities (Khayesi, 1997; Kwakye et al., 1997). In addition, there are several inappropriate roadside activities such as street hawking, jaywalking and nighttime walking that are common practice in developing countries (Damsere-Derry et al., 2010). According to Khayesi (1997) the pedestrian fatality rates were 65% of those imjuried during vehicle/ pedestrian crashes in Nairobi, Kenya; for Latin America if was found to be 54% (Donroe et al., 2008) and 60% have been recorded among urban regions in Ghana (Afukaar et al., 2008). The growing pedestrian casualties in the Gulf countries have also been reported. For Kuwait, the fatality rate was 57% and 46% of those imjuried during vehicle/ pedestrian crashes for Jeddah, Saudi Arabia (Jadaan and Bener, 1993). In contrast, only about 11% of those imjuried during vehicle/ pedestrian crashes has been recorded as fatality in the US (Retting, 2003; Zhu et al., 2008). Again, other studies have established that most urban road users in developing countries felt unsafe while using public transport system or indulging pedestrian activities (Zhu et al., 2008; Mutto, 2002). The vulnerable road users (i.e. pedestrians) are the most affected because pedestrian safety is not given a high priority in most developing countries (Khayesi, 1997; Kwakye et al., 1997). Hence, the various road users compete for road space at the detriment of the most vulnerable - pedestrians (Damsere-Derry et al., 2010; Jadaan and Bener, 1993). Consequently, most cities in developing countries are faced with the daunting challenge of tackling road safety issues. A typical example is the Kingdom of Saudi Arabia, which is a rapidly developing Arab country with high income per capita (Jadaan and Bener, 1993). Most of the cities in Saudi Arabia are facing the difficult challenge of dealing with the growing trend of pedestrian casualties, which is usually caused by over-crowdedness and many other factors. In fact, the pedestrian casualties are more prevalent in religious cities like Makkah and Madinah, especially, during Hajj and other Islamic festivals.

1.3.2 Pilgrim Pedestrian Casualty in Saudi Arabia

There have been several incidents of pedestrian casualties during Hajj (an annual Muslims' pilgrimage to Makkah) in Saudi Arabia that have sparked public outcry, thereby, posing a major challenge to the government of Saudi Arabia (Siddiqui and Gwynne, 2012). Notable among these incidents is the tragedy that occurred in July 2, 1990, which claimed the lives of 1426 pilgrims, many of them Malaysians, Indonesian and Pakistanis, killed in a stampede in overcrowded pedestrian tunnel (Al-Ma'aisim tunnel) leading to holy sites in Makkah (Al Jazeera, 2009; BBC News, 2006; The Guardian, 2006). On 23 May 1994, a stampede killed another 270 pilgrims (most of them Indonesians) at Al-Jamarat, which is the site of one of the main rituals of the Hajj (Al Jazeera, 2009; BBC News, 2006; The Guardian, 2006). Tragedy struck again on 9 April 1998, when about 180 pilgrims were trampled to death when panic erupted after several fell off an overpass at Al-Jamarat (The Guardian, 2006). Another stampede occurred on 5 March 2001, which claimed the lives of 35 people at Al-Jamarat (The Guardian, 2006; Al Jazeera, 2009). The Guardian (2006) also reported a similar incident that occurred on 1 February 2004, killing 244 pilgrims and injuring a similar number of persons at Al-Jamarat. In 2006, the worst stampede in 16 years occurred killing 345 and injuring 600 persons. In addition, at least 76 people were killed when a hostel collapsed that same year (Al Jazeera, 2009). It should be stressed here that stampedes ought to be related to inadequate pedestrian infrastructure Apart from stampede, other serious incidents have also been reported during the Hajj. These include fire outbreaks; bomb explosions; protests and violence; spread of infectious diseases; and road accidents. In fact, a large number of road accidents are reported during Hajj every year, especially, on the roads leading to the holy cities of Makkah and Madinah.

Despite these disasters, over 2.5 million pilgrims travel annually to Makkah to perform the Hajj ceremony and possibly visit other religious sites of significance in Madinah (Memish et al., 2012). Consequently, the Hajj has become increasingly crowded as the largest annually recurring mass gathering in the world (Memish et al., 2012). These pilgrims often make considerable pedestrian movement to these sites where the religious rituals are performed and sight-seeing of religious antiquities at other holy sites. Furthermore, crowds are an attribute of large cities (e.g. Makkah and Madinah), occurring not only at mass gatherings but also involves routine journey to places of daily activities (Johansson et al., 2012). Hence, pilgrims' pedestrian casualty is not confined to the Al Jamarat alone, but also occurs to a lesser extent in other areas of the city of Makkah and other Holy Places (e.g. Madinah) due to the influx of pilgrims and other religious tourists to these sites. Because the pilgrims come from more than 183 countries, the pilgrims' pedestrian casualties are characterized with diverse ethnic origin, races, socio-economic status, sex and age (Memish et al., 2012).

These disastrous occurrences in the past and the potential danger associated with mass gatherings has prompted the authorities in Saudi Arabia to embark on mitigating remedies such as crowd management, security improvement and emergency preparedness (Memish et al., 2012). In other words, the government of the Kingdom of Saudi Arabia strives to ensure that pilgrims for the Hajj and general visitors fulfil their purpose with ease and serenity. For instance, the Custodian of the Two Holy Mosques Institute for Hajj Research at Umm Al-Qura University has been dedicated to the improvement of services to pilgrims and visitors to the Holy cities of Makkah and Madinah. The Planning Research Unit of this institution is concerned with the land use and architectural plan of Makkah, Madinah and other Holy sites (Ministry of Hajj, 2012; CTHMIHR, 2010). While its Transportation and Traffic Research Unit deals with transportation to and from Makkah and Madinah. It studies movement of vehicles and pedestrians inside the Two Holy Cities and the other holy sites. It is also concerned with the movement of pilgrims to and from The Two Holy Mosques as well as their movement inside these Shrines (Ministry of Hajj, 2012; CTHMIHR, 2010). Several other studies have been undertaken to assess the problems associated with crowded Holy Cities (e.g. Makkah and Madinah) as a means of proposing useful remedies. The health of pilgrims during Hajj and visitors to other Holy Sites has been investigated (Johansson et al., 2012; Memish et al., 2012; Almalki et al., 2011; Alzeer, 2009; Ahmed et al., 2006; Shafi et al., 2006; Memish et al., 2003; Memish and Ahmed, 2002; Yousaf and Nadeem, 2000; Samuelssen, et al., 2000; Alzeer et al., 1998; El-Sheikh et al., 1998; Al-Gahtani et al., 1995; Yousaf et al., 1995). Traditional concerns for religious tourism such as crime, spread of infectious diseases and terrorism have been investigated (Wilks and Al-Mubarak, 2005). The accidental injuries of Pilgrims during Hajj have been studied (Al-Harthi & Al-Harbi, 2001; Rahman et al., 1999). Furthermore, many studies have been conducted on road traffic accident in Saudi Arabia (Siddiqui and Gwynne, 2012; Bendak, 2005; AlGadhi & Still, 2003; Al-Ghamdi, 2003; Al-Ghamdi, 2002; Hughes, 2002; Ansari et al., 2000; Shanks et al., 1994; Bener and Jadaan, 1992; AlGadhi & Marmassani, 1990; Ofosu et al., 1988). Few studies have simulated pedestrian conditions during Hajj as a means of proffering solutions to problems associated with crowd management (Siddiqui and Gwynne, 2012; AlGadhi and Still, 2003; AlGadhi and Marmassani, 1990). Nevertheless, there is paucity of detailed research on pilgrims' pedestrian casualties in crowded Holy Cities in Saudi Arabia. Considering the fact that most pilgrims make pedestrian movements to the Mosques and other religious sites in these cities and that a large number of road accidents resulting in pedestrian casualties during Hajj are reported annually, it will be imperative to undertake a detailed research to ascertain the major causes and possible trend in pilgrims' pedestrian casualties in the Holy Cities. Consequently, this research will apply the Geographical Information Technology (GIS) and other statistical techniques to investigate the pilgrims' pedestrian casualties in relationship to land use in the Holy City of Madinah. The advancement and sophistication of mapping data technology such as the GIS and statistical techniques have enable many transportation professionals and engineers world over in managing, planning, evaluating and sustaining transportation systems (Alterkawi, 2001). These tools offers transport planners the opportunity to eliminate unnecessary transportation cost; create full and real-time transparency; improve delivery performance and many more.

1.4 Research Problem

The city of Madinah like other cities in Saudi Arabia has experienced rapid growth in its economy for many decades due to oil boom in the 1970s and during the Gulf war. According to

Al-Fouzan (2009) this has culminated in an improved standard of living and lifestyle of most Saudis, prompting a corresponding increase in its population. It has also triggered an influx of foreign workers in search for lucrative jobs in Madinah. Again, millions of Muslims annually travel to Madinah for Holy pilgrimage and other religious activities. Hence, the net population of the city has increased in recent years. The rapid economic expansion and population growth have resulted in an unprecedented motorization of the highways of most cities in Saudi Arabia including Madinah (Al-Fouzan, 2009). This is because road transportation has been the major means of transportation in most of these cities due to the speed (i.e. the ability to save time) and comfort it offers. Hence, the extensive use of cars in Madinah has spread so dramatically that many car users and other road users, particularly, most pedestrians have been unable to develop cultural awareness and acquire proper education on road safety to cope with the adverse effect of road transportation. In other words, the lack of cultural and educational awareness of road safety issues has exposed most pedestrians to greater danger brought about by the extensive use of cars in Madinah. Consequently, the fatality rates of road traffic accidents have drastically increased in Madinah, which the fourth largest city in Saudi Arabia (i.e. after Riyadh, Jeddah and Makkah). For example, Madinah recorded 257 fatalities from 14,595 road accidents in 2004; which have increased to 569 deaths from 43,543 road accidents in 2013 (See Table 2.1 in Chapter Two). The accident statistics of Madinah from 2004 to 2013 shows the fatality and accident rates have increased by 121% and 300%, respectively. In the context of the entire country, among the more than 6,000 people in the 485,931 traffic accidents recorded across Saudi Arabia in 2008 (General Directory of Traffic, 2010); Madinah contributes about 400 fatality and 29,213 accidents. These constitute about 7% of the fatalities and 6% of the accidents in the entire Saudi Arabia. These accident statistics are alarming and drains both human and economic resources of the country. For instance, road traffic accidents have been found to mainly affect the productive age group (15 – 44 years) that are supposed to contribute to national development and children among whom the fatality rates are high (Barrimah et al., 2012). Again, huge amount of money is lost as a result of road traffic accidents. According to the National Committee of Traffic Safety (2010) Saudi Arabia lost around 13 billion Saudi Riyals due to road traffic accidents in 2008. In Saudi Arabia, the economic cost of road traffic accidents has been estimated to be between 2.2% and 9% of the national income compared to 1% – 2% in the developed countries (Ansari et al., 2000; Saudi Arabia Monetary, 1997). This is an enormous loss of national income for a developing country such as Saudi Arabia, which is supposed to utilize its valuable resources for important developmental projects.

There is a growing trend of pedestrian casualties in most Saudi cities due to over-crowdedness; increased number of vehicles; reckless driving; poor road safety regulations etc. In fact, pedestrian casualty is becoming a major health concern for the government of Saudi Arabia. It is even worse in cities like Madinah due to its religious significance. Madinah being one of the custodians of the Holy Mosque of the Prophet, attracts immense number of pilgrims making the city over-crowded, especially, during the period of Hajj and other religious festivals. The land use types (e.g. for religious purposes) of a place has been found to be the generator of trips to that place. Many of the pilgrims are pedestrians that walk to the Mosques and other religious sites to perform their prayers, religious rites and rituals. Hence, these religious or 'pilgrim pedestrians' are susceptible to road traffic accidents on daily basis. In fact, pilgrim pedestrian casualty has been on the increase in most Saudi cities (e.g. Makkah and Madinah), thereby, prompting the Saudi government to take urgent action in tackling incidence of road traffic accidents which is becoming a major health problem. Hence, there is need to extensively study several aspects of road traffic accidents in Saudi Arabia as a means of providing the relevant government authorities of the extent of the problems. In Saudi Arabia, most studies undertaken on road traffic accidents focused on the occupants of the vehicles, neglecting the pedestrians which are the most vulnerable category (Barrimah et al., 2012; Ansari et al., 2000; Al Ghamdi, 1998; Bener and Jadaan, 1992; Ofosu et al., 1988; Mufti, 1983). Although a detailed study of pedestrian casualty has been done for some other countries (Sullivan and Flannagan, 2011; Sullivan and Flannagan, 2007; Eluru et al., 2008; Wedegama et al., 2008, 2006; Lee and Abdel-Aty, 2005; Schneider et al., 2004), but these results obtained from other countries may not be entirely applicable to Saudi Arabia due to its unique attributes (Mufti, 1983). For instance, Saudi Arabia has its unique socio-economic, political, cultural, religious, environmental and historical heritage which may affect the results of studies undertaken on road traffic accident studies. To the best of our knowledge, there is paucity of research that has been focused on pedestrian casualty in Saudi Arabia, especially, as it affects pilgrim in those overcrowded religious cities. Since the destinations of pedestrians are often determined by the land use, it is imperative to undertake a thorough assessment of the relationship between land use and pilgrim pedestrian casualty in religious city like Madinah (its full name: Al Madinah Al Monawwarah). Findings from this study will enable the government of Saudi Arabia to take urgent and appropriate actions to curb this menace because most road traffic accidents are preventable, but require concerted efforts for effective prevention mechanisms (Peden et al., 2004).

1.5 Research Questions

Several research questions that have been proposed to assist in fulfilling the purpose of this research as highlighted below:

- i.) What are the contributing factors to pedestrian accidents rates and severities in Madinah?
- ii.) What are the trends in pedestrian accident rates and severities at different parts in the transport system?
- iii.) Are accidents rates and severities influenced by the presence of pilgrim and/or different types of land use in Madinah?

1.6 Research Aims and Objectives

The research aim at investigating the relationship between pilgrims' pedestrian casualty and urban land use types in Madinah. It will identify the land use types that are highly associated with pilgrim casualties. It will also attempt to identify any patterns or trend of pilgrim casualties on the various land use types. The study will also focus on an assessment of the road safety system in Madinah, especially, pedestrian safety. It will highlight its successes and failures. Furthermore, the study will attempt to proffer remedies to the pedestrian safety problems by recommending a proposal of suitable solutions. These recommendations will be comprised of long term as well as short term plans for pedestrian safety system of Madinah. In order to achieve the above aims, the study will pursue the following main objectives as highlighted below:

1. To carry out a literature review of studies on pedestrian accidents' as well accident analysis and investigation in Saudi Arabia and elsewhere.

2. Select Madinah as a case study area in Saudi Arabia to conduct the study and assess accident rates as well as the significance of the religious nature of Madinah.

3. Examine factors and accident patterns (frequencies and severities) of pedestrian accidents in Madinah, including impacts of land use activities and policies.

4. Explore, investigate and model pedestrian accident rates in Madinah using appropriate statistical models.

5. Draw conclusions on the results and identify gaps in data collection, reporting and data analysis methodology in Madinah. These will be useful and applicable for other Saudi cities.

1.7 Research Contributions

This research will add knowledge to the scanty literature of pilgrim pedestrian casualties in Madinah, which is one of the custodians of the Holy Mosque. Most studies when considering road traffic accidents focuses on the passengers inside the vehicles, neglecting the most vulnerable victims, which is the 'pedestrians'. Even those studies that dealt with pedestrian casualties are restricted to one or more categories such as children; low income earners or the most deprived; socio-economic; environmental etc (Ukkusuri et al., 2012; Dissanayake et al., 2009; Loukaitou-Sideris et al., 2007; Wedagama et al., 2006; Geyer et al., 2005; Graham et al., 2005; Sideris and Liggett, 2005). However, this research has considered a broad range of issues that may affect pilgrims' pedestrian casualty. They include – gender, age, nationality, road type, speed limit; and various land use types. Furthermore, this research is very important because of its novelty of being the first of its kind in Saudi Arabia that attempt to model the relationship between pilgrims' pedestrian casualty and land use type in Madinah, which is the second most important Islamic city in the world. It is unique and different from other road traffic accident studies it provides insight on the influence of the different land use type on pilgrims' pedestrian casualty during prayer time, non-prayer time, weekends, weekdays, high season and low season months. To the best of our knowledge, no other study on road traffic accident has focused on 'pilgrims' pedestrian casualty' which is associated with Holy cities such as Madinah. Nevertheless, this study will not only be useful to both vehicle drivers and pilgrims' pedestrians in Madinah who may benefits from its findings and recommendations in preventing avoidable pedestrian-vehicle collisions; but will also contributes to the understanding of the relationships between urban development and traffic safety by providing insight into the pedestrian casualty in an over-crowded city like Madinah, which is relevant to transport planners, policy makers and other stakeholders in curbing the menace of road accidents. For instance, the findings and recommendations from this research will be useful to policy makers in enacting laws that will assist in tackling the growing problem of pilgrims' pedestrian casualty in Madinah and other Saudi cities. The implementation of these policies or laws may require the concerted efforts and collaboration from several stakeholders such as the Ministry of Hajj, Ministry of Interior, Ministry of Transport, Ministry of Health and other government departments concern with the safety and well-being pilgrim pedestrians. It may also involve other non-governmental organizations such as the Saudi Red Crescent Authority. Finally, the benefits that may be derived from this study are not limited to Saudi Arabia. In other words, the conclusions and recommendations reached in this research could be extended beyond the shores of Saudi Arabia to the cities of other countries that play host to similar mass gathering events.

1.8 Research limitations

Despite several variables are associated with traffic road accidents, most studies undertaken to unravel the causes, impact and possible remedy of traffic road accidents are constrained to focus mainly on selected number of these variables. This was due to the unpredictability of the occurrence of road traffic accidents, being unplanned events and the constraint of resources. Most accident data does not record the origin and destination of the accident victims (Wedagama, 2006). The Pilgrim Pedestrian casualty data used in this research was not an exception; it also excluded this useful information which would have unraveled the purpose of the victim's trip and assist in the interpretation of the accident data. In addition, traffic flow data has not been used because was not avaiolable nor recorded by the traffic department. Furthermore, the population of Madinah was irrelevant to this study since it focuses mainly on pilgrims' pedestrian casualty. In other words, the population of Madinah does not necessarily relate directly to the actual number of people indulging in pedestrian activities in this Holy city which attracts Muslims from every parts of the world. This is because of the current absence of these statistics in Al-Madina. Muslim pilgrims and other religious tourists frequently visit this city in an unpredictable numbers, therefore, the population of the city not only fluctuates, but also difficult to ascertain at a given period. In other words, the population of the Madinah erratically fluctuates and could be unusually high during the Hajj and Umrah. Hence, it may be misleading to use the population census of Madinah in this study. Based on the afore-mentioned reasons, developing accident prediction models using the population density of this city would be intrinsically unreliable. Another limitation of this research was that the traffic flow was not used as a variable.

1.9 Research Structure

This research has been organized into several Chapters for cohesiveness and better presentation of the information gathered. It is structured into the following Chapters as presented below:

Chapter 1: This Chapter defines a mass gathering event such as the Hajj and highlighted the complex public health challenges they pose to the host community or nation. Typical mass gathering events such as the Hajj, the Vatican, the Hindu festivals, the Olympic Games and FIFA World Football Competitions were mentioned here. This Chapter identifies the research gap regarding mass gathering events and suggests the need for more research to be undertaken on religious mass gatherings like the Hajj. It also emphasized that more attention should be given to other public health challenges besides the spread of diseases. Consequently, the need to investigate the health implications of road traffic accidents in a host community of a religious mass gathering event was presented here. This Chapter also presents a general background about road traffic accidents by providing some important global statistics on road accident casualties. It also provides an overview of road accidents in Saudi Arabia with emphasis on pedestrian/ motor vehicle collisions by highlighting incidence of pilgrim pedestrian casualties. This Chapter concludes by clearly stating the research problem; research questions; aims and objectives of the research; research contributions and limitations; and the hypothesis of the research.

Chapter 2: This Chapter discusses the general accident statistics and pedestrian/ motor vehicle collisions in Madinah. It relates the fatalities from these accidents to the population of Madinah.

This provides insight on the exposure of accident victims such as pedestrians to the risks of accidents in the context of population density. Literature review of related studies that have been conducted in the past are also presented in this Chapter. It covers topics such as the risk factors associated with pedestrian casualty in Madinah and causes of pedestrian/ motor vehicle collisions in Madinah.

Chapter 3: The relationship between the concepts of accident, exposure and risk were explored in this Chapter. The theoretical definitions of these concepts were dealt with as means of clarifying the ambiguity associated with the concept of pedestrian exposure to risk of road accident. The relevance of these concepts to traffic safety studies was also highlighted. In addition, some important aspects of pedestrian exposure were considered. They include factors that influence pedestrian exposure and methods of measuring this important concept in road traffic research. Limitations of pedestrian exposure measures and ways of overcoming these challenges were presented in this Chapter.

Chapter 4: This Chapter reviews previous studies on pedestrian casualties in relationship with land use. It also presents some important researches on road accidents that have been undertaken in Saudi Arabia. Several techniques used road accident studies were considered in this Chapter.

Chapters 5: This Chapter explores the study area – the city of Madinah. It highlights the reasons for choosing Madinah as the study area and other relevant attributes such as its location, socio-cultural, economical and religious significance. This chapter also considers the transport system and road network of Madinah in order to provide insight on the challenges faced by pilgrims in general and how it could impact on pilgrims' pedestrian casualty. The initiatives of Saudi government concerning road safety were highlighted as the road safety policies in Madinah with emphasis on pedestrian safety were discussed in this chapter. Furthermore, the various districts of Madinah and their land uses were described in this Chapter.

Chapters 6: The methodology of the study is presented in this Chapter. It gives detailed description of the source and nature of pilgrims' pedestrian casualty data used in this study. The limitations of the accident data and its restructuring (or categorization) to suit the purpose of assessing the relationship of pilgrims' pedestrian casualty and land use type were discussed. It also covers the both the preliminary and advanced analysis of the data. The preliminary analysis deals with the descriptive statistics; while the advanced analysis discussed the selection of the appropriate variables for development of accident models.

Chapter 7: The results and discussion are presented in this chapter. The descriptive statistics of the accident data exposed important features of the pilgrims' pedestrian casualty in Madinah. Fundamental questions like which gender or age category or nationality are most affected is answered in this chapter. The statistics of pilgrims' pedestrian casualty for prayer time and non-prayer times; high season and low season; and weekends and weekdays were clearly presented here. In addition, this chapter vividly presents the distributions of pilgrims' pedestrian casualty among the land use types for the studied period. While the accident models attempt to establish the relationship between the pilgrims' pedestrian casualty and the land use types in Madinah. These results were discussed and compared to other similar studies. It also presents the road safety policy analysis component.

Chapter 8: This Chapter deals with the conclusions by highlighting the important findings of the research and clarify if its objectives and hypotheses have been answered. Based on the findings, several recommendations were proffered that could assists government departments, policy makers, transport planners and other stakeholders in providing traffic safety countermeasures to would help curb the menace of pilgrims' pedestrian casualty in Madinah. Furthermore, this chapter highlights some limitations of the study by suggesting some areas for further research.

1.10 Research Hypothesis

"Pilgrims' pedestrian casualties are strongly associated with the land use type in Madinah." The land use type considered in this study are as follows: Major land use (Agriculture, Government Offices, Accommodation, Commercial, Residential and Religious); Road Type (Unknown roads, Single carriageway – 4+ lanes, Single carriageway – 3 lanes, Single carriageway – 2 lanes, Single carriageway – single track, Dual carriageway – 3+ lanes, Dual carriageway – 2 lanes, One way street and Roundabouts-these only include large and signalised roundabouts while standard roundabouts are included in the junction categories) and Junction Details (Other junction, Private drive or entrance, Multiple junction, Crossroads, Slip road, T, Y or staggered junction, Mini-roundabout, Roundabout and Not at junction or within 20 metres).

1.11 Summary

The growing concern about the public health risks associated with mass gathering events have been discussed in this Chapter. Mass gathering events was defined as organized or spontaneous public events held at a specific location for a specified period and usually involves enormous number of people capable of posing public health challenge to the host nation. The debate regarding the number of attendees that characterized a mass gathering event discussed and clarified. Furthermore, several examples of the most common mass gathering events were highlighted. They include sporting events (e.g. Olympic Games and FIFA World Football Competition), musical concerts (e.g. Rock Concerts), political campaigns (or demonstrations), and religious gatherings (e.g. the Hajj, Vatican and Hindu festivals). Although mass gathering events have common characteristics and are attended by people of common interest; but each event has it uniqueness. For example, rock concerts are more likely to be associated with the abuse of illicit drugs compared to a religion gathering. Literature reviewed on mass gathering events indicate that majority of the studies that have been undertaken on mass gathering events were focused on musical concerts and sporting events compared to religious mass gatherings. Again, the spread of diseases during mass gatherings were given more consideration by researchers. It was stressed that road accidents is one of the most common cause of death by foreigners or tourists attending a mass gathering event. Consequently, it was stressed that researchers should devote more resources and time in investigating religious mass gathering events such as the Hajj. In addition, researchers should also turn their attention to other health challenges of mass gathering events such as road traffic accidents. This prompted the need for this study, which is aimed at establishing the relationship between pilgrims' pedestrian casualty and land use type in Madinah, Saudi Arabia.

This Chapter also explored the background of road accidents on a global context by highlighting the alarming rate of fatality, especially, in developing countries like Saudi Arabia. An overview of road accident in Saudi Arabia, with emphasis on pedestrian casualty was also discussed. In general, it was found that there is a growing trend of road accidents in Saudi Arabia caused by several factors which may include the following: increasing population; rapid motorisation of Saudi roads; expansion of the road network and poor enforcement of road safety regulations etc. Pedestrian casualty in Saudi Arabia, particularly, pilgrims' pedestrian casualty was also reviewed. Some of the worst pilgrims' pedestrian casualties caused by stampedes were highlighted. The growing trend of pedestrian casualties from road accidents in most Saudi cities like Madinah was stressed and will be discussed in more details in subsequent Chapters. Furthermore, over-crowdedness; increased number of vehicles; reckless driving; poor road safety regulations are some of the factors linked to the increasing pedestrian casualties in most Saudi cities. In fact, the growing fatality from road accidents, especially, among pilgrims' pedestrian in the Holy cities like Madinah is becoming a major health burden for the Saudi government. Both human and material loses associated with road accidents were also highlighted in this Chapter. Viable human lives; mostly young people have been wasted as a result of such accidents. These could have contributed in strengthening the country's economy. Again, other valuable material and financial resources that could have been channelled into developmental projects to improve the well-being of the Saudi people are being wasted to road accidents. Consequently, the Saudi government has intensified its effort to curb this menace by introducing countermeasures and road safety policies or regulations that requires collaboration from the several government establishments and non-governmental agencies to be effectively implemented. Furthermore, the quest to better understand the growing problem of pilgrims' pedestrian casualty has prompted the need for this research. The aims and objectives of this research which focuses on modelling the relationship between pilgrims' pedestrian casualty and land use type in Madinah were clearly stated. The novelty, significance and limitations of this study were also highlighted. Finally, this Chapter presents the structure of the thesis and a concise description of each of the eight Chapters that makes up the thesis.

Chapter Two: Road Accidents in Madinah

“These roads do not serve transportation alone, they also bind our Fatherland”

– **Fritz Todt**

Chapter Two: Road Accidents in Madinah

2.1 Introduction

Despite the effort of the government of Saudi Arabia to improve the quality of roads and the strict enforcement of road safety regulations which are conformity with global traffic codes, there are prevalent occurrence of road accidents in most Saudi cities. The problem is more serious in the larger cities like Madinah which has progressively experienced rapid population growth caused by economic migrants and regular visits by huge number of pilgrims from all over the world to Madinah for religious purposes. In addition, increased motorisation of the city and poor compliance to road safety regulations may also have contributed to the increasing number of accidents road accidents and fatality in cities such as Madinah. Hence, it is essential to undertake a critical review of the general accident trend in Madinah, which has been selected as the study area of this research. This Chapter discusses the rapid population growth in Madinah in relationship to the general accident trend over a specified period. Furthermore, the trend of pedestrian casualties during the specified period was also considered in this Chapter. This was necessary because pilgrims' pedestrian casualty is the focus of this research. Furthermore, pedestrians-vehicles conflicts are responsible for more than a third of all traffic-related deaths and injuries worldwide. The reason being that pedestrians are more vulnerable in such conflicts which often culminate in the pedestrians sustaining more multiple injuries, with higher injury severity scores and higher mortality rates than the occupants of the vehicle. Again, several risk factors have been attributed to road traffic accidents leading to pedestrian casualty. The identification and detailed understanding of these factors are prerequisites for the effective tackling of pedestrian casualty. This would provide a comprehensive insight of the problem which is needed not only to save lives but also make available necessary information that will assist both the government and other private sectors to improve their future transport planning and efficient budgeting (Ameen and Naji, 2001). Consequently, it is imperative to also discuss the main risk factors that impact on pedestrian casualty in this section. This section gives a detailed review of the following: (i) Risk factors exposing pedestrians to road accident in

Madinah; (ii) Causes of pedestrian/ motor vehicle collisions in Madinah; (iii) Factors that affect the severity of pedestrian casualty in Madinah; and (iv) Factors that aggravate the severity of post-crash injuries.

2.1 General Trend of Accidents in Madinah

Madinah is the fourth largest city in Saudi Arabia with high population density due to the influx of pilgrims and economic migrants from over the world. The regular presence of substantial number of foreigners (e.g. pilgrims) that may not be conversant with road safety regulations of the city in combination with other prevalent exposure measures to the risks of accident make this city one of the most susceptible to road accidents. In fact, Madinah has among the highest fatality in Saudi Arabia after Riyadh, Makkah and the Eastern region (Hassan and Al-Faleh, 2013). The population and general accident statistics of Madinah as shown in Table 2.1, was obtained from the Madinah Police Department and then presented graphically for easy interpretation as illustrated in Figures 2.1A to 2.1F.

Table 2.1: Population and general accident statistics of Madinah (**Source:** Madinah Police Department).

Year of Accident	Population of Madinah	Number of Accidents	Total Fatality	†Fatality/1000 Traffic Accidents	†Fatality/100,000 Persons
2004	1,513,000	14,595	257	18	17
2005	1,562,000	14,688	297	20	19
2006	1,608,000	13,955	289	21	18
2007	1,649,000	23,707	346	15	21
2008	1,688,000	29,213	388	13	23
2009	1,742,000	34,375	436	13	25
2010	1,778,000	34,917	391	11	22
2011	1,821,000	33,249	437	13	24
2012	1,914,000	39,869	517	13	27
2013	1,963,000	43,543	569	13	29
Total	**N/A**	**282,110**	**3,928**	**N/A**	**N/A**

The population of Madinah as indicated in Table 2.1 and illustrated in Figure 2.1A follow a similar trend as that obtained for the entire country presented in Figure 1.4A. It shows that Madinah has also experienced rapid population growth over the years. According to the population figures in Table 2.1, it has increased from 1,513,000 to 1,963,000 over the ten years period (i.e. from 2004 to 2013). This represents an increase of 29% over the period under consideration. Again, the population steadily increases during this period (Figure 2.1A).

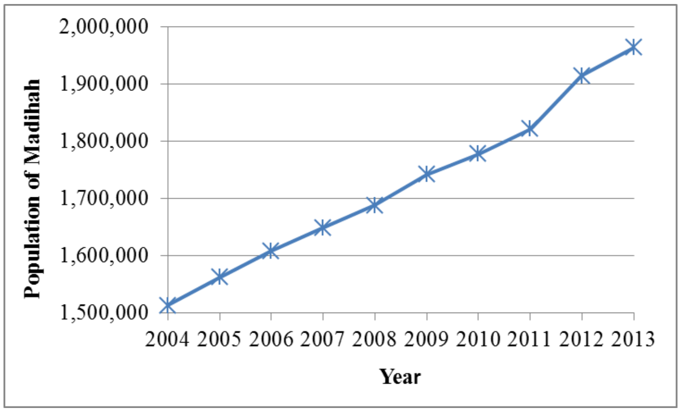

Figure 2.1A: Population of Madinah from 2004 to 2013.

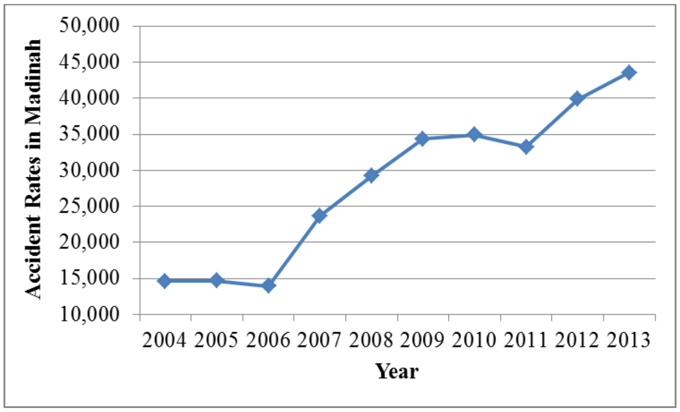

Figure 2.1B: Trend of accident rates in Madinah from 2004 to 2013.

In general, the accident rates increases over the years from 2004 to 2013 (Figure 2.1B). However, the accident rates of Madinah almost remain constant from 2004 to 2005, and then declined in 2006. Afterwards there was a rapid increase in the accident rates from 2006 to 2010. Again, it dropped in 2011 before increasing to its peak in 2013. The accident rate of Madinah ranged from 13,955 in 2006 to 43,543 in 2013; which represents 212% increase of accident rates over the specified period. This increase in accident rate over this period is alarming and deserves detail investigation to ascertain the contributing factors to this problem.

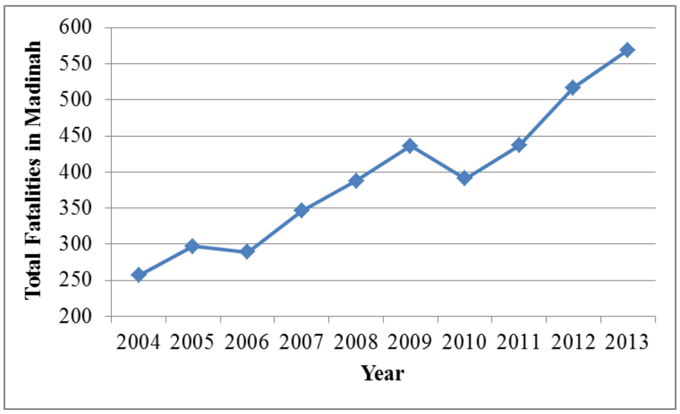

Figure 2.1C: Total fatality from road accidents in Madinah from 2004 to 2013.

Figure 2.1C shows the total fatality rates in Madinah during the specified period. In general, the fatality rate increases over this period; although there were sudden decline in the fatality rates in 2006 and 2010. Nevertheless, the fatality from road accidents in Madinah ranged from 257 to 569 persons killed in 2004 and 2013, respectively. Consequently, the fatality rate has increased about 121% since 2004 to date.

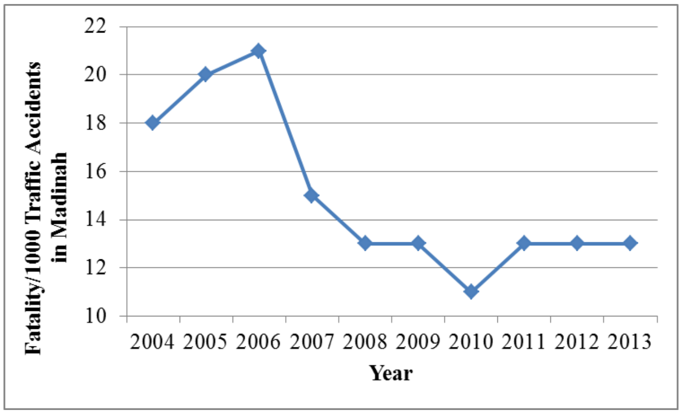

Figure 2.1D: Trend of fatality per 1000 traffic accidents in Madinah from 2004 to 2013.

In terms of fatality per 1000 traffic accidents in Madinah, it increases from 2004 to 2006, then suddenly declined until it reaches its lowest in 2010 before increasing again and become steady in recent years (Figure 2.1D). In this case, the number of persons killed per 1000 traffic accidents generally decreases before becoming steady.

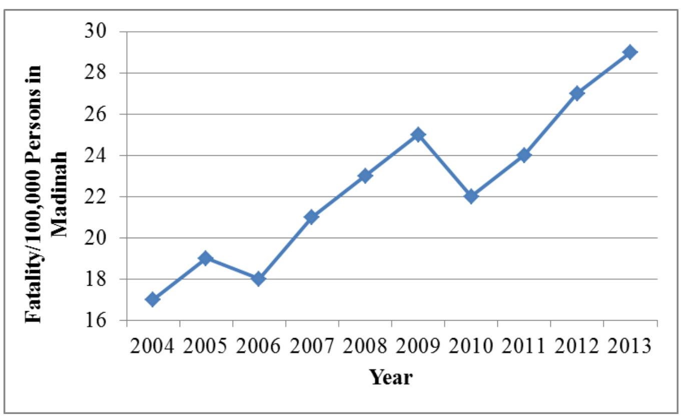

Figure 2.1E: Trend of fatality per 100,000 persons in Madinah from 2004 to 2013.

While the number of persons killed in road traffic accidents in Madinah generally increases with increase in the population as indicated in Figure 2.1E. It ranges from 17 to 29 deaths per 100000 persons in Madinah. In this case, the minimum and maximum fatality per 100,000 persons occurred in 2004 and 2013, respectively. The sudden drop in fatality per 100000 persons in 2006 and 2010 may be attributed to government intervention measures to curb road accidents. Nevertheless, each of these exposure measures used to describe road accidents in Madinah provide insight on the severity of the problem.

2.2 Pedestrian/ motor vehicle collisions in Madinah

Since pedestrian/ motor vehicle collisions constitutes more one-fifth of the total road accidents globally (WHO, 2013), it will be necessary to examine the pedestrian casualties in Madinah. Moreover, pedestrian casualty is the core of this study. Hence, the pedestrian crash and fatality figures also obtained from the Madinah Police Department are presented in Table 2.2. Similarly, these figures were converted to graphs for better illustration as presented in Figures 2.2A-2.2E

Table 2.2: Population and pedestrian crash/fatality figures (**Source:** Madinah Province Police Department).

Year	Population of Madinah	†Total Accidents	#Total Fatality	Pedestrian / motor vehicle collisions	‡Pedestrian Fatality	Pedestrian Fatality /1000 Pedestrian-Vehicle Collisions	Pedestrian Fatality /100,000 Persons
2004	1,513,000	14,595	257	464	84 (33%)	181	6
2005	1,562,000	14,688	297	496	103 (35%)	208	7
2006	1,608,000	13,955	289	481	91 (31%)	189	6
2007	1,649,000	23,707	346	515	98 (28%)	190	6
2008	1,688,000	29,213	388	562	117 (30%)	208	7
2009	1,742,000	34,375	436	644	155 (36%)	241	9
2010	1,778,000	34,917	391	631	126 (32%)	200	7
2011	1,821,000	33,249	437	686	155 (35%)	226	9
2012	1,914,000	39,869	517	724	191 (37%)	264	10
2013	1,963,000	43,543	569	752	227 (40%)	302	12
Total	**N/A**	**282,110**	**3,928**	**5,955**	**1,347**	**N/A**	**N/A**

†Total accidents refer to the sum of the various road accidents involving the different road users.

#Total Fatality also refers to the sum of the fatality from types of the road users.

‡Pedestrian Fatalities as a proportion of all road traffic deaths are presented in the parentheses.

Pedestrian/ motor vehicle collisions in Madinah also follow similar trend as general road accidents. In general, it increases over the specified period considered (Figure 2.2A). Pedestrian/ motor vehicle collisions in Madinah ranged from 464 to 752. The minimum number of pedestrian/ motor vehicle collisions occurred in 2004; while the maximum pedestrian/ motor vehicle collisions took place in 2013. Again, there were occasional decline in the pedestrian/ motor vehicle collisions as noted in 2006 and 2010. In this case, pedestrian/ motor vehicle collisions appear to increase as the population of Madinah increases. From 2004 to 2013, an estimated 5,955 crashes involving pedestrians occurred in Madinah, resulting in pedestrian deaths 1,347.

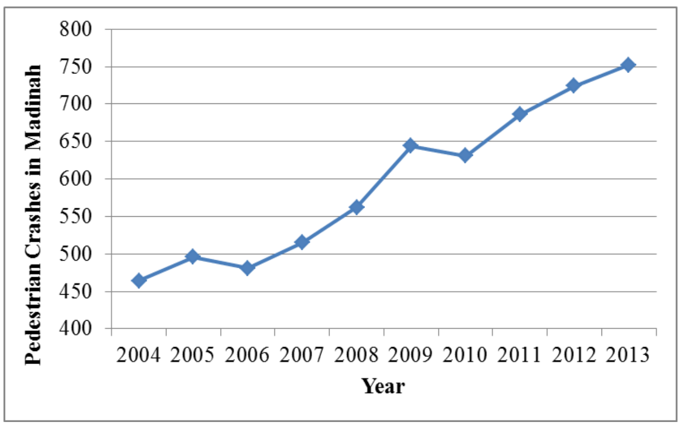

Figure 2.2A: Pedestrian/ motor vehicle collisions in Madinah from 2004 to 2013.

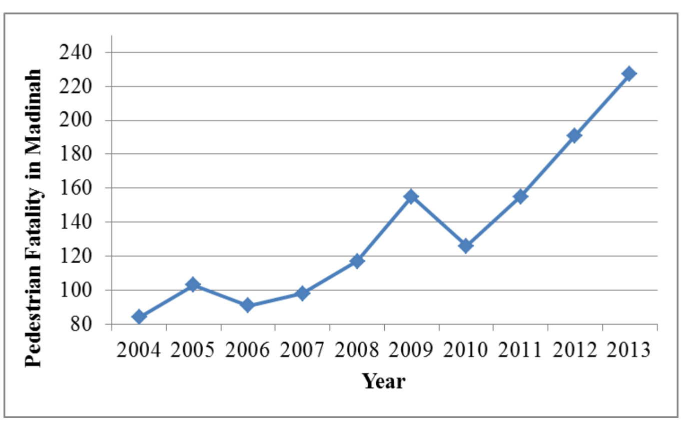

Figure 2.2B: Pedestrian fatalities in Madinah from 2004 to 2013.

Similarly, pedestrian fatality in Madinah also increases over the ten years period considered (i.e. from 2004 to 2013). Again, there were occasional decline in the pedestrian fatality as observed in 2006 and 2010 (Figure 2.2B). Nevertheless, fatality in Madinah ranged from 84 to 227, which occurred in 2004 and 2013, respectively.

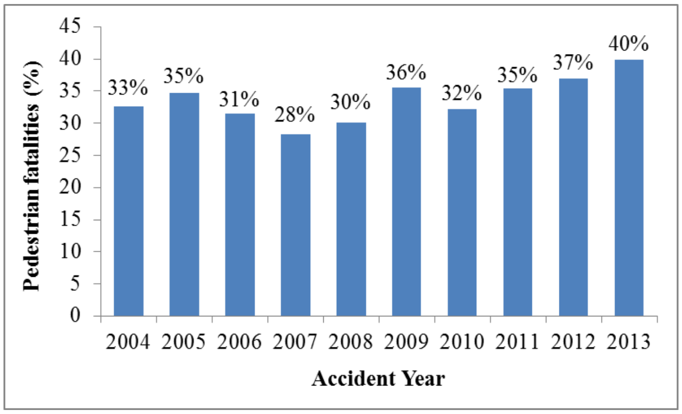

Figure 2.2C: Pedestrian fatalities as a proportion of all road traffic deaths in Madinah from 2004 to 2013.

Pedestrian fatalities as a proportion of the entire road traffic deaths are also illustrated in Figure 2.2C. This shows that pedestrians have a large share in road traffic fatalities in Madinah, varying between 28% and 40 % (Figure 2.2C). This range is higher than the values obtained in most cities.

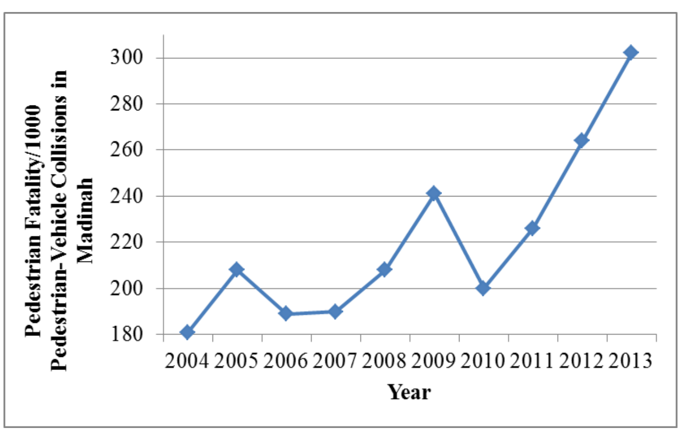

Figure 2.2D: Pedestrian fatality per 1000 pedestrian-vehicle collisions from 2004 to 2013.

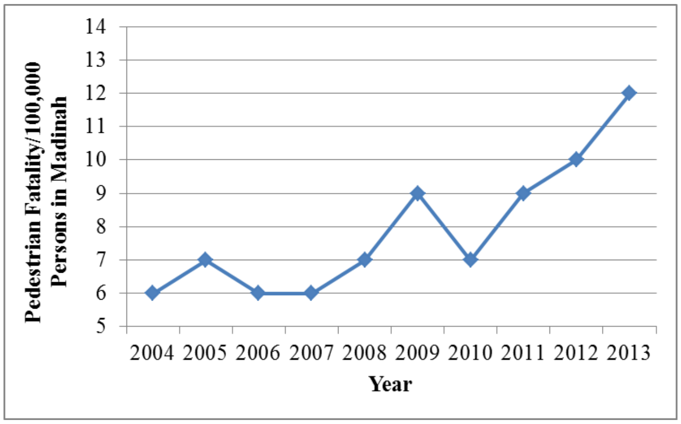

Figure 2.2E: Pedestrian fatality per 100,000 persons from 2004 to 2013.

Pedestrian fatality per 1000 pedestrian-vehicle collisions shows a pattern (Figure 2.2D). In general, the pedestrian fatality increases with increase in the number of pedestrian-vehicle collisions over the period. The trend is strikingly similar to the pedestrian fatality per 100,000 persons in Madinah over the same period as illustrated in Figure 2.2E. In general, both cases increases over the ten years specified period considered with occasional decline in 2006 and 2010. In fact, all the graphs that illustrates pedestrian fatality regardless of the context show striking resemblance (Figures 2.2A – 2.2E). This is a clear indication that the population of Madinah, which is also proportional to the number of pedestrian-vehicle collisions was a dominant exposure factor that influences pedestrian/ motor vehicle collisions and fatalities in Madinah.

2.3 Risk Factors Associated With Pedestrian Casualty in Madinah

2.3.1 Risk Factors Exposing Pedestrians to Road Accident in Madinah

The necessity to embark on a given trip (e.g. for religious, business, recreational or educational purposes etc.) exposes that individual to some form of risk. The extent of the risk faced by the individual will depend on several factors which may include the means of transportation used (e.g. walking); the location (i.e. the path followed by the person); the purpose and time of the trip etc. This section will discuss the main risk factors exposing pedestrians to road accidents in Madinah, as presented below:

2.3.1 Rapid Motorization

Although the increasing use of motor vehicles and the development of road infrastructure have brought benefits to the society, it has also resulted in a significant increase in road traffic accidents which sometimes involve pedestrians (Peden et al., 2004). For several decades, Saudi Arabia has experienced rapid economic growth following the oil booms in the 1970s and 1990s (during the Gulf war). Consequently, there has been rapid expansion of road construction and increase in the number of vehicles resulting to corresponding increase in road traffic accidents (Barrimah, 2012; Al-Fouzan, 2009). This conforms to the findings of other studies which stipulate that motorization rate rises with income (Kopits and Cropper, 2003). Hence, the financial empowerment of the people in Saudi Arabia enables them to buy cars, thereby, increasing the number of cars on the Saudi roads. For instance, the number of registered vehicles and driving licences issued to drivers in Madinah and other Saudi cities have dramatically increased. Consequently, the occurrence of road accidents and fatality rates has also correspondingly increased in most of these cities in Saudi Arabia. A typical example is the case of Riyadh as shown in Table 2.3 (Ministry of Interior, 2012).

Table 2.3: Statistics of Riyadh City from 1990 to 1999 (Ministry of Interior, 2012).

Year	Number of Vehicles Registered	Driving Licences Issued	Number of Accidents	Number of Injuries	Number of Fatalities
1990	52919	84148	19960	3958	217
1991	52806	81013	20775	3867	299
1992	60441	77407	23070	4678	361
1993	80884	84542	34751	8247	372
1994	108590	103886	42639	3234	467
1995	108954	110545	42359	2330	365
1996	106755	101608	39815	2312	318

1997	100338	110131	40226	1965	302
1998	129139	92145	52289	4883	525
1999	120061	114962	78303	7842	920

Most major cities in Saudi Arabia such as Madinah follow similar trend of road accident statistics as shown in Table 2.3. The city of Madinah has also experienced rapid increase in the registration of vehicles; issuance of driving licences; number of accidents; and the extent of casualties recorded. In other words, the rapid motorization of Madinah has culminated in several road accidents over the years as shown in Table 2.3. The more vehicles on the roads of Madinah Province, the higher the tendency of pedestrians-vehicles conflicts which will ultimately results in more pedestrian casualty. Thus, rapid motorization enhances the risk of exposing pedestrian to road accidents.

2.3.2 Demographic Factors

Human population is characterized by diverse groups (e.g. different ages, genders, incomes, ethnicities etc.) which are often refers to as demographic factors. The people of these various demographic groups have different exposure to risk, which changes with time as the population changes (Wedagama et al., 2006). In other words, the demographic structure of a given society is dynamic as the population changes. In general, certain demographic factors have been found to strongly impact on the casualty rate of road traffic accidents (Wedagama et al., 2006). Since the demographic factors depend on the population and other attributes of a given society, its equilibrium or size may vary from one country to the other. Consequently, the impact of demographic factors on road traffic accidents will vary from country to country. A concise presentation of the main demographic factors that influencing exposure to road accidents in Madinah are given below:

2.3.2.1 Age

One of the most demographic factors exposing pedestrians to road accident in any society is the age of the driver of a vehicle and the pedestrians. The more reckless either of the actors (i.e. driver or pedestrians) becomes as a result of their age, the higher the pedestrians-vehicles conflicts. The different age categories of the population have different levels of exposure to road accidents. For instance, young drivers (i.e. 18 – 40 years), particularly males, are at significantly higher risk of being involved in a road traffic accident compared to other age groups, according to research conducted in various nations (Constantinou et al., 2011; Massie et al., 1995). As a result of youthful exuberant and hasty conclusion, they are likely to take more risky decisions on road traffic issues compared to other age category. Again, laboratory driving simulations have shown that young drivers over-estimate their driving ability which makes them to indulge in reckless and aggressive driving (Fisher et al., 2002; McKenna and Crick, 1991; Reason et al., 1990; Finn and Bragg, 1986; Brown, 1982). Again, the elderly drivers (i.e. over 65 years) are also susceptible to the danger of road traffic accidents because they are more prone to fatigue and deteriorating performance resulting from eyesight defects (e.g. diminished visual acuity, narrowed peripheral vision, and cataracts), slowed speed of perception and response to stimuli, and reduced muscle strength (Di Milia et al., 2011; Scherrer, 1992; Holliday, 1995). Studies have also found that young (less than 30 years) and older drivers appear to be more susceptible to drowsiness which exposes these age categories to the danger of road accidents (Di Milia et al., 2011; Smolensky et al., 2011). The recklessness of vehicle drivers based on their ages as explained above will definitely affect the frequency of pedestrians-vehicles conflicts.

Studies have also shown that the age of the pedestrian affects their judgements, decisions and tendency to take risk while crossing motor roads. Many studies have exposed that children are more likely to make erroneous decisions due to poor judgement while crossing roads. Whereas teenager pedestrians are more likely to make reckless decision or take greater risk while indulging in pedestrian activities. As a result of fatigue, elderly pedestrians are often sluggish while crossing roads. It is evident that poor judgements, decisions and higher risking taking by pedestrians often bring them into conflict with vehicles. Hence, the age of pedestrians affect their exposure to road accidents. Most road accident studies undertaken indicated that child pedestrians are more affected by road accidents because they usually play close to roads and their poor judgement.

2.3.2.2 Sex

Norris et al. (2000) have emphasized that the disparity in the frequency of accidents can partly be attributed to differences in personality between men and women. Another study concluded that men are higher in impulsivity and sensation seeking compared to women, especially in younger age categories (Arnett, 1994). Hence, male pedestrians are likely to take greater risk compared to their female counterparts. Madinah is exclusively an Islamic city which restricts women from certain activities. In most cases, women are expected to stay at home and look after the children, thereby, exposing them to less pedestrian activities. Again, the national legislation does not permit women to drive vehicles. Consequently, the pedestrian casualty is much higher in men than women as revealed by most studies undertaken in Saudi Arabia. These findings clearly indicate that gender is an important factor that influences the exposure of an individual to pedestrian activities in Madinah.

2.3.2.3 Socio-economic Status

Another important demographic factor that impact on pedestrian casualty is the socio-economic status of the individuals in the society. Socio-economic status is often used to categorize an individual's position in society because it provides some indication about the resource capabilities of the individual (Di Milia et al., 2011). According to Stewart (2002), educational attainment, occupational status, and income are the most widely used indicators of Socio-economic status. Others variables include marital status and race/ethnicity, which are beyond the scope of this research. Hasselberg et al. (2005) concluded that the types and severity of road accidents varied among different socio-economic classes. Similarly, Braver (2003) has identified that low per-capita income as a determinant of injury mortality. Studies undertaken in several other countries indicate that non-compliance of road safety regulations was related to the socio-economic background of the individual (Wells et al., 2002; Shinar et al., 2001; Shin et al., 1999). Hence, pedestrians from a deprived socio-economic background are more likely to be involved in road accidents due to violations of these safety regulations. Similarly, pedestrians with poor socio-economic background are more susceptible to road accidents in Madinah.

2.3.3 Absence of Pedestrian Facilities in Madinah

A fundamental factor in high-income countries is the fact that the modern traffic system is designed largely from the perspective of a motor vehicle user. Provision for road safety facilities for pedestrians and cyclists in developing countries such as Saudi Arabia is rudimentary or even non-existent. The principal risk factor for unprotected road users is the mixing of unprotected people with motor vehicles capable of high speeds. The survival of unprotected users depends upon ensuring either that they are separated from the high speeds of motor vehicles or – in the more common situation of shared use of the road – that the vehicle speed at the point of collision is low enough to prevent serious injury on impact with crash-protective safer car fronts. The absence of adequate separate pedestrian and cyclist facilities, such as footpaths or cycle tracks, creates a high risk for these road users.

If separation is not possible, road management and vehicle speed management are essential. At low speeds, drivers have more time to react to unexpected events and to avoid collisions. At speeds of less than 30 km/h, pedestrians and cyclists can mix with motor vehicles in relative safety. Poor provision at crossings and junctions is also a feature of unsafe shared use. In urban areas, most fatal or serious cyclist crashes occur at junctions. In Madinah, pedestrian facilities are minimal or non-existent in most roads, thereby, contributing to the cause road accidents resulting to pedestrian casualty.

2.3.4 Land Use

Land use planning practices influences pedestrians' choice of trip and the length of a trip (Peden et al., 2004). In other words, land use is a trip generator (Wagadama et. al, 2003). According to Ha and Thill (2011) the intensity of land development and the type of land use in the adjacent area are also major contributing factors in all types of pedestrian/ motor vehicle collisions . In Saudi Arabia, the location of Mosques and other religious sites influences the route and destination of pedestrians. Similarly, other land uses (e.g. commercial, industrial, agricultural etc.) as trip generators have varied impact on pedestrians. In Madinah, enormous number of Muslim pilgrims visits the Prophet's Mosque and other religious sites (e.g. the burial site of Prophet Mohammed). However, there is absence of proper land-use planning in most developing countries and Saudi Arabia is not an exception. Improper land-use planning will result in the residential, commercial and industrial activity evolving in a haphazard pattern, and road traffic also evolving to meet the needs of these various activities (Peden et al., 2004). Consequently, heavy flows of traffic through residential areas will definitely expose high speed vehicles with the reach of pedestrians. Furthermore, the absence of proper land-use planning may create traffic congestion and the diversion of heavy duty vehicles to routes not designed for such vehicles around residential. Hence, the exposure to traffic injury can be high for the vulnerable road users, such as pedestrians (Peden et al., 2004).

2.3.5 Increased Need for Travel

Urbanization of most cities in Saudi Arabia including Madinah has prompted the movement of residents from rural areas to the urban area for the search of better opportunities. Again, the rapid expansion of the Saudi economy following the oil booms has triggered urban development and socio-economic changes in most of the cities including Madinah, thereby, leading to a profusion of supermarkets, shopping centres, clinics, schools, Mosques etc. Consequently, there is an increasing need for people to travel via public transport (or by walking) to a variety of places on daily basis (Peden et al., 2004). For instance, most pilgrims travel to the Mosque through either public transport or walking in order to fulfil their one of the 'Pillars of Islam' (which requires them to pray five times a day). High frequency of travelling generates increased traffic, and greater exposure to risk of road accidents.

2.3.6 Over-population

Over-populated Saudi cities such as Makkah and Madinah expose more pedestrians to higher risk of pedestrian/ motor vehicle collisions . Furthermore, Madinah being the custodian of two Holy Mosques of Islam and other important religious sites (e.g. the Tomb of Prophet) attract Muslims all over the world. The influx of pilgrims and other religious visitors to Madinah causes over-crowdedness, especially, during Hajj and other religious festivals. This over-crowdedness exposes enormous number of pilgrims' pedestrians to road traffic accidents. In other words, the over-crowdedness in cities like Madinah increases the probability of pedestrians interacting with vehicles. Consequently, the exposure or risk of pedestrians (including pilgrims) involving in road traffic accidents is enhanced.

2. 4 Causes of Pedestrian/ motor vehicle collisions in Madinah

It is not uncommon for society to hastily conclude that pedestrian errors (e.g. violation of traffic laws, being confused or distracted and sometimes in a hurry) are responsible for most pedestrian-automobile collisions that often lead to pedestrian casualties (Ha and Thill, 2011; Campbell et al., 2004). Nevertheless, it seems that this conclusion may be overstated for several reasons (Dhillon et al., 2001; Brustman, 1999; Roberts and Coggan, 1994). In addition to pedestrian error, there are several causes of pedestrian/ motor vehicle collisions which need to be considered to provide insight on how best to tackle the problem. For instance, those factors that influence the motorists (i.e. drivers) and/or the vehicles (e.g. brake failure) may also culminate in pedestrian/ motor vehicle collisions . In general, factors contributing to pedestrian/ motor vehicle collisions can be subdivided into three broad categories (Ha and Thill, 2011) – (i) Human factors; (ii) Environmental factors; and (iii) Vehicular factors. In some cases, pedestrian/ motor vehicle collisions may be caused by a complex combination of these factors (Peden et al., 2004). This section will discuss the likely causes of pedestrian casualty in Madinah:

2.4.1 Human Factors

2.4.1.1 Behavioural Factor

Since pedestrian casualty usually involves the interaction between pedestrians and vehicles, the behaviour of both the pedestrians and drivers could contribute adversely to road accidents. Drivers' behaviour could lead to errors or deliberate violation of road traffic laws which contributes significantly to 90–95% of crashes (Ha and Thill, 2011; Campbell et al., 2004; Evans, 1993). Consideration of driver's behaviour is a complex issue that should be dealt with caution. Fast driving is but one of many dangerous and harmful driving habits acquired partly through faulty education and training (Mekky, 1984). There are many other aspects of driver's behaviour that contributes adversely to road traffic accidents. For instance, some drivers are disobedient to authority, thereby, violating road traffic laws. Some drivers may also be addicted to narcotic and other hard drugs which may hamper their judgement while driving resulting to fatal accidents. The attitudes of drivers are also influenced by their socio-economic background. Wrong driving attitudes of drivers could lead to road accidents, which sometimes affect pedestrians.

Pedestrian casualty does not only depend on drivers' behaviour, but also depend on the behaviour of the pedestrians (Damsere-Derry et al., 2010). Hence, the wrong attitudes of pedestrians (e.g. wearing headphones, talking on a cell phone, and eating, drinking, smoking or talking while crossing the roadway) could also cause road traffic accidents culminating in pedestrian casualty (Bungum et al., 2005). Similar to the behavioural problems of drivers, pedestrians could also be disobedient to authority by violating traffic laws. In fact, most road accidents involving pedestrians are caused by non-compliance with road safety regulations. The consumption of alcohol, narcotics and other hard drugs by pedestrians could impair their judgement, which may result in erroneous road traffic decision culminating in pedestrian casualty (LaScala et al., 2001; Mock et al., 2000; National Highway Traffic Safety Administration, 1997; Vestrup and Reid, 1989). However, the violation of road safety regulations due to alcohol intoxication and other hallucinating drugs are almost non-existence in Saudi Arabia. Almost all Islamic countries, including Saudi Arabia, the consumption of alcohol and other hallucinating drugs are prohibited, and culprits of this heinous crime could face severe punitive measure. Again, Madinah is exclusively an Islamic city which adheres to the strict compliance to alcohol and drugs prohibition. Consequently, the consumption of alcohol and drugs by both drivers and pedestrians in Madinah is very minimal. Therefore, the influence of alcohol and drugs on pedestrian-vehicle collision is very low in Madinah.

2.4.1.2 Speed

Over-speeding of motorists has been shown to be the major cause of road accidents which often lead to pedestrian casualty. “Excess speed” is defined as a vehicle exceeding the relevant speed limit; whereas “inappropriate speed” refers to a vehicle travelling at a speed unsuitable for the prevailing road and traffic conditions. The speed of a driver is influenced by several factors such as the nature of the road (e.g. its width or alignment or markings), the type of vehicle (e.g. maximum speed of vehicle), road traffic (e.g. congestion, density), environment (e.g. weather, road lighting etc). In addition, the demographic factors (e.g. age and sex) and behavioural attributes of the driver also influences the speed the vehicle would be travelling (Peden et al., 2004). Several studies have established the relationship between vehicle speed and crash risk (Peden et al., 2004; Andersson and Nilsson, 1997; Nilsson, 1982). The probability of a crash involving an injury is proportional to the square of the speed. The probability of a serious crash is proportional to the cube of the speed. The probability of a fatal crash is related to the fourth power of the speed (Andersson and Nilsson, 1997; Nilsson, 1982).

According to Peden et al. (2004) speed has an exponentially detrimental effect on safety. Hence, the number and severity of the casualty rises as the speeds increase. Evidence have shown that pedestrians have a 90% chance of surviving car crashes at a speed of 30 km/h or below, but less than a 50% chance of surviving impacts at 45 km/h or above. Another study have indicated that the probability of a pedestrian fatality rises by a factor of eight as the impact speed of the car increases from 30 km/h to 50 km/h. Over-speeding has been identified as the main cause of road traffic accidents in most developing countries, including Saudi Arabia (Ansari et al. 2000; Mekky, 1984).

2.4.1.3 Driver Fatigue

Drivers' fatigue or tiredness) can be caused by a range of factors such as long-distance driving, sleep deprivation and the disruption of circadian rhythms. As a result of fatigue, drivers can fall asleep while driving resulting to road accidents which sometimes wreak havoc on pedestrians. However, most fatigue related crashes occur at night during which pedestrian activities are usually reduced. Paradoxically, pedestrians killed or injured at the peak of fatigue related crashes are less at night. But fatigue related crashes at day time are likely to result in greater number of casualty. For the above reasons, more pilgrims' pedestrian casualty caused by fatigue related crashes are likely to occur at daytime in Madinah.

2.4.1.4 Poor Vision of Drivers (or Pedestrians)

Pedestrian-automobile collision can also be caused by impaired eyesight of either the vehicle driver or pedestrians. A driver needs a good vision to be able to see and avert looming danger such as pot-holes that could lead to road accidents. Without a good vision vehicle drivers would not be able to see on-coming pedestrians to avoid unnecessary collision. Similarly, pedestrians need good vision to avoid impending danger that could lead to collision. Furthermore, traffic lights and Zebra (or Pedestrian) crossing must be clearly seen by pedestrians to enable them effectively comply with road safety regulations.

2.4.1.5 Other Medical Conditions of Drivers (or Pedestrians)

There are other medical conditions of drivers or pedestrians that could cause pedestrian-vehicle collision. For example, certain prescribed medications taken by drivers (or pedestrians) due to their medical conditions may cause drowsiness or hallucination that could lead to fatal road traffic accidents. *Epilepsy*, which is a diverse set of chronic neurological disorders characterized by seizures can also pose danger to road safety. Sufferers of this medical condition could experience seizure while driving or walking leading to fatal road accidents. Another typical health condition that poses danger to road safety is heart attack. Hence, road users (e.g. drivers and pedestrians) are advised to stay in-doors after taken certain medications in order to avoid any unpleasant road disaster. Again, sufferers of certain medical conditions (e.g. epilepsy) are advised not to drive. In extreme cases, these persons are not issued drivers' license based on their medical conditions to prevent them from driving.

2.4.1.5 Hand-held Mobile Telephones

In many high-income countries such as Saudi Arabia, the use of hand-held mobile telephones has become very rampant because they affordable by most Saudis. The use of hand-held mobile telephones is invaluable for effective communication, but it can adversely affect driver behaviour. For instance, the process of dialling or receiving calls influences a driver's ability to react to impending danger such as pot holes or pedestrians. According to a report by Peden et al. (2004) researches have shown that the reaction times of vehicle drivers can be increased by 0.5–1.5 seconds when communicating through a mobile telephone and drivers who use hand-held mobile phones while driving are four times likely to crash compared to those who do not use them. Similarly, the use of hand-held mobile phones by pedestrians while crossing roadway could cause road accidents leading to pedestrian casualty (Bungum et al., 2005). Many causes of pedestrian-vehicle collisions in Madinah might be as result of the inappropriate use of mobile phone while driving or walking, however this needs further research.

2.4.2 Environmental Factors

2.4.2.1 Inadequate Visibility

Good visibility (which is the ability to see clearly and be seen) is a fundamental prerequisite for the safety of all road users. Hence, poor visibility is a major factor cause of road traffic accidents which affects all types of road users (Peden et al., 2004). This problem of inadequate visibility of roadways seems to be less serious in developed countries because of the strict implementation of road safety regulations and maintenance of street lightings. According to the World Report on

Road Traffic Injury and Prevention, in the state of Victoria, Australia, poor visibility contributes to 65% of crashes between cars and motorized two-wheelers and the sole cause in 21% of them. While in Germany, nearly 5% of severe truck crashes can be linked to poor visibility of the truck or its trailer at night (Peden et al., 2004). The impact of inadequate visibility on pedestrian casualty have also been highlighted by a review of European in-depth research which indicated that about 33% of pedestrian casualties had difficulty in seeing the striking vehicle; while 40% of drivers had difficulty in seeing the pedestrian (Allsop, 1999). However, in most developing countries including Saudi Arabia, the poor visibility of motorways and road users (e.g. pedestrians and motorists) is a serious problem. In Saudi city such as Madinah, there are fewer roads with adequate illumination at night time due to the absence of street lightings. In places where street lights are installed, some may not be functioning as a result of poor maintenance. Again, some motorists drive vehicles with faulty head-lights without been arrested due to the ineffective implementation of road safety measures in most of these developing countries. These harmful practices in Madinah decrease the visibility of roadways at night. Consequently, they expose road users to the danger of road accidents. The more conspicuous the road users (i.e. motor vehicles and non-motorists e.g. pedestrians) are to one another, the better the opportunity of averting road accidents.

2.4.2.2 Road-Related Factors

The road network of a city greatly affects how road users perceive their environment and also provides instructions for road users, through signs and traffic controls (Peden et al., 2004). Hence, the choices of the route taken by road users, the time spent on the route and the congestion (or traffic volume) encounter by the road users are influenced by the road network. The type and nature of the roads in any given environment influences the frequency and severity of road traffic crashes. As a result of the disparity in road-type or nature, road traffic accidents are unevenly distributed throughout the network. For example, road type such as a single carriageway is most likely to lead to a fatality rather than roundabouts, one-way streets, or dual carriageways. While not being at a junction or within 20 metres of one has been found to be associated with the most severe injuries (Gray et al., 2008). Again, there are safety concerns of the nature of roads because they contribute to crash risk. For instances, driving on bent or hilly roads may prevent the driver of the vehicle from seeing afar. Similarly, pedestrians may be unable to see approaching vehicles on certain bent or hilly roads. Slippery roads also pose danger to both drivers and pedestrians. A common example is the weakening of the effectiveness of the brake system of vehicles by slippery roads, which may lead to road accidents. Pedestrians may also trip-over while crossing a slippery road (or walking on slippery foot path) leading to pedestrian casualty. In fact, many fatal accidents occur along bent, hilly and slippery roads.

Understanding the contribution of road-related factors to road crashes enable road engineers to effectively tackle this menace by constructing roads that will help in reducing the frequency and severity of road traffic crashes. Poor construction of roads can contribute to crashes (Peden et al., 2004). Consequently, the planning, designing and maintenance of the road network usually involves four important elements which affects road safety as highlighted below (Ross, 1991):

i.) safety-awareness in the planning of new road networks;

ii.) the incorporation of safety features in the design of new roads;

iii.) safety improvements to existing roads;

iv.) remedial action at high-risk crash sites.

These four road safety elements are less taken into consideration in most developing countries due to several factors which may include poor governance, corruption of government officials, and poor implementation of road projects. Hence, road- related factors have greater impact on Madinah being a city in a developing country.

2.4.2.3 Environmental Conditions

The environmental conditions such as bad weather, storms, dust, rain, hail snow, fog, and numerous other factors can adversely affect driving. For instance, severe weather conditions can result to poor visibility which will affect the safety of road users. The trends show that vehicles either ram into the rear of a stationary/slow-moving vehicle or there may be angled/head-on collisions. In other cases, the poor visibility results to the collision between pedestrians and vehicles.

2.4.3 Vehicular Factors

Mechanical failure (e.g. braking failure, burst tyres etc.) has been found to be one of the main causes of road accidents. In addition, the design of the vehicle, its handling, maintenance and overloading are prerequisites that influence the tendency of the vehicle to involve in road accidents. For instance, the design of a motor vehicle has been found to contribute to crashes to a level of 3% in the developed world, while for Kenya its contribution has been found to be 5%. The maintenance of vehicles in Saudi Arabia is poorly regulated. Hence, the contribution of vehicular factor to pedestrian casualty could be much higher in Madinah due to poor maintenance of vehicles.

2.5 Risk Factors Influencing the Severity of Pedestrian Casualty in Madinah

Well-established risk factors that contribute to the severity of pedestrian/ motor vehicle collisions are concisely presented below since most of these issues (e.g. demographic factors) that highlight the difference between gender with regards to accidents have already been discussed in detail in the previous sections:

2.5.1 Excessive and Inappropriate Speed

The severity of pedestrian casualty is usually proportional to the impact between the pedestrian and vehicle. Excessive and inappropriate speed above the safety regulations are prohibited because its tendency of causing death. Consequently, drivers are urged to drive at low speed by complying with the road safety regulations.

2.5.2 Pedestrians' Age or Gender

The age and gender of pedestrians may also influence the severity of their injuries. Children and elderly people are known to suffer more severe injuries than other age categories due to their fragility. Similarly, females are more susceptible to suffer severe injuries compared to their male counterparts.

2.5.3 Inadequate Roadside Protection

Roadside protections such as rails or bars protect pedestrians from getting into contact with vehicles. Hence, it protects pedestrians from sustaining severe injuries. Vehicular roads that lack such roadside protections as commonly found in developing countries exposes pedestrians to greater impact of collision with vehicles thereby increasing their tendency of sustaining severe injuries.

2.6 Risk Factors Influencing Post-Accident Injury Outcome of Pedestrians

Studies worldwide have shown that death was potentially preventable in a large proportion of those who died as a result of road crashes before they reached hospital. Again, many studies have clearly indicated that the probability of dying increased as the socioeconomic level of the victim decreased. Morbidity outcomes are also influenced by factors related to post-impact care. In the case of major injuries, the potential help towards recovery that survivors can receive can be viewed as a chain with several links:

- actions, or self-help, at the scene of the crash, by the victims themselves, or more frequently by bystanders;
- access to the emergency medical system;
- help provided by rescuers of the emergency services;
- delivery of medical care before arrival at the hospital;
- hospital trauma care;
- rehabilitative psychosocial care.

2.6.1 Pre-Hospital Factors

Weak public health infrastructure in many low-income and middle-income countries is a major risk factor. In high-income countries, the pre-hospital risk factors are not so pronounced, but where they exist, are associated with the need to improve the existing elements of post-impact care. Evacuation and transport to hospital is more often carried out by bystanders, relatives, commercial vehicles or the police.

2.6.2 Hospital Care Factors

Hospital care in Madinah like most cities in developing countries is sub-standard in many ways compare to the standard offered in develop countries. Hence, the injuries of pedestrians can be aggravated due to lack of the necessary specialist treatments in the country.

2.6.3 Lack of Trained Expertise in Trauma Care

Trauma treatment in cities of high-income countries is usually seen as a chain of care performed by well-trained practitioners, even if many of its elements have room for improvement. In cities of low-income countries (e.g. Madinah), the post-impact chain of care is often delivered by personnel lacking formal training.

2.7 Summary

Pedestrian casualty contributes more than a third of all traffic-related deaths and injuries worldwide. This high casualty rate is an indication that pedestrians are among the most vulnerable road users. The risk factors exposing pedestrians to road accident in Madinah have been identified to include: increased motorization; demographic factors (e.g. age, gender or socio-economic status); lack of pedestrian facilities; land use; increased need for travel. The causes of pedestrian/ motor vehicle collisions in Madinah have been categorized into – human, environmental and vehicular factors. While excessive vehicular speed, age and gender of pedestrians and inadequate roadside protection are among the factors that affect the severity of pedestrian casualty in Madinah. Furthermore, sub-standard medical care and lack of trained medical personnels are some of the factors that aggravate the severity of post-crash injuries of pedestrians in Madinah.

Chapter Three:

Pedestrians Exposure to Road Accidents

"Accidents, and particularly street and highway accidents, do not happen - they are caused" – **Ernest Greenwood**

Chapter Three: Pedestrians Exposure to Road Accidents

3.1 Introduction

Traffic safety research usually involves the concepts of accident, exposure and risk due to their inter-relationship and their relevance in establishing effective road safety countermeasures (Lam et al., 2014; Hakkert and Braimaister, 2002). Hence, the exclusion of any of these concepts (i.e. exposure, risk and accident casualty) in a traffic safety research would be a serious limitation. In other words, these concepts need to be thoroughly dealt with for this research to be robust and complete (Lam et al., 2014; Hakkert and Braimaister, 2002; Keall, 1995). While the concept of accident, usually expressed in terms of its rate or number of casualty (e.g. pilgrim pedestrian casualty), forms the principal focus of this research; the risk factors affecting pedestrian casualty has been discussed in previous chapters. Therefore, it would be appropriate to dedicate this chapter to the theoretical possibilities of defining exposure; pedestrian exposure to road accidents; discusses the problems associated with the use of pedestrian exposure; how it affects accident rates, its limitations and many more issues related to pedestrian exposure to risks of accidents that could lead to pedestrian casualty.

3.2 The Concepts of Accident, Exposure and Risk

Although the definition of a 'road accident' is generally well-understood in road safety research, but the concepts of 'exposure' and risk are much less well-defined (Van den Bossche et al., 2005; Hakkert and Braimaister, 2002). In general, the ambiguity associated with these concepts could be clarified by the theoretical or mathematical relationship between them as expressed below:

$$\text{Accident Rate (Number of accidents)} = \text{Exposure} \times \text{Risk} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.1$$

From the above equation, the *'Exposure'* refers to the magnitude of the activity that could results in accidents. It is a measure of the opportunity for accidents to occur; and the *'Risk'* measures the probability of an accident happening at a given level of exposure (Lassarre et al., 2007; Van den Bossche et al., 2005; Hakkert and Braimaister, 2002; Qin and Ivan, 2001; Bly et al., 1999). The above definitions are general and broad, but as usually required in road safety practice, these terms have to be defined within the context of the issue studied (i.e. pedestrians). Hence, 'pedestrian exposure' can be referred to "the rate of contact that a pedestrian has with vehicular traffic" (Qin and Ivan, 2001); while 'risk' of accident for pedestrian is a measure of the probability of an accident happening to a pedestrian (Qin and Ivan, 2001). In fact, a more traditional and comprehensive definition in the road safety field considers the risk of accident for pedestrian as a rate of accident involvement per unit of time spent on the road network (Lassarre et al., 2007). In principle, pedestrians are exposed to risk of a crash whenever they are walking in the vicinity of vehicular traffic (Lam et al., 2014). Therefore, a change in one of these dimensions will definitely change the entire safety situation as expressed in *Equation 3.1*.

Naturally, the degree of risk faced by road users such as pedestrians will vary depending on the degree of exposure presented by the different types of built environment (e.g. road type or junction detail) and land use (Qin and Ivan, 2001; Bly et al., 1999). Hence, it is obvious that the more exposure to traffic, the greater is the risk of being involved in a road accident (Elias and Shiftan, 2014; Milligan et al., 2013; Qin and Ivan, 2001; Keall, 1999). The risk of pedestrians being hit by vehicles will be greater in some road environments than others. For example, pedestrians walking on a footpath that is very close to heavy or fast traffic will be more susceptible to road accidents (Bly et al., 1999).

Exposure is key information that may also account for the differences in accident rates of the various countries in the world. The differences in the level of exposure of road users (e.g. pedestrians) in the various countries may reflect differences in socio-cultural make-up of the society which may not readily be influenced by the country's safety policy (Bly et al., 1999). For example, the Islamic tradition that stipulates that Moslem men go to the mosque to offer their prayers five times daily will lead to more exposure of men to road accidents in Islamic country like Saudi Arabia compared to a non-Islamic country. Even within the same country, the level of exposure of a segment of the population may vary among the cities. This is exemplified by the greater exposure of pilgrims' pedestrians to road accidents in cities within the Hajj region. This greater exposure of pilgrims' pedestrians to road accidents arises from the increased pedestrian activity within these cities. Hence, it is important that information on the exposure of road users such as pedestrians are obtained to assists in formulating policies that would curb road accidents. Besides differences in exposure, the risk of pedestrian casualty may be higher in one country than another, even in a similar road environment. In such a case, it is important to critically examine the design of the road environment, the behaviour of both pedestrians and drivers and the safety policies of various countries to enable effective comparable measure of risk in the different countries that will help curb pedestrian casualty (Lassarre et al., 2007; Qin and Ivan, 2001; Bly et al., 1999).

3.5 Factors Influencing Pedestrian Exposure to Risk

3.5.1 Economic Factors

Economic development of a country influences pedestrian exposure to risk. For example, people in poor developing countries are more likely to indulge in pedestrian activities, thereby, have increased exposure to risk of road accidents compared to their counterparts from developed countries that are less likely to walk. Similarly, the social deprivation of individuals exposes them to greater risks of road accidents (see for example Graham et al., 2005).

3.5.2 Demographic Factors

Demographic factors such as the age and sex of pedestrian influences their exposure to risk of road accidents. For instance, children and the elderly are more prone to certain risk of road accidents compared to other age categories. In terms of gender, males take more risk than females because of certain behaviour associated with the gender. Other demographic factors that may influence exposure to risk of pedestrian accidents include educational background, ethnicity or cultural background, see for example Haegi et al., 1995).

3.5.3 Land Use Planning Practices

Land uses are trip generators and influences the length of trip and mode of travel. The various land use types attract pedestrians differently. Hence, they have different degree of pedestrian exposure to risk of road accidents. For example, commercial land use type has been shown to attract more pedestrians exposing them to greater risk (WHO, 2013; Dissanayake et al., 2009; Wedagama et al, 2006; 2007 and 2008; Kim and Yamashita, 2002).

3.5.4 Population Density

Highly populated environment exposes pedestrians to greater risk of road accidents. This is especially so when there is a mixture of high-speed motorized traffic with vulnerable road users such as pedestrians. There are several cities like Delhi, India, with high density of pedestrians that often mixed with vehicles thereby exposing these pedestrian to greater risk of road accidents (WHO, 2013). Over-crowded situation such as mass gathering events may also increase the pedestrian exposure to road accidents (Rosselló and Saenz-de-Miera, 2011).

3.5.5 Lack of Infrastructural Development

Lack of infrastructural development, particularly, in developing countries increases the exposure of pedestrians to the risk of road accidents. For example, the insufficient attention to integration of road functions with decisions about speed limits, road layout and design (WHO, 2013; Peden et al, 2004). In most developing countries, the absence of pedestrian lanes, over-head crossing bridges, signalized traffic crossing exposes pedestrians to greater risks to accidents.

3.4 Pedestrian Exposure Measures

Pedestrian exposure can be a useful explanatory variable for modelling crashes and establishing effective road safety countermeasure; but obtaining this information could be difficult and expensive (Lam et al., 2014; Milligan et al., 2013; Lassarre et al., 2007; Van den Bossche et al., 2005; Hakkert and Braimaister, 2002; Wolfe, 1982). Pedestrian exposure measures are difficult to accomplish because the choices of pedestrian routes are more manoeuvrable and complex than those taken by vehicles based on their surrounding environment. Unlike vehicles which are confined to specified lanes and sometimes direction, pedestrians are not restricted to use a particular pathway or lanes; they can pause and abruptly change their direction making it a daunting task to gather useful information on their trip (Lam et al., 2014). Nevertheless, pedestrian exposure measures are generally expressed in a form related to the distance travelled in the vicinity of vehicular traffic (Lam et al., 2014; Keall, 1995). It involves the collection of pedestrian exposure data which is usually achieved through two basic methods (Wolfe, 1982).

3.4.1 Exposure Measure While The Trip Progresses

This involves the gathering of pedestrian exposure data while the trips are in progress. It is usually done using mechanical traffic counters, human observations and the use of automatic cameras. In this case, the number of roads or intersections crossed by pedestrians could be monitored using cameras. Again, pedestrians could be monitored from their homes to destination and then back home using cameras. A major drawback of this approach may include lack of vital information such as the purpose of the trip; it is very expensive approach due to the use of advanced technological devices such as cameras; it is also a very restrictive method Keall (1995).

3.4.2 Exposure Measure After The Trip

This approach of pedestrian exposure measures are accomplished after the trips are completed by using in-person interviews, telephone interview and any other forms of questionnaires. This is usually done in the form of travel surveys which will contain information relevant to pedestrian exposure to risk of road accident (Lam et al., 2014; Van den Bossche et al., 2005; Keall, 1995):

(i) Number of trips.
(ii) Time spent walking on public streets.
(iii) Number of roads crossed.
(iv) Number of unsignalised (zebra) pedestrian crossings crossed.
(v) Number of intersections crossed.
(vi) Duration of the trip.
(vii) Time of year of trip.
(viii) Purpose of trip.

In transport studies, the most widely used pedestrian exposure measure are distance travelled and the number of intersection crossed, but the accuracy of using these variables have been questioned since they have limited power in explaining the risk of pedestrian exposure to road accident (Thouez et al., 2005; Janke, 1991). These variables do not account for trip attributes such as the speed at which pedestrians travels which might influence the risk (Chliaoutakis et al., 2005; Van den Bossche et al., 2005). Yet the speed at which the pedestrians travel is rarely incorporated in most pedestrian exposure measures because of the complications that may be introduced. Nevertheless, the main disadvantages of after trip approach may include exaggeration of answers to questions on the questionnaires or during interviews. For instance, the respondents may not accurately recall all of their trips with and without the use of a trip log form. Similarly, they may not accurately estimate the distances travelled on particular trips without recording the actual odometer readings. Hence, the reliability of the feedbacks given after the trip has been completed can be questioned. This has necessitated the need for frequent combining of both methods to produce a more comprehensive and reliable pedestrian exposure data.

3.4.3 Other Classification of Exposure Measures

Pedestrian exposure measures could also be categorized into two levels – aggregated and disaggregated (Lam et al., 2014). These approaches are concisely discussed below:

3.4.3.1 Aggregated Exposure Measure

This approach involves measuring pedestrian exposure on a holistic perspective without differentiating pedestrians by their individual factors like age and gender (Lam et al., 2014). At the aggregate level, place-based and trip-based measures have been widely used to estimate pedestrian exposure to road accident (Wundersitz and Hutchinson, 2008; Greene-Roesel et al., 2007). A typical example of place-based method is the estimation of the pedestrian exposure of population living within a given predefined areal units like census blocks (Weir et al., 2009; Chakravrthy et al., 2010). While aggregated trip-based measures considers discrete distance travelled and duration of the trip. In this case, one trip type is examined at a time and trip chaining effects are avoided (Lam et al., 2014). This is exemplified by the measuring of pedestrian volume which is usually accomplished by counting of the number of pedestrians passing through designated measurement point (e.g. intersection crossings) over a period of time. In this case, the personal attributes (e.g. age and gender) of the pedestrians are disregarded and focus was placed on the pedestrian volume which was considered as a unit. Nevertheless, aggregated methods have the advantage of efficiently making use of readily available data sources; but could also lead to erroneous conclusions by obscuring the variability of pedestrian activities within the area considered (Lam et al., 2014).

3.4.3.2 Disaggregated Exposure Measure

This approach involves estimating pedestrian exposure by finding the number and routes of the vulnerable population and the possible environment through which the exposed population transverse (Lam et al., 2014). In this case, personal characteristics or category of a segment of the population is considered as exemplifies by the estimation of child pedestrian exposure to road accident. Although, time geography (using devices such as Geographical Information System) is seldom applied in pedestrian safety analysis; but present a potential tool for unravelling the exposure of people to traffic risk on a road network. It has been successfully applied in studying exposure to environmental conditions in health research (Kestens et al., 2010; Rainham et al., 2010); environmental pollution (Gulliver and Briggs, 2005) and examining individual accessibility in transport studies (Loo and Lam, 2011). Similarly, time geography can be extended to the study of disaggregated pedestrian exposure. For example, the *space-time path* (STP) could be applied to trace the walking path of a pedestrian within the constraint of a given time. In this case, the walking speed of the pedestrian is taken into consideration, thereby, producing a more reliable pedestrian exposure data compared to the use of ordinary street camera. But this innovative approach may be very expensive and required advanced specialized skills.

3.5 Limitations of Pedestrian Exposure Measures

There are several limitations or problems associated with pedestrian exposure measures which need to be tackled to improve the quality of the exposure data collected. Some of these limitations are highlighted below:

(i) There is no widely accepted and adopted metric system used to measure pedestrian exposure.

(ii) There is no universally accepted pedestrian exposure method since there is considerable disagreement on what pedestrian exposure measures are most appropriate to be collected and how they should be applied in solving particular road safety research problems. This makes comparison of pedestrian exposure data difficult among researchers. In fact, the absence of detailed and reliable exposure data is one of the reasons that in many cases international comparisons are conducted on a per capita or per vehicle basis.

(iii) Limited financial budget in many countries impedes the acquisition of high quality and reliable pedestrian exposure data. Consequently, various accident rates are based on total population, or numbers of registered vehicles, or numbers of licensed drivers which are not surrogates for exposure data.

3.6 Overcoming the Challenges of Pedestrian Exposure Measures

Since the acquisition of high quality and reliable pedestrian exposure data is necessary to effectively assess the risk of pedestrian involvement in road accidents, concerted effort has to be made by the government of the various countries, traffic safety associations, researchers and other stakeholders to overcome the challenges of pedestrian exposure measures. The following actions are worthy of consideration:

i.) There should be collaboration and co-operation from all stakeholders concerned with road traffic safety to work towards adopting a universally accepted metric system that could be used to measure pedestrian exposure. This will make comparison of pedestrian exposure data obtained from different countries easier.

ii.) Understandably, it is a daunting task to develop universally accepted pedestrian exposure methods that will possibly eliminate any disagreement on what pedestrian exposure measures are most appropriate to be collected and how they should be applied in solving particular road safety research problems. Nevertheless, this goal is worth pursuing to enable not only the acquisition of reliable exposure data but also the comparison of accident rates that are based on pedestrian exposure data internationally.

iii.) Governments, traffic safety organizations and other stakeholders should endeavour to provide more funds and support for researches that would improve the understanding of pedestrian exposure measures should be encouraged.

iv.) Traffic safety regulators (both locally and internationally) should endeavour to set standards and regulate the acquisition of pedestrian exposure data.

3.7 Pedestrian Exposure in Madinah

The Holy City of Madinah is usually a host to an unprecedented number of pilgrims from all over the world every year. These pilgrims may go through prescribed procedure which may require them to travel on foot to various locations such as the mosques, shrines and other historic religious sites to perform specific activities. Consequently, the pilgrims' pedestrian volume increases in Madinah during certain period of the year (i.e. month) or day of the week or time of the day since Islamic festivals (e.g. the Hajj) is influence to a considerable extent on place-time factors (Al-Rakeiba, 1991). For example, certain religious activities (e.g. prayers) may be confined to a specific place (e.g. mosques) and schedule; while others may be dependent on a specific place, with flexibility regarding the time element. While a considerable number of the pilgrims' pedestrians use the designated walkways; many can be seen walking along the vehicular roads making them more prone to severe pedestrian-vehicle conflict. This was partly due to the absence of sidewalks on many of the vehicular roads and no convenient cross-walk paths to connect with the main walk areas. This situation compels the pilgrims' pedestrians to use the vehicular roads to get from one place to another within the city of Madinah. Again, many pilgrims' pedestrians are found crossing vehicular roads going to or returning from the mosques and other historic religious sites. The road capacity is also reduced by the presence of vendors who use the pavements for some kind of business transactions (Al-Rakeiba, 1991). In most cases, the pilgrims' pedestrians (particularly, non-Saudis) may not be familiar with the pedestrian roads. Hence, they may resort to short paths in order to keep their walking distance to a minimum. These attitudes of pilgrims' pedestrians violating the road safety rules and regulation exposes them to vehicle-pedestrian conflicts which occur frequently at many places in Madinah, thereby impeding traffic flow.

The seasonal increase of pilgrims' pedestrian volume in Madinah definitely results in increased pilgrims' pedestrian exposure to the risk of road accidents. Although high quality and reliable pedestrian exposure data is a prerequisite for the effective assessment of the relationship between the pilgrims' pedestrian casualty and the land use type in Madinah; but this pedestrian exposure data is lacking due to several factors (e.g. high cost of its acquisition etc.) which has already been highlighted above. In other words, the Madinah Province Police which is the custodian of accident data does not have any record showing the distance travelled or the number of intersections crossed by pilgrims' pedestrians in Madinah. Neither does the record give indication of the duration or purpose of the trip. However, the Police record show the time of the year of trip (which was presented as the year, month, day and time of accident). The unavailability of pedestrian exposure data has prompted the need for an alternative means of restructuring the pilgrims' pedestrian casualty data to reflect some elements of exposure (i.e. time of the year of trip). Consequently, the accident data was restructured or categorized based on the influence of the 'time-factor' on the exposure of these pilgrims' pedestrians to the risk of accidents. This was necessary as the religious and tourist activities of these pilgrims are considerably seasonal, thereby, strongly influence by the period of the year (i.e. month) or day of the week or time of the day as was dictated by Islamic calendar and instructions. Hence, the data was categorized into six categories namely: (i) Prayer Time (ii) Non-Prayer Time (iii) High Season (iv) Low Season (v) Islamic Weekdays and (vi) Islamic Weekends. Details of these categories are presented in the chapter that deals with Methodology. Nevertheless, the restructuring or categorizing of the pilgrims' pedestrian casualty data in this manner will help compensate for the absence of high quality pedestrian exposure data in Madinah.

3.7 Summary

In road safety practice, the concepts of accident, exposure and risk are usually discussed due to their inter-relationship and their relevance in establishing effective road safety countermeasures. These concepts should be considered in a traffic safety research in order to avoid serious limitation. The definition of 'accident' is well established, but ambiguity is still associated with the definitions of exposure and risk as applied to road traffic studies. Hence, terms 'exposure' and 'risk' should be defined within the context of the issue studied. In this research, exposure was approached within the context of the pedestrian. Exposure has been shown to be key information that may account for the differences in accident rates of the various countries in the world. The differences in the level of exposure of a country reflects its unique in socio-cultural make-up of that society. In addition, several factors that influence pedestrian exposure to the risk of road accidents were discussed. They include economic, demographic, land use planning practices, population density and lack of infrastructural development. The different approaches of pedestrian exposure measures were also highlighted – (i) measuring of exposure while the trip is in progress and (i) after the trip has been completed. Furthermore, pedestrian exposure measures could also be categorized into two levels – aggregated and disaggregated. The absence of widely accepted and adopted metric system; no universally accepted pedestrian exposure method and sparse research funding have been identified to be constraints to pedestrian exposure measures. Remedies of overcoming these challenges were suggested. They included effort towards adopting widely accepted metric system and pedestrian exposure method that would enable international comparison of pedestrian accident rates among the various countries. Also, governments, traffic safety organizations and other stakeholders were encouraged to provide more funding on researches concerning pedestrian exposure. Finally, the pedestrian exposure to road accidents in Madinah was discussed. The Madinah Police records lack high quality and reliable pedestrian exposure data which are indispensable for effective assessment of the relationship between the pilgrims' pedestrian casualty and land use type in Madinah. However, the Police record show the time of the year of trip which was used to restructure or categorize the pilgrims' pedestrian casualty data into six categories (Prayer Time; Non-Prayer Time; High Season; Low Season; Islamic Weekdays and Islamic Weekends) to reflect some elements of exposure and compensate the deficiency presented in the Police record.

It is important to emphasize that this Chapter focused more on aspects of pedestrian exposure; but refrained from considering exposure on a broader context. Only issues that are relevant to this research were carefully included. For example, topics such as factors influencing pedestrian exposure and overcoming the limitations of exposure measures were considered. Some other aspects such as increasing number of registered vehicles were not considered.

Chapter Four: Review of Pedestrian Accident Studies

“You have got to connect your land use decisions with transportation decisions” –
Tim Kaine

Chapter Four: Review of Pedestrian Accident Studies

4.1 Introduction

In the past decades, safety researchers have focused primarily on vehicle occupants when investigating road traffic accidents (Eluru et al., 2008). However, the growing pedestrian fatalities in most countries have led to increased attention given to traffic accidents involving non-motorists. Researchers have extensively investigated different aspects of non-motorized mode-related accident rates and severity of casualties to enable safety engineers and transport planners to improve the safety of non-motorized users (Eluru et al., 2008). Consequently, there is a vast literature highlighting the factors affecting the occurrence of pedestrian/ motor vehicle collisions and the level of casualties. This Chapter review previous studies of road accidents with emphasis on pedestrian casualty and other related subjects (e.g. land use) that could shed more light on this study.

4.2 Review of Road Accident Studies

The relationship between land use type and pedestrian casualties have been investigated (Aziz et al., 2013; Ukkusuri et al., 2012; Dissanayake et al., 2009; Loukaitou-Sideris et al., 2007; Wedagama and Bird, 2007; Wedagama et al., 2006; Kim et al., 2006; Geyer et al., 2005). Different conclusions were reached by these researchers concerning the impact of land use on pedestrian casualties. For example, commercial land use has been shown to increase the probability of pedestrian fatality (Aziz et al., 2013). Similarly, pedestrian casualties have also been found to be associated with an increase in retail and community land use during working hours (Wegadama et al., 2006; 2008; Aryaija et al., 2009). Ukkusuri et al. (2012) investigated the influence of land use, road design and the level of spatial aggregation on the frequency of pedestrian accidents. They found that industrial, commercial and open land use types have greater tendency of pedestrian/ motor vehicle collisions. While residential land use type have significantly lower likelihood of pedestrian/ motor vehicle collisions. Their results also indicated that the probability of pedestrian-vehicle collision increases with the number of lanes and road width (Ukkusuri et al., 2012). Other researchers have emphasized the difficulty in studying the relationships between motor crashes and land use (Kim and Yamashita, 2002). According to them, the pattern of motor crashes and the underlying use of land are difficult to describe as detailed information on land use is typically excluded in accident data reported by the police (Kim and Yamashita, 2002).

Al-Ghamdi (2002) investigated pedestrian-vehicle crashes in Riyadh from 1997 to 1999 to establish the relationship between the severity of pedestrian casualties and the vehicle type. The impact of motorized vehicle attributes, roadway characteristics and environmental factors on the severity of pedestrian casualties were considered. Al-Ghamdi (2002) found that the relationship between the severity of pedestrian casualties and the vehicle type was statistically insignificant and the probabilities of sustaining a severe injury are higher for crashes occurring on two-way roadways with a median. Again, the likelihood of pedestrians being killed at night was found to be 1.81 times higher than for day time. Sze and Wong (2007) also investigated pedestrian injury severity in traffic crashes using accident data from Hong Kong Transport Department from 1991 to 2004. They used logistic regression model to establish the impact of several factors (e.g. non-motorist, roadway, environmental and other crash frequency characteristics) on pedestrian casualties in Hong Kong. Their results indicated that younger male pedestrians aged less than 15 years were susceptible to lower risk of fatality. In contrast, older pedestrians above 65 years are more likely to suffer fatality from crashes. They also found that crashes involving vehicles travelling at speed limit above 50 km/h increased the tendency of fatality and that crashes that occurred at intersections with traffic signals were more severe than intersection with other traffic signs. In addition, they found that Multi-dual carriageway roads are more prone to crashes than one-way roadways and the probabilities of fatality are higher for crashes that occur at night from 7.00 pm to 7.00 am. Sze and Wong (2007) also concluded that the severity of casualties was much higher for pedestrians crossing the roads and the inattentiveness of pedestrians to road signs and other road safety regulations increases the tendency of sustaining a fatality.

A comprehensive analysis of vehicle-pedestrian/ motor vehicle collisions at intersections in Florida has been undertaken by Lee and Abdel-Aty (2005). The accident data used for this study was obtained from the Florida traffic crash record database from 1999 to 2002 and their findings were similar to those obtained by Sze and Wong (2007). For example, Lee and Abdel-Aty (2005) also found that pedestrians older than 65 years are more prone to severe injuries than their younger counterpart and the higher the vehicle speed the higher the tendency of sustaining severe injuries. Other results obtained by Lee and Abdel-Aty (2005) revealed that non-sedan (van, truck and bus) crashes resulted in more severe casualties and that severe pedestrian-vehicle crashes are likely to occur in rural areas caused by bad road network. They also found that the consumption of alcohol by pedestrians increases the severity propensity and crashes that occur at a crossing with a traffic control device are disposed to lower severity of casualty. Furthermore, environmental factors such as dark lighting and adverse weather conditions increase the tendency of pedestrians sustaining severe injuries (Lee and Abdel-Aty, 2005). Similar conclusions to those by Sze and Wong (2007) and Lee and Abdel-Aty (2005) were also reached by Zajac and Ivan (2003) after studying the factors that influences injury severity of motor vehicle crossing pedestrian/ motor vehicle collisions in rural Connecticut using accident data from 1989 to 1998 supplied by the Transportation Department.

According to Zajac and Ivan (2003), pedestrians older than 65 years are also susceptible to severe injuries and the consumption of alcohol by both vehicle drivers and pedestrians increases the severity of injuries. The effect of alcohol consumption on outcome of pedestrian victims have also been investigated and the results show that pedestrians intoxicated are subject to higher Injury Severity Score (ISS) and that the proportion of alcohol related pedestrian casualties were higher among the youth age group ranging from 25 to 35 years (Jehle and Cottington, 1988). Atkins et al. (1988) investigated the severity of pedestrian injuries in Oxford (from 1983 to 1984). They found that the peak injuries to pedestrians lie within the age range of 16 to 65 years and occurs at night during the period of 11.00 pm and 12.00 am. The influence of age, sex and blood alcohol concentration on the severity of pedestrian casualties has been studied by

Holubowyez (1995). He considered accident data from Adelaide, Australia (from 1981 to 1992) and found that fatality rates were highest among the elderly pedestrians aged 75 or more and that a large proportion of the pedestrian casualties were males. Again, the blood alcohol concentrations were high among the fatally injured young and middle-aged male pedestrians (Holubowyez, 1995). Contrary to most studies (Sze and Wong, 2007; Lee and Abdel-Aty, 2005; Holubowyez, 1995; Jehle and Cottington, 1988), they found that consumption of alcohol by pedestrians did no influence the severity of injuries sustained by intoxicated pedestrians. Furthermore, the severity of pedestrian injuries was found to increase with the vehicle weight (Atkins et al., 1988).

The adverse effect of excess speed of vehicles in relation to pedestrian safety in Denmark has been studies by Jensen (1999). In his study, accident data from 47 Danish cities obtained from Denmark police were considered and the results revealed that increased speed limit leads to higher proportion of pedestrian fatalities (Jensen, 1999). Similarly, Lefler and Gabler (2003) found that higher speed limits of vehicles are associated with severe injuries. In addition, they found that the probability of pedestrians sustaining a fatal injury is higher in collisions involving light truck vans (Lefler and Gabler, 2003). Also Roudsari et al. (2004) compared the severity of injuries sustained by pedestrians involving collision with light truck and passenger vehicles in some major cities in United States. Their findings indicate that adult mortality is higher than that of children in pedestrian-vehicle crashes. After eliminating the influence of pedestrian age and speed at impact, light truck vans were found to be associated with higher tendency of resulting to severe injuries compared to passenger vehicles. In addition, higher vehicle speeds have resulted in severe casualties of the victims (Roudsari et al., 2004). The influence of alcohol use among pedestrians and the odds of surviving an injury have been examined using accident data (1988 – 1990) Florida Department of Highway Safety (Miles-Doan, 1996). He found that an increase in age correspondingly increases the probability of sustaining severe injuries and alcohol consumption by pedestrians increases their chances of sustaining serious injury or fatality. Exceeding the speed limit of 40 mph and the accident location (e.g. rural area) also affects the severity of injury. Again, other environmental factors (e.g. during the dark period of the day) and crash characteristics (e.g. a vehicle colliding straight ahead with the pedestrian) result in severe injuries (Miles-Doan, 1996). The relationship between pedestrian injuries and vehicle type in

Maryland was undertaken by Ballesteros et al. (2003). Their results obtained from analyzing accident data (1995–1999) from Maryland Automated Accident Reporting System shows that the severity of injury sustained by pedestrians depends on the vehicle type. For instance, pedestrians hit by Smart Utility Vehicles (SUVs) and pick-ups were more likely to suffer fatal injuries compared to conventional passenger cars and vans (Ballesteros et al., 2003). The vehicle weight and its speed limit increased the probability of pedestrian sustaining injury when a van is involved. Furthermore, their findings show that increasing the speed limits of vehicles proportionally increases pedestrian mortality and the Injury Severity Score (ISS) of the accident victims (Ballesteros et al., 2003).

Several researchers have extensively investigated various aspects of pedestrian casualties, for instance, the relationship socio-economic, environmental and land use types on pedestrian casualties (Aziz et al., 2013; Ukkusuri et al., 2012; Dissanayake et al., 2009; Dissanayake et al., 2009; Loukaitou-Sideris et al., 2007; Wedagama et al., 2006; Kim et al., 2006; Geyer et al., 2005; Graham, Glaister and Anderson, 2005; Sideris and Liggett, 2005). For example, the relationships between casualty rates and social deprivation indicators for the casualties' zone of residence have also been investigated (Abdulla et al., 1997). In general, it was found that the casualty rates amongst residents from areas classified as relatively deprived were significantly higher than those from relatively affluent areas (Abdulla et al., 1997). While Jones et al. (2008) demonstrated that a geographical approach to road traffic accident analysis can be used to identify contextual associations that conventional studies of individual road sections would neglect.

Most road accident studies undertaken in Saudi Arabia focus on the occupants of the vehicle, giving little consideration to the most vulnerable category which is the pedestrian. For instance, Bener and Jadaan (1992) investigated an epidemiological aspect of fatalities from motor accidents in Jeddah by analyzing data obtained in 1987. The results show that the fatality rate was high and the cost of road traffic fatalities in Jeddah, Saudi Arabia was difficult to estimate due to lack of reliable accident data. However, the study shows that cost of 1987 road fatalities in Jeddah was estimated to be 648.7 million Saudi Riyals (Bener and Jadaan, 1992). The magnitude of road traffic accidents in Saudi Arabia has been assessed and the results compared to other rich developing countries with similar trend of development (Ofosu et al., 1988). They concluded that Saudi Arabia has lower accident rates but higher casuality and fatality rates than Kuwait. Similarly, Ansari et al. (2000) investigated the causes and effects of road traffic accidents in Saudi Arabia using accident data obtained from 1971 to 1997. Their findings indicated high fatality rate which is equivalent to 3.5% of the total population in Saudi Arabia. Excess speed and/or drivers' violation of traffic signals were identified to contribute over 60% of road traffic accidents in Saudi Arabia (Ansari et al. 2000).

Al-Ghamdi (2003) investigated traffic accidents that occurred at both intersections and non-intersection sites in Riyadh, with the aim of finding the characteristics associated with such accidents and recommend remedies to curb the occurrence of such accidents. This study found that improper driving behavior is the principal cause of accidents at signalized urban intersections in Riyadh; running a red light and failing to yield are the primary contributing causes. The study recommends that there is an urgent need to review existing intersection geometry along with the traffic control devices installed at these sites and improve public education campaigns and law enforcement strategies concerning road safety (Al-Ghamdi, 2003). Nevertheless, the relationship between pilgrim pedestrian casualties and land use has never been investigated to the best of our knowledge. Hence, this study will contribute to knowledge regarding the impact of land use on pilgrim pedestrian casualties in Madinah. The findings and recommendations of this research will positively contribute to current safety practice in Madinah by assisting the Hajj Ministry, local authorities, transport planners and other relevant bodies to improve pilgrim pedestrian safety in Madinah and could also be extended to other cities in Saudi Arabia that play host to mass gathering events.

4.3 Techniques Used in Road Accident Studies

There is considerable number of techniques used in the analysis of road traffic accidents (Oppe, 1992). The choice of the technique to be adopted depends on the purpose of the studies been undertaken and advantages the adopted technique has to offer. However, caution must be taken in the selection of the appropriate technique since casualties from road traffic accidents are always discrete events which result in non-negative values (Dissanayake et al., 2009). Some of the techniques that have been employed in analyzing data obtained from road traffic accident include Geographical Information System (GIS); Poisson and Negative Binomial regression; Generalized Linear Models (GLM); Zero-inflated Distributions and Multinomial Logit Model (MLM). This Section discusses some of the frequently used techniques in road accident studies.

4.3.1 Spatial Association

Whilst there are no studies to the best of our knowledge that have attempted to understand pilgrims' pedestrian casualties and land use, other studies have been undertaken to establish the relationship between pedestrian casualty and land use (Sideris et al., 2005; Wedagama, 2004; Petch et al., 2000; Joly et al., 1991). For example, Wedagama (2004) using data for the period 1998–2001 in the city of Newcastle found that pedestrian casualties were associated with certain land use types on weekdays and weekends. These included the following land use types: retail, offices, leisure and junction density. Wedagama (2004) also found that different land use types as trip attractors were associated with a temporal variation in cyclist and pedestrian casualties. The study was not concerned with disaggregating the pedestrians by age. Similarly, Wedagama et al. (2006) found that retail land use is associated with male and female casualties for adults of working age (16–64) in Newcastle Upon Tyne. These two studies were making direct associations between non-motorised casualties to land use types by using spatial modelling and count data regression methods.

Other studies have found that in terms of the spatial distribution of child casualties that some neighbourhoods were at a higher risk than others (Sideris et al., 2005). Using a combination of land use, socio-economic and pedestrian traffic variables, Sideris et al. (2005) determined that educational, vacant, medium and high density residential, road density, and commercial land use types, as well as population density could be used as variables to predict pedestrian casualty numbers. Joly et al. (1991) analyzed geographic and socio-ecologic to investigate the variations of child casualties in Montreal and found that zones with high incidence of pedestrian and cyclist casualties had numerous associated characteristics. Whereas Petch et al. (2000) found that the distribution of child pedestrian/cyclist casualties could not be simply explained by analysis at a district level. It was necessary to analyze at sub district level focusing the study on specific trip attractors, activities and patterns of conflict as there are complex interactions between the different factor groups (Petch et al., 2000). Spatial association of road accident data is usually carried using powerful techniques such as GIS.

4.3.1.1 GIS Techniques

GIS is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data. This technique is widely applied in the spatial analysis of road accident data. They function by combining the database management with digital maps and images. Tortosa (2000) described GIS as 'computer software and hardware systems that enable simulation and advanced analysis of geo-referenced data to manage information that enables decision making'. Foote et al. (2000) observe that the manipulation abilities of GIS primarily involve separation of information in layers and various combination models. A stack of map layers known as coverages can be obtained and by using GIS methods each map extracts a different level of information starting from the base map which contains the topographical identifiers to which all layer maps are then later referenced (Foote, 2000).

4.3.2 Multivariate Data Analysis

Multivariate data analysis refers to any statistical technique used to analyze data that comprises several variables. These techniques essentially models reality such as road accident data which involves more than a single variable. There are several multivariate techniques which include factor analysis, cluster analysis, multiple linear regression, time series etc. These techniques have been widely applied in researches due to their potential of establishing the relationship between the variables and unravel the latent attributes of the huge data set. A number of multivariate statistics are used in developing predictive accident models as explained below:

4.3.2.1 Accident Models

Casualties are considered discrete events which do not take negative values. In statistical theory this kind of data is normally analysed using a number of different methods including Poisson, negative binomial, and Bernoulli methods (www.statsoft.com). There are however other methods which researchers have been using recently in accident modelling, which include Zero Inflated Poisson and Zero inflated Negative Binomial methods (ZIP/ZINB) especially in cases when the data contains many zeroes (Lord et al., 2004, 2003; Lee and Mannering, 2002). The dependent and independent variables have to be defined before modelling can be done, and the latter is used to predict the former. A number of factors are often considered when selecting the type and number of variables to be used. If not done correctly, the model produced may appear to fit well but this may well result in other statistical problems and therefore this should be checked for in the early stages (www.uky.edu). The most well-known techniques in this field are: (i) Poisson and negative binomial regression; (ii) Generalized Linear Model (GLM); (iii) Zero-inflated Distributions; (iv) Multinomial Logit Model (MLM). Each of these techniques has its strength and weakness. Hence, researchers are always cautious when selecting the appropriate technique to be used in a road accident studies. In some cases, a combination of these techniques (e.g. GLM and MLM) is applied to generate robust models. Detailed presentation of these techniques is given below:

4.3.2.1.1 Poisson and Negative Binomial Regression

One of the most common techniques used for road accident studies is the Poisson regression (Wedagama, 2004; Mountain et al., 1996; Famoye et al., 2004; Sideris et al., 2005; Kweon, 2003). Poisson distribution has characteristics of being skewed, non-negative and the data is assumed to have a variance which increases with the mean. This is as opposed to traditional ordinary Least squares regression, which assumes a normal distribution of residuals, produces negative values and assumes that the variance is constant (Simon, 2006). It is important to note that the Poisson distribution assumption of an equal mean and equal variance of events can makes it unsuitable for real life situations where cases of under-dispersion and over-dispersion happen. These situations can occur when the variance observed is less than the mean and greater than the mean respectively (Simon, 2006). In such situations the negative binomial distribution can be used as a good approximation of the Poisson distribution, and one can assume that the variance is significantly larger than the mean if the case of over-dispersion happens (Shankar et al., 1997). The Poisson regression functions through the use of a log transformation to account for the skew and non-negativity of the data (Simon, 2006).

Assuming a dependent variable Y, which represents with a Poisson distribution is to be modelled with predictor variables X_1, X_2, ..., X_m, as follows; (www.uky.edu)

$$P\{Y = k\} = \frac{e^{-\mu}\mu^{k}}{k!} \text{ for k = 0, 1, 2, ...Equation 4.1}$$

For μ >0, and E(Y) = Var (Y) = μ

where the log of the mean μ is assumed to be a linear function of the independent variables. That is,

$$\log \mu = c + b_1 x_1 + b_2 x_2 + ...b_m x_m \text{ ……….. Equation 4.2}$$

Where c = intercept, which implies that μ is the exponential function of independent variables,

$$\mu = e(c + b_1 x_1 + b_2 x_2 + ...b_m x_m) \text{ ………. Equation 4.3}$$

When offsetting a variable is necessary, Poisson regression model can be written in the form;

$$\log \mu = \log(N) + c + b_1 x_1 + b_2 x_2 + ...b_m x_m \text{ …………… Equation 4.4}$$

where N is the total number of subjects at risk. This is done to offset a variable that is over represented in the data such as road length in this study. The logarithm of variable N is used as an offset, that is, a regression variable with a constant coefficient of 1 for each observation. The log of the incidence, log (μ / N), is then modelled as a linear function of independent variables. The maximum likelihood method is used to estimate the parameters of Poisson regression models.

The Negative Binomial distribution is used as a generalization of the Poisson distribution as it does not assume equal chance or randomness for all elements in a distribution e.g. the chance of casualties in one ward/distruct may be higher than in another ward (Simon, 2006). This is observed in cases of over-dispersion. When the variance is larger than the potential of the mean being bigger (over dispersion) or smaller (under dispersion) can indicate that the 'Poisson model does not adequately fit', (www.uky.edu). Miaou et al. (1992) used Poisson regression models to explore the effects of geometric features on truck crashes, and found the data to test positive for over dispersion (Kweon, 2003).

4.3.2.1.2 Generalized Linear Model (GLM)

A number of studies have used the GLM to model casualty data (Wedagama, 2004; Famoye et al., 2004; Mountain et al., 1996; Miaou and Lou, 1993). For instance, Mountain et al. (1996) used the Generalised Linear Model to develop regression estimates of expected casualties for six highway categories. Miaou and Lou (1993) also investigated the effects of geometric features on truck crashes in Utah using Ordinary least squares regression models and Poisson count models and found the former to be severely lacking in adequacy with regards to the count nature of the data, (Miaou and Lou in Kweon, 2003).

"*The Generalised linear model can be used for analyzing linear and non-linear effects of continuous and categorical predictor variables on a discrete or continuous dependent variable*" (www.Statsoft.com).

Therefore the distribution of the response variable can be (explicitly) non-normal, and does not have to be continuous, that is, it can be binomial, multinomial, or ordinal multinomial (i.e., contain information regarding ranks only); a link function can then be used to link the predictors and the response variables(www.statsoft.com).

Assuming a dependent variable Y is linearly associated with values on the *X* variables by

$$Y = b_0 + b_1X_1 + b_2X_2 + ... + b_kX_k) + e$$

where *e* – error term of the GLM takes the form

$$Y = g\ (b_0 + b_1X_1 + b_2X_2 + ... + b_kX_k + e$$

where *g(…)* is a link function such as Poisson distributions, Normal, Gamma, Inverse Normal, Binomial, multinormial etc. The inverse function of *g(…)*, say *f(…)*, is called the link function; so that:

$$f(mu_y) = b_0 + b_1X_1 + b_2X_2 + ... + b_kX_k$$

where mu_y stands for the expected value of *y* (www.statsoft.com).

In order to estimate the GLM, the values of the parameters (b_0 through b_k and the scale parameter) in the generalized linear model are obtained by maximum likelihood (ML) estimation, which involves iteration of the log likelihood (www.statsoft.com). Multiple regression models have been found to be incapable of providing adequate estimates regarding accident data (Sideris et al. 2005) thus the Generalized Linear Model is possibly more appropriate in such a case to normalize the non-linear data.

4.3.2.1.3 Zero-Inflated Distributions

Zero Inflated Poisson (ZIP) and Zero Inflated Negative Binomial (ZINB) models can be used to model discrete data that has many zero counts or show duality in state. For example Shaktar et al. (1997) used Negative Binomial models for crash counts, and compared the applicability of ZIP and ZINB models for a sample of the same data set. Their study found that the zero-inflated models performed better, in a statistically significant way, than the non-inflated models. Accident data may perhaps show some areas that have no casualties recorded (zeroes), this can result in the Poisson regression underestimating the probability of zeroes, so for a study such as this it would be difficult to adequately identify predictor variables associated with areas where no pilgrim casualties occur. ZIP models allows for "excess zeroes" assuming the population has a dual state and thus uses both log specification and Poisson specification to model the data (Sorensen, 1998).

The ZIP distribution is has probability density function $f(x; \theta 0, \lambda)$ given by

$$f(x; \theta 0, \lambda) = \{\theta_0 + (1 - \theta_0)\exp(-\lambda), \text{ if } x = 0;\ (1 - \theta_0)\exp(-\lambda)\lambda^x/x!, \text{ if} x > 0\}$$

The usual Poisson corresponds to $\theta_0 = 0$. The zero-inflated Poisson corresponds to $0<\theta_0\leq 1$. (Thas, 2005). The ZINB distribution can be described as follows:

$$\Pr(Y = y)\ \{\ p + (1 - p)(1 + \lambda/\tau)^{-\Gamma},\ \ y = 0;\ (1 - p)\ (\Gamma(y+\tau))/(y!\Gamma(\tau))\ (1 + \lambda/\tau)^{-y},\ \ y = 1, 2,\ldots\}$$

The mean and variance of the ZINB distribution are

$E(Y) = (1 - p)\lambda$ and $var(Y) = (1-p)\lambda(1+p\lambda + \lambda/\tau)$, respectively (Sorensen, 1998)

4.3.2.1.4 Multinomial Logistic Regression

The multinomial logistic regression model is a simple extension of the binomial logistic regression model. It is used when the dependent variable has more than two nominal (unordered) categories. It analyzes the relationships between a non-metric dependent variable and metric or dichotomous independent variables. It compares multiple groups through a combination of binary logistic regressions.

Dummy coding of independent variables is quite common. In multinomial logistic regression, the dependent variable is dummy coded into multiple 1/0 variables. There is a variable for all categories but one, so if there are M categories, there will be M-1 dummy variables. All but one category has its own dummy variable. Each category's dummy variable has a value of 1 for its category and a 0 for all others. One category, the reference category, does not need its own dummy variable, as it is uniquely identified by all the other variables being 0.

The multinomial logistic regression then estimates a separate binary logistic regression model for each of those dummy variables. The result is M-1 binary logistic regression models. Each one tells the effect of the predictors on the probability of success in that category, in comparison to the reference category. Each model has its own intercept and regression coefficients—the predictors can affect each category differently. In some cases, it is assumed that the qualitative response variable carries only two values, generically, 1 and 0. However, the response variable can be extended to situations where the response variable assumes more than the afore-mentioned two variables. The variables might be related to land use and similar other factors that affect the results.

4.4 Summary

Detailed review of previous studies on pedestrian casualties in relationship with land use was undertaken. The different conclusions reached by the various researchers regarding the impact of land use type on pedestrian casualty were highlighted. It is worth noting that there were diverse opinions regarding the impact of land use on pedestrian casualty. While some researchers concluded that industrial, commercial and open land use types have greater tendency of pedestrian/ motor vehicle collisions . Whereas other researchers have emphasized the difficulty in studying the relationships between motor crashes and land use (Kim and Yamashita, 2002). According to them, the pattern of motor crashes and the underlying use of land are difficult to describe as detailed information on land use is typically excluded in accident data reported by the police (Kim and Yamashita, 2002). Many other studies on pedestrian casualty related to Saudi Arabia were also considered. Aziz et al., 2013 emphasizes that commercial land use increase the probability of pedestrian fatality. Al-Gamdhi (2004) established the relationship between pedestrian casualty and vehicle type in Saudi Arabia. Also considered in this Chapter was the various techniques used in road accident studies. The assumptions of these techniques were highlighted and their advantages and limitations were also discussed. This Chapter also emphasized the need for the selection of the appropriate statistical techniques for analysing accident data. Techniques such as Poisson, Negative binomial, Zero-inflated Poisson were discussed.

Chapter Five: Study Area – Madinah

"I have been ordered by God to a town that eats towns. They call it 'Yathrib', but it is Al-Madina……" – **Prophet Mohammned**

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5.6 Introduction

The study area of a research is the geographic region (or place) from which data are collected and analyzed in order to test certain hypotheses. Hence, it is imperative that reconnaissance visit to the study area is undertaken and relevant issues that could impact on the research noted. This would assist in developing a robust experimental design of the research and ensure hitch-free collection of data for detailed analyses. Again, thorough understanding of the study area would enable effective discussion of the results derived from the analyses in order to proffer useful recommendations that could contribute to society. In other words, it is important for researchers to be conversant with essential features of the study area in order to successfully complete any project. This chapter provides detailed description of the study area – Madinah. Relevant features of Madinah such as its geographical location, population, socio-economic, transportation (including its road network) and religious significance are concisely presented in the chapter.

5.7 Location of Madinah

Madinah (Al-Madinah Al-Monawarah; literally mean the illuminated city) is one of the largest cities in the Kingdom of Saudi Arabia. Madinah is located in the West of the Kingdom of Saudi Arabia on latitudes 24°–28 North and longitudes 39°–36' East (Neyazi, 2006). As shown in Figure 5.1, it is about 400 Km North of Mecca (Makkah Al-Mukarramah) and about 150 Km East of the Red Sea at about 600 m above the sea level (MOI, 2013; Neyazi, 2006; Al-Rakeiba, 1991). As a result of the geographical location of Madinah, it experiences longer daylight during summer (over 13 hours) and the temperature exceeds 45°C from May to August as the city is almost vertically exposed to the sun during this period (Al-Ahmadi, 2005). Unlike most cities in the world, the winter in Al Madinah is warm because the sunlight to the city is oblique and the day length is about 10 hours. However, the temperature sometimes drops to less than 5 °C due to the cold breeze blowing from middle Asia or from Eastern Europe (Al-Ahmadi, 2005). Al Madinah covers approximately 589 km^2 of land mass, of which roughly 50% is an urban area while the remaining part comprises of rural area and rough lands that includes deserts, valleys, mountains, farms and roads (MoI, 2013; Medina Municipality, 1995). The Province has been known for its high population precipitated by the frequent arrival of pilgrims and economic migrants. This has led to the rapid urbanization and development of infrastructures to cater for the growing population of the city. Furthermore, the strategic location, population and religious significance of the city boost its commercial activities. Madinah is also very popular due to its Islamic heritage and considered the second holiest city in Islam (Neyazi, 2006; Al-Rakeiba, 1991). Hence, the Province of Madinah is a popular destination for over a million Muslims that annually visit the holy city on pilgrimage.

Figure 5.1: Map of Saudi Arabia emphasizing on the strategic location of Madinah (Source: http://www.mapsofworld.com/saudi-arabia/)

5.8 Why is Madinah important and chosen for this study

Madinah is being regarded as the first Islamic capital dating from September 622 AD, when Prophet Mohammed built his Mosque there as the core of a new community making the city the peaceful sanctuary of Prophet Mohammed. Ten years later (June 632 AD) Prophet Mohammed died and was buried in his wife Aisha's 'Hujrah' (room) which later became an extension of the Mosque (Neyazi, 2006). Then Madinah became a major destination as a Holy place for visitors and pilgrims who perform Hajj, even when the capital was shifted to Al-kofa by the caliph Ali Bin Abu Talib in 656 AD (Neyazi, 2006). The religious significance of Madinah still remains valid till date due to its Holy Mosques such as the Mosque of Quba's and the Mosque of Qiblatain. Hence, the city of Madinah is one of the custodians of the Holy Mosques and other ancient religious sites. Again, Madinah is one of the cities that constitute the Hajj region (locally referred to as 'Hijaz Region'). The other major cities of the Hajj region include Jeddah and Makkah. The Hajj region also extends beyond these cities to include other smaller cities, towns and villages which are affected by the seasonal activities of the Hajj (Al-Rakeiba, 1991). Many Moslem pilgrims travel extensively within and around the Hajj region every year. For example, some pilgrims travel to Madinah first, then go to Makkah; while others go directly to Makkah, and then after the Hajj activity travel to Madinah (Al-Rakeiba, 1991). The religious significance of Madinah highlighted above makes it a destination for many Muslim pilgrims all over the world who travel to this great Islamic city for religious tourism. Thus, the substantial number of Muslim pilgrims that visits Madinah annually makes it a valid place to study the relationship between pilgrims' pedestrian casualty and land use type.

5.9 Population of Madinah

Madinah is the fourth largest city in Saudi Arabia, after Riyadh, Jeddah and Makkah (Geohive, 2013). Its population fluctuates periodically due to the influx of a huge number of Muslim pilgrims and their departure after a short stay in this city. Hence, it is a daunting task to ascertain the population of this city at any given time. Nevertheless, the population of Madinah like most cities in Saudi Arabia has steadily increased over the years as shown in Figure 5.2. Al-Ahmadi (2005) highlighted some of the factors that may have contributed to increasing population in Madinah includes: improved health care delivery resulting to a decline in death rate; the absence of natural disaster (e.g. wars and diseases) in the city over the decades; increasing economic migrants from other countries to Madinah; and increasing number of religious tourists that may eventually settle in the city. According to City Population (2013), the present population of Madinah is about 2 million and has been projected to continue to increase over the decades.

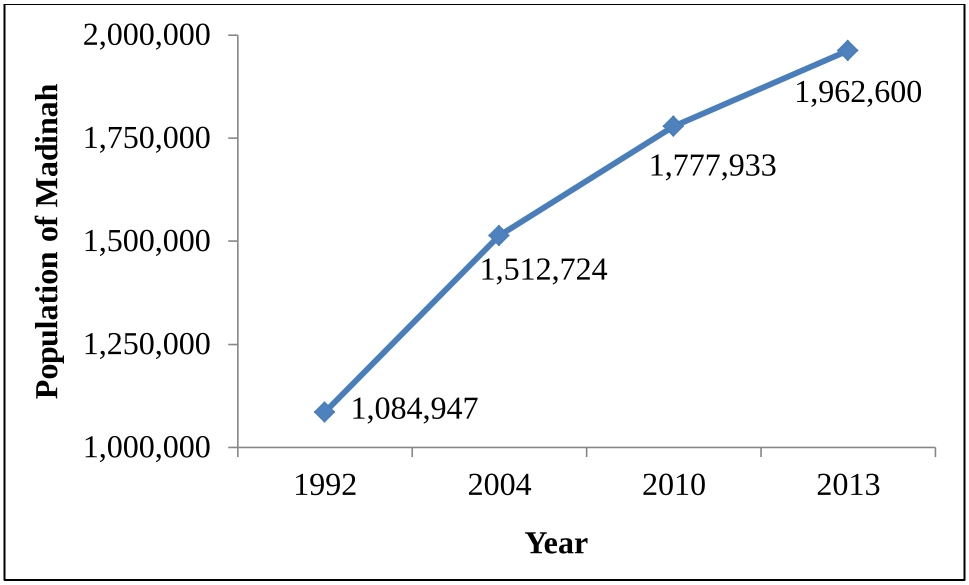

Figure 5.2: Population of Madinah from 1992 to 2013

Although Madinah and Makkah Provinces have almost equivalent land mass, but the population of Madinah Province was approximately one-quarter of that of Makkah as indicated in Table 5.1 (City Population, 2013). The higher population of Makkah can be attributed to higher migration and visitation to its Capital, Makkah (Mecca) and its neighbouring cities within this Province compared to Madinah Province. In other words, Makkah being the most Islamic city attracts more Muslims to this Province compared to Madinah. Table 5.1 shows that the population of Madinah was also approximately one-quarter of that of Riyadh, which is the Capital of Saudi Arabia (City Population, 2013). Furthermore, the 2013 population of Madinah Province constitutes about 6.5% of the entire population of Saudi Arabia (Table 5.1).

Table 5.1: Population of Saudi Arabia and some major Provinces (City Population, 2013; Geohive, 2013).

Name of Country /Province	**Area (Km^2)**	**Year of Population**			
		1992	**2004**	**2010**	**2013**
Saudi Arabia	2,149,690	16,948,388	22,678,262	27,136,977	29,994,300
Riyadh	404,240	3,834,986	5,458,273	6,777,146	7,517,000

Makkah	153,128	4,467,670	5,797,184	6,915,006	7,688,600
Madinah	151,990	1,084,947	1,512,724	1,777,933	1,962,600

Table 5.2: 2010 Population distribution of Madinah (CDSI, 2011)

Saudis			**Non-Saudis**			**Total**		
Male	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
635046	627466	1262512	350488	164933	515421	985534	792399	1777933

Table 5.2 shows the 2010 population distribution of Madinah based on gender and home/foreign nationality (CDSI, 2011). Figures 5.3A–D shows the descriptive statistics of the population distribution in Madinah (derived from Table 5.2). The Saudi nationals in Madinah based on gender shows male and female were almost equally distributed with the proportion of 50.3% and 49.7%, respectively (Figure 5.3A). In other words, the human sex ratio (which is the ratio males to female in a given society) of the Saudi nationals in Madinah was approximately 1:1. In contrast, the population distribution of the foreigners (i.e. non-Saudis) in Madinah shows that male and female were 68% and 32%, respectively. The greater proportion of foreign male compared to their female counterpart was a reflection that more men embarks on economic migration and pilgrimage to Madinah due to the economic prospect and religious significance of the Province.

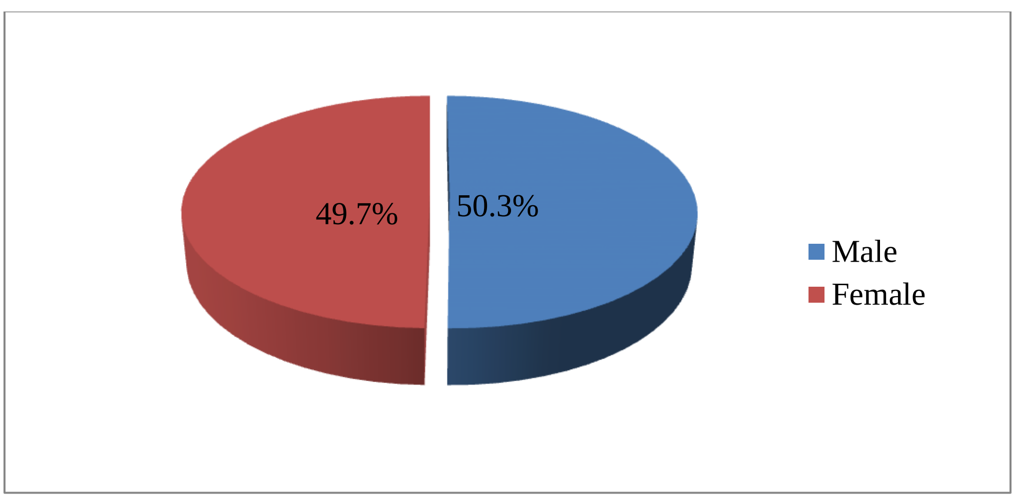

Figure 5.3A: Saudi nationals in Madinah based on gender.

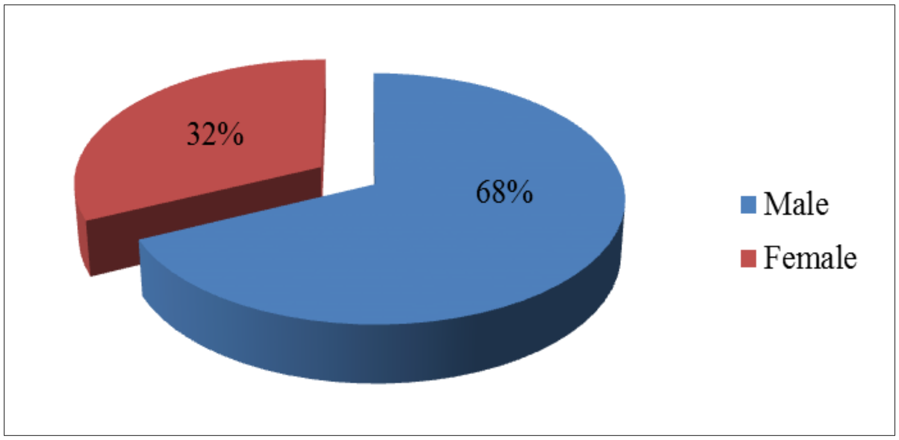

Figure 5.3B: Non-Saudi nationals in Madinah based on gender.

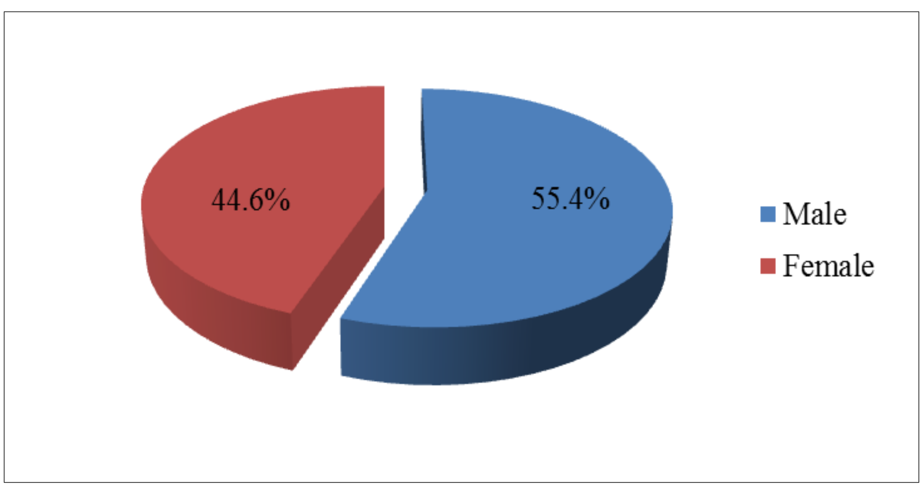

Figure 5.3C: Total population in Madinah based on gender.

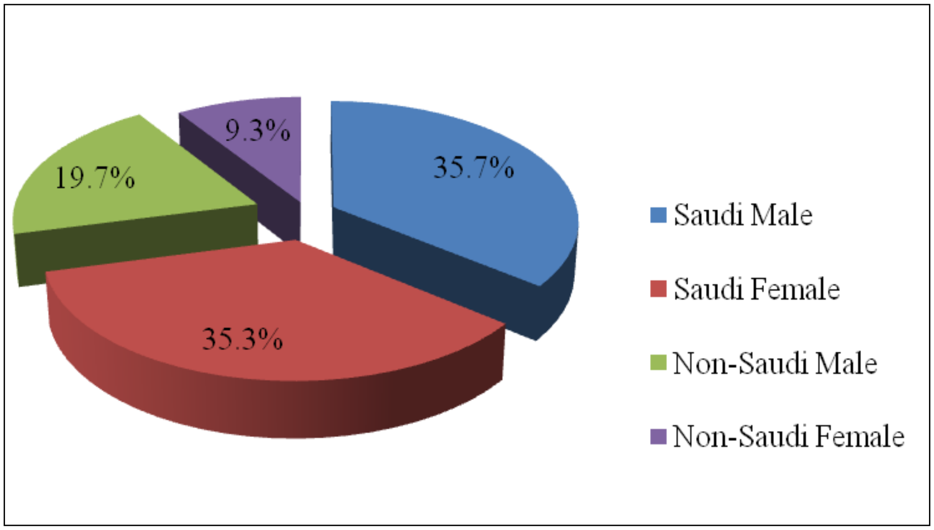

Figure 5.3D: Total population in Madinah based on home/foreign nationality and gender.

Considering the total population distribution (i.e. Saudis and non-Saudi inclusive) in Madinah, the proportion of male and female were 55.4% and 44.6%, respectively (Figure 5.3C). Again, the greater proportion of the male population compared to their female counterpart would be attributed to the higher male migrants to Madinah (Al-Ahmadi, 2005). Figure 5.3D shows a breakdown of the total population in terms of Saudi male/female and non-Saudi male/female. In this case, the Saudis and the non-Saudis represents 71% and 29% of the total population, respectively. While the Saudi male and Saudi female were almost joint highest with the population of 35.7% and 35.3%, respectively. This was followed by the non-Saudi male with a population of 19.7% and then the least was non-Saudi female with 9.3%. The distribution of the total population of any city gives an indication of the vibrancy of its workforce. As illustrated in Figures 5.3C and 5.3D, the total population (2010 Census) of Madinah was well distributed to provide formidable workforce that would boost the economic prosperity of Madinah.

5.10 Socio-Economic Activity in Madinah

In general, Saudi Arabia is a developing country with relatively high income derived from oil exportation (Al-Ahmadi, 2005). This national wealth reflects on the various Provinces (including Madinah) in terms of infrastructural development and standard of living. Madinah is a multi-ethnic city being the second most important Islamic pilgrimage destination after Makkah. Hence, it is inhabited by Saudis and an increasing number of other foreign nationalities which include Muslims and non-Muslim expatriate workers (Al-Ahmadi, 2005). The city can also boast of two Universities namely: Islamic University of Madinah and Taibah University. In terms of economy, Madinah is renowned for its commercial activities and agricultural products such as varieties of dates (which are edible plants) and vegetables. Hence, trading and agricultural sectors are among the main sources of employment for many people in Madinah. Nevertheless, its high unemployment rate has been highlighted (Neyazi, 2006). Consequently, the Medina Knowledge Economic City project (which makes it a city focused on knowledge-based industries) was planned and aimed at boosting development and increasing the job opportunities in Madinah. Generally, the socio-economic activities of Madinah is governed by the Islamic principle of community (i.e. *ummah*) which entails flexibility in social, religious, and political terms and includes a diversity of Muslims who share a general sense of common cause and consensus concerning beliefs and individual and communal actions (McAuliffe, 2001).

5.6 Religious Significance of Madinah

Madinah, which lies 447 kilometers North of the Holy City of Makkah, has a profound Islamic heritage being the home to the three oldest mosques in Islam, namely: Al-Masjid an-Nabawi (which is the Prophet Mosque); Quba Mosque (the first mosque ever built) and Masjid al-Qiblatain. Thus, it is a custodian of one of the Holy Mosques and other historically important religious sites making it the second holiest city in Islam (i.e. after Makkah). Historically, the city of Madinah is prominent as a result of the kindness it bestowed upon Prophet Muhammad (peace be upon him) and his followers after they were spitefully persecuted by the Makkhan merchants and departed in 622 AD. Consequently, the inhabitants of Madinah offered the Prophet and his disciples the opportunity to live amongst them and to arbitrate in their affairs (an invitation taken to mean their rejection of polytheism and submission to the will of the one God, Allah). This kind gesture marked the beginning of Islamic era in Madinah, which is often referred to the city of the Prophet because of its role in the development of Islam. It was in Madinah, the Holy Qur'an was compiled and the Prophet's companions administered the affairs of the Muslim community. Thus, it was the seat of the first Islamic state, where the Holy Jihad spread to other Islamic states. Madinah was also the place in which the Prophet, peace be upon him, was buried. Religious edifice such as the Prophet's Mosque in Madinah is shown in Figure 5.4. Several other Mosques are scattered across the Holy City of Madinah, some of them strategically located close to popular motor roads as shown in Figures 5.5 and 5.6.

Figure 5.4: Prophet's Mosque in Madinah (Source: wmn.gov.sa)

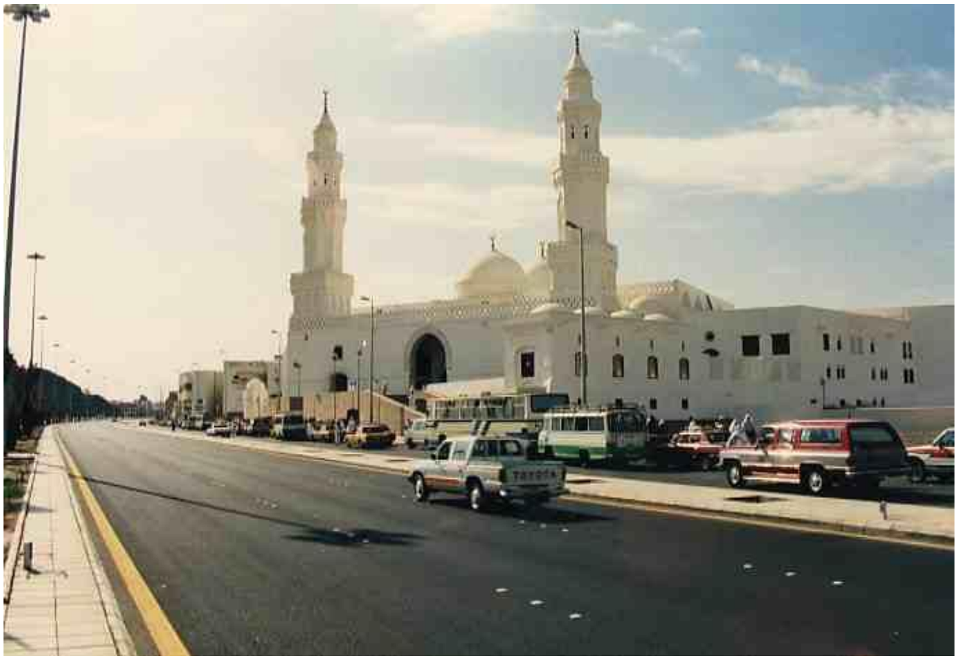

Figure 5.5: Mosque adjacent to a motor road in Madinah
(Source: http://www.saudinf.com/main/a84.htm)

Figure 5.6: Scene of the Holy City of Madinah.

(Source: http://www.saudinf.com/main/a84.htm)

5.6.1 Pilgrimage Season

The significance of the Hajj and Umrah in the socio-economic environment cannot be over-estimated in the life of a Muslim. Consequently, more than 2 million people embark on Holy pilgrimage trip to Mecca annually (Ministry of Planning, 1996). The number of foreign pilgrims (i.e. excluding residents) visiting the Kingdom of Saudi Arabia has been estimated to be about 70% of the Hajjis (about 1.4 million people which is the maximum allowed number). This unprecedented influx of pilgrims to the Kingdom of Saudi Arabia takes place at certain times of the year due to the seasonal nature of the Hajj and other Islamic festivals. For instance, Islamic pilgrimage (Hajj) occurs from the 8^{th} to 12^{th} Month (i.e. from Sha'aban to Dhu al–Hijjah). Since the Islamic calendar is a lunar calendar, it is eleven days shorter than the Gregorian calendar used in the Western world. Consequently, the Gregorian date of the Hajj changes over the years. However, Muslims worldwide considers certain months (or period) to be sacred prompting those that could afford the expenses to embark on pilgrimage to Mecca during this period. Figure 5.7 shows the crowd of pilgrim at Hajj. Furthermore, some of these pilgrims visit other Holy cities such as Madinah before or after they perform Hajj.

Figure 5.7: Crowd at Hajj (Source: Ahmed et al., 2006).

According to informal information provided by the Ministry of Planning, 1.274.000 Hajjis visited Madinah in 2001. Among these pilgrims, 1,024,000 Hajjis arrived using the land transport from Mecca and 97,000 Hajjis arrived using the land transport from other places. While 154,000 Hajjis arrived and left this city by flight via the airport of Madinah. As a result of the growing number of pilgrims over the years as indicated in Table 5.3 and Figure 5.8, there is bound to be serious traffic congestion in the Holy cities such as Mecca and Madinah. During the period of Hajj, these Holy cities experience an unprecedented increase in population due to the influx of pilgrims. Consequently, at these peak periods providing safe and efficient transport for pilgrims and others travelling at these periods is a major challenge for the Government of Saudi Arabia (Ministry of Planning, 1996). The Government of Saudi Arabia has recognized this problem (i.e. safe movement of pilgrims) as an integral part of future transport planning since it has the intention of widening the capacity of Mecca to be able to host more pilgrims in the future. The Government through the Ministry of Hajj will embark on improving the infrastructures, transport system and the traffic to enhance the safety of the maximum pilgrims allowed by the Saudi Authority (Ministry of Planning, 1996).

Table 5.3: The number of pilgrims for the year 1996 to 2011
(**Source:** Central department of statistics and information).

Year	From Within Saudi Arabia	From Outside Saudi Arabia	Total Pilgrims
1996	784769	1080465	1865234
1997	774260	1168591	1942851
1998	699770	1132344	1832114
1999	775268	1056730	1831998
2000	571599	1267555	1839154
2001	549271	1363992	1913263
2002	590576	1354184	1944760
2003	610117	1431012	2041129
2004	592368	1419706	2012074
2005	629710	1534769	2164479
2006	700603	1557447	2258050
2007	724229	1654407	2378636
2008	746511	1707814	2454325
2009	679008	1729841	2408849
2010	699313	1613965	2313278
2011	989798	1799601	2789399

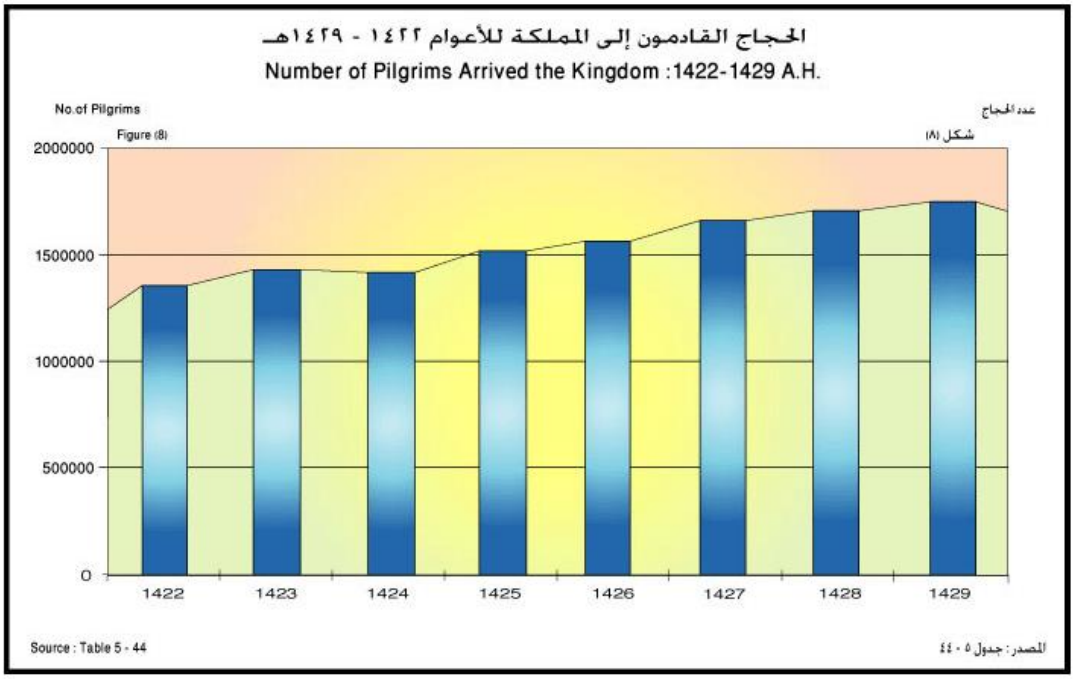

Figure 5.8: Increasing number of pilgrims arriving Saudi Arabia (**Source:** Central Department of Statistics and Information)

5.6.2 Expansion of Religious Facilities in Madinah

Madinah being a custodian of the Holy Mosques and other religious sites continue to experience an unprecedented influx of pilgrims. Hence, there has been rapid urban growth and development in infrastructures and facilities to meet the need of the increasing population. For instance, the expansion and development plans formulated by King Fahd for the Prophet's Mosque in the Holy City of Madinah. These developmental projects are similar to those executed on the Holy Mosque in Makkah. Expansion work on the Prophet's Mosque in Madinah was launched by King Fahd in 1985 (1405/06 AH) with the aim of accommodating an excess of one million worshippers at the busiest times, especially during Hajj season. A unique feature of the expansion project was the development of the 27 main plazas. Each plaza is now capped by a state-of-the-art sliding dome, which can be rapidly opened or closed according to the weather and can be used in unison or separately as required. Elaborately carved stone friezes decorate the domes, and the plazas have been paved in decorative geometrically patterned marble tiles. The project also necessitated the building of six additional minarets, each 105-meter construction crowned with a 4 ton gold-plated crescent.

The development of the surrounding open areas and the seven newly constructed entrances ensure the smooth passage of pilgrims into the Prophet's Mosque. Indeed, the designers of the entire project have masterfully considered every eventuality of the existing and future capacity of the Mosque, and all this within the constraints of the existing architectural pattern. The building extensions have therefore been fitted out with a suitable number of staircases and escalators. The designers have added an extension to the roof area for praying purposes, whilst also allowing for the possibility of adding another floor to accommodate worshippers in the future. Like the splendidly redeveloped Holy Mosque in the Holy City of Makkah, the Prophet's Mosque is now fully air-conditioned. The comfort of worshippers has been further enhanced, however, by the unique and ingeniously conceived shading system. Twelve enormous mechanically operated Teflon umbrellas, six in each court of the Mosque, have been developed by King Fahd's architects to protect pilgrims and help them withstand the high temperatures.

The Prophet's Mosque project also includes provision of extensive car parking facilities and the construction of a new dual carriageway, the Bab Alsalam Road, linking Madinat Alhujaj on the western side of the Holy City of Madinah to the site of the Mosque. A labyrinth of service tunnels, drainage systems and supply networks also now criss-crosses the area. In fact, the magnitude of support services made it necessary to construct a vast basement complex in which to accommodate the service equipment and wiring needs, as well as various other maintenance works. The reconstructed main gate leading into the Mosque site, the new King Fahd entrance, is situated on the northern side, and is topped with a profusion of domes and minarets on both sides. The exquisite decorations and architectural touches here and elsewhere are in complete harmony with earlier building work on the site, and they feature wonderfully crafted golden grilles, cornices, pillars, brass doors and marble works, as well as special ornately carved pigeon holes for the Holy Qur’an. The Planning Process has played a crucial role in the Kingdom's extraordinarily fast industrial development, of which SABIC, the Saudi Arabian Basic Industries Corporation is an outstanding example.

5.7 Transportation in Saudi Arabia

In general, the Ministry of Transport (formerly Ministry of Communications) has the ultimate responsibility to deal with matters on roads and road transport in Saudi Arabia. The responsibility for road transport is concentrated under the Deputy Minister of Transport Affair in the Directorate for Land Transport. Among other responsibilities, the Directorate also has the following functions (Ministry of Planning, 1996):

- Issuance of license and assigning of route to buses and taxis that are providing intra-city and inter-city road transport services for public passengers;
- Licensing of freight transport for public and own account transport by trucks;
- Approving of tariffs for taxis, urban and inter-city buses and road freight vehicles;
- The drafting and introduction of new transport regulations. It also enforces these regulations;
- Keeping of records of registered transport operators in the Kingdom; and
- Executing and commissioning of relevant studies and surveys.

5.7.1 Transport System in Madinah

Transportation in Madinah is very similar to that obtainable in other Saudi cities because it is being controlled by the central government. The Saudi Arabia Public Transport Company (SAPTCO) is responsible for the planning and running of the public transport services within Madinah and between Madinah and the other cities in the Kingdom. In other words, public transport services are mainly provided by the Saudi Arabia Public Transport Company (SAPTCO) and other Private minibus and taxi operators. SAPTCO works through a contract with the Ministry of Transport. According to this contract, the ministry of transport allows the mentioned company to plan and change the axis and the levels of the service to the public without any financial support from the government in order to manage these services. SAPTCO is expected to operate within the tenet of the contract signed with the Government to operate urban and inter-city bus services. Hence, the Office of the Deputy Minister for Transport Affairs is charged with the supervisory role which involves the monitoring of the contract between the Government and SAPTCO (Ministry of Planning, 1996). Besides the Ministry of Transport, other Government institutions such as Ministry of Interior and General Department of Traffic (GDT) are also involves in road transportation in Madinah. For instance, GDT is responsible for the registration of road vehicles in Madinah; traffic safety (i.e. work on preventing traffic accidents and handle accidents once they happen); licensing of drivers; vehicle inspection and enforcement of traffic regulations; decide and collect fines imposed on violators of traffic regulations; prepare annual statistics on traffic accidents and other related issues; collaborate with the Ministry of Information to enlighten the public on road safety issues and many other functions (Ministry of Interior, 2012; Ministry of Planning, 1996).

The transport system of Madinah is a well developed transport system which consists of a huge transport network to accomplish the harmonious movement of the vehicles. Both inter- (i.e. vehicles movement among the cities) and intra- (i.e. within the city) transport services are well established in Madinah. In general, the taxis and minibuses play an important role in answering the requirements of the transport and travel within Madinah. Buses working between Madinah and the other cities are frequent, and they link Madinah with Mecca, Jeddah and Riyadh and other main cities. These services increase in the pilgrimage season, and in Ramadan. Buses inside Madinah are considered non-profitable to (SAPTCO), so they are presented in humble levels in order to keep them inside Madinah. In addition, the airport taxis are also very efficient conveying visitors (e.g. pilgrims) from the airport of Madinah (which is about 13 km far from the north east of the city centre) to various parts of the city. Besides vehicle driven means of transportation, it important to emphasize that substantiate proportion of the people in Madinah indulges in pedestrian activities since the city is well connected with good road network. Pilgrims' pedestrians take advantage of this good road network that link various parts of the city by walking around for site viewing of religious edifices and visiting the mosques.

5.7.1.1 Some Important Features of Transport System in Madinah

The important characteristics of current transportation system in Madinah are as follows:

- The level of the traffic service on the radial and ring roads is good, and it maintains appropriate flowing of traffic on most parts and sectors in all times including Ramadan, pilgrimage season, regular days, and in the regular times on Fridays.
- There is site crowdedness on some main crossings (in rush hours) including the road of the King Abdulaziz, and Qibaa road in the second ring road. This crowdedness causes

lateness on the traffic lights which causes the crowdedness on the main roads and the crossed secondary roads.

5.7.1.2 Some of the Problems Encounter

The increasing crowdedness of the vehicles in the streets and the negative impact of traffic congestion often result to the late arrival of people to their destinations. In addition, this lead to less production, more pollution, more traffic accidents and other negative effects. The difficulty of arriving on time to many places, especially, for the people who do not own cars or who cannot drive is prevalent in Madinah and other Saudi cities. Furthermore, the deficiency of road competence due to the increasing number of visitors that may be unfamiliar with the road safety regulations in Saudi Arabia is a major problem.

These problems form main challenges for the transport sector especially concerning preserving the traffic flow and the moving of the residents, the Hajjis and the visitors. There is need to review the policies which draw the transport movement on many levels. This may include the transportation of Madinah residents as a part of their daily work, back and forth from school, and transporting without restrictions. The transportation pilgrims to the Holy Prophet Shrine and the other holy places related to the main religious activities during Ramadan and the pilgrimage season should be considered. The transportation to the Holy Prophet Shrine and the other holy places for the minor Hajjis and the residents during the year (excluding pilgrimage season and Ramadan) should also be improved. The road network and transportation between the cities such as Madinah, Mecca and Jeddah should be given priority by the government.

These changes of the transportation (of pilgrimage – Ramadan – Fridays – other week days) and the daily changes form great challenges which require following modern and creative methods of solving the problems of transport in order to cover the transport requirements in the future.

5.7.2 Zones and Road Network in Madinah

Madinah is divided into three main zones. The first zone covers the central area around the Prophet’s mosque and the first ring road ‘King Faisal’s Road’. This is the busiest zone in Madinah because it involves the most intense religious activities. This zone comprises of hotels, shops and utilities to serve both the residents and the many visitors. The second zone is located between the first ring road and the second ring road, and mainly consists of multi-storey buildings, and it is in this zone that the population density is the highest. The third zone lies between the second and third ring roads. New development plans are taking place in this zone.

The ring roads are very important in helping traffic get around the city of Madinah. They assist in minimizing congestion, and can be very busy during peak times; religious activities (e.g. praying hours) and shopping hours because important Mosques and other religious sites and retail parks are built close to them.

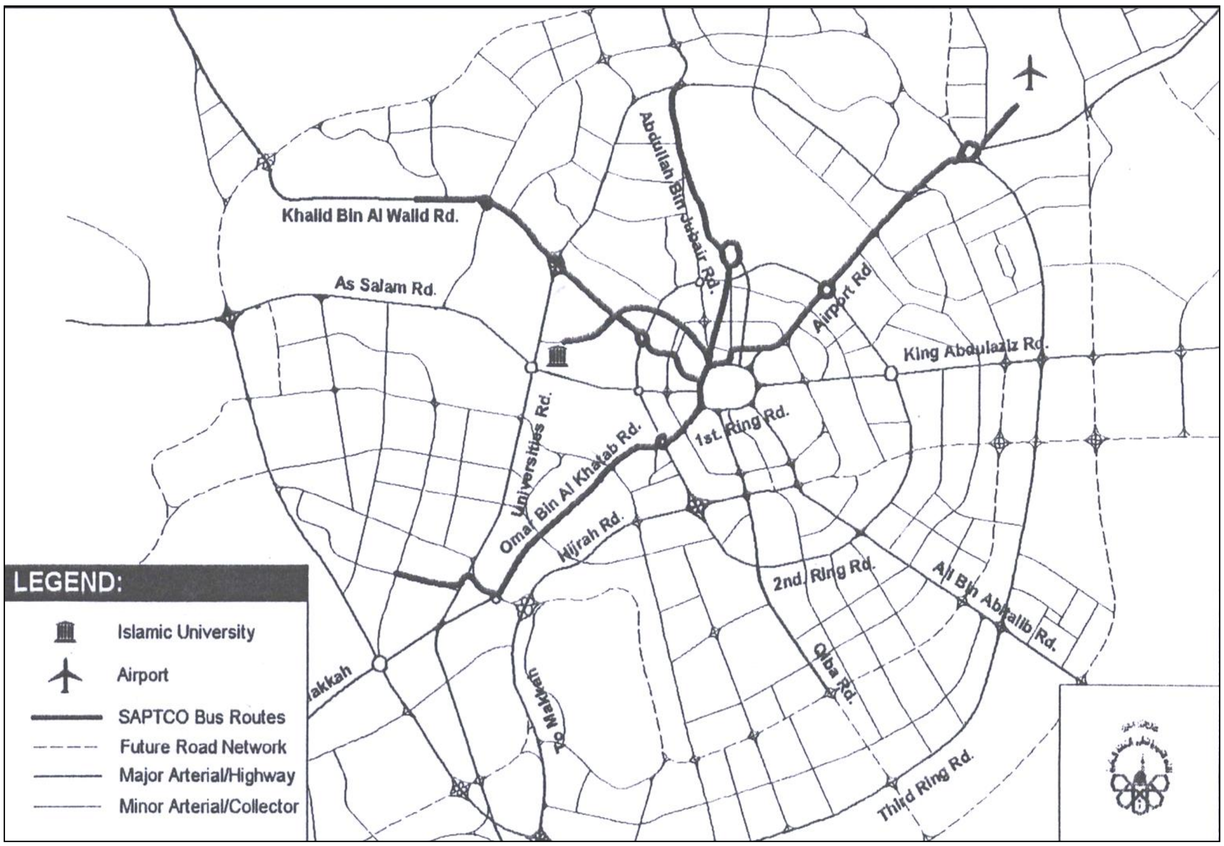

Figure 5.9: The current system of the roads in Madinah.

As indicated in Figure 5.9, Madinah has a well-developed road network comprising of various types of roads which include: One way street; Single carriageway – 2 lanes; Single carriageway – 3 lanes; Single carriageway – 4+ lanes; Dual carriageway – 2 lanes; Dual carriageway – 3+ lanes and Roundabout. This developed road network is aimed at getting people quickly around the Madinah as long as it is not the rush hour and to minimize the occurrence of road. The Government regularly embarks on a number of major construction projects to either improve or modify the roads in order to curb road accidents. Although most of the roads are very good but some have pot holes which require minor repairs. In most cases, the repair of these roads can be very slow, thereby, endangering the lives of commuters. Again, the quality of the repaired road can be very poor resulting to the quick eroding of the surface of the road resulting in holes.

5.7.3 Types of Road Madinah

There are different types of road in Madinah as mentioned above. As illustrated in Figure 5.9, each type of road has its unique characteristics in terms of dimension, design and sometimes allowed speed limit. Hence, the type of road is very important in road safety issues because they can influence the frequency and severity of road traffic accidents. This is section gives a concise description of the types of road in Madinah:

- One way street: This is also refer to as a single-track road or one-lane road is a road which normally permits two-way travel but is not wide enough in most places to allow vehicles to pass one another. A typical example are long driveways of rural properties;
- Single carriageway – 2 lanes: This is also called two-lane road (or two-lane highway). It is a single carriageway with one lane for each direction;
- Single carriageway – 3 lanes: This comprises of three lane roads. This type of road is still regarded as a single carriageway because the lanes on opposite sides of the road are not physically separated by a central reservation;
- Single carriageway – 4+ lanes: Similarly, this type of road comprises of more than four lanes;
- Dual carriageway - 2 lanes: This applies to any road with two lanes on either side that are physically separated with a central reservation;
- Dual carriageway - 3+ lanes: Similarly, this refer to any road with three or more lanes on either side that are physically separated with a central reservation; and
- Roundabout: This includes the huge and signalized roundabouts rather the standards roundabouts.

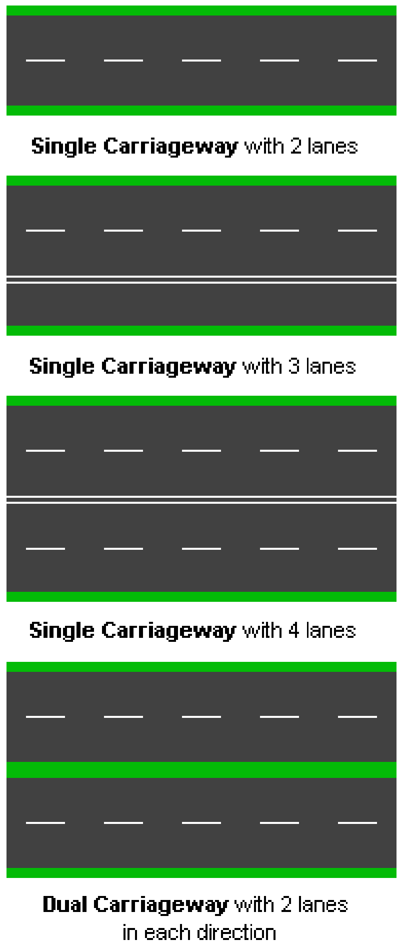

Figure 5.10: Illustration of types of roads – Single and Dual Carriageway.

The type of road has impact on its road traffic safety. For instance, single carriageways have less improved road traffic safety compared to dual carriageways. Typically, the maximum speed limit for single carriageway roads is lower than the maximum for dual carriageway roads. In other words, road traffic safety is generally worse for high-speed single carriageway roads than for dual carriageway due to the lack of separation between traffic moving in opposing directions. Roundabouts also have significant implications on road traffic safety because they help to minimize congestion by diverting vehicles to different routes and forces approaching vehicles to slow down due to the lateral displacement it has to make.

5.7.4 Road Safety in Madinah

5.7.4.1 Pedestrian Safety in Madinah

The growing concern of road traffic accidents in cities like Madinah Arabia has prompted the Saudi government to review its road safety policies to curb the loss of lives and properties (Aljanahi et al., 1999; Bener et al., 1994; Bener and Jadaan, 1992; Ofosu et al., 1988). The government of Saudi Arabia has introduced several initiatives to improve its road safety regulations as a means of protecting its road users, especially, the most vulnerable pedestrians and children. The development of pedestrian safety has been a priority to the government as recognized in the Directives of the Council of Ministers. A cursory look at the pedestrian safety statistics reveals the magnitude of these problems. For example, the Saudi Police Department statistics indicate that pedestrian accidents have increased significantly over the past two decades. Partly, the increase in pedestrian accidents and casualties over the past decades has a direct bearing in the sharp increase of registered vehicles in Saudi Arabia within the same period. Hence, it is imperative for the government of Saudi Arabia give special attention to pedestrian safety for the following reasons:

- The vulnerability of pedestrians is clearly exposed during a collision between vehicles and pedestrians. In this case, the later will almost always suffer an injury or a fatality. Over 90% of non-fatal pedestrian accidents result in pedestrian injuries and over 20% of all motor vehicles related fatalities involve pedestrians.
- While the majority of motorists have been trained and tested, and are legally obligated to operate vehicles in a legal manner while observing the rules of the road. In contrast, the pedestrians (road users that cover a wide range of age and physical abilities) are not as well trained and many may not even be physically or mentally able to cope with the pedestrian facilities provided.

Pedestrian safety could be endangered as a result of deficiencies from a combination of factors, which include – poor planning of pedestrian facilities; low level of education for either the driver or the pedestrians; improper control devices such as reckless driving; lack of enforcement of road safety regulations etc. For the government of Saudi Arabia to proffer appropriate remedies to the numerous pedestrian safety problems plaguing its society, there is need for the authorities to understand the causes, type and magnitude of these problems. In other words, it is an important prerequisite for the government authorities to understand the factors that influences pedestrian casualty in Saudi Arabia. The factors that could have enormous impact on the pedestrian safety are highlighted below:

1. Type of pedestrian involved in the accident: age, disabled, alcohol or drug impaired;
2. Roadway and location classification of the accident: rural vs. urban locations, residential vs. commercial/industrial; and
3. Time of the accident: hour of day, day or week, month of year, and daylight vs. night (Sullivan and Flannagan, 2007).

Despite the effort by the government, pedestrian safety is still very poor in Saudi Arabia. This could be attributed to several factors which include: poor safety education and lack enforcement of road safety regulations in Saudi Arabia. Over the years, the government of Saudi Arabia has taken several initiatives to tackle road traffic accidents. These Traffic safety regulations require effective and efficient plans, programs, traffic regulations and preventive procedures to save people, properties and the national security. Since pedestrian safety depends on several other factors such as the quality and maintenance of the vehicle; the nature and quality of the road; the extent of compliance to road safety regulations etc. It is almost impossible to discuss pedestrian safety without considering other aspects of road safety which involves the quality and efficiency of vehicles, roads and drivers. Hence, the road safety in Saudi Arabia comprises of several components. For example, the traffic safety pillars in Saudi Arabia covers the following aspects: (i) Vehicle safety (ii) road safety and (iii) human factors (e.g. drivers). Below are some highlights of these safety components (Ministry of Information, 2013).

5.7.4.2 Vehicle Safety and Requirements

This covers everything about the proper functioning of the vehicle. Some aspects of vehicle safety considered in Saudi Arabia is to ensure that the vehicle tires are of the right size and its durability, speed rate, production year and storage are as specified by the regulations. The lighting system is checked regularly for clarity, colour and lighting level. Drivers are urged to also ensure that their turning and alarming Signals are working properly. Several other parts of the vehicles are regularly checked. For instance, the Mirrors, Windshield wipers, Service brake and parking brake, Shift Interlock, Sound and light warning indicators (on the dashboard) such as fuel, oil, temperature, speed and battery indicators. In addition, the safety belts, headrests, children seats and air bags must be in good working condition. Vehicle safety requirements as stipulated by the government of Saudi Arabia entails that the vehicle must have Spare tires and the tools used to remove and install them. Items such as fire extinguisher; first aid kit; rollover door locking systems; fireproof furniture and Light reflecting triangle are compulsory.

These government protective measures are aimed at ensuring the vehicle maintenance are effective and standardized in order to prevent traffic accidents. The vehicles are periodically inspected to improve quality of vehicle maintenance in order to minimize traffic accidents and maximize vehicle's service life. Furthermore, the protection of the environment will be improved by proper disposal of scrap vehicles. It will also keep all road users (including drivers, passengers, and the pedestrians) safe and ensure that problems associated with vehicle are discovered before getting worse or causing loss (Early troubleshooting).

5.7.4.3 Traffic Safety on Saudi Roads

Realizing the importance of good roads to safety, the Saudi Government has constructed high quality networks of roads all over the country. The road design and structural plans are effective to forestall preventable accidents. The necessary facilities such as road or street lightings are built. Road traffic safety procedures such as the clearing of natural obstacles (e.g. dust and sand), traffic control instruments (e.g. traffic lights, warning signs, and road cat eyes), vehicle weighing points between the Saudi governorates and cities are also constructed by the government.

5.7.4.4 Drivers' Safety Requirements

Drivers' safety requirements are compulsory in Saudi Arabia**.** This is because drivers of vehicles are the most effective factor in the traffic operations. Hence, a good driver must possess certain good qualities that will enhance effective driving. These qualities include: a sound or healthy state of mind; Healthy senses; Good knowledge of and strict commitment to traffic rules and regulations. Furthermore, a competent driver should have high concentration while driving and a strong sense of responsibility to enable him comply with safety regulations. Good knowledge of the vehicle mechanics and maintenance are also prerequisites. Drivers must have Safety belt, Headrest and Medical instruments such as eye glasses, first aid kit and airbags.

Several procedures and rules have also been established to ensure safe driving. Driver's duties before operating the engine include having a regular check of the vehicle and tires. They must ensure that doors are closed and adjust the driver's seat and the steering wheel. Also they must fasten their belt and make sure that all passengers' belts are fastened. In addition, they must adjust the vehicle rear-view mirrors, notice the fuel and heat indicators on the dashboard. Drivers must also operate the engine; move the vehicle according to traffic laws and regulations. Stopping of the vehicle must be effective. Drivers are also urged to carry out other functions effectively. They include looking at the rear-view mirror that to see the road behind them; start the stop signal; decelerate gradually; push the brakes slowly to stop the car; and when the car stops, pull the hand brake.

Drivers must comply with traffic signs and lights, traffic warning, control and guidance signs. Checkpoints, horizontal and floor signs (e.g. paints, illustrations and sidewalks), traffic Lights and traffic controls in work areas (e.g. signs, cones, barrels, lightened arrows, flag carriers, etc) must be comply with by drivers.

The Saudi government has also put other measures in place to curb road traffic accidents such as fine for the violation of road safety regulations. The government has also established SAHER, which is an automated traffic control and management system which covers major cities in Saudi Arabia including Madinah, and uses digital cameras network linked with the National Information Centre of Ministry of Interior (SAHER, 2013). The objectives of the SAHER project include:

- To improve level of traffic safety.
- To utilize the latest and most advanced technology in the field of intelligent transportation (ITS) in order to create a safe traffic environment.
- To upgrading the existing road network.
- To enhance the public security by using the latest surveillance systems.
- To ensure strict, accurate and constant implementation of traffic regulations.

The Saudi government has also introduced other measures to enforce the compliance of road safety regulations. For example, network of cameras, fixed and mobile radars have been installed to monitor and control traffic violations, as well as issue traffic violation tickets and notifies violators (SAHER, 2013). In other words, financial sanctions are imposed on violators of road safety regulations. Furthermore, the traffic point system regulation operates in Saudi Arabia. For every violation of traffic regulation, a given number of points would be deducted from the driver. When the deducted point gets to the threshold, the appropriate sanction will be imposed on the culprit. This may include withdrawal of the culprit driver's licence (SAHER, 2013). Nevertheless, the road safety measures operating in Saudi Arabia are mainly focused on the vehicle and its occupants. Hence, the Saudi government should make more effort to incorporate more road safety regulations that will drastically curb pedestrian casualties in cities like Madinah where the tendency of pedestrian casualty is high due to its religious significance.

5.7.4.5 Madinah Land Use

Transportation decisions have been shown to affect land use patterns and the resulting economic, social and environmental impacts (Litman, 2012). Land use refers to human use of the earth's surface, including the location, type and design of infrastructure such as roads and building (Litman, 2012). Several land use types exists which may include religious, commercial, industrial, agricultural, residential and open accessed area etc. These land use types are characterized by different attributes which appeal differently to road users. In other words, land use type being a trip generator can have diverse economic, social and environmental impact on road users such as pedestrians.

Madinah's urban planning structure is essentially radial; the roads start from the city centre and radiate in each direction to link external parts to the centre, which is important as it has Alharam (a holy place), trade markets, and hotels. Residential use represents about 34% of the urban area, residential commercial is 1.5%, and 0.5% is for commercial use only. There has been significant explosion in residential building, which more than doubled in about 16 years; the residential area was about 16% of the total urban area in 1978 but by 1994 had increased to 35% (Al-Seryni, 1998). Commercial use mainly exists in the centre of the city around Al-haram, and also alongside the main roads which radiate from the city centre. Industrial land represents 3.2% of the total urban area. It should be mentioned that the main urban concentration is inside the second ring road area. This is where most central government officers' services, Hajjis' (pilgrims') and visitors' residences, as well as public residences are located. The city spreads beyond the second ring road, especially to the west and north parts and recently to the east and south. As a result of the urban extension in all directions during the urban upturn of the last three decades, most of the green land which was near the city has been lost. Just a little green land remains in the form of palm orchards that infiltrate the urban area, but these too are disappearing. Most residential areas do not extend beyond the third ring road, which marks the limit of the city. This section describes the pattern of urban areas in Madinah and also highlights the various districts and their land uses as shown in Tables 5.4 & 5.5 and Appendices B & C. This is because the land use of the district may also provide insight into the pattern of pilgrim pedestrian casualties in the city.

Table 5.4: Description of Accident Data

Variable Name	**Role**	**Variable Type**	**Description**
Accident Year	S	Categorical	Accident year ranged from 2001–2005 (1421AH – 1425AH)
Gender	S	Categorical	0 – Male; 1 – Female.
Age	S	Continuous/categorical	0 - Child Pilgrim: 0-15 years; 1 - Young Pilgrims: 15-45 years; 2 - Middle Age Pilgrims: 45-65 years; 4 - Older Pilgrims > 65 years.

Severity of casualty	S; M and R	Count/categorical	Frequencies of pilgrims' pedestrian casualty / Category of casualty are: 0 – Seriously Injured (SI); 1 – Killed.
Nationality	S	Categorical	0 – Saudi; 1 – 8 Non Saudis (see also Appendix B)
Day of accident	S	Continuous	Accident day in the calendar month
†Month of accident	S and M	Categorical	Categorized based on the influx of pilgrims for the year: 0 – High Season; 1 – Low Season.
†Day of week	S and M	Categorical	Categorized as: 0 – Islamic Week Days 1 – Islamic Weekends
†Time of accident	S and M	Categorical	0 – Prayer Times 1 – Non-Prayer Times
Road Type	S; M and I	Categorical	0 – Roundabout 1 – 8 Not at a roundabout (See also Appendix B)
Speed	S	Categorical	0 – Above 50 Km/h; 1 – Less than 50 Km/h.

Details of Junctions	S; M and I	Categorical	8 - Other junction 7 - Private drive or entrance 0 - Not at junction or within 20 metres 1 – 6 (Junction types (see also Appendix B)
Districts	S		See Appendix C
Land use	S; M and I	Categorical	0 – Religion 1 – Residential 2 – Commercial 3 – Accommodation 4 – Government Office 5 - Agriculture

Table 5.5: Distribution of Pedestrian Casualty in the Districts of Madinah.

S/N	Name of District	Pilgrim Pedestrian Casualty (2001 –2005)					
		2001	**2002**	**2003**	**2004**	**2005**	**Total**
1	Al-Qiblatayn	8	7	12	13	11	51
2	Al-Khandaq Area	12	12	12	16	19	71
3	Al-Dir’	14	13	17	16	14	74
4	Al-Aws Area	13	13	13	13	18	70
5	Al-Wabrah	5	5	6	6	5	27
6	Al-Saih	9	9	11	13	14	56
7	Al-Mabani’	18	15	20	27	27	107
8	Sele’Area	6	6	6	9	9	35
9	Al-Khazraj Area	8	8	9	9	14	48
10	Al-Suqya	11	11	13	16	16	67
11	Al-Zahdyh	14	15	16	16	22	83
12	Al-Fisalyh	5	5	7	9	9	35
13	Quba Area	41	45	50	53	59	248
14	Al-Anabyh	18	18	20	21	28	105
15	Al-Uraid	13	13	13	12	13	64
16	Bani Mawiyah	15	14	16	16	20	81
17	Al-Hrah Alsharqyh	5	6	6	5	7	29
18	Bani Zafar	12	15	16	15	21	79
19	Al-Jumah	14	15	13	15	14	72
20	North Qurban	14	14	13	16	14	71
21	Al-Aliyah Area	17	18	18	19	18	90
22	South Qurban	14	13	17	14	14	73
23	Buda’ah	22	20	31	25	19	117
24	Al-Manakhah	21	22	22	19	21	105
25	Bani Al-Najah	19	22	25	23	22	111
26	Bani Khudrah	22	18	22	22	22	106
27	Al-Baqh – Holy Graveyard	20	24	34	26	26	130
		390	**396**	**458**	**464**	**496**	**2204**

5.8 Summary

Madinah is the fourth largest city in Saudi Arabia and it is located in the Western region of the country and has a very hot climate. It was selected as the study area because of its uniqueness of being the first Islamic capital. In addition, being a custodian of two of the Holy Mosques and several other important religious sites, Madinah attracts huge number of pilgrims annually. The expansion of the Prophet's Mosque and the existence of other important religious sites have continued to attract Muslims all over the world to Madinah. Consequently, the traffic situation and the walkers in Madinah are affected by the religious occasions including pilgrimage, minor Hajj and Ramadan which are considered the most crowded seasons. Although, there are other seasons that are less crowded during the year. Every season differs according to the traffic, the visitors' numbers and the visit arrangements. Consequently, every season needs different transportation arrangements. Pilgrimage season and the minor pilgrimage in Ramadan depend on the lunar calendar (the pilgrimage correlates between the eighth and the thirteenth of Dul Hijja which is the twelfth month in the Islamic Hijri calendar). The important characteristics of current transportation system in Madinah were also highlighted.

The growing population of Madinah caused mainly by the influx of huge number of pilgrims and migrant workers were also highlighted. This affects the congestion of the city which poses not only transport challenges but could also contribute to road accidents. The popularity of Madinah being a religious centre affects its socio-econmic activities. Its socio-economic activities are lively and typical of a city in a developing Arab country. It is an Islamic city that comprises of multicultural and diverse ethnicity. Commercial and agricultual activities are high in Madinah. Madinah can also boost of two higher institutions that promotes education. The educational, employment and other socio-economic indices of Madinah are typical of Saudi Arabia. Educational and employment rates are generally high in Madinah.

Transportation in Saudi Arabia was discussed and the various government establishments involve in this sector were highlighted. The Ministry of Transport is charged with the responsibility of transportation in Saudi Arabia. The public transportation is run by SAPTCO, which a transport company that enters into contract with the government regarding the running of the public transport system. SAPTCO is expected to comply with the terms of contract and serve the public efficiently without making much profit. The services render by SAPTCO to the public are also used by most pilgrims that visits Madinah. The transportation system of Madinah is similar to that obtain in other major cities in Saudi Arabia. Nevertheless, the transport System in Madinah is characterized by certain features. For example, the level of traffic service on the radial and ring roads is good and it maintains the high speed of transporting on most parts and sectors on these types of roads. Therefore, congestion is reduced in the city all times including Ramadan, pilgrimage season, regular days, and in the regular times on Fridays. On the otherhand, the crowdedness at the city centre and on some main crossings (in rush hours) including the road of the King Abdulaziz, and Qibaa road in the second ring road affects the traffic flow. The crowdedness around these areas places burden of the smooth flow of traffic in some occasion. In fact, it often leads to lateness or people not arriving at their destinations on time.

Madinah is divided into three main zones which poses different challenges to the transport system. The road network in Madinah is generally of good standards compared to most cities in the developing nations. In other words, Madinah has a well-developed road network comprising of various types of roads (e.g. One way street, Single carriageway – 2 lanes etc). Although most of the roads are very good but some have pot holes which require minor repairs. Henc, the Saudi government regularly construct, maintain and improve the roads to avoid preventable road accidents. This is essential because the quality and type of road are very important in road safety issues since they can influence the frequency and severity of road traffic accidents. The general road safety in Madinah was highlighted. The growing concern of pedestrian safety in Madinah was also discussed. Many aspects of road safety including vehicle maintenance and safety; vehicle requirements; and drivers' safety requirements were discussed. The urban planning structure of Madinah is mainly radial with the roads starting from the city centre and radiate in each direction to link external parts to the centre. The land use type of Madinah which is predominantly residential. The other land use types of Madinah include commercial, industrial, agricultural and government offices (i.e. land housing government establishments).

Chapter Six: Research Methodology

"I think transportation and corrections are not the first two areas that I would go looking for massive change" – **William Weld**

Chapter Six: Research Methodology

6.1. Introduction

Road traffic accidents are often under-reported in most countries and are usually compiled by the Police Department and other relevant government department such as Ministry of Transport. These accident data are meaningless without the appropriate analysis and are often classified as being either secondary or primary in nature, this distinction is not always clear, and there are cases where data appears to fall within both categories. It is generally accepted that primary data can be defined as that which is collected by the researcher directly, and secondary data is that which has been collected by or for someone else, and will be used for the purpose of a separate, perhaps, non-directly related study. In the former case the researcher has the advantage of crucial first-hand information with regards to the viability and reliability of the data; this is not true with regards to the latter. This Chapter describes the pilgrims' pedestrian casualty data by highlighting its source and several other features.The restructuring of the data and several stages involves in its analysis are presented in the following sections.

6.2 Data Collection

The road accident data used for this study was obtained from Madinah Police Traffic Department, which hold a general accidents data for the city of Madinah. The data consist of details of pilgrim pedestrian casualties over a 5 years period from 2001 to 2005 (i.e. approximately 1421H – 1425H of Islamic calendar). For the purpose of this study, only road accidents data involving pilgrim pedestrian casualty was manually collated. The database comprises of 2204 pedestrian accident records over the five years period (i.e. 2001 – 2005). Several important information regarding the pedestrian casualties that were deemed necessary for the purpose of this research were retrieved. They include: severity of casualty, crash time, day of the week, month, junction details, road type, sex, nationality, age and speed limits.

6.2.1 Explanation of how pedestrian accident data has been obtained from Al-Madina:

1- When an accident happens in Saudi Arabia, people who are involved in the accidents or others who happen to see it, call the transportation department dialling the accident emergency number (993). If people present at the accident location feel that they need medical assistance, an ambulance is called. The process can be very subjective and subject to the availability of people around when an accident occur.

2- When the transportation officer arrives at the accident location, s/he assesses the situation and decides if any emergency help is necessary.

3- The transportation officer fills in an accident form (attached).

4- At the end of his work shift, the transportation officer hands all of the forms to the General Transportation Administration.

5- The clerk at the General Transportation Administration transfers all obtained information from forms to the daily record according to the following (it depends on the handed form):

i. Date, time and day.

ii. Parties involved: the driver, the passenger, pedestrians, the address, phone number, civil record number, age, gender, nationality, injuries and injury risk.
iii. Vehicle: model, make, type of make, manufacturing country, registration number and the issuing country.
iv. Accident location: type of road, speed, crossing type, city, region, district and street/crossing name.
v. An outline of the accident.
vi. Brief description of the accident.
vii. Transportation officer's details.

In order to obtain pedestrian accident data for this research, the researcher carried out a field trip of five months (between September 2007 and February 2008). The five months spent to collect and sort all accident data as follwos:

- Data which the researcher wanted to make a comparison with previous studies was recorded as the following:

i. Year of accident: the month, day and time of the accident.
ii. Gender of the injured.
iii. Age of the injured.
iv. Type of injury.
v. Nationality.
vi. Type of road.
vii. Speed.
viii. Type of crossing.
ix. Region or district.
x. Accident coordinates.

The following limitations in obtaining pedestrian accident data have been observed:

- There were no electronic copies of any accident data at the transportation administration. The only source of information was daily record books
- It was very difficult to distinguish different classes of injured pilgrims, mo'tamreen (religious visitors) or residents). In addition some of the civil record numbers were

missing. There were a series of discussions and investigations carried out in order to determine different types of classes.

- An Excel table was created and the details of injured pedestrians from pilgrims and mo'tamreen were recorded.
- Because there were not accident coordinates to create a special model, the research depended on the description of accidents and information provided by the Madinah Municipality to decide the type of ground in the accident location. Also, some ground information for data and coding were used, and then recorded for every accident in the data table.
- The data file was then analysed using SPSS statistical software. See Appendix P for the forms used in obtaing accident data in Al-Madina.

Nevertheless, the database did not contain information pertaining to the driver's sobriety, vehicle type, light and weather conditions, car passengers' numbers and seat belt usage. Again, there were few missing data which is not uncommon with road traffic accident data, especially, when collated manually as in this case. Hence, the manually collated accident data had to be extracted and converted into an electronic form. The variables in the pilgrim accident files were listed within the database and scrutinized to determine the relevance of each variable to this study. Those variables that were deemed to irrelevant to this study were removed. Then, the data was saved in a (.sav) format of a SPSS database for statistical analysis.

6.3 Restructuring of the Data

As a result of the complexity of the dataset, modeling the raw cell counts can be misleading. Hence, the dataset has to be refined or restructured as presented in Appendix C. In the restructured dataset, only few variables that strongly influence the activities (i.e. the trips) of Muslim pilgrims' pedestrians were selected. Land use dayta was obtained form the city council of Al-Madina. Information about a number of variables were obtained. The selected variables were – (i) Land use (ii) Month of Accidents (iii) Day of Week and (iv) Hour of Accidents. The land use variable has six categories (Religious; Residential; Commercial; Accommodation; Government Offices and Agriculture). Nevertheless, the restructuring of the dataset requires the categorization of other selected variables. The Month of Accidents was categorized into 'High

Season Month' (which comprises of months: 1, 3, 9, 11 and 12) and 'Low Season Month' (i.e. month: 2, 4, 5, 6, 7, 8 and 10); Day of the Week has been categorized into 'Islamic Weekend' (i.e. Thursday and Friday) and Islamic Week Days (Sat, Sun, Mon, Tues and Wednesday); similarly, the Hour of Accidents was placed into two categories which are Prayer Times (5-7, 12-13, 15-16, 17-18 and 19-21) and Non-Prayer Times (0-5, 7-12, 13-15, 16-17, 18-19 and 21-00). Pilgrims' pedestrian casualty has two levels – seriously injured and killed. The selected variables are trip generator for most Muslim pilgrims' pedestrians. Hence, these variables measure the amount of "exposure" to risk of these pilgrims' pedestrians in Madinah and are handled within the generalized linear model as offset variables.

6.4 Preliminary Analysis of Data

A critical examination of Tables and graphs produced following the preliminary analysis was undertaken. This was carried out to identify which categories of the contributing variables related to which casualty severity. The proportions of pilgrim casualties in relation to each variable can be defined and the corresponding patterns and trends could be deduced, allowing reasonable explanations to be derived with regards to these trends and patterns.

6.4.1 Descriptive Statistics

As part of the preliminary analysis, SPSS was used to analyse the accident data to produce a descriptive statistics that could be used in describing the main features of the accident data collected in Madinah. In contrast to multivariate analysis or statistical modelling, descriptive statistics summarizes the accident data, rather than using it to learn about the population that the sample of data the sample represents. In other words, descriptive statistics is different from inferential statistics because they are not developed on the basis of probability theory. Hence, descriptive statistics describe the data set by measuring the central tendency and variability or dispersion e.g. the mean, median and mode etc.

6.4.2 The Spatial Model

It is not uncommon for certain areas of developing countries such as Saudi Arabia to lack geo-referenced data (or EDINA Digimap). The absence of geo-referenced data of Madinah restricted the application of GIS to spatially model the pilgrim casualty data. Hence, the spatial model was not developed using GIS. Nevertheless, the casualty data was spatially presented using graduated symbols done manually due to the absence of GIS co-ordinates. In doing that, land use data was obtained from the city council as Map-Info format. These have been synconised with other demographical data such as population and road system data. Although this is not the most efficient way to obtain and use land use data, it was the only possible and available source for land use data in this case.

6.5 Advanced Analysis of Data

6.5.1 Preliminary tools for removing redundant variables

Several prediction models have been developed by using statistical techniques that are usually categorized into four main domains, namely Multivariate Analysis (Abdel-Aty and Essam Radwan, 2000; Hauer, 2004; Poch and Mannering, 1996); Empirical Bayes Method (Hauer, 2001; Miaou and Song, 2005; Ozbay and Noyan, 2006; Persaud et al., 1999); Fuzzy Logic (Adeli and Karim, 2000; Hsiao et al., 1994; Sayed et al., 1995) and Neural Network (Abdelwahab and Abdel-Aty, 2001; Chiou, 2006; Delen et al., 2006; Mussone et al., 1999). However, the application of the above procedures could be a daunting task when a large number of variables are considered (Caliendo and Parisi, 2005). For instance, most accident studies often involve large data (i.e. numerous variables) which may be disadvantageous to the modelling process by introducing more noise or error. This research focuses on Multivariate Analysis which refers to any statistical technique used to analyse data that comprises of several variables. Apart from being widely used in developing prediction models (e.g. Poisson and Negative Binomial regression) that have significant accident forecasting capability, it is also now being used as a preliminary tool (e.g. Principal Component Analysis, PCA) for eliminating redundant variables (Shi et al., 2011; Caliendo et al., 2007; Davey et al., 2007; Caliendo and Parisi, 2005; Golob and Recker, 2003). This is necessary as many independent variables affect crash frequency and the influence of such variables on road accidents may not be equally significant (Caliendo et al., 2007). Consequently, there is need to extract a reduced number of variables from a vast number of independent variables to be included in the proposed model. In this research, Principal Component Analysis (PCA) has been applied to possibly reduce the independent variables that were included in the proposed accident models. It also provides insight on the significance of the variables on the accident study. While Cluster Analysis (CA) was used to confirm the components derived from the PCA and to show the aggregation of these components.

6.5.1.1 Principal Component Analysis (PCA)

Principal component analysis (PCA) is a statistical technique for new variables (called components) which are linear composite of the original variables. It describes the variability among observed, correlated variables in terms of a potentially fewer number of unobserved variables called components. PCA searches for such joint variations in response to unobserved latent variables. Hence, PCA combines similar variables together into a component that can be interpreted from the qualitative aspects of the study. The maximum number of new variables (or components) that can be formed is equivalent to the number of original variables. These components are uncorrelated among themselves (Sharma, 1996). In dealing with large data with several variables, PCA has the potential of combining similar variables into the same component culminating to only a few components that are meaningful for explaining the latent attributes of these variables.

In many accident researches, high-dimensional data are involved due to the multitude of factors that influences crash frequency. A typical example is the dataset used for this study which describes the pilgrim pedestrian casualty in Madinah. This dataset comprises of 14 variables and 2204 observations (with few missing data). Therefore, PCA was used to eliminate redundant variables and examine the underlying structure of the variables. In the analysis, all the variables in the dataset were included in a single PCA, using the Kaiser Criterion of eigenvalues of over 1.0 and scree plot criteria to determine the number of components to be extracted and varimax rotation to yield maximum discrimination between the scales (Al-Reesi et al., 2013; Paris and Van den Broucke, 2008; Iversen, 2004). The PCA outputs are shown in the result section.

Table 6.1: Advantages and disadvantages of PCA

Advantages	**Disadvantages**
• Reduction of number of variables, by combining two or more variables into	• PCA can be only as good as the data allows.

a single factor. • Identification of groups of inter-related variables, to see how they are related to each other.	• More than one interpretation can be made of the same data factored the same way, and factor analysis cannot identify causality.

6.5.1.2 Cluster Analysis (CA)

Cluster analysis is a statistical technique that classifies data into groups (cluster) of variables or cases. In other words, it is aimed to group homogenous data together and account for potential heterogeneity that exists between groups (De Oňa et al., 2013; Mohamed et al., 2013; Ng et al., 2002). It is often referred to as an unsupervised technique due to the clustering of the variables (or cases) based on certain given similarity or non-similarity distance measures among the variables (or cases). Hence, the variables (or cases) in each group are similar in terms of the given distance criterion. They often share some common characteristics, which are identified and further investigated by the researcher. The similarity-based techniques have been categorized as follows:

(i) hierarchical method (e.g. Ward's method, a single linkage method) and
(ii) partitioning method (e.g. K-means).

Despite the statistical properties of these methods are relatively unknown (Fraley and Raftery, 2002); they have been extensively used in accident studies (Ng et al., 2002; Wong et al., 2004; Pardillo-Mayora et al., 2010).

The probability model-based commonly referred to as Latent Class Clustering (LCC) is another clustering techniques that are commonly used because of the advantages it has over the similarity-based techniques (Moustaki and Papageorgiou, 2005; Vermunt and Magidson, 2002). These advantages include:

(i) the statistical properties of Latent Class Clustering (LCC) are better understood (Fraley and Raftery, 2002). Hence, several statistical criteria that help to decide the most appropriate number of clusters are provided by this method.

(ii) LCC allow probability classifications to be made by using subsequent membership probabilities estimated with maximum likelihood method.

Despite these advantages of Latent Class Clustering (LCC) over the similarity-based techniques, it is inevitable to introduce some kind of subjective judgment in deciding the best results of whatever cluster analysis method used (Hair et al., 1998; Magidson and Vermunt, 2002; Vermunt and Magidson, 2005).

6.5.1.2.1 Number of Clusters Selection

Given that the number of clusters is unknown at the start, the aim is to find the model that can explain or adapt the best clustering pattern for the data being used. In this thesis we have used several information criterions for discovering the model that provides the most information on reality. The criterions are: Bayesian Information Criterion (BIC) (Raftery, 1986), Akaike Information Criterion (AIC) (Akaike, 1987) and Consistent Akaike Information Criterion (CAIC) (Fraley and Raftery, 1998). In clustering contexts, the BIC criterion has shown better performance than other criteria (Biernacki and Govaert, 1999). In general, the lower the value of the indicators, the better the model is, because it is more parsimonious and adapts better to the data. Nonetheless, when analysing large samples, the BIC and other information criteria often do not reach a minimum value with increasing number of clusters (Bijmolt et al., 2004). In that case, the percentage and additional criteria, such as entropy, should be used to select the optimal number of clusters. Entropy varies between 0 and 1, and values over 0.90 denote a clear cluster differentiation; and also the interpretability of the clusters (McLachlan and Peel, 2000).

Although cluster analysis is not a modelling technique, but it can be used to confirm the results of PCA and assist in the selection of the necessary variables of a given dataset to be included in the modelling process. Hence, it can be adopted to improve the accuracy of the estimates from the mathematical models in some previous studies. In this study, cluster analysis was used to confirm and provide better insight about the variables that made up the principal components given by PCA.

6.5.2 Statistical Modelling

Statistical modeling is an activity that results in the mathematical description of a process (e.g. road accidents) in terms of the variables (e.g. time of accident; gender; road type etc.) of the process (Abraham and Ledolter, 2006). It often involves several stages and assumptions depending on the purpose and type of statistical model require. Nevertheless, the derivation of a satisfactory model could be applicable for several different purposes as highlighted below (Abraham and Ledolter, 2006):

6.5.2.1 Purpose of Developing Accident Models

6.5.2.1.1 Description of the Variable

The model could be used to describe the main features of the data. The impact of the explanatory variables on the response is emphasized by the model. Hence, the explanatory variables that need to be changed for the desired response to be obtained can be exposed through the model. Furthermore, those variables that have no impact on the response could be eliminated because there may be little reason to measure or control these variables (Abraham and Ledolter, 2006). In some cases, two or more variables may have correlated impact on the response. Consequently, there may be need to save time and resources by avoiding the measuring of these variables. Statistical models developed from variable reduction techniques (e.g. Principal Component Analysis) enable us to eliminate variables that have identical impact on the response.

6.5.2.1.2 Estimation of the Response

The functional relationship between the response and the explanatory variables (as expressed by the model) enable us to estimate the response from known values of the explanatory variables. In other words, we can infer the response for explanatory variables that were not directly studied (Abraham and Ledolter, 2006).

6.5.2.1.3 Prediction of Future Events

Another useful application of a good statistical model involves the reliable prediction of future events such as the frequency of accidents. Hence, accident models are commonly developed to predict the frequency of accident. The outcome of applying such a model will help transport planners and other government authorities to strategize on how to tackle the problem.

6.5.2.1.4 Saving Valuable Resources

Statistical model obtained by regression analysis may expose that a variable that is difficult and expensive to measure can be explained to a greater extent by other variables that easy and cheap to obtain (Abraham and Ledolter, 2006). Consequently, the substitution of those variables that are difficult and expensive to measure with others which are easy and cheaper to determine will eventually culminate in the saving of valuable resources such as time and money.

6.5.2.1.5 Developing Statistical Model

There are several approaches in developing statistical model which may involve multiple steps depending on the purpose. For instance, statistical model can be derived from a well-developed theory and used for the estimation of unknown parameters and ascertain the robustness of the theory by verifying its consistency with empirical knowledge (Abraham and Ledolter, 2006). Any inconsistencies between theory and data will prompt further modification or improvement of the model and a subsequent verification of the agreement between the revised theory and data (Abraham and Ledolter, 2006). Another common approach of developing statistical model involves starting from the data and use an empirical modelling technique to derive a model that provides a reasonable characterization of the relationship between the parameters (Abraham and Ledolter, 2006).

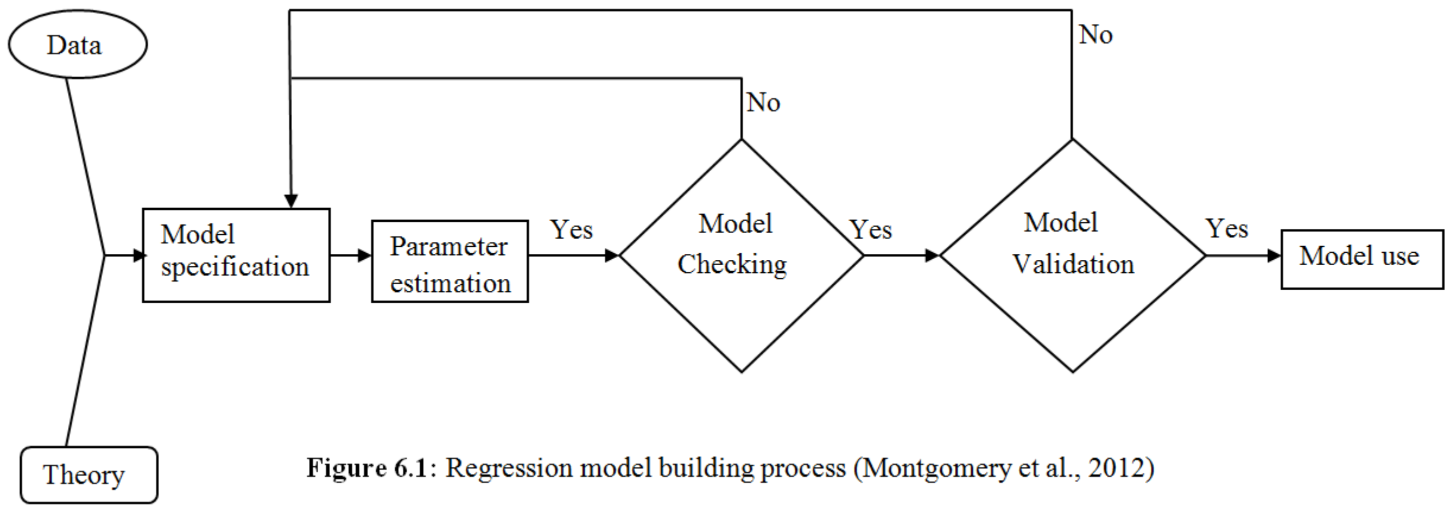

Figure 6.1: Regression model building process (Montgomery et al., 2012)

This approach is typically used in road accident studies and the model obtained from this approach may lead to a new theory which will be subjected to scrutiny to check its consistency with empirical knowledge. Regardless of the approach adopted, the development of a good model involves series of activities that proceed towards convergence as indicated in Figure 6.1. Road traffic accidents are unplanned activities that often results in discrete data. Hence, available theory (e.g. binomial distribution) will suggest certain models that may be appropriate for the accident data.

6.5.2.2 Statistical Modelling Techniques

Considerable research has been conducted on the development of accident prediction models to establish the mathematical relationship between the dependent variable (accident frequency or severity) and explanatory variables (Pulugurtha et al., 2013; Couto and Ferreira, 2011; Elvik, 2011; Dissanayake et al., 2009; Abraham and Ledolter, 2006). These models provide better understanding of the factors influencing accident frequency or its severity (Pulugurtha et al., 2013). Useful information derived from accident models could assist transport planners and policy makers on the best approach to adopt in tackling the scourge of road accidents (Aziz et al., 2013). Consequently, the urgent need for reliable accident models has triggered the development of a wide variety of methods over the years (Savolainen et al., 2011; Elvik, 2011; Lord and Mannering, 2010). Again, the need to overcome the limitations of each of these methods has resulted to the evolution of alternative modelling techniques. Earlier models were based on Multiple Linear Regression which has the assumptions of normally distributed errors and homoscedacity (Caliendo et al., 2007; Chin and Quddus, 2003). However, the restrictive application of this technique in accident studies soon became apparent based on its assumptions (Zegeer et al., 1990; Jovanis and Chang, 1986). This is because accident studies are characterized by count data (which are discrete, non-negative integers and skewed) that does not assume normal distribution. Count data are usually modelled with a Poisson regression which has the prerequisite of the mean of the count data equals its variance (Couto and Ferreira, 2011; Dissanayake et al., 2009; Wedagama et al., 2006; Noland and Quddus, 2004; Chin and Quddus, 2003). However, accident data have been shown to exhibit over-dispersion where the variance significantly exceeds the mean (Caliendo et al., 2007; Lord et al., 2005; Chin and Quddus, 2003). The conventional Poisson regression model has been shown to be inadequate in modelling over-dispersed data and generally underestimates the number of sites with zero accidents (Connors et al., 2013;

Deublein et al., 2013). The root cause of over-dispersion has been attributed to the exclusion of accident variables affecting the site mean in the fitted model (Hauer, 2001). Lord et al. (2005) also demonstrated that only when conditions are homogeneous does the Poisson model provide a good fit; but does not usually fit in heterogeneous conditions which are generally dominated by excess zeroes. Furthermore, they concluded that excess zeroes and over-dispersion are mainly caused by the following factors: (i) spatial or time scales that are too small; (ii) under- or mis-reporting of road accidents; (iii) accident sites that are marked with low exposure and high risk; and (iv) omission of important variables describing the accidents. Poisson regression models are the most basic accident models with the potential of providing easy estimates of the variables. But it does not provide a good fit for over- and under-dispersion count data. It is also adversely affected by the low sample-mean and small sample size bias (Lord and Mannering, 2010). Hence, Poisson regression gives better results when applied to high mean dataset of considerable size. This is because as the mean of the dataset increases, Poisson distribution approximates Normal distribution.

Limitations of conventional Poisson regression model has led to the derivation of other variants such as the generalized linear model framework (McCullagh and Nelder, 1989), where the most common approach is a "quasi-likelihood" with Poisson like assumptions (referred subsequently as quasi-Poisson) or Negative Binomial regression (Poisson-gamma) which has the capacity of modelling over-dispersion count data (Deublein et al., 2013; Pulugurtha and Sambhara, 2011; Lord and Mannering, 2010; Caliendo et al., 2007; Lord et al., 2005; Washington et al., 2003), but cannot handle under-dispersion data and can be adversely affected by the low sample-mean and small sample size like Poisson model (Lord and Mannering, 2010). However, Poisson-lognormal is a more flexible model compared to Negative Binomial regression in dealing with over-dispersion. The disadvantages of Poisson-lognormal models are similar to those highlighted above for Negative Binomial regression, but to a lesser extent. In addition, Poisson-lognormal models cannot estimate a varying dispersion parameter (Lord and Mannering, 2010). It has also been shown that accident data could have excessive zeros since it is an event that rarely occurs; this could be model using the Zero-inflated method. Despite the advantage of handling datasets with a large number of zero-crash observations, the Zero-inflated method can create theoretical inconsistencies and can also be negatively affected by the low sample-mean and small sample bias to a varying degree (Lord and Mannering, 2010). There are several other modelling techniques (with their respective advantages and limitations) that could be applied to accident data that cannot be considered here. However, there is no general rule that establishes the superiority of one modelling technique over another. Instead, empirical evidence from several studies suggests that the superiority of one method over another could depend heavily on data (Savolainen and Mannering, 2007). In other words, the nature of the accident data will influence the choice of the appropriate modelling techniques that will be required.

6.5.2.3 Modelling Pilgrims' Pedestrian Casualties

6.5.2.3.1 Selection of Modelling Techniques

It is important to select the appropriate modelling technique in order to obtain valid accident models. Hence, several important assumptions or criteria have to be met to ascertain the robustness and applicability of the models developed in real world situation. Based on the advantages highlighted in the previous section, the quasi-Poisson and the Negative Binomial regression models were chosen to analyse the pilgrims' pedestrian casualty data. Both modelling techniques have the capacity to overcome the possible restrictions (e.g. over- or under-dispersion) associated with normal Poisson models (McCullagh and Nelder, 1989). Again, the application of quasi-Poisson and Negative Binomial regression on the accident data enable comparison of both modelling techniques to ascertain which one better explain the data.

6.5.2.3.2 Quasi-Poisson and Negative Binomial regression

The conventional Poisson regression is the basis of quasi-Poisson and Negative Binomial regression models, both being among the most widely used generalized linear models due to their ability to handle over-dispersed data commonly encounters in real life situations such as road accidents. Poisson regression assumes the dependent variable (Y) has a Poisson distribution which approximate Normal distribution as the mean of the dataset increases. Hence, the link function is used to transform the dependent variable (Y) in generalized linear models. If *Y* be a random variable such that: the expectation *E(Y)* is equivalent to mean (μ) of the distribution.

$$\mathrm{var}(Y) = \nu\mathrm{poi}\ (\mu) = \theta\mu \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where var*(Y)* is the variance of *Y*;

$\nu poi\ (\mu)$ is the variance of a Poisson distribution;

$\mu > 0$ (characteristic of count data with non-negative integer);

and $\theta > 1$ (θ is the over-dispersion parameter).

As expressed in Eq 1, the close relationship between the expectation and the variance of a Poisson distribution along with the use of a log link function to transform the expectation *Y* to approximate Poisson distribution (denoted as $Y \sim$ Poi (μ, θ). Hence, this is referred to as a "quasi-Poisson" model. The logarithm of the response variable is linked to a linear function of the explanatory variables. For this reason, Poisson regression model is sometimes known as a log-linear model as expressed by the equation below:

$$\mathrm{Log_e}(Y)_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \ldots + \beta i X i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

The above equation can also be expressed in the exponential form:

$$Y = exp^{(\beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 \ldots + \beta iXi)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots......(3)$$

In other words, the typical Poisson regression model expresses the Log outcome rate (e.g. number of pedestrians killed) as a linear function of a set of predictors (e.g. Land use, Road type and Junction details). The quasi model derivation as shown in Equations 3 and 4, can be easily be interpreted and compared with similar models. It also allows standard model diagnostics without a loss of efficient fitting algorithms.

Negative binomial distribution can also be used in modelling over-dispersed data because it take into consideration the effect of unobserved heterogeneity due to omitted variables (Pulugurtha et al., 2013). The random variable *Y* having a Negative Binomial distribution can also be denoted as $Y \sim$ NB(μ, α). The negative binomial dispersion parameter addresses the difference between the variance and mean of the over-dispersed data as shown in Eq 1 (McCullagh and Nelder, 1989):

$$Variance = \sigma^2 = \nu_{NB}\ (\mu) = \mu + \alpha\mu^2 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(4)$$

Where σ^2 is the standard deviation of crashes;

$\mu > 0$ (the estimated mean number of crashes);

and $\alpha > 0$ (the negative binomial dispersion parameter).

In contrast to the quasi-Poisson, the over-dispersion (the amount in excess of μ) is the multiplicative factor $1+ \alpha\mu$, which depends on the mean (μ). An important difference between these two modelling techniques as deduced from Eqs 1 and 4, is that for Poisson, the variance is linearly related to the mean, whereas for Negative Binomial the variance is quadratic in the mean. These two techniques are widely applied because the mean which is a single and common parameter of both methods can vary as a function of covariates.

6.5.2.3.3 Selection of Variables for the Accident Models

Since the purpose of this study was to establish the relationship between land use and pilgrim pedestrian casualties in Madinah, it was necessary to include in the accident models those variables that describe both the land use type (including its related variables) and the severity of casualties of the victims.

6.5.2.3.3.1 Dependent Variables

The dependent variable investigated was pedestrian injury severity which has been categorized into two levels: (i) seriously injured and (ii) killed.

6.5.2.3.3.2 Independent Variables

Since the identification of the land use type and those hazardous road locations that are more prone to pedestrian casualty are usually the first step in improving pedestrian safety (Yao and Loo, 2012), covariates that describes the land uses and those related to it (e.g. road type and junction details) were investigated to accomplish the purpose of this research which is aimed at establishing the relationship between the pilgrims' pedestrian casualty (either seriously injured or killed) and land use type of Madinah. These variables were grouped into three categories: (a) Land use; (b) Road types and (c) Junction details. The Districts of Madinah was excluded in developing the model because it overlaps the attributes of the covariates mentioned above. If included, it will serve as duplication and possibly increase the error in the model. The independent variables used for this study are concisely described below:

6.5.2.3.3.2.1 Land Use Types

Land use as a principal determinant of trips is one of the main factors that influence the frequency of crashes (Dissanayake et al., 2009; Wedagama, et al., 2006). Hence, different land use patterns would generate or attract different number of pilgrim pedestrians. Hence, the different land use patterns may lead to different pedestrian casualty rates (Dissanayake et al., 2009). The land use variables selected were categorized as follows: Agriculture, Government Offices, Accommodation, Commercial, Residential and Religious.

6.5.2.3.3.2.2 Road type

Road Type characteristics comprises of the following: Unknown roads, Single carriageway – 4+ lanes, Single carriageway – 3 lanes, Single carriageway – 2 lanes, Single carriageway – single track, Dual carriageway – 3+ lanes, Dual carriageway – 2 lanes, One way street and Roundabout (these include large and signalised roundabouts). Standard roundabouts are included in junction types).

6.5.2.3.3.2.3 Junction details

Junction Details (Other junction, Private drive or entrance, Multiple junction, Crossroads, Slip road, T, Y or staggered junction, Mini-roundabout, Roundabout (these don't include include the large and signalised roundabouts, which are included in Road type and Not at junction or within 20 metres).

6.5.2.4 Analysing the Accident Data

As previously stated, the accident data for this research was saved in SPSS package as *pilgrim pedestrian casualties.sav.* for analyses which comprises of two sections, namely: the preliminary and the advanced analyses. In the preliminary analysis, the dataset was analyzed using SPSS for descriptive statistics purposes. In addition, the spatial distribution of the pilgrims' pedestrian casualties was done manually using graduated symbols; the absence of GIS co-ordinates for the study area does not permit the use of automated process such as GIS software. Furthermore, to accomplish the aims and objectives of this study requires advanced analysis commonly referred to a modelling. Therefore, the dataset was analyzed also using SPSS to establish the relationship between pilgrims' pedestrian casualties and land use type of Madinah Municipal Province, Saudi Arabia. The resulting models can assist in determining which land use in Madinah that are most susceptible to pilgrims' pedestrians casualties. Real accident data of pilgrims' pedestrian casualties from 2001 to 2005 was collected from the Madinah Traffic Police Department for this research. In addition, the 2010 accident data was also analyzed for the validation of the models. In this case, quasi-Poisson developed by McCullagh and Nelder (1989) was used to overcome the restricted assumptions of variance must be equivalent to the mean. Furthermore, Negative binomial regression method was also applied to the data to enable comparison of the two techniques that fits the accident data the most. Using quasi-Poisson, models for seriously injured and killed were developed for each category namely: Prayer Time; Non-Prayer Time; High Season; Low Season; Islamic Weekday and Islamic Weekends. Hence, twelve quasi-Poisson models were developed. Similarly, the process was repeated using Negative binomial regression, which also produced twelve models. Therefore, we have a total of twenty-four models for the main research data. Again, the above process was repeated for the 2010 accident data for validation purposes. The results of the descriptive statistics, graduated symbols and models are presented in Chapter eight.

6.6 Summary

Accident data are meaningless if not properly analyzed. This Chapter discusses broad aspects of methods used for the analysis of accident data. The pilgrims' pedestrian casualty data has been described. It was collected from the Madinah Traffic Police Department and comprises of several variables such as the year, month, week, day and time of the accident. It also emphasized the gender, age and nationality of the pedestrian victims as well as the districts and land use types the accident occurred. As a result of the complexity of the data, it was restructured to make it suitable for the purpose of this research. Hence, it was categorized into six categories namely: Prayer Time; Non-Prayer Time; High Season; Low Season; Weekend and Working Days.

Analysis of the accident data involves two aspects namely: preliminary and advanced analysis. The preliminary analysis involves using SPSS to analyze the data for descriptive statistics purposes. Furthermore, the absence of GIS co-ordinates in Madinah prompted the need to undertake the spatial distribution of pilgrims' pedestrian casualties manually using graduated symbols. However, the advanced analysis of the accident data also involves two aspects. PCA and Cluster analysis was demonstrated as vital tools for removing redundant variables from a multivariate dataset. If properly applied, these techniques have the potentials for saving time and resources by enabling researchers to focus on those variables that would better describe the dataset. In addition, statistical modelling of accident data was discussed. Its importance was highlighted to include for the description of variables and estimation of the response. It could also be used for predictive purposes such as predicting the frequency of pedestrian/ motor vehicle collisions . This will enable transport planners to budget appropriately in tackling pedestrian/ motor vehicle collisions . Consequently, valuable time and resources will be saved.

Selection of the appropriate modelling techniques was stressed in order to overcome their limitations. In this study, Poisson and Negative binomial regressions were discussed and applied to the dataset to ascertain which method fits the data best. These methods were also applied to the 2010 accident data of Madinah for validation purposes. The appropriate selection of the dependent and independent variables were also stressed to optimize the outcome of the modelling process.

Chapter Seven: Results and Discussion

"The life work of the engineer consists in the systematic application of natural forces and the systematic development of natural resources in the service of man" – **Harry Walter (H.W.) Tyler**

Chapter Seven: Results and Discussion

7.1 Introduction

Results from the analyses of the pilgrims' pedestrian accident data are presented in this Chapter. Because several analyses were performed on the data, the results are presented into two different sections in this Chapter for better understanding of the outputs from the analyses and their interpretations. The first section will discuss results from the preliminary analyses which will include: the descriptive statistics and spatial distribution of pilgrims' pedestrian casualties in Madinah. While the second section will discuss results from the advanced data analyses obtained from data reduction tcechniques such as PCA and Cluster analysis. In addition, the results from the statistical modelling will also be discussed in this Chapter. The important findings deduced from the results will be highlighted.

7.2. Preliminary Analysis

7.2.1 Descriptive Statistics

This section focuses on the results of the preliminary analysis to identify the relationship between the variables considered in this study, which include: gender, age, nationality, time of the day, day of the week, and month of the year. A brief investigation of these factors will help in a better understanding of the relationship between these factors and the accidents. The results show that pedestrian casualty was gradually increasing in Madinah over the years as indicated in Table 7.1 and illustrated in Figure 7.1. In 2001, the frequency of pedestrian casualty was 390 and progressively increased to 496 in 2005. This is an indication of the growing trend of the population of Muslims making Holy pilgrimage to Makkah and other religious cities such as Madinah over the years. The pilgrim pedestrian casualty ranges from 5 to 104 years over the period of investigation. The most affected are the youth age category ranging from 16 to 50 years, which are the economically viable people that are supposed to contribute to national development. Again, the male and female pedestrian casualty were 1296 and 905, respectively. This result corresponds to 59% and 41% for male and female, respectively (Figure 7.2). The male to female pedestrian casualty ratio was 1.4:1, which is similar to those obtained from other road accident studies in Arab-Muslim countries which also recorded higher male casualty compared to female. The results reflect a greater tendency of males making Holy pilgrimage to Makkah and other religious cities like Madinah. According to the statistics for pilgrimage seasons for the past three years, about 52% of pilgirms were male and 48% of themn were female pilgrims who embarked on the Holy trip or visit religious sites. Although the disparity between male and female pilgrim pedestrian casualty in Madinah was not as wide as those recorded in other Arab-Muslim countries. In other Muslim-Arab cities, the difference between male and female accident casualty is as high as 6:1. The not so wide disparity between male and female casualty may be attributed to the fact that Madinah is a religious city strictly reserved for Muslim like Makkah. Hence, most of its land uses are for religious purposes which also attract more women to make pedestrian trips than other Muslim-Arab cities which are less involve in religious activities.

Table 7.1: Frequency of pilgrim pedestrian casualty from 2001 to 2005.

Accident Year	Frequency	Percent
1421 (2001)	390	17.7
1422 (2002)	396	18.0
1423 (2003)	458	20.8
1424 (2004)	464	21.1
1425 (2005)	496	22.5
Total	**2204**	**100.0**

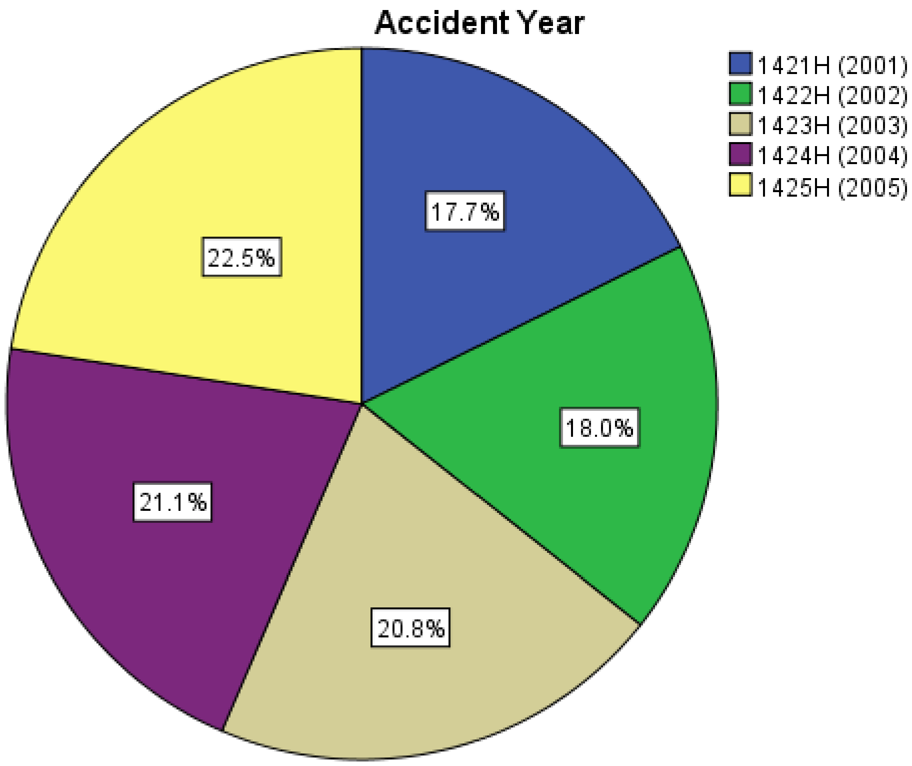

Figure 7.1: Pilgrim pedestrian casualties of the various years from 2001 to 2005

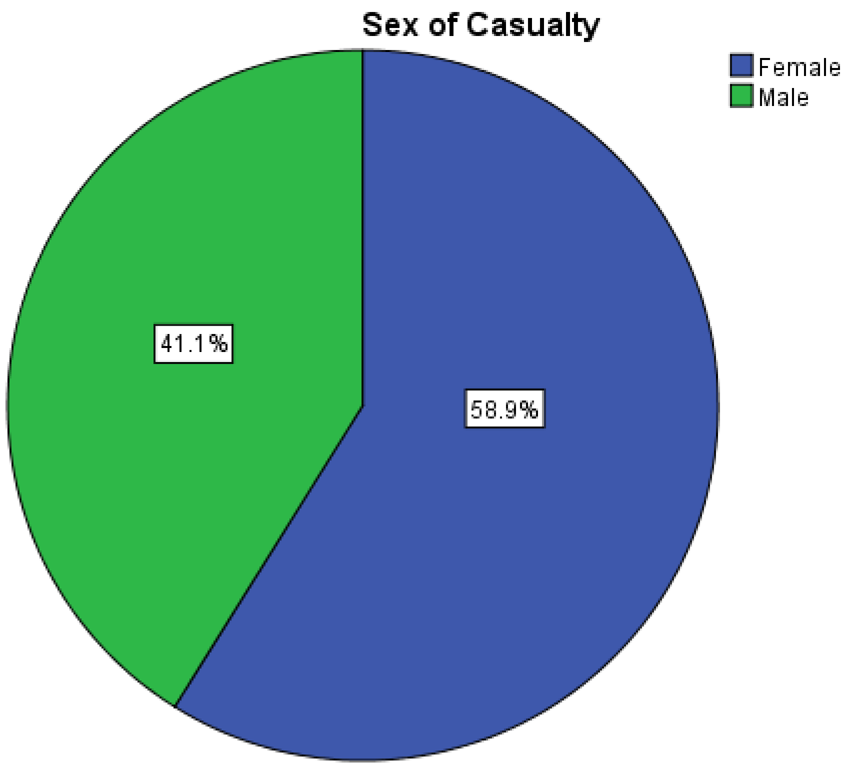

Figure 7.2: The distribution of pilgrim pedestrian casualty based on sex.

The results show that male pilgrims are more susceptible to pedestrian accidents than female in Madinah as indicated over the 5 years period (i.e. 2001–2005). This slightly higher male pedestrian casualty may be attributed to several factors (e.g. risk taking; nature of active life; the tendency to make a pedestrian trip; difference in profession; Islamic culture etc.). For instance, male pilgrims are likely to take greater risk than their female counterpart. In general, Muslim men are more active than the women and may have indulged in more pedestrian activities than the women. The Islamic culture may also contribute to this disparity in frequency of casualty between male and female pilgrim pedestrians. In most Muslim cities, including Madinah, women are restricted from certain social activities (Moaddel, 1998; Meeky, 1984). A typical example is the ban of women from driving vehicles in Saudi Arabia which makes them less susceptible to road traffic accidents. Again, men are capable of travelling alone in Saudi Arabia, whereas women need to be accompanied, therefore the increased frequency of male accidents is not unusual. In most Muslim countries, the women are more engaged in domestic activities and reluctant to embark on pedestrian trips. Most men are the breadwinners of the family, hence indulge in more pedestrian trips than the women that prefer to cater for the children at home and engage in other domestic activities.

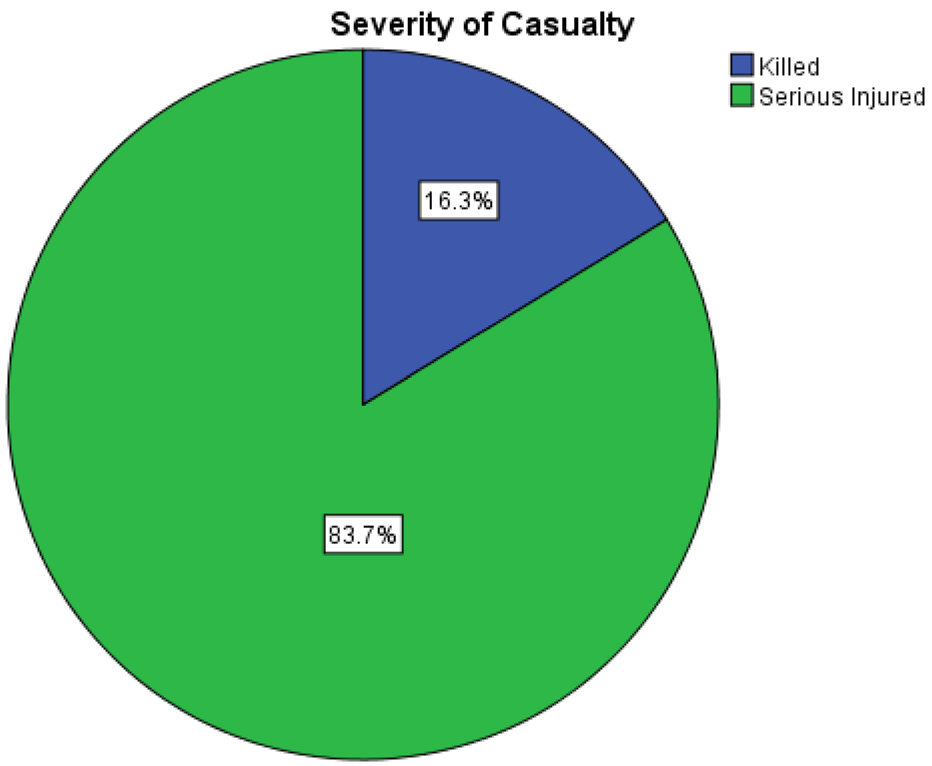

Figure 7.3: Severity of casualty of pedestrian pilgrims.

As indicated in Figure 7.3, the majority of accidents are not fatal during the five years period considered in this study. Only about 16.3% of the pilgrims were killed while a vast majority (about 83.7%) of the pilgrims experiencing a casualty sustained serious injuries. In terms of number of persons, more men (i.e. 290) are killed compared to women (i.e. 150). Similarly, 1087 male pilgrims sustained serious injuries compared to 755 female (which were in excess of 332 male). This may be justified considering the fact that greater number of male embarks on pilgrimage compared to their female counterpart. However, a detailed breakdown of the severity of casualty as shown in Table 7.2 revealed that the values are almost identical for both male and female casualties as a proportion of the total casualties within their category, with 16.1% and 16.6% killed and 83.9% and 83.4% seriously injured respectively. The severity of pilgrims' pedestrian casualty in Madinah is unusual compared to results obtained from other accident studies which often indicate that women are more prone to be killed or sustaining serious injuries in road accidents compared to men. Again, these unusual results may be attributed to the predominant land use of the city which is religious. Hence, more women are eagerly engaged in religious activities in Madinah compared to other Muslim-Arab cities apart from Makkah.

Table 7.2: Gender and Severity of Casualty of pedestrian pilgrims

Sex of Casualty	Frequency	Percent
Male Killed	209	16.1
Serious Injured	1087	83.9
Total	1296	100.0
Female Killed	150	16.6
Serious Injured	755	83.4
Total	905	100.0

Road type also plays a crucial role in accident severity as indicated in Table 7.3. The highest casualty occurred on 2 lanes single carriageway which recorded 275 fatalities and 1387 persons seriously injured as indicated in Figure 7.4. Whereas the least casualty occurred at a roundabout which resulted in the death of 2 persons and 33 others injured. The vast majority of accidents eventually result in serious injury. There are 3 death and 23 injured person that could not accounted for based on the road type, which is normal for a road accident research where certain information are sometimes not reported. Most of the roads around the Holy Mosque are single carriageway-2 lanes (around 50%), it is strikingly clear that this kind of roads are responsible for inducing the vast majority of accidents in both male and female pilgrims, accounting for 75.7% and 75.1% of casualties respectively.

Table 7.3: Severity of Casualty and Road Type

Road Type			Frequency	Percent	Valid Percent	Cumulative Percent
.	Valid	Killed	1	50.0	50.0	50.0
		Serious Injured	1	50.0	50.0	100.0
		Total	2	100.0	100.0	
Roundabout	Valid	Killed	2	5.7	5.7	5.7
		Serious Injured	33	94.3	94.3	100.0
		Total	35	100.0	100.0	
One way street	Valid	Killed	25	18.1	18.1	18.1
		Serious Injured	113	81.9	81.9	100.0
		Total	138	100.0	100.0	
Dual carriageway - 2 lanes	Valid	Killed	30	21.6	21.6	21.6
		Serious Injured	109	78.4	78.4	100.0
		Total	139	100.0	100.0	
Dual carriageway - 3+ lanes	Valid	Killed	6	12.8	12.8	12.8
		Serious Injured	41	87.2	87.2	100.0
		Total	47	100.0	100.0	
Single carriageway - single track	Valid	Killed	10	14.3	14.3	14.3
		Serious Injured	60	85.7	85.7	100.0
		Total	70	100.0	100.0	
Single carriageway - 2 lanes	Valid	Killed	275	16.5	16.5	16.5
		Serious Injured	1387	83.5	83.5	100.0
		Total	1662	100.0	100.0	
Single carriageway - 3 lanes	Valid	Killed	5	16.1	16.1	16.1
		Serious Injured	26	83.9	83.9	100.0
		Total	31	100.0	100.0	
Single carriageway - 4+ lanes	Valid	Killed	2	3.7	3.7	3.7
		Serious Injured	52	96.3	96.3	100.0
		Total	54	100.0	100.0	
Unknown	Valid	Killed	3	11.5	11.5	11.5
		Serious Injured	23	88.5	88.5	100.0
		Total	26	100.0	100.0	

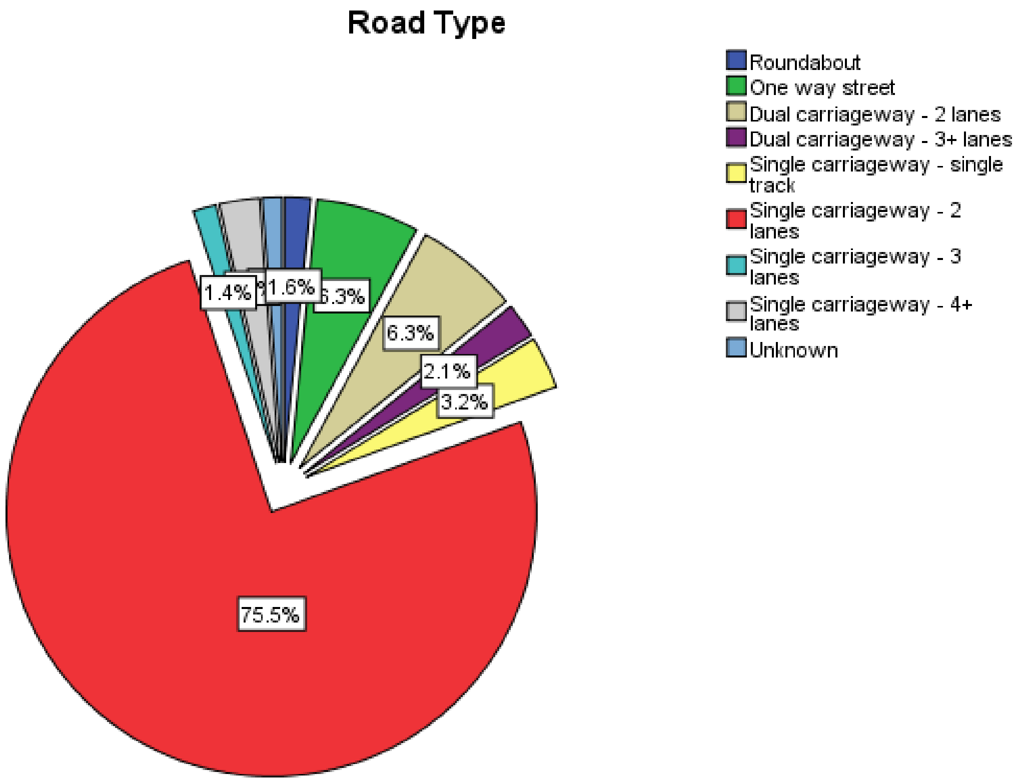

Figure 7.4: Severity of pilgrim pedestrian casualty based on road type.

When taking into consideration the road type, the number and nature of accidents could perhaps be attributed to the issue of cars, and other motorized vehicles being driven on the right hand side of the road as opposed to the left, which could confuse the foreign national pilgrims. However, several of the countries in the sample also drive on the right-hand side in their respective countries.

Table 7.4: Pilgrims' pedestrian casualties at junction based on gender.

Sex of Casualty			Frequency	Percent	Valid Percent	Cumulative Percent
.	Valid	Not at junction or within 20 metres	2	66.7	66.7	66.7
		T, Y or staggered junction	1	33.3	33.3	100.0
		Total	3	100.0	100.0	
Male	Valid	Not at junction or within 20 metres	576	44.4	44.4	44.4
		Roundabout	35	2.7	2.7	47.1
		Mini-roundabout	7	.5	.5	47.7
		T, Y or staggered junction	464	35.8	35.8	83.5
		Slip road	6	.5	.5	84.0
		Crossroads	127	9.8	9.8	93.8
		Multiple junction	23	1.8	1.8	95.5
		Private drive or entrance	22	1.7	1.7	97.2
		Other junction	36	2.8	2.8	100.0
		Total	1296	100.0	100.0	
Female	Valid	Not at junction or within 20 metres	379	41.9	42.0	42.0
		Roundabout	21	2.3	2.3	44.3
		Mini-roundabout	3	.3	.3	44.6
		T, Y or staggered junction	332	36.7	36.8	81.4
		Slip road	5	.6	.6	81.9
		Crossroads	94	10.4	10.4	92.4
		Multiple junction	21	2.3	2.3	94.7
		Private drive or entrance	18	2.0	2.0	96.7
		Other junction	30	3.3	3.3	100.0
		Total	903	99.8	100.0	
	Missing	System	2	.2		
	Total		905	100.0		

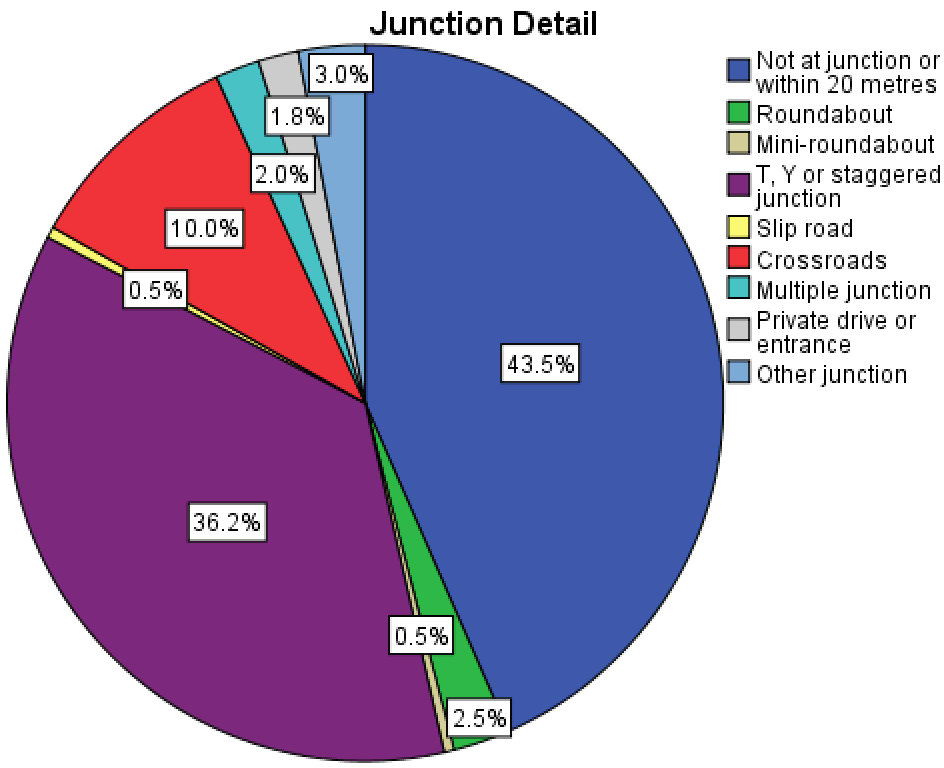

Figure 7.5: Pilgrim pedestrian casualty based on Junction details.

Nevertheless, when taking into consideration junction design, again there appears to be very little disparity between male and female pilgrims as evidenced in Table 7.4 above. Although taking all junctions together, the majority of accidents occur at these locations, the singlest biggest locational category is not at a junction or within twenty metres. Most of the accidents occurred not at junction or within 20 metres of the junction (43.5%) as shown in Figure 7.5. The results indicate that the majority of accidents appear to occur in proximity to junctions or close to T, Y or staggered junctions. Although there are no readily available official statistics about the different kinds of junctions, motor accidents are more prevalent at, or around junctions due to the concentration of conflicting in speeds and changing direction of vehicles. The least number of accident occurred around Slip road (0.5%) and mini-roundabout (0.5%), which is followed by the private driveway or entrance (1.8%). Pilgrim casualties and junction design are similar to the findings for nationality. Again T, Y and staggered junctions are key sites for accidents.

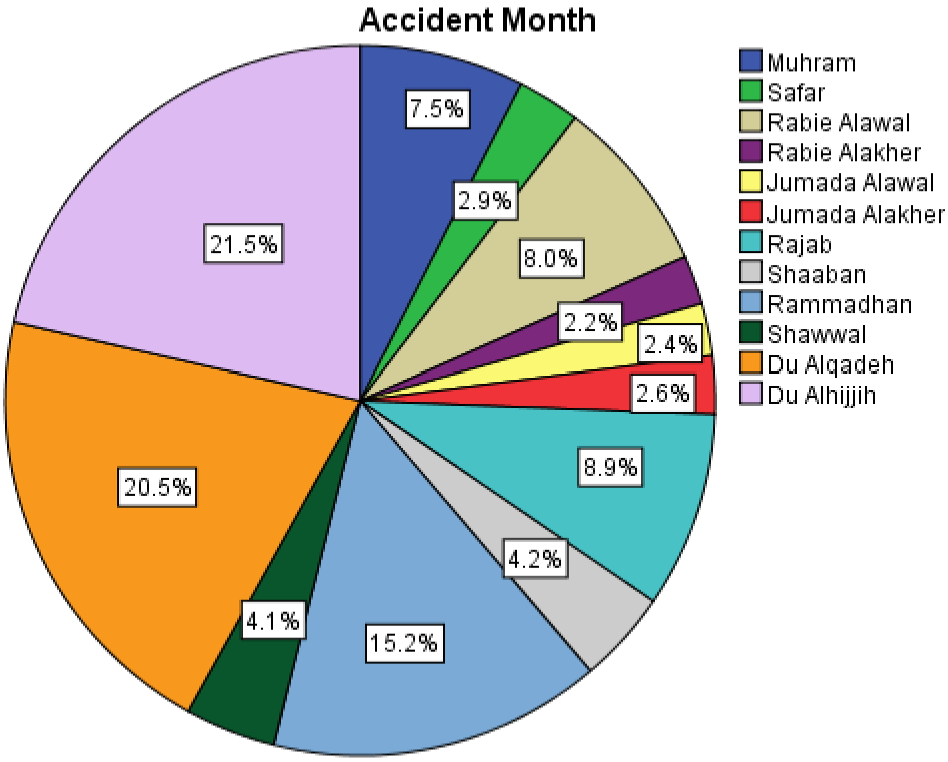

Figure 7.6: Distribution of pilgrims' pedestrian casualty according to Months.

The data also indicates that with regards to the seasonality of casualties, male and female pilgrims appear to have accidents around the same time of year, i.e. during similar months as shown the Figure 7.6. It should be highlighted that the Islamic calendar is the one adopted for this study since pilgrimage time is conducted according to this Hijri calendar (the season of Hajj time corresponds to the 11th and 12th months of the Islamic calendar, and these cannot be defined for the Western calendar since the time of Hajj is fixed in the Islamic calendar but changeable in the Western one; the Islamic year is 11 days shorter than the Western one). The seasonality of accidents was obvious during the three months of Du Alhijn (21.5%), Du Alqadeh (20.5%) and Rammadan (15.2%). These are important months in the Islamic calendar, and there are significantly greater numbers of pilgrims during these periods, hence the rise in the number of casualties is anticipated. It is perhaps understandable that pilgrim accidents are more prevalent during the three aforementioned months because as stated pilgrim numbers are often significantly higher during these periods, and given the international nature of arriving pilgrims and their lack of local knowledge regarding local road network.

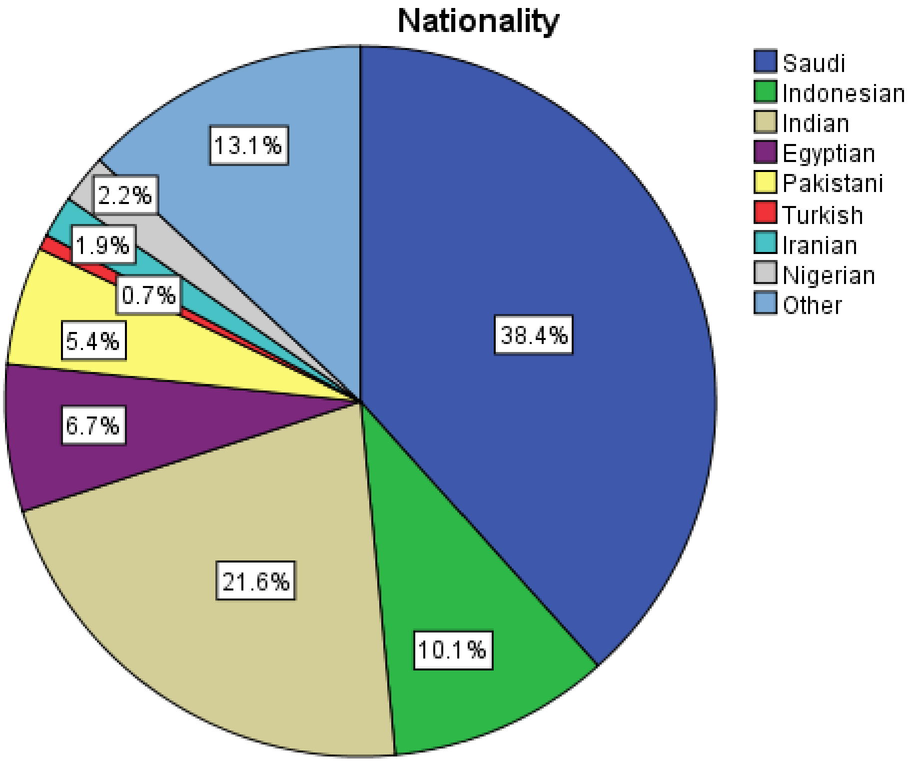

Figure 7.7: Distribution of pilgrims' pedestrian casualty based on nationality

In terms of nationality, Saudis are the most affected in terms of pedestrian casualty (Figure 7.7). The fact that Saudis are more likely to perform Hajj (last year around 50 % or the pilgrims were Saudis), explains the statistics that the percentage of accidents for Saudis was higher than other nationalities. Nevertheless, from the percentages given, there are similar numbers between the pilgrims from the other countries mentioned in Figure 7.7.

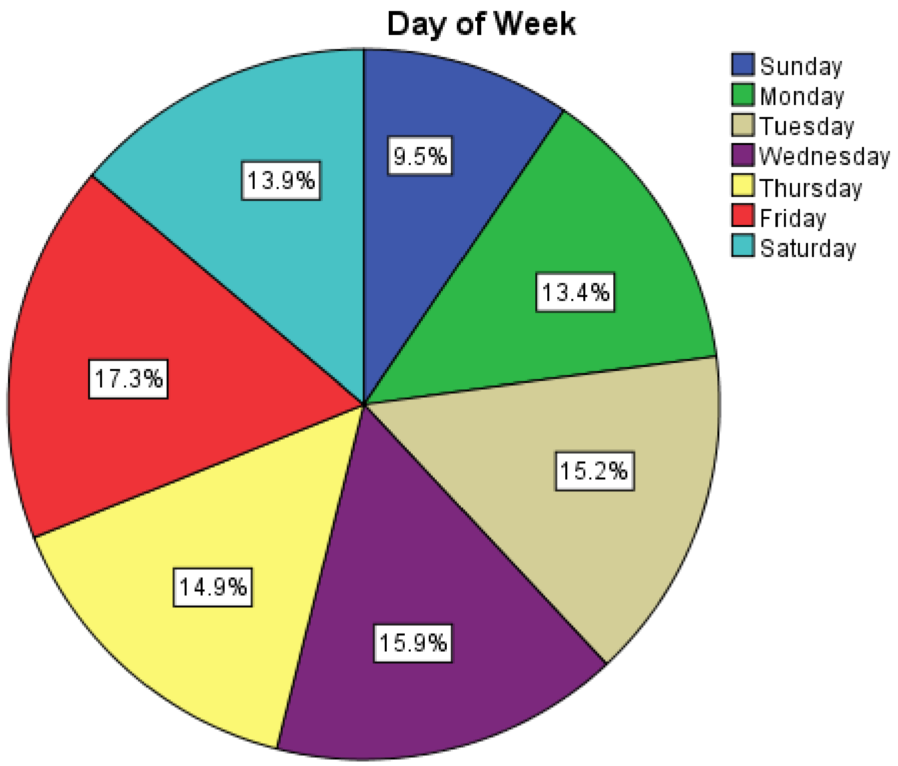

Figure 7.8: Distribution of pilgrims' pedestrian casualty in the days of the week.

The distribution of pilgrim pedestrian casualty in the days of the week shows that the highest casualty occurs on Friday which is the peak of Muslim religious activities of the week. As shown in Figure 7.8, for Friday the casualty was 17.3% and lowest for Sunday (9.5%). Although there is no much disparity of pedestrian casualty among the days of the week, but the slight increase in the number of accidents that took place on Friday, which is an important day for worship for Muslims, and a slight decrease in the number of causalities on Sunday, pilgrim casualties appear fairly consistent over the week.

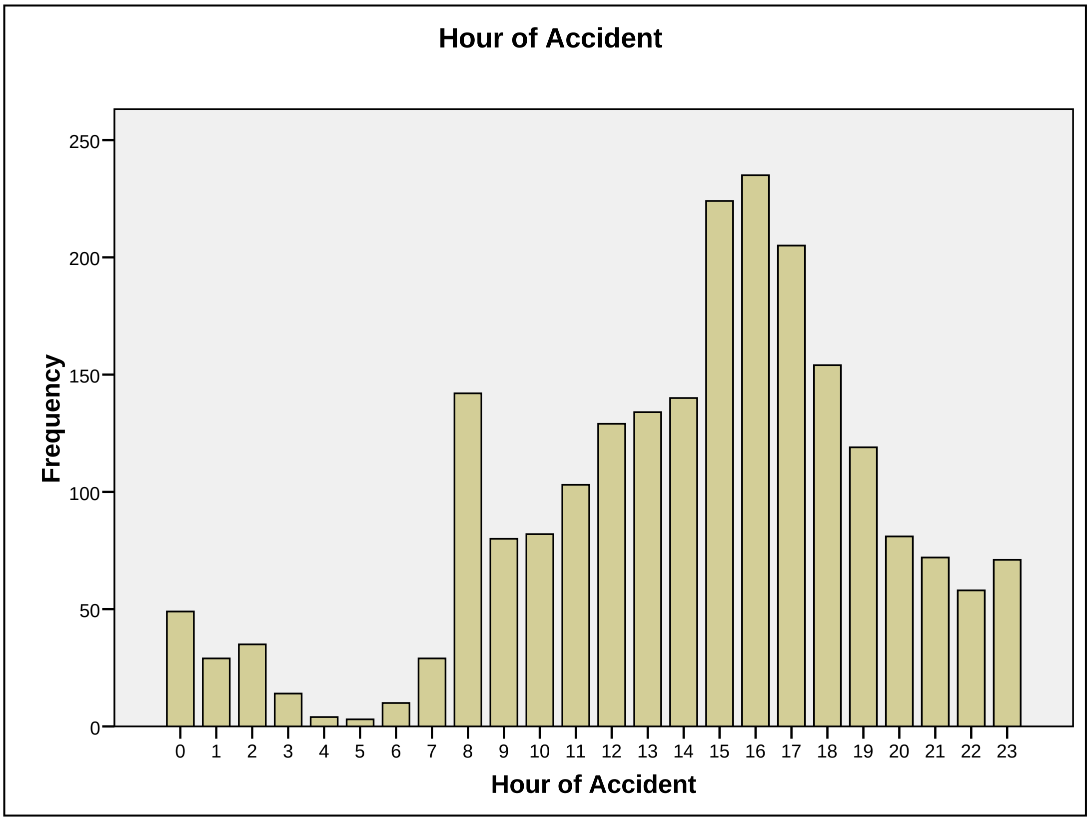

Figure 7.9: Distribution of pilgrims' pedestrian casualty based on time of accident.

If we also consider time of day and accident frequency, as shown in Figure 7.9 above, it was clear that accidents are more prevalent between the hours of 15.00 and 18.00 which is the peak of certain activities such as students returning from schools and workers also leaving their place of work. However, there was a drastic reduction in the number of accidents during the early hours of the morning, as would be expected since there was no traffic at such times as pilgrims go to perform the dawn prayer. However, there was a sharp increase in accidents from 8.00 due to travellers leaving their accommodation to begin their daily activities, and also workers leaving to work.

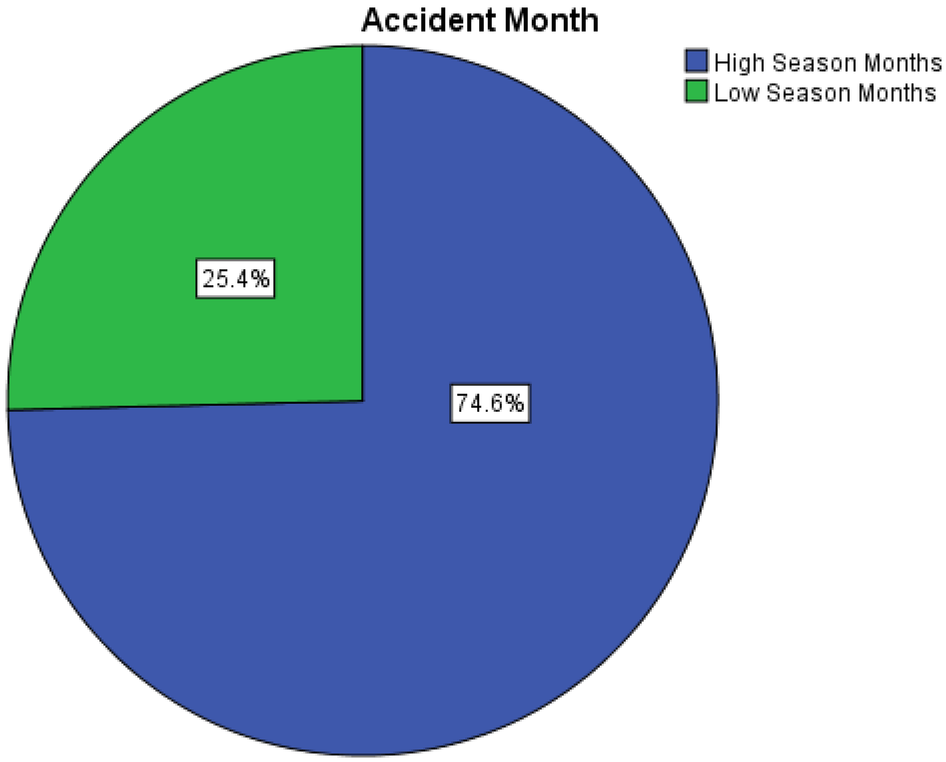

Figure 7.10: Pilgrims' pedestrian casualties during high and low season months

Figure 7.10 shows that almost three-quarter of the pilgrim pedestrians sustained their casualties during high season months. This is expected considering the enormous number of pilgrims that travel to Madinah during these sacred months of Islamic calendar. Hence, the probability of collision between pedestrians and vehicles are very high during high season months compared to low season months.

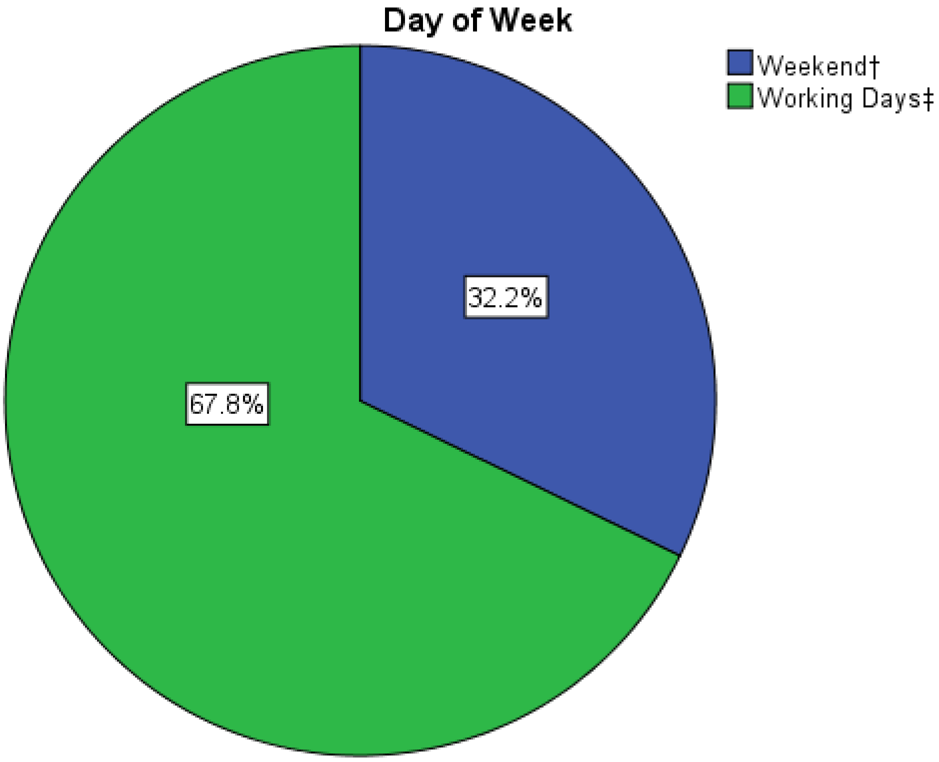

Figure 7.11: Pilgrims' pedestrian casualties during weekends and working days

About 68% of pilgrim pedestrians suffer casualty during working days. In contrast, about only 32% of pilgrims sustained casualty. In Madinah, the working days are very busy because of business activities. Most pilgrim pedestrians have the opportunity to go to the various retail or shopping complex, museums and other religious sites or resorts during the working days. Hence, pilgrim pedestrians interact more with vehicles during the working days than weekends when they prefer to relax at home (or accommodation).

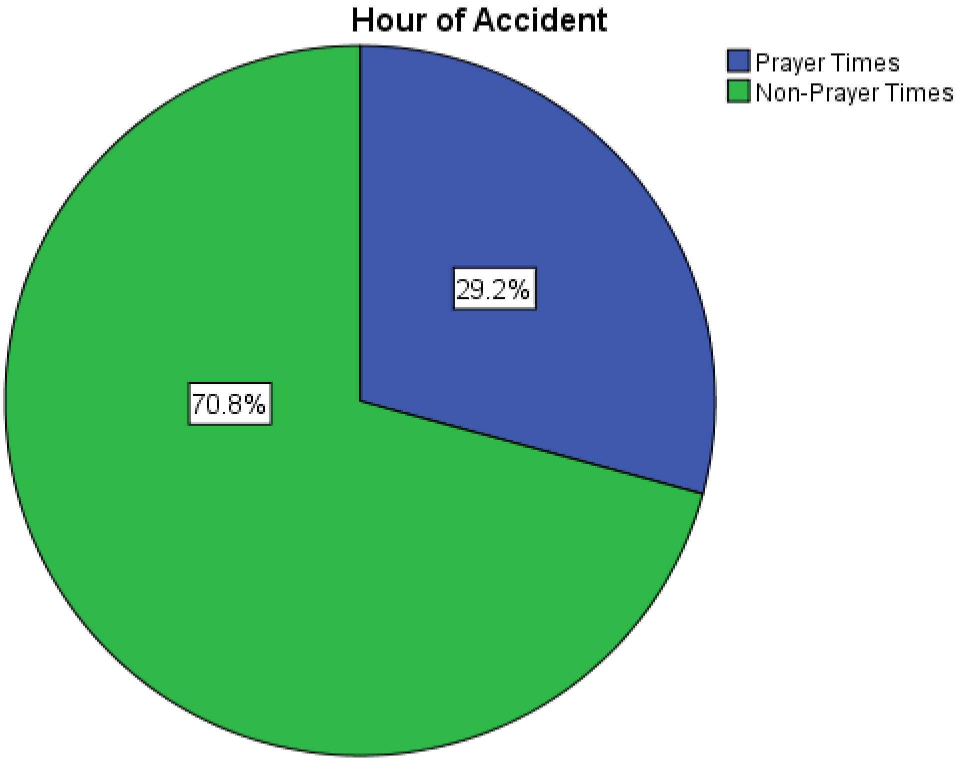

Figure 7.12: Pilgrims' pedestrian casualties during prayer and non-prayer times

During prayer time, most of the pilgrim pedestrians would either be in the Mosque or residence fulfilling their obligation to pray. Consequently, they will interact less with vehicles. However, they are more exposed to vehicles during non-prayer time resulting in more casualties during this period. Figure 7.12 shows that 70.8% of pilgrim pedestrians were either killed or seriously injured during non-prayer time. In contrast, only 29.2% of pilgrim pedestrians suffers casualty during prayer time.

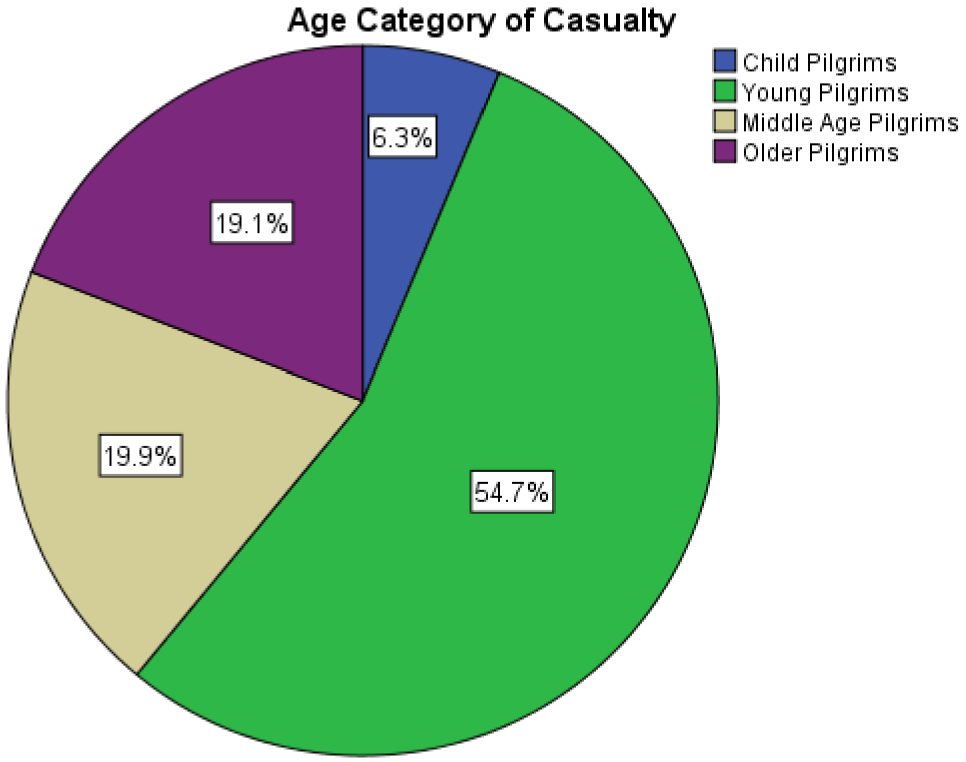

Figure 7.13: Pilgrims' pedestrian casualties based on age category.

In terms of age category, young pilgrim pedestrians (age range of 12-20 years old) suffer the most casualty. While the least casualty was recorded for child pilgrim pedestrians (under 12 years old) as illustrated in Figure 7.13. This may be attributed to the risk taking of the young pilgrim pedestrians and they are more active than other age categories. Furthermore, the young pilgrim pedestrians embarked on pilgrimage than the other age categories. In contrast, children are more likely to refrain from pedestrian activities due to their fragility. Again, the population of children that embark on pilgrimage is far less than other age categories. Hence, the probability of children interacting with vehicles is far less than other categories with vehicles

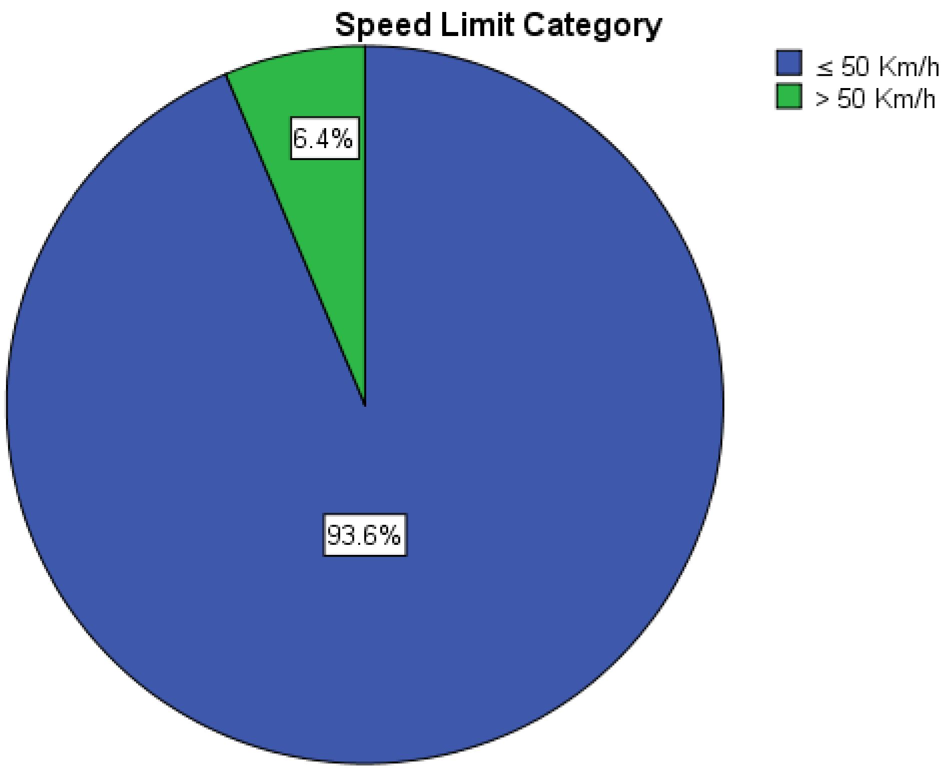

Figure 7.14: Pilgrims' pedestrian casualties based on the speed limit of vehicle involved

More pilgrim pedestrians are killed at speed less than 50 km/h due to several reasons which may include that most vehicles travel with speed limit required by the law around the land use type (i.e. less than 50 km/h). Hence, more pilgrim pedestrians interact with vehicles travelling at less than 50 km/h.

7.2.2 Distribution of Pedestrian Casualty Using Graduated Symbols

Graduated symbols are tools in GIS mainly to illustrate the distribution of entities (e.g. accident casualty) based on magnitude (or size). Despite several land uses (e.g. religious; commercial; residential; accommodation; agricultural; government offices) dominates the landscape of Madinah, the highest pilgrims' pedestrian casualties occur within the first ring road which has presumably has the highest traffic levels and population (or crowd) of pilgrims' pedestrians at a given period. The land use in a given district may not be entirely homogeneous. In other words, there may be residential land uses occurring within commercial or agricultural land use. Despite this ambiguity, care was taken to assert the predominant land use whenever such overlapping of land uses was encountered. Some interesting patterns regarding the relationships between pilgrims' pedestrian casualty and land use can be deduced from the overlay map using graduated symbols:

- The frequency pilgrims' pedestrian casualty by district.
- The frequency of pilgrims' pedestrian casualty by land use category.

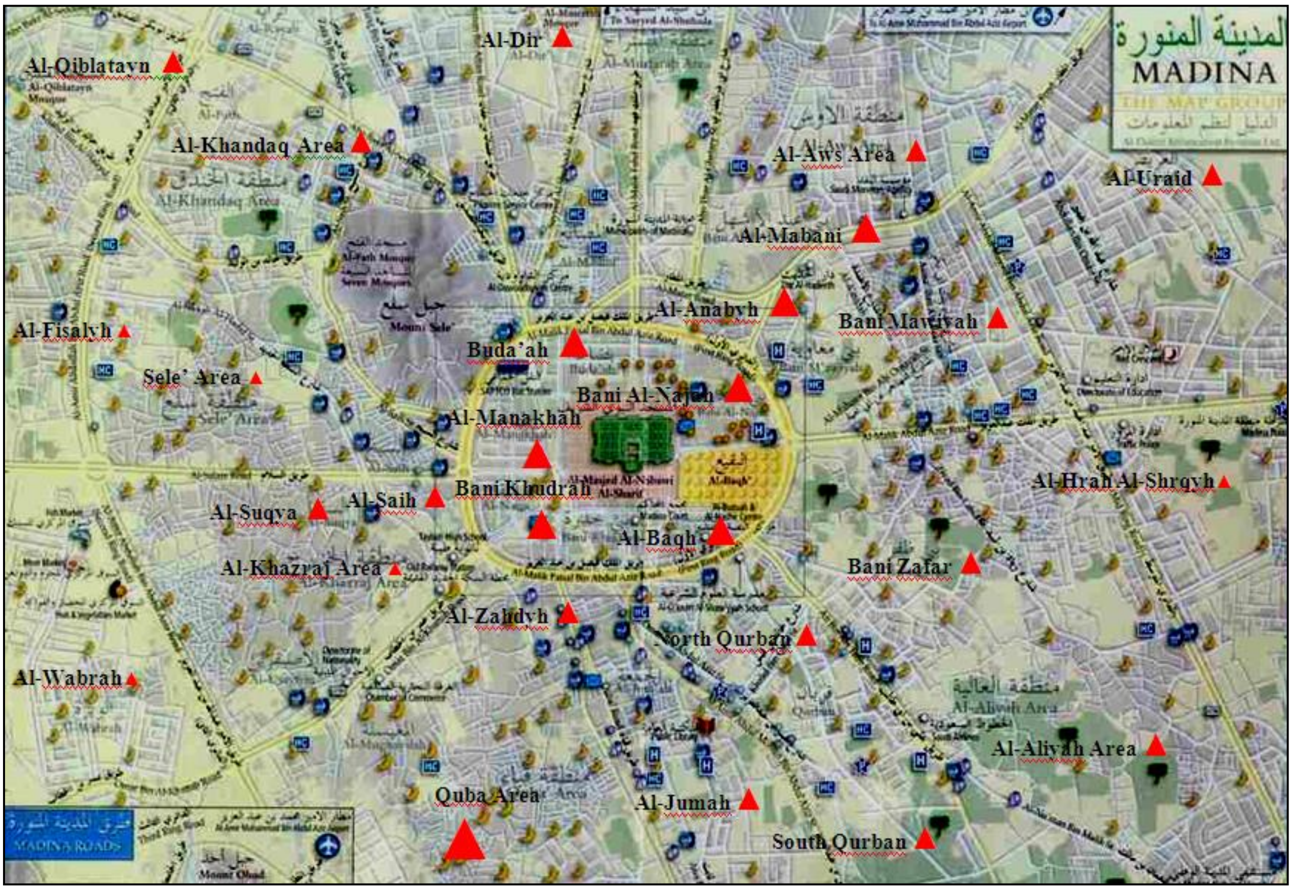

Figure 7.15: Distribution of Pilgrims' Pedestrian Casualty in Madinah from 2001 to 2005.

Pilgrims' Pedestrian Casualty	Graduated Symbol
1 – 50	▲
51 – 100	▲
101 – 150	▲
151 – 300	▲

Appendix C shows the frequency of pilgrims' pedestrian casualties recorded by various districts in Madinah. Tables 5.4 & 5.5 and Appendix B and Appendix C show the total number of pilgrims pedestrian casualties recorded over the 5-year period (i.e. from 2001 to 2005) by the various districts. From the tables it is clear that the largest proportion of pilgrim pedestrian casualties occurred at Quba area (248 accidents). Whereas, the least was recorded at Al-Wabrah (27 accidents). From inspecting accident data and land use data as explained earlier, it appears that mostly high frequency of pilgrim pedestrian casualties occurring near mosques, schools and other institutions. This reflects the impact of land use and transport system design. In Al-madina, as well as in many other Saudi cities, big mosques and schools are usually built on the main roads. That causes pedestrian and children accidents nearby these amenities. crowdedness of pilgrims due to the monumental religious edifices and intensity of traffic around these areas.

7.3. Advanced Data Analysis

7.3.1 Principal Component Analysis

The PCA results are expressed by the scree plot shown in Figure 7.16. The scree plot is a graphical representation of the Eigenvalues of the principal components. It shows that the maximum number of components formed is equivalent to the number of original variables. In this case, we have fourteen components which are equal to the number of variables considered in this study. However, only five principal components exceeded the Kaiser Criterion of eigenvalues 1.0 as indicated by the scree plot. Hence, the original fourteen variables of the pilgrims' pedestrians casualty has been reduced to five principal components without losing any useful information. The Eigenvalues and percentage variance explained by the components are given in Table 7.5. Despite we have five principal components, none of them hugely dominates due to the closeness of the Eigenvalues and percentage variance of these components. The five principal components could only explained 48% of the variance of the dataset as shown in Table 7.5. In fact, the nearness of the Eigenvalues of components 6, 7 and 8 to the threshold value of 1.0 show the difficulty of rendering any of the variables redundant. In other words, one could approximate the Eigenvalues of component 6, 7 and 8 to the threshold value of 1.0 and conclude that eight principal components could be used to explain the dataset with 72% variance. Although the PCA produced five components but there is no clear domination of any of the component. For the fact that the variance explained by these five principal components is only 48%. It will be sensible to consider those components close to the domain of the threshold of Eigenvalue of 1 in other not to discard relevant information about the dataset of pilgrims' pedestrian casualty.

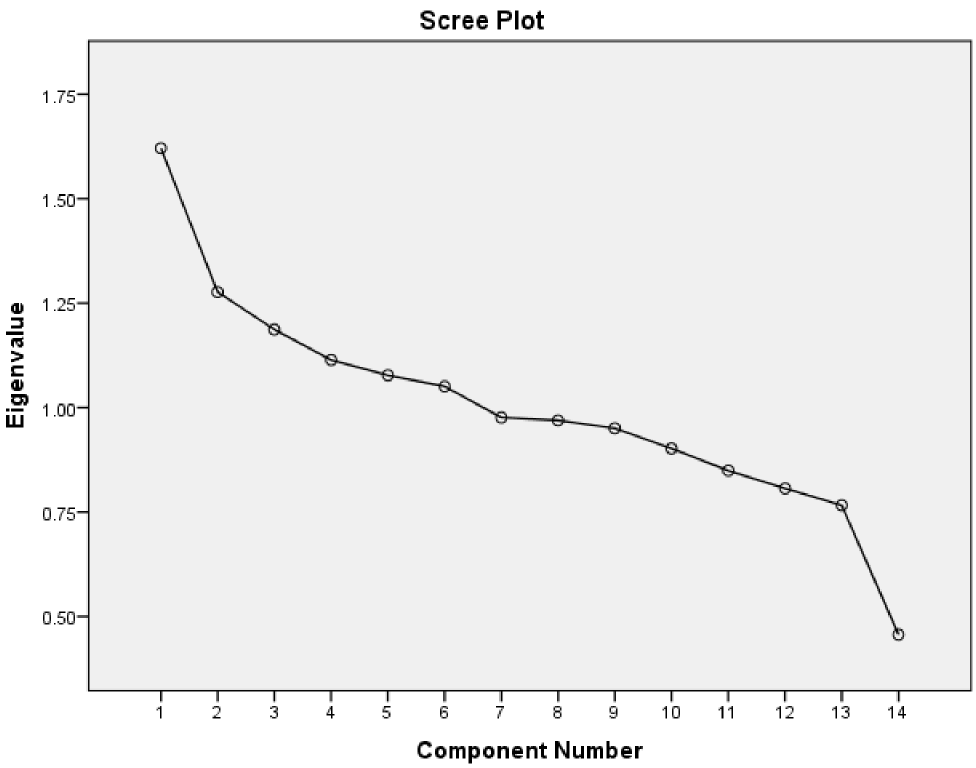

Figure 7.16: Scree plot of showing the principal components

Table 7.5: Eigenvalues and percentage variance explained by the components

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**1.300**	**10.833**	**10.833**	**1.300**	**10.833**	**10.833**
2	**1.188**	**9.900**	**20.733**	**1.188**	**9.900**	**20.733**
3	**1.151**	**9.594**	**30.327**	**1.151**	**9.594**	**30.327**
4	**1.082**	**9.021**	**39.347**	**1.082**	**9.021**	**39.347**
5	**1.049**	**8.745**	**48.092**	**1.049**	**8.745**	**48.092**
6	.984	8.201	56.292			
7	.968	8.068	64.360			
8	.954	7.948	72.308			
9	.890	7.416	79.724			
10	.862	7.185	86.909			
11	.806	6.715	93.624			

12	.765	6.376	100.000			

Extraction Method: Principal Component Analysis.

7.3.2 Cluster analysis

7.3.2.1 Agglomeration Schedule

The agglomeration schedule shown in Table 7.6 gives the change in the distance measure as additional cases are merged into clusters. It shows which steps the clusters are combined. The coefficient column present the values of the distance statistically used to form the clusters. Cluster analysis can produce a range of solutions, but a good cluster solution is the one prior to a sudden jump in the distance coefficient. Table 7.6 below shows that there are several jumps (or gaps) in the coefficients involving the various stages. Hence, Cluster analysis of the accident data *(pilgrims' pedestrian casualty.sav)* produced a myriad of solutions. However, the best cluster solution is the one involving a large jump between stages 1 (Coefficient, 12.64) and 2 (Coefficient, 18.028), which produced 6 clusters as shown in Table 7.6 and emphasized by the red line in Figure 7.16 (Vertical Icicle Plot). This is the best Cluster analysis result hypothesized based on the results obtained by PCA, which produced 6 factors. These 6 clusters corresponds to combining Cluster 1 (variables 1, 2, 4, 7, 8, 9, 10, 11 and 14); Cluster 2 (variable 3); Cluster 3 (variable 5); Cluster 4 (variable 6); Cluster 5 (variable 12); Cluster 6 (variable 13) as shown in Table 7.6 (Cluster Membership), which are also illustrated in Figures 1 and 2. Expressing the components of the clusters obtained from this analysis in a more lucid form, Cluster 1 (Accident Year, Sex of Casualty, Severity of Casualty, Accident Month, Day of Week, Hour of Accident, Road Type, Speed Limit, and Land use of Madinah); Cluster 2 (Age of Casualty); Cluster 3 (Nationality); Cluster 4 (Accident Day); Cluster 5 (Junction Detail) and Cluster 6 (Districts of Madinah). Although there are other possible range of cluster solutions as depict by the several sudden large jump or gap in the distance of the coefficients as shown in Table 7.6. However, the best cluster solution is that described in this research.

Table 7.6: Agglomeration Schedule

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	1	4	12.640	0	0	2
2	1	2	18.028	1	0	3
3	1	10	24.297	2	0	4
4	1	14	26.256	3	0	5
5	1	11	28.816	4	0	6
6	1	8	36.837	5	0	7
7	1	7	48.807	6	0	8
8	1	9	52.371	7	0	9
9	1	5	56.029	8	0	10
10	1	13	66.066	9	0	11
11	1	12	68.453	10	0	12
12	1	6	78.769	11	0	13
13	1	3	85.792	12	0	0

7.3.2.2 Linking of the Clusters

The agglomeration schedule also shows how the accident variables are combined to form clusters at the various stages. In other words, the agglomeration schedule explains the linking of the clusters as illustrated in Figure 7.17 (Dendrogram).

7.3.2.3 Icicle Plot

The Icicle Plot is a visual representation of the agglomeration schedule, which can be presented either in a vertical or horizontal orientation depending on personal preference. Figure 7.18 shows the vertical icicle plot of the accident data and it is usually read from the bottom to top due to its orientation. As shown below, the absence of white space between the cases is an indication that the cases have joined to form a cluster. In this research, the best cluster solution comprises of 6 Clusters as hypothesized based on the results obtained from Factor analysis. Therefore, 6 Clusters as presented by the icicle plot: the variables 'Accident Year' and 'Sex of Casualty' are joined by 'Severity of Casualty', 'Accident Month', 'Day of Week', 'Hour of Accident', 'Road Type', 'Speed Limit', and 'Land use of Madinah' to form

Cluster 1; with the remaining 5 variables (i.e. 'Age of Casualty', 'Nationality', 'Accident Day', 'Junction Detail' and 'Districts of Madinah') forming individual referred to Cluster 2 through Cluster 6.

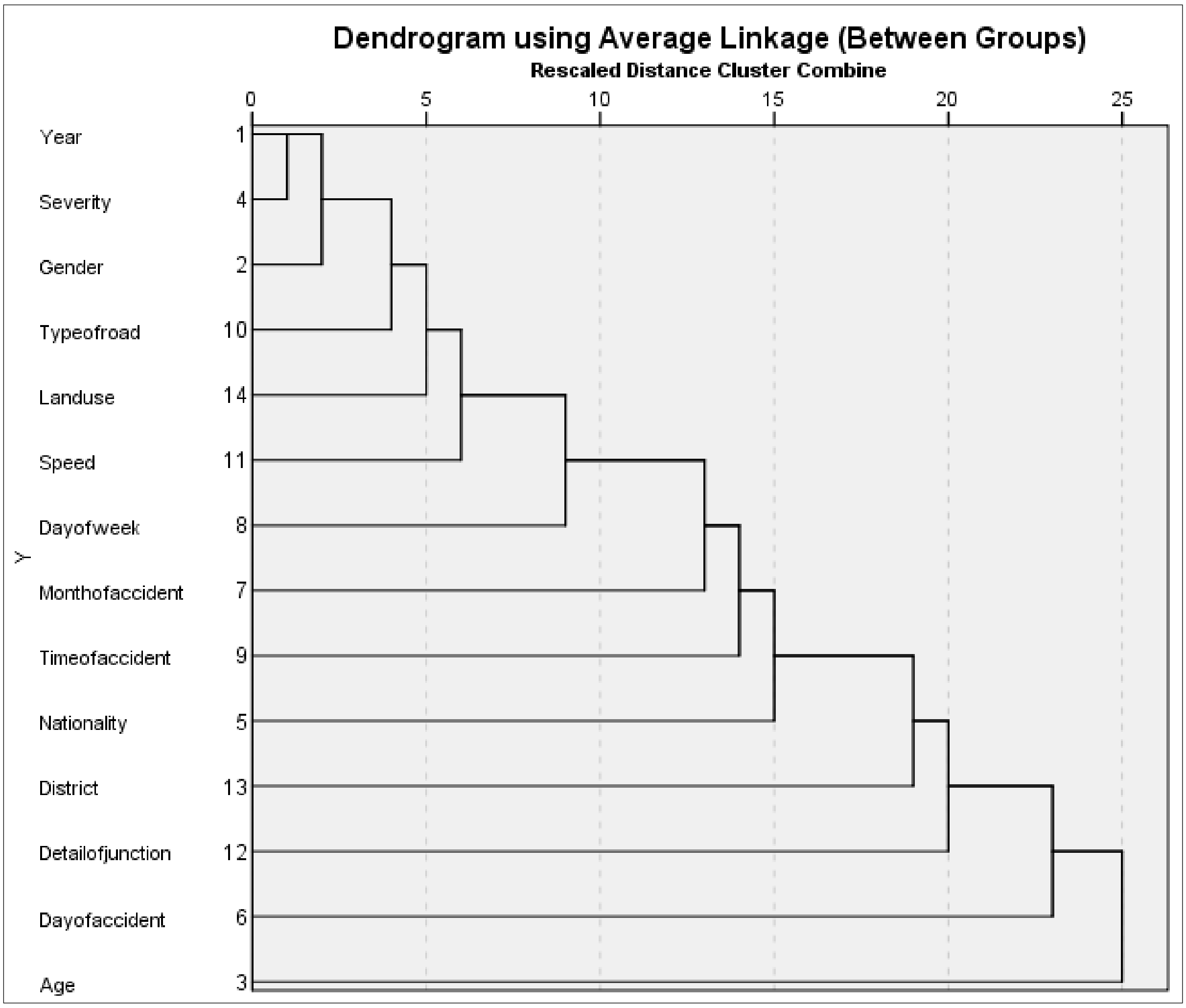

Figure 7.17: Dendrogram linking the variables

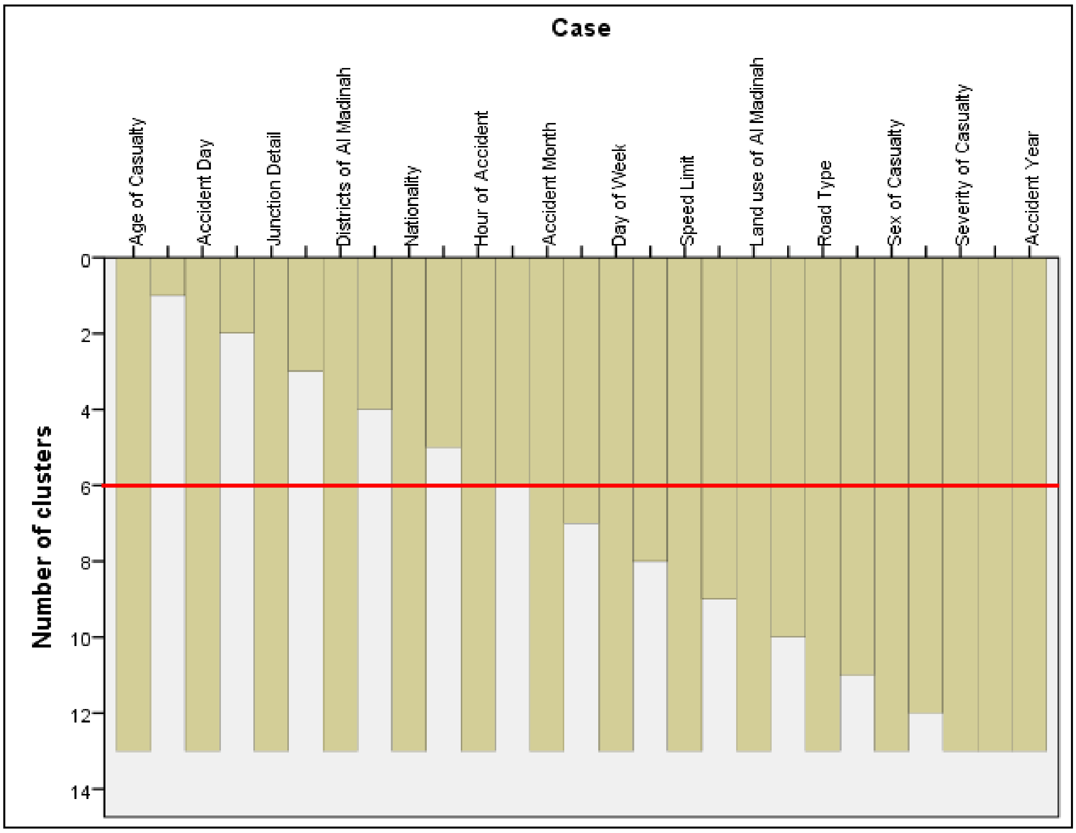

Figure 7.18: Vertical Icicle Plot of Cluster Analysis of Accident Data

The Cluster analysis results agreed with those obtained through PCA. Consequently, both multivariate techniques could be used to validate each other. These multivariate techniques have shed more light on the similarity or/and dissimilarity of the variables of the accident data. Furthermore, these techniques have given insight on those variables that are likely to strongly influence one another in road accident studies. Relevant information as such would assist road transport researchers not to duplicate the measurement of variables that will have exact or similar effect on road accident models. Hence, time, effort and research cost will be saved. For instance, PCA which often referred to as reduction technique was invaluable to reduce the fourteen variables to six factors. With the application of Cluster analysis, the results of the PCA were validated and a better understanding of these six factors was presented in the form of clusters. From the results obtained using both multivariate techniques (i.e. PCA and Cluster analysis), one can deduce that the variables of the accident data *(pilgrims' pedestrian casualty.sav)* that are likely to have strong impact on any reliable accident model are contained in Cluster 1 (Accident Year, Sex of Casualty, Severity of Casualty, Accident Month, Day of Week, Hour of Accident, Road Type, Speed Limit, and

Land use of Madinah). Consequently, these variables are of paramount importance when undertaking the investigation of pilgrim pedestrian casualty or similar studies. In future studies, eliminating those variables as contained in Cluster 2 through Cluster 6 may have little effect on the road accident model.

Several reasons can be postulated for the little contribution of these variables (i.e. Age of Casualty; Nationality; Accident Day; Junction Detail and Districts of Madinah) in the study of pilgrims' pedestrian casualty in Madinah. For instance, the 'Age of Casualty' has little impact on this study because pilgrims' pedestrians are likely to comprise of less of the most vulnerable pedestrian categories such as children and the elderly. In other words, most Muslims that indulge in pilgrimage are predominantly agile and healthy persons, probably, between the ages of 15 and 65 years. Hence, the tendency of Muslim pilgrims from these age categories (i.e. children and elderly) to suffer pedestrian casualty in Madinah may be reduced despite other road accident studies have emphasized the impact of age on the casualty of pedestrians, particularly, among children. Multivariate analyses also revealed that pilgrims' nationality has little impact on the accident data. Justifiably, most road safety regulations are universal or the same worldwide. Again, the foreign pilgrims may not be unfamiliar with the road safety regulations in Madinah. It is also important to emphasize that not all the foreign nationals in Madinah that were visitors or new to the environment. Many foreign nationals embarking on pilgrimage may have integrated into the society due to their long stay in Madinah or other cities in Saudi Arabia. Therefore, the nationality of pilgrims' in pedestrian activities will has little effect on a reliable accident model. Similarly, the 'Accident Day' (i.e. day of accident within a given month) has been shown to contribute little to any road accident model that would be developed using the accident data (*pilgrims' pedestrian casualty.sav.)*. Instead, the results obtained from the Multivariate analyses gave precedence to other variables such as 'Accident Month', 'Day of Week' and 'Hour of Accident'. This strongly agrees with Islamic principles regarding pilgrimage (Hajj). For instance, Islamic pilgrimage (Hajj) occurs from the 8^{th} to 12^{th} Month (i.e. from Sha'aban to Dhu al–Hijjah). This emphasizes the importance of certain months (or period) to pilgrims, who usually travel to Holy cities such as Madinah. In contrast to 'Accident Day', the results obtained from the Multivariate analyses have shown that 'Day of Week' will contribute strongly to the accident model. Pilgrims' pedestrian activities are strongly influence by the 'Day of Week'. For example, the religious significance of Friday (Jumu'ah) to most Muslim pilgrims are likely to make them to indulge in more pedestrian activities on this day (i.e. Friday) than any other. Similarly, prayer times are very important to Muslim pilgrims and will definitely influence their pedestrian activities. Again, peak hours of the day also have impact on the pedestrian activities of pilgrims. Consequently, the 'Hour of Accident' would strongly contribute to the robustness of the accident model as predicted by the Multivariate analyses. Furthermore, the results have revealed that 'Road Type' would contribute more to the model than the 'Junction Detail'. While the 'Land use' is also a more important variable to the accident model compared to the 'Districts of Madinah'.

Although the results indicate that, for the case studied herein, only few variables may be ignored out of the set of fourteen original variables despite the PCA produced five principal components. Nevertheless, we believe that the use of PCA is appropriate for removing redundant variables in accident analysis. Hopefully, future researchers on accident studies will show greater interest in this methodology (Caliendo and Parisi, 2005). Clustering analysis yielded clusters based on the association of variables that strongly pilgrims' pedestrian casualty. Cluster 1 (Accident Year, Sex of Casualty, Severity of Casualty, Accident Month, Day of Week, Hour of Accident, Road Type, Speed Limit, and Land use of Madinah) show the variables that have strong impact or association on Land use of Madinah which is the focus of this research. Specifically, the Severity of Casualty is associated with the Land use of Madinah. It also revealed the dissimilarities or lack of association of certain variables. For instance, Nationality and District of Madinah has little association with Land use of Madinah. The segmentation of the dataset into clusters provides insights for further studies on pilgrims' pedestrian casualty. These variables forming clusters can separately analysed to extract further information that will assist transport planners to develop ways to curb pedestrian casualty. Clustering of the dataset into homogeneous subsets helps identify important contributing factors that would be concealed if the whole dataset was used. Consequently, PCA and Clustering could be used not only for descriptive analysis, but also as a preliminary tool for eliminating redundant variables and their segmentation for a more detailed and standard statistical analysis.

7.4 Results of Accident Models

Elaborate details of the accident models can be seen in the ***Appendices*** M-V and summary of these results are shown in Tables 7.7 – 7.14, are based on 95% significance of pilgrim pedestrian casualties. The results as presented in the Tables 7.7 – 7.14, show the estimated coefficients and standard errors of the explanatory variables (including the constants) of the accident models for Prayer Time; Non-Prayer Time; Weekends; Working Days; High Season and Low Season. In addition, summary of the modelling statistics were shown to justify the fitting of either Poisson or Negative binomial regression models. In other words, the summary of the modelling statistics enable the comparison of the two different models (i.e. Poisson and Negative binomial regression) in order to justify the model that better explain the accident data. Again, for easy comparison of the estimated coefficients of the explanatory variables in each land use category, one of the variables was set to zero (i.e. held redundant). For the Main land use, 'religious' was set at zero for reference purpose. Similarly, for Road Type and Junction Details, 'Roundabout' and 'Not at junction or within 20 metres' were also set at zero, respectively. The parameter estimates summarizes the effect of each predictor. The signs (i.e. positive or negative) of the coefficients for covariates and relative values of the coefficients for factor levels provide insights into the effects of the predictors in the models. For instance, covariates with positive coefficients indicate positive relationships between the predictors and the outcome. While an inverse relationships exist between the predictors and outcome for covariates with negative coefficients. Therefore, a covariate with a higher positive coefficient corresponds to higher pilgrim pedestrian casualty. Nevertheless, the estimated marginal means of all the explanatory variables (including those held redundant for comparison purposes) for the various land use categories are shown in the ***Appendices M1-M8.*** As indicated in these ***Appendices***, the estimated marginal means of the explanatory variables in each category are given by their estimated coefficients plus the estimated marginal means of the reference variable. Hence, the sign of coefficients in a given category is dependent on the relative sign and value of the reference variable of the category.

7.4.1 Fitness of the Poisson and Negative Binomial Models

The assessment of the fitness of Poisson regression model and the alternative model (i.e. Negative Binomial regression model) was necessary to confirm the validity of the statistical method applied to the dataset. Though, there is no formal procedure to test Poisson regression versus the alternative model. A commonly used test to determine whether there is over-dispersion in the dataset is to perform a likelihood ratio test between the Poisson regression and Negative Binomial regression with all other settings identical. In addition, the Goodness-of-fit statistics Tables shown in the ***Appendices M-1.6 to M-1.8*** provides measures that are useful for comparing competing models such as Poisson and Negative Binomial regression. The Value/df for the Deviance and Pearson Chi-Square statistics taken from the Goodness-of-fit outputs as summarized in Tables 7.7 – 7.14, also gives corresponding estimates for the scale parameter. These values should be closer to 1.0 for a Poisson regression. Furthermore, the fact that these values are greater than 1.0 indicates that fitting the over-dispersed model may be reasonable. The Value/df for the Deviance and Pearson Chi-Square for Poisson models are closer to 1.0 compared to those obtained for the Negative Binomial regression (Tables 7.7 – 7.14). In general, the Log Likelihood values reported for the Negative Binomial regression were smaller than those obtained for Poisson regression (Tables 7.7 – 7.14). For example, the Log Likelihood values for Poisson and Negative Binomial regression models for Seriously Injured (SI) pilgrim pedestrians during Prayer Time were –171 (Adjusted Log Likelihood: –107) and –206, respectively. Hence, the Negative Binomial regression does not offer an improvement over the Poisson regression. The unsuitability of using the Negative Binomial regression to analyse the pilgrim pedestrian casualty dataset is also reflected on the results as more of the estimated coefficients of the explanatory variables were insignificant at 5% level when the dataset was analysed with Negative Binomial regression compared to Poisson regression. Consequently, detailed discussion of the accident models was mainly focused on the estimated parameters derived from Poisson regression.

7.4.2 Models for Seriously Injured Pilgrim Pedestrians in Madinah

7.4.2.1 Model for Seriously Injured During Prayer Time

The Poisson model during prayer time indicates that major land use such as agriculture and government offices show negative association with reference to religious land use regarding pilgrim pedestrian casualties (Table 7.7). In other words, the least pilgrim pedestrian casualties was found within government offices and then followed by agricultural land use. This was expected because most pilgrim pedestrians would have left their jobs (i.e. government offices) and farmlands (i.e. agriculture) for religious activities during prayer time. Furthermore, the sacredness of most religious areas discourage reckless attitude from both drivers and pedestrians making them to comply more to road safety regulations, especially, during prayer time. According to this model, the highest pilgrim pedestrian with serious injuries was observed within the commercial areas, especially, those retail outlets close to the Mosques where pilgrims engaging in prayer can hurriedly visit to purchase essential items. Following commercial land use are pilgrim accommodation and residential areas which have approximately the same number of seriously injured pilgrim pedestrians. Considering the road type category, the single carriageway – 3 lanes and dual carriageway – 3+ lanes were found to have the lowest seriously injured pilgrim pedestrians during prayer time. While roundabout (i.e. reference variable) had the highest seriously injured pilgrim pedestrians during prayer time. Similarly, roundabout and not at junction or within 20 metres (the reference for junction details) have the lowest and highest seriously injured pilgrim pedestrians during prayer time, respectively. The Poisson model also estimated the marginal means which describes all relations between the explanatory variables. Estimated marginal means for the seriously injured during prayer time are shown in ***Appendices M-1.6 to M-1.8.*** All the explanatory variables for major land use; all the road type variables except single carriageway – 2 lanes and roundabout; and all the junction details variables except T, Y or staggered junction and not at junction or within 20 metres have negative association with seriously injured pilgrim pedestrian casualties during prayer time. The estimated coefficients of single carriageway – 2 lanes were not significant at 5% level for all the Poisson models as indicated in Table 7.7. Furthermore, the coefficients of slip road and T, Y or staggered junction were found to be insignificant at 5% level for the Poisson model for prayer time.

7.4.2.2 Model for Seriously Injured During Non-Prayer Time

Poisson regression model for non-prayer time follow similar trend as prayer time except that the estimated coefficients of most of the land use types increases during non-prayer time. Again, for major land use category, government offices and agricultural land use have the lowest coefficients which suggested that pilgrim pedestrian casualties of these land use type were lower than the casualties recorded in religious areas. In contrast, the highest number of seriously injured pilgrim pedestrians during non-prayer time was recorded in the commercial area, followed by accommodation and residential areas. Expectedly, government offices and agricultural land use were the least trip attractors for pilgrims during non-prayer time. Most pilgrims would be more attracted to other land use type (e.g. accommodation, commercial and religious areas) that would positively contribute to their pilgrimage. For road type category, the lowest and highest casualties were recorded at unknown roads and roundabouts, respectively. Similarly, mini-roundabout and not at junction or within 20 metres (the reference for junction details) have the lowest and highest seriously injured pilgrim pedestrians during non-prayer time, respectively. Estimated marginal means for the explanatory variables show that agriculture, government offices, residential and religious land use type were negatively associated with pilgrim pedestrian casualties during non-prayer time. While accommodation and commercial areas were positively associated with pilgrim pedestrian casualties during non-prayer time (***Appendix M-3.6***). All the road type variables except single carriageway – 2 lanes and roundabout show negative association with pilgrim pedestrian casualties during non-prayer time (***Appendix M-3.7***). Similarly, all the junction detail variables except T, Y or staggered junction and not at junction or within 20 metres have negative association with pilgrim pedestrian casualties during non-prayer time (***Appendix M-3.8***). The higher estimated marginal means for most explanatory variables suggested that more pilgrim pedestrians were seriously injured during non-prayer time compared to prayer time. For example, accommodation, commercial and residential land use show substantial increase in seriously injured pilgrims during non-prayer time. However, agriculture, government and religious areas remained fairly unchanged compared to prayer time. Similarly, most road type and junction detail variables also show increase in casualties during non-prayer time. During this period, most pilgrim pedestrians will be actively visiting religious sites and engaging in shopping within the commercial areas. While others would either be busy or relaxing in their accommodation (or residential area). Consequently, most pilgrim pedestrians would be more disposed to interact with vehicles resulting to higher casualties in most land use type.

Table 7.7: Poisson regression model for seriously injured (SI) pilgrim pedestrians

Explanatory Variables	Prayer Time		Non-Prayer Time		Weekends		Working Days		High Season Months		Low Season Months	
	Coeff	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**
Constant	3.30	0.72	4.21	0.46	3.38	0.52	4.34	0.57	4.23	0.45	2.40	0.82
Major Land Use												
Agriculture	-1.87	0.59	-1.82	0.35	-1.53	0.41	-2.15	0.47	-1.81	0.35	-1.91	0.86
Government Offices	-2.23	0.59	-2.49	0.54	-2.27	0.87	-2.19	0.53	-2.83	0.62	-1.68	0.56
Accommodation	0.73	0.19	1.03	0.14	0.95	0.18	0.89	0.16	0.81	0.14	1.24	0.21
Commercial	0.78	0.19	1.05	0.14	0.89	0.18	0.97	0.16	1.05	0.14	0.66	0.22
Residential	0.70	0.19	0.81	0.14	0.86	0.18	0.74	0.16	0.69	0.15	1.06	0.21
Religious	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Road Type												
Unknown	-3.24	0.88	-4.00	0.55	-3.82	0.86	-3.99	0.66	-4.31	0.69	-2.55	0.87
Single carriageway – 4+ lanes	-3.17	0.80	-3.43	0.49	-2.68	0.58	-3.65	0.62	-3.46	0.51	-2.22	0.85
Single carriageway – 3 lanes	-3.49	0.95	-3.78	0.53	-3.65	0.66	-3.99	0.67	-3.77	0.55	-3.12	1.00
Single carriageway – 2 lanes	**-0.15**	**0.71**	**-0.37**	**0.44**	**-0.20**	**0.50**	**-0.49**	**0.55**	**-0.18**	**0.44**	**0.11**	**0.80**
Single carriageway – single track	-2.82	0.77	-3.32	0.49	-2.91	0.57	-3.46	0.61	-3.19	0.49	-2.60	0.86
Dual carriageway – 3+ lanes	-3.49	0.88	-3.49	0.50	-3.42	0.60	-3.76	0.64	-3.44	0.53	-2.84	0.88
Dual carriageway – 2 lanes	-2.38	0.73	-2.87	0.46	-2.80	0.55	-2.84	0.58	-2.75	0.47	-2.01	0.82
One way street	-2.62	0.75	-2.73	0.46	-2.51	0.54	-2.86	0.59	-2.58	0.47	-2.21	0.84
Roundabout (Only include large and signalised roundabouts)	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Junction Details												
Other junction	-2.49	0.34	-2.51	0.23	-2.29	0.27	-2.63	0.30	-2.68	0.26	-2.23	0.33
Private drive or entrance	-2.88	0.49	-2.80	0.27	-3.36	0.55	-2.68	0.31	-2.86	0.29	-2.78	0.54

Multiple junction	-2.65	0.36	-3.11	0.31	-3.08	0.41	-2.85	0.33	-3.18	0.33	-2.30	0.37
Crossroads	-1.24	0.19	-1.45	0.14	-1.35	0.17	-1.41	0.17	-1.70	0.16	-0.78	0.17
Slip road	**-1.03**	**0.77**	-3.96	0.49	-3.18	1.22	-3.70	0.52	-3.99	0.50	-2.06	0.85
T, Y or staggered junction	**-0.13**	**0.12**	-0.19	0.09	-0.28	0.11	**-0.16**	**0.10**	-0.30	0.09	0.09	0.13
Mini-roundabout	-2.89	0.74	-4.46	0.65	-4.24	0.79	-4.29	0.71	-4.49	0.68	-3.28	0.79
Roundabouts (these include standard)	-3.08	0.57	-3.30	0.34	-3.03	0.40	-3.51	0.44	-3.23	0.33	-2.97	0.69
Not at junction or within 20 metres	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Summary of modelling statistics												
Number of Casualties (n)	538		1306		605		1239		1341		454	
Observation Used (N)	93		140		98		142		139		95	
Deviance (Dv)	83		149		83		153		129		78	
Degree of freedom (df)	71		118		76		120		117		73	
Value/df for the Deviance	1.17		1.26		1.10		1.27		1.10		1.08	
Value/df for the Pearson Chi-Sq.	1.60		1.91		1.46		2.62		2.25		1.40	
Log Likelihood	-171[b,c]	(-107[d])	-288[b,c]	(151[d])	-181[b,c]	(-123[d])	-288[b,c]	(-110)[d]	-275[b,c]	(-122[d])	-166[b,c]	(-119[d])

Dependent Variable: Count_SI; Model: (Intercept), Major land use, Road Type, Junction Detail.

Bold figures are not significant at 95% Confidence level.

a. Set to zero because this parameter is redundant (This enable the comparison of the coefficients of land use variables in each land use category);

b. Computed based on the Pearson chi-square.

c. The log likelihood is based on a scale parameter fixed at 1;

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test

Table 7.8: Negative Binomial regression model for seriously injured (SI) pilgrim pedestrians

Explanatory Variables	Prayer Time		Non-Prayer Time		Weekends		Working Days		High Season Months		Low Season Months	
	Coeff	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**
Constant	2.75	1.00	3.19	0.75	2.93	0.84	3.34	0.79	2.99	0.69	1.96	0.64
Major Land Use												
Agriculture	**-1.35**	**0.84**	-1.21	0.53	**-1.23**	**0.74**	-1.19	0.58	**-0.96**	**0.51**	-1.58	0.64
Government Offices	**-1.63**	**0.86**	-1.99	0.86	**-1.86**	**1.22**	**-1.44**	**0.80**	-1.95	0.87	-1.59	0.49
Accommodation	**0.47**	**0.42**	0.99	0.33	**0.52**	**0.43**	0.82	0.33	0.84	0.33	0.84	0.24
Commercial	**0.57**	**0.41**	0.85	0.32	**0.50**	**0.42**	0.74	0.32	0.96	0.31	**0.24**	**0.24**
Residential	**0.36**	**0.41**	0.71	0.34	**0.43**	**0.44**	**0.64**	**0.33**	0.71	0.33	0.61	0.24
Religious	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Road Type												
Unknown	-2.49	1.17	-2.71	0.82	-2.80	1.19	-2.80	0.84	-2.99	0.85	-1.59	0.69
Single carriageway – 4+ lanes	-2.30	1.11	-2.31	0.75	**-1.73**	**0.93**	-2.52	0.79	-2.13	0.71	-1.41	0.67
Single carriageway – 3 lanes	-2.68	1.24	-2.56	0.77	-2.81	0.92	-2.75	0.83	-2.41	0.73	-2.26	0.75
Single carriageway – 2 lanes	0.04	0.97	**0.12**	**0.68**	**0.13**	**0.77**	**-0.08**	**0.73**	**0.41**	**0.63**	**0.39**	**0.62**
Single carriageway – single track	**-2.03**	**1.08**	-2.29	0.78	-2.06	0.92	-2.35	0.81	-1.99	0.71	-1.85	0.68
Dual carriageway – 3+ lanes	**-2.88**	**1.16**	-2.42	0.78	-2.60	0.91	-2.64	0.83	-2.20	0.76	-2.04	0.68
Dual carriageway – 2 lanes	**-1.56**	**0.98**	-1.84	0.72	-1.93	0.84	-1.76	0.75	-1.56	0.66	-1.32	0.63
One way street	**-1.95**	**1.05**	-1.68	0.73	-1.75	0.86	-1.79	0.78	-1.40	0.69	-1.33	0.65
Roundabout	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Junction Details												

Other junction	-1.81	0.56	-1.65	0.42	-1.73	0.53	-1.58	0.44	-1.85	0.47	-1.55	0.30
Private drive or entrance	-2.21	0.73	-2.15	0.49	-2.92	0.80	-1.99	0.46	-2.23	0.48	-2.20	0.43
Multiple junction	-1.76	0.56	-2.31	0.48	-2.13	0.64	-2.09	0.47	-2.40	0.48	-1.28	0.35
Crossroads	**-0.63**	**0.43**	-0.99	0.33	**-0.82**	**0.42**	-0.92	0.33	-1.22	0.34	**-0.33**	**0.23**
Slip road	**-0.77**	**0.95**	-3.02	0.65	-3.06	1.48	-2.51	0.61	-2.86	0.62	-1.80	0.61
T, Y or staggered junction	**0.03**	**0.35**	**-0.11**	**0.27**	**-0.27**	**0.33**	**-0.14**	**0.27**	**-0.21**	**0.28**	**0.19**	**0.19**
Mini-roundabout	**-1.95**	**1.11**	-3.38	0.82	-3.49	1.02	-3.11	0.73	-3.15	0.76	-2.62	0.61
Roundabout	-2.28	0.79	-2.27	0.52	-2.21	0.65	-2.47	0.54	-2.16	0.49	-2.23	0.57
Not at junction or within 20 metres	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Summary of modelling statistics												
Number of Casualties (n)	538		1306		605		1239		1341		454	
Observation Used (N)	93		140		98		142		139		95	
Deviance (Dv)	22.6		36.8		21.0		41.6		33.9		23.6	
Degree of freedom (df)	71		118		76		120		117		73	
Value/df for the Deviance	0.32		0.31		0.28		0.35		0.29		0.32	
Value/df for the Pearson Chi-Sq.	0.34		0.35		0.29		0.40		0.37		0.31	
Log Likelihood	-206[b]		-346[b]		-220[b]		-345[b]		-339[b]		-202[b]	

Dependent Variable: Count_SI; Model: (Intercept), Major land use, Road Type, Junction Detail.

Bold figures are not significant at 95% Confidence level.

a. Set to zero because this parameter is redundant (This enable the comparison of the coefficients of land use variables in each land use category);

b. Fixed at the displayed value of 1 (i.e. The log likelihood is based on a scale parameter fixed at 1);

-- in Coeff and Std error: indicates that these parameters are not estimated.

7.4.2.3 Model for Seriously Injured During Weekends

Considering the major land use category, the seriously injured pilgrim pedestrians were lowest in government offices and followed by agricultural land use during the weekends (Table 7.7). Although government offices are closed during the weekends, the estimated coefficient for this land use type did not indicate substantial reduction in casualties during weekends compared to prayer time and non-prayer time. Similarly, the pilgrim pedestrians seriously injured in the agricultural areas did not change much during the weekends compared to prayer time and non-prayer time. This may be attributed to the fact that most pilgrim pedestrians are Saudis from other parts of the country and foreigners visiting Madinah for pilgrimage purpose. Hence, these pilgrims would not be disposed to engage in agricultural activities and government employment in the city of Madinah during weekends. Contrary to the results given by the Poisson models for prayer time, non-prayer time, working days and high season, the Poisson model for weekend indicate that the highest seriously injured pilgrim pedestrians was recorded in the accommodation areas during the weekends. Next to accommodation in terms of casualties, were commercial and residential areas. The increased casualty in the accommodation areas was probably because most pilgrim pedestrians preferred to stay within the vicinity of their accommodation during the weekends. Like other models in this study, the Poisson model for weekends indicated that the lowest and highest casualties occurred at unknown roads and roundabout, respectively. For the junction detail category, mini-roundabout and not at junction or within 20 metres were also found to have the lowest and highest casualties. According to this model, the estimated marginal means for the explanatory variables show that all the major land use variables are negatively associated with seriously injured pilgrim pedestrian casualties during weekends (***Appendix M-9.6***). Whereas all the road type variables except single carriageway – 2 lanes and roundabout; and all the junction details variables except T, Y or staggered junction and not at junction or within 20 metres are negatively associated with pilgrim pedestrian casualties during weekends (***Appendices M-9.7 and M-9.8***).

7.4.2.4 Model for Seriously Injured During Working Days

Similar to other models, the Poisson model for working days show that the casualties recorded at agricultural land use and government offices were very low because most of the pilgrims were foreigners that would not indulge in agricultural activities or take up government employment during their visit. Even the local pilgrim pedestrians (i.e. Saudis) may not have been disposed to work in Madinah since most of them may have come from other parts of Saudi Arabia for pilgrimage purpose. The lowest and highest casualties were recorded in the agricultural and commercial areas during working days. Furthermore, the casualties for accommodation and residential land use were also high relative to religious land use. The results show that most of the pilgrim pedestrians were either busy shopping in the commercial areas or engaging in other activities in the accommodation and residential areas during working hours. As earlier explained, the relatively low casualty in the religious areas may be attributed to the compliance with road safety regulations by most pilgrim pedestrians due to the sacredness of these areas. For road type category, the model for working days show that both unknown roads and single carriageway – 3 lanes had the lowest seriously injured pilgrim pedestrians. The highest casualty occurred on roads with roundabouts. For junction detail category, this model also shows that mini-roundabout and not at junction or within 20 metres had the lowest and high casualties, respectively. Again, the estimated marginal means for the major land use show that agriculture, government offices, residential and religious areas were negatively associated with pilgrim pedestrian casualties during working days. In contrast, accommodation and commercial areas had positive association with pilgrim pedestrian casualties during working days (***Appendix M-13.6***). Similar to non-prayer time model, all the road type variables except single carriageway – 2 lanes and roundabout show negative association with pilgrim pedestrian casualties during working days (***Appendix M-13.7***). All the junction detail variables except T, Y or staggered junction and not at junction or within 20 metres have negative association with pilgrim pedestrian casualties during non-prayer time (***Appendix M-13.8***). Furthermore, this model shows that the estimated coefficient of T, Y or staggered junctions was not significant at 5% confidence level.

Table 7.9: Poisson regression model for killed pilgrim pedestrians

Explanatory Variables	Prayer Time		Non-Prayer Time		Weekends		Working Days		High Season Months		Low Season Months	
	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error
Constant	**0.99**	**1.32**	**1.65**	**0.95**	**-0.89**	**0.95**	**1.82**	**1.17**	**1.69**	**1.12**	**-0.45**	**0.91**
Major Land Use												
Agriculture	**-1.61**	**1.08**	-2.35	0.78	--	--	-1.85	0.76	-2.47	1.01	**-1.27**	**0.89**
Government Offices	**-1.61**	**1.08**	-2.34	0.56	**-1.41**	**0.95**	-1.85	0.76	-1.78	0.73	--	--
Accommodation	**0.46**	**0.37**	0.73	0.17	**0.70**	**0.36**	0.56	0.22	0.65	0.22	0.88	0.30
Commercial	0.85	0.35	0.79	0.17	0.89	0.36	0.63	0.21	0.94	0.21	**0.45**	**0.33**
Residential	0.76	0.36	0.53	0.18	**0.61**	**0.37**	**0.40**	**0.22**	0.53	0.22	**0.50**	**0.32**
Religious	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Road Type												
Unknown	-1.80	1.49	**-0.92**	**1.23**	**0.00**	**1.25**	**-1.80**	**1.38**	**-2.63**	**1.49**	**0.19**	**1.08**
Single carriageway – 4+ lanes	--	--	-2.18	1.09	**0.36**	**1.29**	**-2.22**	**1.56**	**-1.97**	**1.50**	**-0.06**	**1.23**
Single carriageway – 3 lanes	**-0.97**	**1.48**	**-2.00**	**1.04**	**2.48**	**1.57**	**-2.10**	**1.27**	**-2.10**	**1.22**	**1.49**	**1.30**
Single carriageway – 2 lanes	**0.62**	**1.29**	**0.69**	**0.94**	2.39	0.91	**0.73**	**1.16**	**0.78**	**1.11**	**1.72**	**0.88**
Single carriageway – single track	**-0.65**	**1.51**	-2.04	0.98	--	--	**-1.81**	**1.21**	**-1.89**	**1.16**	**-0.15**	**1.25**
Dual carriageway – 3+ lanes	--	--	-2.08	0.99	**0.54**	**1.11**	**-2.12**	**1.27**	**-2.24**	**1.22**	**0.28**	**1.08**
Dual carriageway – 2 lanes	**-1.20**	**1.36**	**-1.18**	**0.96**	**0.82**	**0.93**	**-1.24**	**1.18**	**-0.99**	**1.12**	**-0.02**	**0.97**
One way street	**-0.90**	**1.39**	**-1.30**	**0.96**	**0.81**	**0.97**	**-1.18**	**1.19**	**-1.48**	**1.14**	**0.49**	**0.93**
Roundabout	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Junction Details												
Other junction	-1.19	0.52	-1.77	0.29	-1.29	0.55	-2.13	0.34	-2.03	0.30	**-0.54**	**0.92**
Private drive or entrance	-1.72	0.79	-2.42	0.40	-2.30	0.65	-2.48	0.53	-2.40	0.46	-2.15	0.87
Multiple junction	-1.80	0.55	-1.49	0.33	-2.20	0.91	-1.88	0.38	-2.07	0.59	-1.54	0.41

Crossroads	-0.78	0.30	-1.26	0.17	-0.87	0.28	-1.17	0.22	-1.32	0.22	-0.58	0.27
Slip road	--	--	--	--	--	--	--	--	--	--	--	--
T, Y or staggered junction	**-0.37**	**0.26**	**0.00**	**0.11**	**-0.08**	**0.21**	**-0.15**	**0.15**	**-0.24**	**0.14**	**0.09**	**0.22**
Mini-roundabout	--	--	-2.35	0.78	--	--	-2.54	1.05	--	--	**-1.27**	**0.89**
Roundabout	-1.84	0.76	-2.45	0.55	0[a]	--	-2.45	0.53	-2.63	0.51	0[a]	--
Not at junction or within 20 metres	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Summary of modelling statistics												
Number of Casualties (n)	104		254		104		254		258		91	
Observation Used (N)	36		65		36		65		62		37	
Deviance (Dv)	18.9		24.3		13.8		41.3		31.7		13.5	
Degree of freedom (df)	18		44		19		44		42		18	
Value/df for the Deviance	1.05		0.55		0.73		0.94		0.75		0.75	
Value/df for the Pearson Chi-Sq.	1.07		0.59		0.79		1.07		0.98		0.72	
Log Likelihood	-55[b,c]	(-51[d])	-99[b,c]	(-167[d])	-53[b,c]	(-68[d])	-106[b,c]	(-100[d])	-99[b,c]	(-101[d])	-53[b,c]	(-73[d])

Dependent Variable: Count_SI; Model: (Intercept), Major land use, Road Type, Junction Detail.

Bold figures are not significant at 95% Confidence level.

a. Set to zero because this parameter is redundant (This enable the comparison of the coefficients of land use variables in each land use category);

b. Computed based on the Pearson chi-square;

c. The log likelihood is based on a scale parameter fixed at 1;

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test;

-- in Coeff and Std error: indicates that these parameters are not estimated.

Table 7.10: Negative Binomial regression model for killed pilgrim pedestrians

Explanatory Variables	**Prayer Time**		**Non-Prayer Time**		**Weekends**		**Working Days**		**High Season Months**		**Low Season Months**	
	Coeff	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**
Constant	**0.71**	**1.95**	**1.72**	**1.95**	**-0.53**	**1.62**	**1.50**	**1.70**	**1.65**	**1.70**	**-0.42**	**1.63**
Major Land Use												
Agriculture	**-1.57**	**1.56**	**-2.42**	**1.51**	--	--	**-1.66**	**1.32**	**-2.47**	**1.51**	**-1.27**	**1.57**
Government Offices	**-1.57**	**1.56**	-2.45	1.12	**-1.55**	**1.61**	**-1.66**	**1.32**	**-1.77**	**1.33**	--	--
Accommodation	**0.27**	**0.78**	**0.36**	**0.55**	**0.42**	**0.79**	**0.33**	**0.54**	**0.33**	**0.55**	**0.59**	**0.72**
Commercial	**0.78**	**0.75**	**0.40**	**0.56**	**0.53**	**0.80**	**0.44**	**0.53**	**0.58**	**0.54**	**0.42**	**0.81**
Residential	**0.70**	**0.75**	**0.28**	**0.55**	**0.47**	**0.76**	**0.19**	**0.53**	**0.19**	**0.55**	**0.44**	**0.76**
Religious	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Road Type												
Unknown	**-1.45**	**2.14**	**-1.02**	**2.41**	**0.00**	**2.00**	**-1.29**	**1.98**	**-2.23**	**2.18**	**0.19**	**1.89**
Single carriageway – 4+ lanes	--	--	**-2.04**	**2.16**	**0.14**	**2.19**	**-1.69**	**2.22**	**-1.56**	**2.21**	**-0.02**	**2.11**
Single carriageway – 3 lanes	**-0.50**	**2.17**	**-1.71**	**2.08**	**2.11**	**2.61**	**-1.59**	**1.81**	**-1.65**	**1.81**	**1.27**	**2.26**
Single carriageway – 2 lanes	**0.85**	**1.84**	**0.69**	**1.87**	**2.16**	**1.53**	**0.85**	**1.64**	**0.82**	**1.64**	**1.68**	**1.56**
Single carriageway – single track	**-0.36**	**2.22**	**-1.86**	**1.97**	--	--	**-1.29**	**1.73**	**-1.48**	**1.72**	**-0.14**	**2.19**
Dual carriageway – 3+ lanes	**-0.77**	**1.84**	**-1.87**	**1.98**	**0.50**	**1.88**	**-1.69**	**1.81**	**-1.83**	**1.80**	**0.33**	**1.90**
Dual carriageway – 2 lanes	--	--	**-1.00**	**1.93**	**0.71**	**1.58**	**-0.83**	**1.67**	**-0.60**	**1.66**	**0.14**	**1.75**
One way street	**-0.34**	**2.07**	**-1.04**	**1.93**	**0.74**	**1.65**	**-0.62**	**1.71**	**-1.00**	**1.71**	**0.56**	**1.63**
Roundabout	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Junction Details												
Other junction	**-1.02**	**0.93**	**-1.25**	**0.75**	**-0.97**	**1.11**	-1.63	0.63	-1.47	0.63	**-0.59**	**1.63**
Private drive or entrance	**-1.49**	**1.27**	-2.10	0.95	**-2.10**	**1.12**	-1.84	0.92	-1.83	0.90	**-1.86**	**1.53**
Multiple junction	**-1.54**	**0.94**	**-1.22**	**0.77**	**-2.05**	**1.53**	**-1.27**	**0.70**	**-1.70**	**1.03**	**-1.29**	**0.82**

Crossroads	**-0.75**	**0.71**	**-0.98**	**0.50**	**-0.78**	**0.68**	**-0.78**	**0.52**	**-1.03**	**0.56**	**-0.43**	**0.64**
Slip road	--	--	--	--	--	--	--	--	--	--	--	--
T, Y or staggered junction	**-0.37**	**0.64**	**0.06**	**0.39**	**-0.07**	**0.55**	**-0.02**	**0.41**	**-0.27**	**0.40**	**0.12**	**0.61**
Mini-roundabout	--	--	**-2.42**	**1.51**	--	--	**-2.35**	**1.50**	--	--	**-1.27**	**1.57**
Roundabout	**-1.50**	**1.23**	**-2.12**	**1.30**	0[a]	--	-1.94	0.90	-2.23	0.88	0[a]	--
Not at junction or within 20 metres	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Summary of modelling statistics												
Number of Casualties (n)	104		254		104		254		258		91	
Observation Used (N)	36		65		36		65		62		37	
Deviance (Dv)	5.57		6.09		3.85		11.8		9.3		3.6	
Degree of freedom (df)	18		44		19		44		42		18	
Value/df for the Deviance	0.31		0.138		0.20		0.27		0.22		0.20	
Value/df for the Pearson Chi-Sq.	0.29		0.136		0.20		0.27		0.24		0.19	
Log Likelihood	-70[b]		-132[b]		-70[b]		-133[b]		-129[b]		-69[b]	

Dependent Variable: Count_SI; Model: (Intercept), Major land use, Road Type, Junction Detail.

Bold figures are not significant at 95% Confidence level.

a. Set to zero because this parameter is redundant (This enable the comparison of the coefficients of land use variables in each land use category);

b. Fixed at the displayed value of 1;

-- in Coeff and Std error: indicates that these parameters are not estimated.

7.4.2.5 Model for Seriously Injured During High Season Months

Poisson model for high season months also follow similar trend to other models (Table 7.7). For example, the results for the major land use indicates that agricultural land use has the least and commercial the highest casualties. For road type category, the unknown roads and roundabouts had the lowest and highest casualties, respectively. Similarly, those junction details with mini-roundabout and not at junction or within 20 metres had the lowest and highest pilgrim pedestrian casualties. In this case, all the major land use variables except commercial land use type were negative associated with pilgrim pedestrian casualties during high season months. While the association of road type and junction detail variables with casualty follow the general trend as explained in other models above. According to the estimated coefficients in Table 8.5, the Poisson model for high season months bear great similarity to those of non-prayer time and working days. For instance, the casualties for accommodation and commercial were much higher for these models (i.e. non-prayer time, working days and high season months) compared to other models for prayer time, weekends and low season months. In contrast to Poisson models for non-prayer time and working days, accommodation was found to be negatively associated with casualty during high season months. Consequently, the seriously injured pilgrim pedestrian in the accommodation areas during high season months was lower than during non-prayer time and working days. In other words, pilgrim pedestrians are more reluctant to stay in their accommodation during high season months. Instead, they prefer to walk to places of interest such as shopping centres, ancient religious sites and Mosques for religious activities. Hence, the probability of pilgrim pedestrian casualty was high during the high season months. Furthermore, the seriously injured pilgrim pedestrians during high season months were considerably higher than low season months due to the enormous number of pilgrims visiting Madinah during high season months which are considered sacred by Muslim pilgrims.

7.4.2.6 Model for Seriously Injured During Low Season Months

This model shows that for the major land use category, agriculture and then followed by government offices had the lowest casualties for similar reasons explained above. The highest casualties were found to occur in accommodation and residential areas during low season months. Expectedly, the absence of religious festivals during this period would discourage most pilgrim pedestrians from visiting other land use type. Instead, these pilgrim pedestrians would prefer to engage in activities around their homes resulting in the high casualties in accommodation and residential areas. This model also shows that shopping was at its lowest compared to the other models due to the low population of pilgrims travelling to Madinah during this period. Hence, the pilgrim pedestrian casualty in the commercial areas during this period was far lesser than casualty figures recorded during high season months. This model also shows that for road type category, single carriageway – 3 lanes and roundabouts has the lowest and highest casualties, respectively. While for the junction detail category, roundabouts and not at junction or within 20 metres has the lowest and highest casualties, respectively. Again, this model show that all the major land use variables were negatively associated with seriously injured pilgrim pedestrians during low season months. Like other models, all the road type variables except single carriageway – 2 lanes and roundabout; and all the junction details variables except T, Y or staggered junction and not at junction or within 20 metres are negatively associated with pilgrim pedestrian casualties during low season months (Table 7.11). In general, lesser number of pilgrims across the globe travels to Madinah during low season months. Hence, pilgrim pedestrian casualty during low season months was found to be much lower than those obtained for high season months as reflected in the estimated coefficients.

7.4.3 Models for Killed Pilgrim Pedestrians in Madinah

In general, the Poisson models for killed pilgrim pedestrians in Madinah shows that most of the estimated coefficients were not significant at 5% confidence level which may be due to the small number of observations used for the analysis compared to those of seriously injured (Table 7.9). The lack of significance was predominantly obvious particularly with the coefficients of road type variables which probably indicated that the number of observations in this category was fewer than major land use and junction details. The results also show that some of the coefficients were not estimated due to the same reasons explained above. Generally, the coefficients of the major land use types follow similar trend for both seriously injured and killed models. For example, agriculture has the lowest casualty throughout the models for both seriously injured and killed. Although for some Poisson models for killed pilgrim pedestrians, both agriculture and government offices had equivalent coefficient. Similarly, commercial land use has the highest casualty for all models for both seriously injured and killed except for low season months. While both seriously injured and killed models for low season months indicated that accommodation has the highest casualty (Table 7.9). In contrast, the coefficients of the road type and junction detail categories seem not to follow a clear pattern for killed models compared to the seriously injured models. Furthermore, the casualties recorded for killed models are much lower than seriously injured models.

7.4.3.1 Model for Killed During Prayer Time

Poisson model for killed during prayer time show that for the major land use category, the coefficients for agriculture and government offices were equivalent and lowest as emphasized above (Table 7.9). Hence, the lowest fatalities occurred in these land use types. While commercial land use has the highest fatality during prayer time. For road type category, the lowest and highest fatalities occurred on unknown roads and single carriageway – 2 lanes, respectively. The fatality trend for road types was different from that observed for seriously injured during prayer time. While for junction details, the lowest and highest fatalities occurred on roundabouts and not at junction or within 20 metres, respectively (Table 7.9). Again, all the major land use variables except commercial; all the road type variables except single carriageway – 2 lanes; all the junction detail variables except not at junction or within 20 metres were negatively associated with the killed pilgrim pedestrians. The same reasons given for seriously injured during prayer time also hold in this case.

Table 7.11: Poisson regression model showing the coefficients† for seriously injured pilgrim pedestrians

Explanatory Variables	Prayer Time		Non-Prayer Time		Weekends		Working Days		High Season Months		Low Season Months	
	Coeff	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**
Constant*	3.30	0.72	4.21	0.46	3.38	0.52	4.34	0.57	4.23	0.45	2.40	0.82
Major Land Use												
Agriculture	-2.77	0.60	-2.69	0.35	-2.91	0.44	-2.96	0.48	-2.70	0.36	-3.27	0.86
Government Offices	-3.12	0.60	-3.37	0.54	-3.64	0.89	-2.99	0.54	-3.72	0.63	-3.04	0.57
Accommodation	-0.17	0.21	0.15	0.14	-0.43	0.22	0.09	0.16	-0.08	0.16	-0.12	0.20
Commercial	-0.12	0.21	0.17	0.14	-0.49	0.22	0.17	0.16	0.16	0.15	-0.70	0.22
Residential	-0.20	0.21	-0.06	0.14	-0.52	0.23	-0.07	0.17	-0.20	0.16	-0.29	0.21
Religious	-0.90	0.24	-0.88	0.17	-1.38	0.26	-0.80	0.20	-0.89	0.18	-1.35	0.25
Road Type												
Unknown	-2.08	0.56	-2.45	0.37	-2.93	0.75	-2.30	0.41	-2.92	0.56	-2.07	0.43
Single carriageway – 4+ lanes	-2.01	0.42	-1.88	0.27	-1.80	0.38	-1.96	0.33	-2.07	0.32	-1.74	0.38
Single carriageway – 3 lanes	-2.33	0.67	-2.23	0.34	-2.77	0.50	-2.30	0.42	-2.38	0.38	-2.64	0.65
Single carriageway – 2 lanes	**1.01**	**0.20**	**1.18**	**0.16**	**0.68**	**0.25**	**1.20**	**0.17**	**1.21**	**0.17**	**0.59**	**0.25**
Single carriageway – single track	-1.66	0.36	-1.76	0.27	-2.03	0.37	-1.77	0.32	-1.80	0.29	-2.12	0.40
Dual carriageway – 3+ lanes	-2.33	0.56	-1.94	0.29	-2.54	0.41	-2.07	0.36	-2.05	0.34	-2.36	0.44
Dual carriageway – 2 lanes	-1.22	0.29	-1.32	0.23	-1.91	0.33	-1.15	0.25	-1.35	0.24	-1.54	0.32
One way street	-1.46	0.30	-1.18	0.22	-1.62	0.32	-1.17	0.26	-1.18	0.24	-1.74	0.34
Roundabout	1.16	0.68	1.55	0.40	0.88	0.49	1.69	0.52	1.39	0.41	0.48	0.74
Junction Details												
Other junction	-1.89	0.39	-1.21	0.26	-1.54	0.33	-1.36	0.33	-1.42	0.30	-1.88	0.39
Private drive or entrance	-2.27	0.52	-1.50	0.30	-2.61	0.58	-1.41	0.34	-1.61	0.32	-2.43	0.58
Multiple junction	-2.04	0.41	-1.80	0.33	-2.33	0.45	-1.59	0.36	-1.93	0.36	-1.95	0.42

Crossroads	-0.63	0.26	-0.14	0.18	-0.60	0.26	-0.14	0.22	-0.45	0.21	-0.42	0.26
Slip road	**-0.43**	**0.78**	-2.66	0.51	-2.42	1.23	-2.44	0.54	-2.74	0.53	-1.71	0.87
T, Y or staggered junction	**0.48**	**0.21**	1.12	0.14	0.48	0.21	**1.10**	**0.17**	0.96	0.17	**0.44**	**0.23**
Mini-roundabout	-2.28	0.76	-3.15	0.64	-3.49	0.79	-3.03	0.70	-3.23	0.68	-2.93	0.78
Roundabout	-2.48	0.54	-1.99	0.33	-2.28	0.40	-2.24	0.42	-1.98	0.33	-2.62	0.66
Not at junction or within 20 metres	0.61	0.21	1.31	0.14	0.75	0.21	1.27	0.16	1.26	0.16	0.35	0.22

* Constants taken from the parameter estimates in the Appendices.

† Coefficients taken from the estimated marginal means of the land use variables in the Appendices.

Table 7.12: Poisson regression model showing the estimated coefficients for killed pilgrim pedestrians

Explanatory Variables	Prayer Time		Non-Prayer Time		Weekends		Working Days		High Season Months		Low Season Months	
	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error
Constant*	**0.99**	**1.32**	**1.65**	**0.95**	**-0.89**	**0.95**	**1.82**	**1.17**	**1.69**	**1.12**	**-0.45**	**0.91**
Major Land Use												
Agriculture	**-2.42**	**1.09**	-3.38	0.80	--	--	-2.94	0.79	-3.70	1.03	**-2.03**	**0.91**
Government Offices	**-2.42**	**1.09**	-3.38	0.58	**-2.34**	**0.94**	-2.94	0.79	-3.01	0.75	--	--
Accommodation	**-0.35**	**0.36**	-0.30	0.22	**-0.23**	**0.31**	-0.53	0.29	-0.59	0.27	0.12	0.33
Commercial	0.04	0.30	-0.24	0.21	-0.04	0.30	-0.46	0.28	-0.29	0.25	**-0.31**	**0.36**
Residential	-0.05	0.34	-0.51	0.21	**-0.32**	**0.30**	**-0.69**	**0.28**	-0.71	0.26	**-0.26**	**0.30**
Religious	-0.81	0.40	-1.04	0.24	-0.93	0.42	-1.09	0.31	-1.23	0.31	-0.76	0.38
Road Type												
Unknown	-2.10	0.82	**-1.17**	**0.81**	**-1.70**	**0.94**	**-1.93**	**0.79**	**-2.83**	**1.03**	**-0.89**	**0.68**
Single carriageway – 4+ lanes	--	--	-2.43	0.59	**-1.33**	**0.95**	**-2.35**	**1.08**	**-2.17**	**1.03**	**-1.14**	**0.91**
Single carriageway – 3 lanes	**-1.27**	**0.81**	**-2.25**	**0.50**	**0.78**	**1.21**	**-2.24**	**0.58**	**-2.30**	**0.56**	**0.40**	**0.96**
Single carriageway – 2 lanes	**0.32**	**0.31**	**0.44**	**0.21**	0.69	0.26	**0.59**	**0.25**	**0.59**	**0.25**	**0.63**	**0.27**
Single carriageway – single track	**-0.95**	**0.83**	-2.29	0.35	--	--	**-1.94**	**0.42**	**-2.08**	**0.42**	**-1.23**	**0.91**
Dual carriageway – 3+ lanes	--	--	-2.34	0.38	**-1.16**	**0.70**	**-2.25**	**0.58**	**-2.43**	**0.56**	**-0.80**	**0.67**
Dual carriageway – 2 lanes	**-1.50**	**0.56**	**-1.44**	**0.27**	**-0.88**	**0.36**	**-1.38**	**0.36**	**-1.19**	**0.32**	**-1.10**	**0.48**
One way street	**-1.20**	**0.62**	**-1.55**	**0.27**	**-0.88**	**0.43**	**-1.32**	**0.35**	**-1.68**	**0.36**	**-0.60**	**0.39**
Roundabout	-0.30	1.26	-0.25	0.93	-1.70	0.94	-0.14	1.16	-0.20	1.10	-1.08	0.91
Junction Details												
Other junction	-1.08	0.60	-1.78	0.36	-1.10	0.63	-1.97	0.44	-2.09	0.42	**-0.44**	**0.95**
Private drive or entrance	-1.62	0.84	-2.43	0.45	-2.11	0.72	-2.32	0.60	-2.46	0.54	-2.05	0.91
Multiple junction	-1.70	0.64	-1.50	0.40	-2.01	0.85	-1.72	0.47	-2.13	0.66	-1.44	0.46

Crossroads	-0.68	0.47	-1.27	0.27	-0.68	0.40	-1.01	0.35	-1.38	0.37	-0.48	0.36
Slip road	--	--	-0.01	0.24	--	--	--	--	--	--	--	--
T, Y or staggered junction	**-0.27**	**0.43**	**-2.36**	**0.81**	**0.11**	**0.34**	**0.01**	**0.30**	**-0.30**	**0.32**	**0.19**	**0.33**
Mini-roundabout	--	--	-2.46	0.54	--	--	-2.38	1.08	--	--	-1.17	0.92
Roundabout	-1.74	0.74	-0.01	0.23	0.19	0.35	-2.29	0.55	-2.69	0.54	0.10	0.30
Not at junction or within 20 metres	0.10	0.38	-1.78	0.36	0.19	0.35	0.16	0.28	-0.06	0.30	0.10	0.30

* Constants taken from the parameter estimates in the Appendices.

† Coefficients taken from the estimated marginal means of the land use variables in the Appendices.

7.4.3.2 Model for Killed During Non-Prayer Time

This model also show similar trend for the major land use variables as described above. For road type category, single carriageway – 3 lanes and single carriageway – 2 lanes had the lowest and highest fatalities. While for junction details, roundabout and not at junction or within 20 metres had the lowest and highest fatalities. In this model, all the major land use variables; all the road type variables except single carriageway – 2 lanes; and all the junction details were negatively associated with killed pilgrim pedestrians. In general, there appears to be noticeable increase in the number of fatalities for the non-prayer time compared to prayer time. Nevertheless, the number of pilgrim pedestrians killed was less than those seriously injured during non-prayer time.

7.4.3.3 Model for Killed During Weekends

In this model, the coefficient for agriculture was not estimated probably due to the small number of observation used. Hence, the lowest fatality for the major land use occurred in the government offices during the weekends. Same as most of the other models, commercial land use had the highest fatality. Again, the road types unknown and single carriageway – 3 lanes had the lowest and highest fatality. For junction details, the highest fatalities occurred at roundabouts and not at junction or within 20 metres (both variables came out as references in this category). While the lowest fatality occurred on a private drive or entrance junction for this model (Table 7.9). This model also shows that all the major land use variables; all the road type variables except single carriageway – 3 lanes and single carriageway – 2 lanes; and all the junction detail variables except T, Y or staggered junction, roundabout and not at junction or within 20 metres were negatively associated with killed pilgrim pedestrians during weekends.

7.4.3.4 Model for Killed During Working Days

This model follows the general trend for the major land use. For instance, agriculture and government offices which coincidentally had the same coefficient recorded the least fatality and commercial had the highest fatality. For road type category, the single carriageway – 4+ lanes and single carriageway – 2 lanes has the lowest and highest fatalities, respectively. While for junction details, mini-roundabout and not at junction or within 20 metres has the lowest and highest fatalities, respectively. Similarly, this model shows that all the major land use variables; all the road type variables except single carriageway – 2 lanes; and all the junction detail variables except T, Y or staggered junction and not at junction or within 20 metres were negatively associated with killed pilgrim pedestrians during working days. The number of pilgrim pedestrians killed was considerably lower than those seriously injured during working days. Furthermore, the fatality during working days is much greater than during weekends.

7.4.3.5 Model for Killed During High Season Months

The Poisson model for killed during high season months also follows the general trend for the major land use category. Agriculture and commercial land use having the lowest and highest fatalities, respectively. However, the road type category show that unknown and single carriageway – 2 lanes had the lowest and highest fatality, respectively. While for junction details, roundabouts and not at junction or within 20 metres had the lowest and highest fatality, respectively. This model shows that all the major land use variables; all the road type variables except single carriageway – 2 lanes; and while all the junction detail variables were negatively associated with killed pilgrim pedestrians during high season months. The number of pilgrim pedestrians killed during high season was the highest compared to other models.

7.4.3.6 Model for Killed During Prayer Time

The Poisson model for killed during high season months also follows the general trend for the major land use category. Agriculture and accommodation land use having the lowest and highest fatalities, respectively. However, the road type category shows that single carriageway – single track and single carriageway – 2 lanes had the lowest and highest fatality, respectively. While for junction details, private drive or entrance and not at junction or within 20 metres (or roundabouts which was also referenced redundant) had the lowest and highest fatality, respectively. This model shows that all the major land use variables except accommodation; all the road type variables except single carriageway – 3 lanes and single carriageway – 2 lanes; and while all the junction detail variables except T, Y or staggered junction, mini-roundabout, roundabout and not at junction or within 20 metres were negatively associated with killed pilgrim pedestrians during low season months. The number of pilgrim pedestrians killed during low season was the lowest compared to other models.

7.5 Validation of Accident Models

Model validation is the process of deciding when the numerical results quantifying hypothesized relationship between variables are acceptable in describing the data. The validation process can involve analysing the goodness fit of the model by checking whether the regression residuals are random and check whether the model's predictive performance depreciates substantially when the model is applied a data of similar characteristics (or source) but not used in the model estimation. The coefficient of determination (R^2) is sometimes used to validate a model, but unfortunately, a high coefficient of determination (R^2) does not guarantee the model fits the data well. Hence, the application of the coefficient of determination in validating a model could be misleading because its measure of model validity can always increase by adding more variable into the model, unless the added variables are entirely uncorrelated with the dependent variable. Nevertheless, other methods can be used to validate a model.

It is imperative to validate the various models developed to be able to use them in real life situations. The robustness of the models were ascertained by validating them using real accident data with similar conditions or parameters. In this case, the pilgrims' pedestrian casualty data for the year 2010 from Madinah was used to validate the Poisson models developed. The Poisson regression models were fitted for the 2010 accident data for the validation purposes (Tables 7.13 and 7.14). This was done to compare the coefficients of the main accident models for the period of 2001 to 2005 (Tables 7.7 – 7.12) and 2010 data (Tables 7.13 and 7.14). The nearness of the values of the coefficients will give indication of the robustness of the main accident models. Unfortunately, most of the coefficients of the models for the validation (i.e. 2010 data) were insignificant as highlighted in Tables 7.13 and 7.14. The insignificance of most of the variables could be attributed to the fact that the number of observations (N) used for 2010 accident data was small resulting to this problem.

Table 7.13: Poisson regression model for seriously injured (SI) pilgrim pedestrians (2010 accident data results for validation)

Explanatory Variables	**Prayer Time**		**Non-Prayer Time**		**Weekends**		**Working Days**		**High Season Months**		**Low Season Months**	
	Coeff	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**
Constant	**1.98**	**1.39**	2.41	0.90	**-1.17**	**0.60**	2.56	0.86	2.67	0.79	**-1.02**	**0.87**
Major Land Use												
Agriculture	**-0.31**	**1.43**	**2.52**	**1.43**	--	--	**-0.31**	**0.85**	**-0.56**	**0.99**	--	--
Government Offices	--	--	-2.15	0.82	--	--	-2.43	0.82	-2.51	1.20	**-1.47**	**0.86**
Accommodation	0.88	0.40	0.81	0.27	1.27	0.34	0.62	0.24	0.73	0.26	1.02	0.30
Commercial	**0.54**	**0.41**	1.01	0.26	1.15	0.34	0.74	0.24	1.01	0.25	**0.39**	**0.31**
Residential	**0.65**	**0.43**	0.76	0.27	1.07	0.34	0.62	0.25	0.73	0.27	0.64	0.31
Religious	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Road Type												
Unknown	--	--	-2.84	1.40	**0.73**	**1.05**	--	--	--	--	**-0.04**	**1.17**
Single carriageway – 4+ lanes	**-1.88**	**1.48**	-2.41	0.92	**1.38**	**0.71**	-2.40	0.89	-2.53	0.83	**0.77**	**0.95**
Single carriageway – 3 lanes	--	--	-3.13	1.07	**0.85**	**1.05**	-3.19	1.15	-3.34	1.01	--	--
Single carriageway – 2 lanes	**-0.18**	**1.34**	**-0.09**	**0.85**	2.63	0.53	**-0.07**	**0.83**	**-0.17**	**0.74**	2.45	0.83
Single carriageway – single track	**-1.82**	**1.50**	-2.36	0.90	**0.59**	**0.61**	-2.32	0.90	-2.56	0.81	**0.83**	**0.94**
Dual carriageway – 3+ lanes	**-2.41**	**1.90**	-2.76	0.95	**1.75**	**1.08**	-2.71	0.93	-3.41	1.09	**1.12**	**0.98**
Dual carriageway – 2 lanes	**-2.13**	**1.45**	-2.02	0.90	**0.90**	**0.66**	-2.07	0.88	-2.35	0.81	**0.52**	**0.92**
One way street	**-1.81**	**1.55**	-2.43	0.93	**0.90**	**0.65**	-2.60	0.93	-2.46	0.83	**1.25**	**1.03**
Roundabout	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Junction Details												
Other junction	**-1.47**	**0.82**	-2.34	0.43	-2.64	0.64	-2.22	0.42	-2.29	0.41	-2.45	0.83
Private drive or entrance	-1.86	0.63	--	--	--	--	-2.51	0.52	-2.90	0.60	-1.81	0.84
Multiple junction	--	--	-2.59	0.57	--	--	-2.52	0.58	-2.98	0.69	**-0.39**	**0.94**

Crossroads	-1.50	0.46	-1.50	0.25	-1.65	0.30	-1.53	0.27	-1.80	0.29	-0.91	0.27
Slip road	--	--	-2.50	0.80	--	--	-2.11	0.67	**0.16**	**1.10**	--	--
T, Y or staggered junction	**-0.12**	**0.27**	-0.37	0.16	-0.83	0.22	**-0.11**	**0.16**	-0.44	0.17	**0.04**	**0.21**
Mini-roundabout	**-1.81**	**1.38**	-2.52	0.80	-2.29	0.65	**-0.57**	**1.22**	-2.01	0.85	-2.45	0.83
Roundabout	-2.58	0.97	-2.63	0.65	0[a]	--	-2.84	0.52	-2.99	0.54	0[a]	--
Not at junction or within 20 metres	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Summary of modelling statistics												
Number of Casualties (n)	123		241		106		258		261		96	
Observation Used (N)	36		69		39		69		68		34	
Deviance (Dv)	22.0		44.6		17.6		42.6		47.9		10.5	
Degree of freedom (df)	19		48		23		48		47		16	
Value/df for the Deviance	1.16		0.93		0.77		0.89		1.02		0.66	
Value/df for the Pearson Chi-Sq.	1.77		1.23		0.79		1.28		1.38		0.66	
Log Likelihood	-58[b,c]	(-33[d])	-109[b,c]	(-89[d])	-56[b,c]	(-72[d])	-109[b,c]	(-86[d])	-111[b,c]	(-80[d])	-48.2[b,c]	(72.8[d])

Dependent Variable: Count_SI; Model: (Intercept), Major land use, Road Type, Junction Detail.

Bold figures are not significant at 95% Confidence level.

a. Set to zero because this parameter is redundant (This enable the comparison of the coefficients of land use variables in each land use category);

b. Computed based on the Pearson chi-square.

c. The log likelihood is based on a scale parameter fixed at 1;

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table 7.14: Poisson regression model for killed pilgrim pedestrians (2010 accident data results for validation)

Explanatory Variables	**Prayer Time**		**Non-Prayer Time**		**Weekends**		**Working Days**		**High Season Months**		**Low Season Months**	
	Coeff	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**	**Coeff**	**Std Error**
Constant	**0.74**	**0.88**	**-0.09**	**0.53**	**0.00**	**0.61**	**0.25**	**0.44**	**0.00**	**0.51**	**-0.38**	**0.53**
Major Land Use												
Agriculture	--	--	--	--	--	--	--	--	--	--	--	--
Government Offices	--	--	--	--	--	--	--	--	--	--	--	--
Accommodation	**-0.13**	**0.40**	1.08	0.33	**0.10**	**0.92**	0.78	0.25	0.75	0.25	**0.67**	**0.40**
Commercial	**0.51**	**0.36**	**0.47**	**0.35**	**-0.31**	**0.94**	**0.38**	**0.26**	**0.42**	**0.27**	**0.30**	**0.39**
Residential	**-0.05**	**0.39**	**0.31**	**0.36**	**0.00**	**0.86**	**0.18**	**0.28**	**0.11**	**0.29**	**0.43**	**0.40**
Religious	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Road Type												
Unknown	--	--	--	--	--	--	--	--	--	--	--	--
Single carriageway – 4+ lanes	--	--	--	--	--	--	--	--	--	--	--	--
Single carriageway – 3 lanes	**0.00**	**0.60**	**1.47**	**0.92**	**0.00**	**0.86**	**0.71**	**0.78**	**1.17**	**0.81**	**-0.04**	**0.67**
Single carriageway – 2 lanes	**-0.05**	**0.71**	1.40	0.46	**1.21**	**0.67**	1.21	0.38	1.60	0.55	**0.39**	**0.42**
Single carriageway – single track	**-0.74**	**0.98**	**-0.29**	**0.90**	--	--	**-0.28**	**0.59**	**0.03**	**0.63**	--	--
Dual carriageway – 3+ lanes	--	--	**-0.39**	**0.59**	--	--	--	--	--	--	--	--
Dual carriageway – 2 lanes	**0.27**	**0.87**	0[a]	--	**0.28**	**0.79**	**-0.19**	**0.53**	**0.22**	**0.68**	**-0.18**	**0.55**
One way street	0[a]	--	--	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Roundabout	--	--	--	--	--	--	--	--	--	--	--	--
Junction Details												
Other junction	--	--	-1.62	0.77	--	--	-1.63	0.62	-1.71	0.54	--	--
Private drive or entrance	**-0.69**	**0.52**	--	--	0[a]	--	-1.06	0.46	-1.60	0.55	0[a]	--
Multiple junction	--	--	**-1.31**	**0.78**	--	--	-1.45	0.62	-1.60	0.55	--	--

Crossroads	**-0.34**	**0.25**	-1.69	0.35	**-0.46**	**0.32**	-1.13	0.33	-1.28	0.25	**0.04**	**0.32**
Slip road	**-0.74**	**0.98**	--	--	0[a]	--	--	--	0[a]	--	--	--
T, Y or staggered junction	-0.97	0.35	-0.70	0.24	-0.92	0.40	-0.71	0.19	-0.82	0.18	**-0.05**	**0.30**
Mini-roundabout	--	--	-1.58	0.55	--	--	-1.66	0.44	-2.02	0.53	**0.00**	**0.63**
Roundabout	--	--	--	--	--	--	--	--	--	--	--	--
Not at junction or within 20 metres	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--	0[a]	--
Summary of modelling statistics												
Number of Casualties (n)	22		56		23		55		54		21	
Observation Used (N)	15		25		13		24		19		17	
Deviance (Dv)	0.54		5.80		1.39		3.44		1.25		1.89	
Degree of freedom (df)	3		12		4		10		5		7	
Value/df for the Deviance	0.18		0.48		0.35		0.34		0.25		0.27	
Value/df for the Pearson Chi-Sq.	0.18		0.53		0.37		0.35		0.26		0.27	
Log Likelihood	-17.2[b,c]	(-95.3[d])	-32.7[b,c]	(-62.0[d])	-16.2[b,c]	(-43.7[d])	-31.1[b,c]	(-90.3[d])	-25.6[b,c]	(-9.9[d])	-19.1[b,c]	(-70.1[d])

Dependent Variable: Count_SI; Model: (Intercept), Major land use, Road Type, Junction Detail.

Bold figures are not significant at 95% Confidence level.

a. Set to zero because this parameter is redundant (This enable the comparison of the coefficients of land use variables in each land use category);

b. Computed based on the Pearson chi-square;

c. The log likelihood is based on a scale parameter fixed at 1;

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test;

-- in Coeff and Std error: indicates that these parameters are not estimated.

However, the main accident models were then used to predict the casualties of the 2010 accident data. The results are given below, shows over-predictability in most cases. Nevertheless, the values are close enough to be used for predictive purposes. Again, the models gave descriptive relationships of pilgrims' pedestrian casualties and land use types.

Table 7.15: Prediction of casualties for 2010 using accident models developed for SI

	Prayer Time	**Non-Prayer Time**	**Weekends**	**Working Days**	**High Season Months**	**Low Season Months**
Observed	123	241	106	258	261	96
Predicted	146	256	88	236	253	88

Table 7.16: Prediction of casualties for 2010 using accident models developed for Killed

	Prayer Time	**Non-Prayer Time**	**Weekends**	**Working Days**	**High Season Months**	**Low Season Months**
Observed	22	56	23	55	54	21
Predicted	46	67	38	67	61	31

Although most of the estimated coefficients of the land use types were not significant at 5% confidence level due to lack of sufficient number of observations. In other words, the 2010 pilgrim pedestrian data has small number of observations used to produce the Poisson models that was used to validate the results obtained for 2001 to 2005 data. In general, the validation models for seriously injured and killed bear similarity with those models obtained for the data used in this study (i.e. from 2001 to 2005). For example, most of the models revealed that Poisson regression model show that the estimates for most of the land use type obtained for 2010 data also follow similar trend as those given by the data for this study. In most cases, the major land use category indicates that government offices and agricultural land use have the lowest coefficients which suggested that pilgrim pedestrian casualties of these land use type were lower than the casualties recorded in religious areas. In contrast, the highest number of seriously injured pilgrim pedestrians for most of the model was recorded in the commercial area, followed by accommodation and residential areas. Expectedly, government offices and agricultural land use were the least trip attractors for pilgrims during non-prayer time. Most pilgrims would be more attracted to other land use type (e.g. accommodation, commercial and religious areas) that would positively contribute to their pilgrimage. For road type category, the lowest and highest casualties were recorded at unknown roads and roundabouts, respectively. Similarly, mini-roundabout and not at junction or within 20 metres (the reference for junction details) have the lowest and highest seriously injured pilgrim pedestrians for most of the models as obtained for the data used in this study.

7.6 Summary

Accident models are essential tools in predicting the frequencies of road accidents. They could also be used used to describe the relationships between variables. In this Chapter, several accident models were developed for both seriously injured and killed pilgrims' pedestrians using 2001 to 2005 accident data obtained from the Madinah Traffic Police Department. These models were used to explain the reelationships between pilgrims' pedestrian casualty and land use types in Madinah. The results indicate strong association between pilgrims' pedestrian casualties and commercial land use. Similar relationship was found between pilgrims' pedestrian casualties and religious land use. The models also revealed that the coefficients for other land use categories such as road types and junction details were not significant as highlighted in bold in Tables 7.7 – 7.14. Modelling the relationship between the pilgrims' pedestrian casualties and land use type has fulfilled the aims and objectives of this research.

Chapter Eight: Conclusions and Recommendations

"The story of civilization is, in a sense, the story of engineering – that long and arduous struggle to make the forces of nature work for man's good"

— **Lyon Sprague DeCamp**

Chapter Eight: Conclusions and suggestions for further research

8.1 Introduction

The growing incidence of road traffic accidents has become a public health challenge. Annually, over a million people are killed in road accidents. Among those killed, pedestrians constitute substantial proportion due to their vulnerability in sustaining casualty during pedestrian-vehicle collision. The fatalities of pedestrians are even higher in cities such as Madinah that play host to a mass gathering events. In an attempt to curb the growing fatality of pedestrians in Saudi Arabia, the government has taken several steps to thoroughly assess the extent of the problem in order to improve pedestrian safety in the country, especially, in cities like Madinah which has religious significance that attract enormous number of Moslems globally. Consequently, the streets in Madinah are often over-crowded with both Saudis and foreign pilgrims that are susceptible to pedestrian-vehicle collision that frequently leads to casualties. It was against this backdrop that this research was undertaken to assess or model the relationship between pilgrims' pedestrian casualty and the land use type in Madinah. The novelty of the research has been stressed as none other study has investigated the relationship between pilgrims' pedestrian casualty and land use of any city that play host to a religious mass gathering event like the Hajj.

8.2 Research Findings

In order to achieve the aims and objectives of the research, extensive literature review was carried out to explore the background of road traffic accidents and other related topics that will assist in answering the research questions such as critical review of literature of previous studies of road accidents with emphasis on pedestrian casualty. This Chapter concisely presents the main research findings and attempts to answer the research question and hypothesis proposed in Chapter One. The study undertook extensive literature review of studies on pedestrian accidents' as well accident analysis and investigation in Saudi Arabia and elsewhere. Most of the findings in the literature review were consistent with the findings in Madinah. A typical example is the contribution of over-crowdedness or increase in population in pilgrims' pedestrian casualty. Again, this study also found strong association between pilgrims' pedestrian casualties and commercial and religious land use types. Hence, the hypothesis proposed in Chapter One has been answered.

One of the main findings of this research is that the serious accident pattern indicates the need for improved pedestrian facilities for pilgrims. This is the major outcome of the modelling and the analysis in general. Other research findings show that male pilgrims are over represented in pedestrian casualty in Madinah. Male and female pedestrian casualties were found to represent 59% and 41%, of the sampled data respectively. Hence, the male to female pedestrian casualty ratio was 1.4:1, which is similar to those obtained from other road accident studies in Arab-Muslim countries which also recorded higher male casualty compared to female. Again, it is consistent with the fact that more men embark on pilgrimage than their female counterpart.

The percentage of fatalities of pedestrians pilgrims' was 16.3%, while a vast majority (83.7 %) of the pilgrims sustained serious injuries. In terms of road type, the highest casualties occurred on single carriageway-2 lanes and mostly on roads around the Holy. While for the junction, most of the accidents occurred not at junction or within 20 metres of the junction. The results indicate that the majority of accidents appear to occur in proximity to junctions or close to T, Y or staggered junctions.

In terms of pilgrims' pedestrian casualty based on days, the highest fatality occurred on Fridays, which is a very important day of worship for Moslems. Whereas on Sundays has the lowest. The seasonality of accidents was obvious during the three months of Du Alhijn, Du Alqadeh and Rammadan. Again, these are important months in the Islamic calendar. Consequently, significantly greater numbers of Moslems embarked on pilgrimage during these periods. Almost three-quarter of the pedestrians pilgrim sustained their casualties during high season months.

Most pilgrims' pedestrians suffer casualty during non-praying time because during prayer time, because most of them would either be in the Mosque or residence fulfilling their obligation to pray. Consequently, they interact less with vehicles during prayer time. In terms of age category, young pilgrim pedestrians (12-20 years old) suffer the most casualties; while the least casualty was recorded for child pilgrim pedestrians (under 12 years old).

In modelling the relationship between pilgrims' pedestrians and land use type, quasi-Poisson regression models fitted the accident data better than Negative Binomial regression models.

There was strong association between commercial land use type and pedestrian casualties for models in the following categories – prayer time, non-prayer time, working days and high season. While for weekends and low season, the casualties were high for accommodation and residential areas. In these models, the highest casualties were recorded for accommodation religious land use types, while the highest killef were recorded at the commercial sites, except for low season. Although nearly all the coefficients estimated were insignificant but considering the coefficients that are significant in general, the highest fatality was for Single carriageway – 2 lanes and the lowest was found in dual carriageway – 3+ lanes (for weekend model). For junction details, T, Y or staggered junction was found to be insignificant for all models. The highest casualty was for not at junction or within 20 metres, as the case in western countries for example. This is a mjor findings of this research; and one which will have implications for junction, road and transport system designs. Also implications for traffic engineers will be drawn based on these results. Better pedestrian facilities should be provided in order to reduce accident pedestrians at variuous locations of thetransport systems in Al-Mdina.

8.3 Suggestions for further research This research has modelled the relationship between pilgrims' pedestrian casualty and land use type in Madinah, Saudi Arabia. Similar studies could be extended to other religious (or Holy Cities) such as Makkah and Jeddah. This is because Makkah, Madinah and Jeddah predominantly made up the Hajj region frequently visit by Muslim pilgrims to perform religious rites and tourism purposes. Since this research is novel being the first of its kind, conducting similar research in Makkah and Jeddah would enable comparison of results for validation purpose. Furthermore, similar study could be extended beyond the shores of Saudi Arabia to the cities of other countries that usually play host to mass gathering events. For example, the Vatican City play host to Christian pilgrims (i.e. Catholics); while the Hindu festivals are being hosted in certain cities in India. Besides religious festivals, similar research could also be extended to other mass gathering events that are prone to high incidence of pedestrian casualties. Typical examples include the Olympic Championships, FIFA World Football Cup Competitions, Political and Musical Concerts gatherings etc.

Developing accident models that incorporates other variables besides land use type would assist policy makers to tackle specific targets that lead to high incidence of pedestrian casualty. Although this study examined the influence of the 'land use type' on pilgrims' pedestrian casualty, but other road accident studies have established the influence of many other variables (e.g. Socio-economic deprivation, Age category, Educational level and Population etc.) on pedestrian casualty. Therefore, it would be interesting to undertake research in the future that would model the relationship between pilgrims' pedestrian casualty and either of the above mentioned variables. In other words, such research would give a measure of he influence of the above mentioned variable on pilgrims' pedestrian casualty. Developing accident models that incorporates such as Socio-economic deprivation can provide insight on the extent to which the income of the pilgrims' pedestrians affects the casualty rate. Similarly, the accident model would give indication of the impact the various age categories and educational levels would have on the pedestrian casualty rate.

Policy makers should make training programmes such as driving test and induction courses for drivers compulsory. This will ensure that drivers are properly taught the art of safe driving and the high standard for issuing drivers' licences are maintained. This is necessary because drivers' behaviour has been identified from the literature reviewed to be responsible for many of the road accidents in most countries, including Saudi Arabia.

1. The government of Saudi Arabia should enact legislation that imposes severe penalty on drivers and pedestrians that violates road safety rules and regulations. Such punitive measures taken against offenders would serve as deterrent to reckless driving and pedestrians' reluctance to use the crossing at the traffic light.
2. The law enforcement agencies should be strengthened and made more functional. This would help to enforce the legislations enacted on road traffic safety.
3. In general, road users should be encouraged to comply with the road safety rules and regulations. For example, bad practices such as using the mobile phone while driving or walking along the vehicular roads should be avoided. Pedestrians should use the pedestrian lanes (if available) while walking along the vehicular roads. In addition, pedestrians should endeavour to cross the vehicular roads using the 'Zebra crossing' and 'traffic light crossing' to forestall unnecessary pedestrian-vehicle collision. Complying with these road safety rules and regulations would help to minimize pedestrian pilgrims' casualty.
4. The government should take measures to reduce driving speed in those areas with high incidence of pedestrian pilgrims' casualty. Furthermore, there is need to effectively monitor and enforce the speed limits of vehicles within the various land

use types. This can be accomplished by installing speed cameras in strategic locations, especially, those areas with high incidence of pedestrian casualty.

5. This study has highlighted the importance of exposure data to road traffic studies; hence the government of the Kingdom of Saudi Arabia should endeavour to collect and stored high quality exposure data of road users such as pedestrians. This would assist in providing more insight into the causes of road accidents e.g. pedestrian-vehicle collision. Furthermore, a reliable exposure data would help the local authorities and transport planners to identify hazardous locations and proffer counter-measures that will help curb road accidents.
6. Provide adequate resources to tackle the hotspots found in this study.
7. Efforts to improve pedestrian safety should be pursue by establishing a programme that will deal with the root causes of pilgrim pedestrian accidents in Madinah. This may include the following:

   I. Construction of new pedestrian lane and improvement of existing ones;

   II. Improving the design of road and pedestrian lanes around the accident hotspots;

   III. Reduce the speed limits of vehicles in areas with high accident records by developing variable speed limit signing;

   IV. Distinctive skid resistant pavements should be installed to improve the braking capability of vehicles on wet and dry surfaces. A skid resistant pedestrian lane will also make the surface less slippery, thereby, reducing pedestrian casualty;

   V. Install pedestrian fencing and other barriers type to demarcate the pedestrian facilities from areas with high risk of road accident. This will discourage pedestrians from crossing at these areas that are prone to accident;

   VI. Embark on high profile publicity programmes to educate road users of the need to comply with road safety regulations. The programme should target the most vulnerable groups e.g. high risk pedestrian and driver groups;

   VII. Strict enforcement of safety regulations on road users e.g. targeting the unsafe behaviours of pedestrians and drivers at locations and times of the day and periods (e.g. during Hajj and Umrah) with high risk of road accident.

8.4 Summary

The purpose of this research has been achieved considering the fact that the proposed research questions were answered. For instance, extensive literature review of studies on pedestrian accidents' as well accident analysis and investigation in Saudi Arabia and elsewhere were successfelly undertaken. The reswarch was focused on Madinah as a case study area in Saudi Arabia to conduct the study and assess accident rates as well as the significance of the religious nature of Madinah. Pilgrims' pedestrian casualty was found to be on the increase in Madinah. The factors and accident patterns (frequencies and severities) of pedestrian accidents in Madinah, including impacts of land use activities and policies were also examined. Several factors were identified to contribute to pilgrims' pedestrian casualties in Madinah. They include over-crowdedness as a result of the influx of enormous number of Moslem pilgrims from all over the world to Madinah. The results obtained from the study also suggest pattern that are consistent with previous studies. For example, the casualties of male pilgrims were over-represented compared to their female counterpart. The accident models show strong association between pilgrims' pedestrian casualties and commercialas well as religious land use types. However, most of the other land use types (e.g. road types and junction details) were found to insignificant in most of the models. Based on the findings, useful recommendations were proffered to assist policies makers on steps to take to curb pilgrims' pedestrian casualties.

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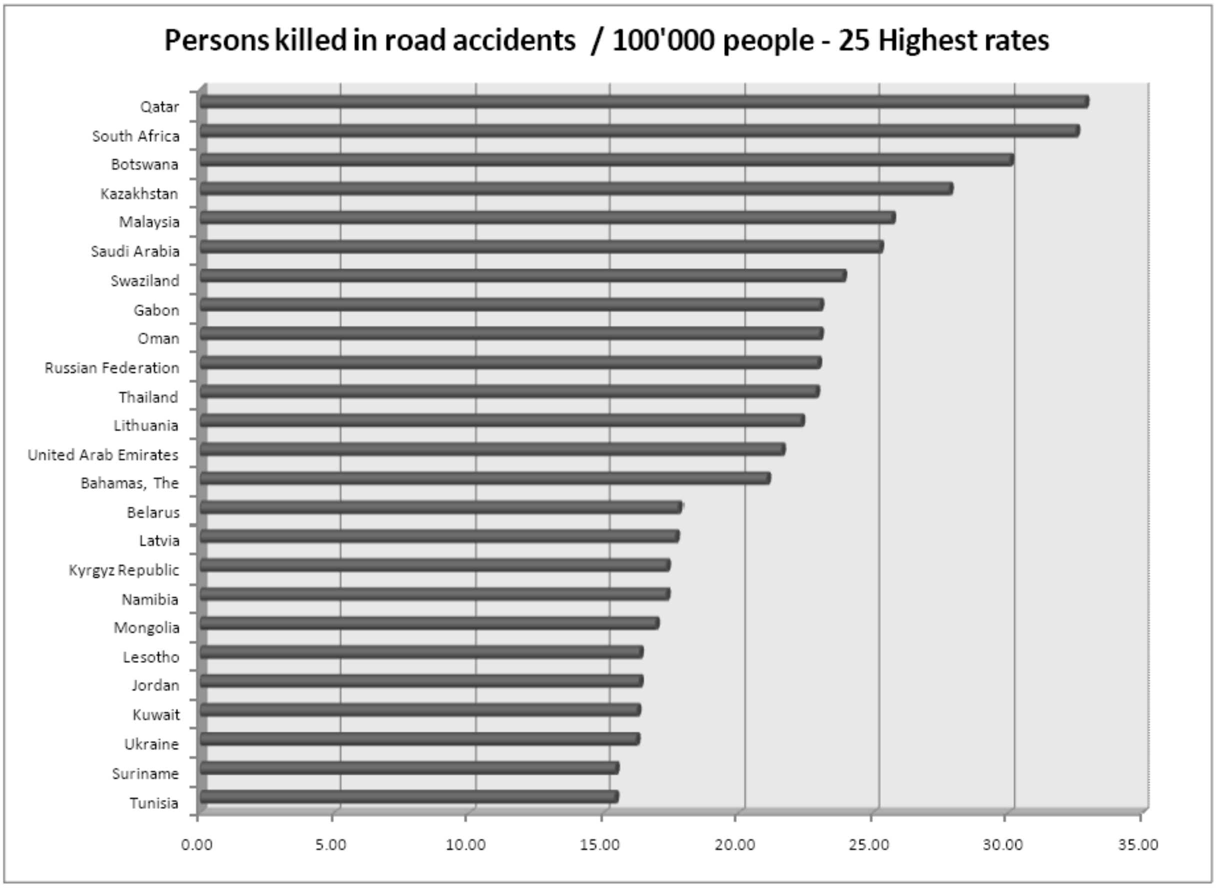
Appendices

Appendix A: World Road Statistics 2008



Appendix B: Description of Accident Data

Variable Name	Role	Variable Type	Description
Accident Year	S	Categorical	Accident year ranged from 2001–2005 (1421AH – 1425AH)
Gender	S	Categorical	0 – Male; 1 – Female.
Age	S	Continuous/categorical	0 - Child Pilgrim: 0-15 years; 1 - Young Pilgrims: 15-45 years; 2 - Middle Age Pilgrims: 45-65 years; 4 - Older Pilgrims > 65 years.
Severity of casualty	S; M and R	Count/categorical	Frequencies of pilgrims' pedestrian casualty / Category of casualty are: 0 – Seriously Injured (SI); 1 – Killed.

Nationality	S	Categorical	0 – Saudi; 1 – Indonesian; 2 – Indian; 3 – Egyptian; 4 – Pakistan; 5 – Turkish; 6 – Iranian; 7 – Nigerian 8 - Others
Day of accident	S	Continuous	Accident day in the calendar month
†Month of accident	S and M	Categorical	Categorized based on the influx of pilgrims for the year: 0 – High Season; 1 – Low Season.
†Day of week	S and M	Categorical	Categorized as: 0 – Islamic Week Days 1 – Islamic Weekends
†Time of accident	S and M	Categorical	0 – Prayer Times 1 – Non-Prayer Times

Road Type	S; M and I	Categorical	0 – Roundabout 1 - One way street 2 - Dual carriageway – 2 lanes 3 - Dual carriageway – 3+ lanes 4 - Single carriageway – single track 5 - Single carriageway – 2 lanes 6 - Single carriageway – 3 lanes 7 - Single carriageway –4+ lanes 8 - Unknown
Speed	S	Categorical	0 – Above 50 Km/h; 1 – Less than 50 Km/h.
Details of Junctions	S; M and I	Categorical	8 - Other junction 7 - Private drive or entrance 0 - Not at junction or within 20 metres 1 – Roundabout 2 - Mini-roundabout 3 - T, Y or staggered junction 4 - Slip road 5 – Crossroads 6 - Multiple junction
Districts	S		See Appendix B
Land use	S; M and I	Categorical	0 – Religion 1 – Residential 2 – Commercial 3 – Accommodation 4 – Government Office 5 - Agriculture

Symbols: S – Used for descriptive statistics; M – Used for accident model; R – Response or dependent variable; I – Independent variables;

† – The accident models were developed based on the categories of these variables. Hence, these were neither response nor independent variables.

Appendix C: Distribution of Pedestrian Casualty in the Districts of Madinah.

S/N	Name of District	Description of Land Use	Pilgrim Pedestrian Casualty (2001 –2005)					
			2001	2002	2003	2004	2005	Total
1	Al-Qiblatayn	Religious; residential; and commercial activities.	8	7	12	13	11	51
2	Al-Khandaq Area	Religious; residential; and commercial activities.	12	12	12	16	19	71
3	Al-Dir'	Religious and residential.	14	13	17	16	14	74
4	Al-Aws Area	Residential and commercial activities	13	13	13	13	18	70
5	Al-Wabrah	Mainly commercial area	5	5	6	6	5	27
6	Al-Saih	Residential and commercial.	9	9	11	13	14	56
7	Al-Mabani'	Residential and pilgrim accommodation.	18	15	20	27	27	107
8	Sele'Area	Predominantly residential.	6	6	6	9	9	35
9	Al-Khazraj Area	Predominantly residential.	8	8	9	9	14	48
10	Al-Suqya	Residential and pilgrim accommodation.	11	11	13	16	16	67
11	Al-Zahdyh	Residential and pilgrim accommodation.	14	15	16	16	22	83
12	Al-Fisalyh	Residential area.	5	5	7	9	9	35
13	Quba Area	Religious, residential and commercial area	41	45	50	53	59	248
14	Al-Anabyh	Very important pilgrim accommodations.	18	18	20	21	28	105
15	Al-Uraid	Residential area	13	13	13	12	13	64
16	Bani Mawiyah	Residential area with some pilgrim accommodations.	15	14	16	16	20	81
17	Al-Hrah Alsharqyh	Residential area and government offices (e.g. Traffic Police Dept.; Police Station).	5	6	6	5	7	29
18	Bani Zafar	Residential and pilgrim accommodation.	12	15	16	15	21	79
19	Al-Jumah	Residential; commercial; and pilgrim	14	15	13	15	14	72

S/N	Name of District	Description of Land Use	Pilgrim Pedestrian Casualty (2001 –2005)					
			2001	2002	2003	2004	2005	Total
		accommodations.						
20	North Qurban	Commercial and pilgrim accommodations.	14	14	13	16	14	71
21	Al-Aliyah Area	Residential; pilgrim accommodations; and commercial; and agricultural.	17	18	18	19	18	90
22	South Qurban	Residential and commercial area.	14	13	17	14	14	73
23	Buda'ah	Pilgrim accommodations and commercial (around the Prophet Mosques).	22	20	31	25	19	117
24	Al-Manakhah	Pilgrim accommodations and commercial (around the Prophet Mosques).	21	22	22	19	21	105
25	Bani Al-Najah	Pilgrim accommodations and commercial (around the Prophet Mosques).	19	22	25	23	22	111
26	Bani Khudrah	Pilgrim accommodations and commercial (around the Prophet Mosques).	22	18	22	22	22	106
27	Al-Baqh – Holy Graveyard	Pilgrim accommodations and commercial (around the Prophet Mosques).	20	24	34	26	26	130
		Total Pilgrim Pedestrian Casualty	**390**	**396**	**458**	**464**	**496**	**2204**

Appendices M and V: Statistical models for Pilgrim Pedestrian Casualty in Madinah

Note: The letter 'M' was used to designate the statistical models for Pilgrim Pedestrian Casualty for the study period from 2001 to 2005; whereas, 'V' for models of the accident data of 2010 used for the validation i.e.

M-1 – M-24: Statistical models for Pilgrim Pedestrian Casualty from 2001 to 2005.

V-1 – V-24: Statistical models of Pilgrim Pedestrian Casualty for the year 2010 used for the validation.

Hence, we have a total of 48 models (i.e. 24 models for the accident data from 2001 to 2005 and 24 models for 2010 data used for the validation). For Poisson regression models, odd numbers followed the letters 'M' and 'V'; while for the negative binomial regression models even numbers followed the letters 'M' and 'V'.

Appendix M-1: Poisson Regression Model for Seriously Injured (SI) during Prayer Time.

Table M-1.1: Model Information

Data set	Prayer Time
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	93

Table M-1.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	83.185	71	1.172
Scaled Deviance	52.093	71	
Pearson Chi-Square	113.375	71	1.597
Scaled Pearson Chi-Square	71.000	71	
Log Likelihood[b,c]	-170.763		
Adjusted Log Likelihood[d]	-106.939		
Akaike's Information Criterion (AIC)	385.527		
Finite Sample Corrected AIC (AICC)	399.984		
Bayesian Information Criterion (BIC)	441.244		
Consistent AIC (CAIC)	463.244		

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.
c. The log likelihood is based on a scale parameter fixed at 1.
d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table M-1.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
670.601	21	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table M-1.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	26.920	1	.000
Major land use	64.062	5	.000
Road Type	366.007	8	.000
Junction Detail	196.961	8	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-1.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	3.295	.7211	1.881	4.708	20.876	1	.000
Agriculture	-1.872	.5881	-3.024	-.719	10.131	1	.001
Government Offices	-2.225	.5874	-3.376	-1.073	14.345	1	.000
Accommodation	.734	.1879	.366	1.102	15.252	1	.000
Commercial	.780	.1861	.416	1.145	17.586	1	.000
Residential	.702	.1878	.334	1.070	13.982	1	.000
Religious	0[a]	.	.	.	.	.	.
Unknown	-3.239	.8795	-4.963	-1.516	13.565	1	.000
Single carriageway –4+ lanes	-3.173	.7982	-4.738	-1.609	15.803	1	.000
Single carriageway – 3 lanes	-3.487	.9502	-5.349	-1.624	13.466	1	.000
Single carriageway – 2 lanes	-.152	.7064	-1.536	1.233	.046	1	.830
Single carriageway – single track	-2.821	.7662	-4.322	-1.319	13.553	1	.000
Dual carriageway – 3+ lanes	-3.491	.8774	-5.211	-1.771	15.831	1	.000
Dual carriageway – 2 lanes	-2.376	.7338	-3.814	-.937	10.481	1	.001
One way street	-2.621	.7493	-4.090	-1.153	12.240	1	.000
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-2.493	.3380	-3.156	-1.831	54.415	1	.000
Private drive or entrance	-2.875	.4872	-3.830	-1.920	34.806	1	.000
Multiple junction	-2.648	.3614	-3.357	-1.940	53.711	1	.000
Crossroads	-1.241	.1894	-1.612	-.869	42.904	1	.000
Slip road	-1.033	.7687	-2.539	.474	1.805	1	.179
T, Y or staggered junction	-.126	.1238	-.368	.117	1.031	1	.310
Mini-roundabout	-2.887	.7391	-4.335	-1.438	15.257	1	.000
Roundabout	-3.083	.5735	-4.207	-1.959	28.902	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1.597[b]						

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table M-1.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-2.771	.599	-3.946	-1.596

Government Offices	-3.124	.601	-4.303	-1.945
Accommodation (Hostels or Hotels)	-.165	.211	-.578	.248
Commercial	-.119	.206	-.523	.285
Residential	-.197	.208	-.605	.211
Religious	-.899	.242	-1.374	-.424

Table M-1.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-2.078	.559	-3.174	-.983
Single carriageway –4+ lanes	-2.012	.422	-2.840	-1.185
Single carriageway – 3 lanes	-2.326	.668	-3.634	-1.018
Single carriageway – 2 lanes	1.009	.203	.611	1.407
Single carriageway – single track	-1.660	.358	-2.361	-.959
Dual carriageway – 3+ lanes	-2.330	.558	-3.423	-1.237
Dual carriageway – 2 lanes	-1.215	.294	-1.791	-.638
One way street	-1.461	.300	-2.049	-.872
Roundabout	1.161	.684	-.180	2.502

Table M-1.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.885	.387	-2.643	-1.128
Private drive or entrance	-2.266	.523	-3.291	-1.242
Multiple junction	-2.040	.405	-2.834	-1.246
Crossroads	-.632	.261	-1.143	-.122
Slip road	-.425	.781	-1.956	1.107
T, Y or staggered junction	.482	.211	.068	.896
Mini-roundabout	-2.279	.763	-3.774	-.784
Roundabout	-2.475	.542	-3.537	-1.413
Not at junction or within 20 metres	.608	.206	.204	1.012

Appendix M-2: Negative Binomial Regression Model for Seriously Injured (SI) during Prayer Time.

Table M-2.1: Model Information

Data set	Prayer Time
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)

Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	93

Table M-2.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	22.628	71	.319
Scaled Deviance	22.628	71	
Pearson Chi-Square	24.267	71	.342
Scaled Pearson Chi-Square	24.267	71	
Log Likelihood[b]	-205.571		
Akaike's Information Criterion (AIC)	455.142		
Finite Sample Corrected AIC (AICC)	469.600		
Bayesian Information Criterion (BIC)	510.860		
Consistent AIC (CAIC)	532.860		

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.

Table M-2.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
116.558	21	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table M-2.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	3.362	1	.067
Major land use	13.007	5	.023
Road Type	63.564	8	.000
Junction Detail	34.651	8	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-2.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	2.745	1.0026	.780	4.710	7.495	1	.006
Agriculture	-1.349	.8417	-2.999	.301	2.569	1	.109
Government Offices	-1.634	.8592	-3.318	.050	3.616	1	.057
Accommodation	.465	.4218	-.362	1.292	1.215	1	.270
Commercial	.569	.4138	-.242	1.380	1.889	1	.169
Residential	.364	.4094	-.439	1.166	.790	1	.374
Religious	0[a]	.	.	.	.	.	.
Unknown	-2.490	1.1740	-4.791	-.189	4.500	1	.034
Single carriageway –4+ lanes	-2.296	1.1093	-4.471	-.122	4.285	1	.038
Single carriageway – 3 lanes	-2.679	1.2398	-5.109	-.249	4.668	1	.031
Single carriageway – 2 lanes	.040	.9732	-1.868	1.947	.002	1	.968
Single carriageway – single track	-2.032	1.0772	-4.144	.079	3.559	1	.059
Dual carriageway – 3+ lanes	-2.875	1.1593	-5.147	-.603	6.149	1	.013
Dual carriageway – 2 lanes	-1.562	.9751	-3.473	.349	2.566	1	.109
One way street	-1.947	1.0469	-3.999	.104	3.460	1	.063
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.813	.5645	-2.919	-.706	10.313	1	.001
Private drive or entrance	-2.208	.7271	-3.633	-.783	9.223	1	.002
Multiple junction	-1.757	.5622	-2.859	-.655	9.762	1	.002
Crossroads	-.627	.4282	-1.466	.212	2.143	1	.143
Slip road	-.768	.9536	-2.637	1.101	.649	1	.420
T, Y or staggered junction	.031	.3483	-.652	.713	.008	1	.930
Mini-roundabout	-1.947	1.1062	-4.115	.221	3.097	1	.078
Roundabout	-2.284	.7910	-3.835	-.734	8.340	1	.004
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Fixed at the displayed value.

Table M-2.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-1.628	.801	-3.198	-.058
Government Offices	-1.913	.831	-3.542	-.284
Accommodation (Hostels or Hotels)	.186	.346	-.492	.864
Commercial	.290	.324	-.346	.925
Residential	.085	.315	-.533	.702
Religious	-.279	.387	-1.038	.480

Table M-2.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-1.274	.706	-2.657	.110
Single carriageway –4+ lanes	-1.079	.578	-2.212	.053
Single carriageway – 3 lanes	-1.462	.821	-3.072	.148
Single carriageway – 2 lanes	1.257	.287	.694	1.819
Single carriageway – single track	-.815	.510	-1.815	.184
Dual carriageway – 3+ lanes	-1.658	.691	-3.012	-.304
Dual carriageway – 2 lanes	-.345	.413	-1.155	.465
One way street	-.730	.448	-1.609	.148
Roundabout	1.217	.933	-.611	3.045

Table M-2.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.093	.582	-2.234	.048
Private drive or entrance	-1.488	.750	-2.957	-.018
Multiple junction	-1.036	.554	-2.121	.049
Crossroads	.094	.421	-.733	.920
Slip road	-.048	.923	-1.856	1.760
T, Y or staggered junction	.751	.322	.119	1.383
Mini-roundabout	-1.226	1.119	-3.419	.967
Roundabout	-1.564	.726	-2.986	-.142
Not at junction or within 20 metres	.720	.327	.079	1.361

Appendix M-3: Poisson Regression Model for Killed during Prayer Time.

Table M-3.1: Model Information

Data set	Prayer Time
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	36

Table M-3.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	18.899	18	1.050
Scaled Deviance	17.708	18	

Pearson Chi-Square	19.211	18	1.067
Scaled Pearson Chi-Square	18.000	18	
Log Likelihood[b,c]	-54.790		
Adjusted Log Likelihood[d]	-51.337		
Akaike's Information Criterion (AIC)	145.581		
Finite Sample Corrected AIC (AICC)	185.816		
Bayesian Information Criterion (BIC)	174.084		
Consistent AIC (CAIC)	192.084		

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.
c. The log likelihood is based on a scale parameter fixed at 1.
d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table M-3.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
83.824	17	.000

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table M-3.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	6.786	1	.009
Major land use	15.488	5	.008
Road Type	34.536	6	.000
Junction Detail	25.135	6	.000

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-3.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.

(Intercept)	.992	1.3248	-1.605	3.588	.560	1	.454
Agriculture	-1.609	1.0812	-3.728	.510	2.216	1	.137
Government Offices	-1.609	1.0812	-3.728	.510	2.216	1	.137
Accommodation	.459	.3685	-.263	1.181	1.551	1	.213
Commercial	.849	.3498	.163	1.534	5.887	1	.015
Residential	.760	.3560	.063	1.458	4.561	1	.033
Religious	0[a]	.	.	.	.	.	.
Unknown	-1.797	1.4898	-4.717	1.123	1.455	1	.228
Single carriageway – 3 lanes	-.973	1.4836	-3.880	1.935	.430	1	.512
Single carriageway – 2 lanes	.618	1.2861	-1.903	3.138	.231	1	.631
Single carriageway – single track	-.647	1.5131	-3.613	2.319	.183	1	.669
Dual carriageway – 2 lanes	-1.197	1.3560	-3.854	1.461	.779	1	.378
One way street	-.900	1.3933	-3.631	1.830	.418	1	.518
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.185	.5152	-2.195	-.175	5.288	1	.021
Private drive or entrance	-1.724	.7944	-3.281	-.167	4.707	1	.030
Multiple junction	-1.797	.5496	-2.874	-.719	10.688	1	.001
Crossroads	-.783	.3014	-1.374	-.192	6.745	1	.009
T, Y or staggered junction	-.374	.2613	-.886	.138	2.049	1	.152
Roundabout	-1.840	.7609	-3.332	-.349	5.849	1	.016
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1.067[b]						

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table M-3.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-2.417	1.089	-4.552	-.283
Government Offices	-2.417	1.089	-4.552	-.283
Accommodation (Hostels or Hotels)	-.349	.355	-1.045	.347
Commercial	.041	.300	-.547	.628
Residential	-.048	.337	-.707	.612
Religious	-.808	.398	-1.589	-.028

Table M-3.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std.	95% Wald Confidence Interval

		Error	Lower	Upper
Unknown	-2.098	.821	-3.707	-.488
Single carriageway - 3 lanes	-1.273	.809	-2.860	.313
Single carriageway - 2 lanes	.317	.312	-.294	.929
Single carriageway - single track	-.947	.827	-2.568	.673
Dual carriageway - 2 lanes	-1.497	.564	-2.602	-.392
One way street	-1.201	.622	-2.420	.018
Roundabout	-.301	1.262	-2.775	2.174

Table M-3.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.084	.604	-2.269	.100
Private drive or entrance	-1.623	.842	-3.274	.027
Multiple junction	-1.696	.642	-2.955	-.438
Crossroads	-.682	.470	-1.604	.239
T, Y or staggered junction	-.274	.430	-1.117	.570
Roundabout	-1.740	.741	-3.192	-.288
Not at junction or within 20 metres	.100	.383	-.651	.851

Appendix M-4: Negative Binomial Regression Model for Killed during Prayer Time.

Table M-4.1: Model Information

Data set	Prayer Time
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	36

Table M-4.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	5.573	18	.310
Scaled Deviance	5.573	18	
Pearson Chi-Square	5.121	18	.285
Scaled Pearson Chi-Square	5.121	18	
Log Likelihood[b]	-69.544		
Akaike's Information Criterion (AIC)	175.088		

Finite Sample Corrected AIC (AICC)	215.324		
Bayesian Information Criterion (BIC)	203.592		
Consistent AIC (CAIC)	221.592		

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.

Table M-4.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
20.525	17	.248

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table M-4.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	2.213	1	.137
Major land use	4.630	5	.463
Road Type	9.884	6	.130
Junction Detail	5.335	6	.502

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-4.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	.714	1.9501	-3.108	4.536	.134	1	.714
Agriculture	-1.568	1.5599	-4.625	1.490	1.010	1	.315
Government Offices	-1.568	1.5599	-4.625	1.490	1.010	1	.315
Accommodation	.274	.7775	-1.250	1.798	.124	1	.725
Commercial	.784	.7481	-.682	2.251	1.100	1	.294

Residential	.697	.7508	-.775	2.168	.861	1	.353
Religious	0[a]	.	.	.	.	.	.
Unknown	-1.454	2.1411	-5.651	2.742	.461	1	.497
Single carriageway – 3 lanes	-.500	2.1657	-4.744	3.745	.053	1	.818
Single carriageway – 2 lanes	.854	1.8377	-2.748	4.456	.216	1	.642
Single carriageway – single track	-.361	2.2219	-4.716	3.993	.026	1	.871
Dual carriageway – 3+ lanes	-.766	1.8393	-4.371	2.839	.174	1	.677
One way street	-.343	2.0711	-4.402	3.717	.027	1	.869
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.020	.9323	-2.847	.807	1.197	1	.274
Private drive or entrance	-1.489	1.2707	-3.980	1.001	1.373	1	.241
Multiple junction	-1.539	.9395	-3.380	.302	2.684	1	.101
Crossroads	-.748	.7073	-2.134	.639	1.117	1	.290
T, Y or staggered junction	-.370	.6442	-1.633	.892	.331	1	.565
Roundabout	-1.498	1.2260	-3.901	.905	1.494	1	.222
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table M-4.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-2.173	1.553	-5.218	.871
Government Offices	-2.173	1.553	-5.218	.871
Accommodation (Hostels or Hotels)	-.332	.649	-1.603	.939
Commercial	.179	.459	-.721	1.079
Residential	.091	.531	-.950	1.132
Religious	-.606	.703	-1.984	.773

Table M-4.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-1.923	1.245	-4.363	.518
Single carriageway - 3 lanes	-.968	1.216	-3.351	1.415
Single carriageway - 2 lanes	.386	.470	-.536	1.307
Single carriageway - single track	-.830	1.275	-3.328	1.668

Dual carriageway - 2 lanes	-1.235	.812	-2.827	.358
One way street	-.811	.986	-2.744	1.122
Roundabout	-.468	1.793	-3.982	3.046

Table M-4.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.904	.969	-2.802	.995
Private drive or entrance	-1.373	1.286	-3.892	1.147
Multiple junction	-1.423	.955	-3.294	.449
Crossroads	-.631	.857	-2.311	1.048
T, Y or staggered junction	-.254	.741	-1.707	1.199
Roundabout	-1.382	1.158	-3.651	.888
Not at junction or within 20 metres	.116	.584	-1.028	1.261

Appendix M-5: Poisson Regression Model for Seriously Injured (SI) during Non-Prayer Time.

Table M-5.1: Model Information

Data set	Non-Prayer Time
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	140

Table M-5.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	149.065	118	1.263
Scaled Deviance	77.917	118	
Pearson Chi-Square	225.749	118	1.913
Scaled Pearson Chi-Square	118.000	118	
Log Likelihood[b,c]	-287.941		
Adjusted Log Likelihood[d]	-150.508		
Akaike's Information Criterion (AIC)	619.882		
Finite Sample Corrected AIC (AICC)	628.532		
Bayesian Information Criterion (BIC)	684.598		
Consistent AIC (CAIC)	706.598		

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.
c. The log likelihood is based on a scale parameter fixed at 1.
d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table M-5.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
1689.455	21	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table M-5.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	46.143	1	.000
Major land use	171.859	5	.000
Road Type	961.879	8	.000
Junction Detail	508.009	8	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-5.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	4.206	.4566	3.311	5.101	84.874	1	.000
Agriculture	-1.816	.3473	-2.497	-1.136	27.348	1	.000
Government Offices	-2.488	.5368	-3.541	-1.436	21.489	1	.000
Accommodation	1.028	.1375	.758	1.297	55.849	1	.000
Commercial	1.045	.1369	.777	1.314	58.330	1	.000
Residential	.814	.1416	.536	1.091	33.053	1	.000
Religious	0[a]	.	.	.	.	.	.
Unknown	-3.998	.5514	-5.079	-2.918	52.585	1	.000

Single carriageway –4+ lanes	-3.430	.4880	-4.387	-2.474	49.419	1	.000
Single carriageway – 3 lanes	-3.780	.5264	-4.812	-2.748	51.555	1	.000
Single carriageway – 2 lanes	-.374	.4354	-1.228	.479	.739	1	.390
Single carriageway – single track	-3.315	.4882	-4.272	-2.358	46.107	1	.000
Dual carriageway – 3+ lanes	-3.487	.4960	-4.459	-2.514	49.412	1	.000
Dual carriageway – 2 lanes	-2.873	.4648	-3.784	-1.962	38.207	1	.000
One way street	-2.727	.4626	-3.633	-1.820	34.737	1	.000
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-2.514	.2322	-2.969	-2.059	117.237	1	.000
Private drive or entrance	-2.800	.2731	-3.335	-2.265	105.118	1	.000
Multiple junction	-3.106	.3078	-3.709	-2.502	101.813	1	.000
Crossroads	-1.445	.1383	-1.716	-1.174	109.088	1	.000
Slip road	-3.962	.4930	-4.928	-2.996	64.585	1	.000
T, Y or staggered junction	-.190	.0859	-.359	-.022	4.903	1	.027
Mini-roundabout	-4.457	.6518	-5.734	-3.179	46.753	1	.000
Roundabout	-3.296	.3363	-3.955	-2.637	96.086	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1.913[b]						

Dependent Variable: Count_SI
Model: (Intercept Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Computed based on the Pearson chi-square.

Table M-5.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-2.694	.352	-3.383	-2.005
Government Offices	-3.366	.542	-4.428	-2.304
Accommodation (Hostels or Hotels)	.150	.136	-.116	.416
Commercial	.168	.135	-.097	.433
Residential	-.064	.142	-.343	.216
Religious	-.878	.170	-1.211	-.544

Table M-5.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-2.447	.374	-3.180	-1.715

Single carriageway –4+ lanes	-1.879	.272	-2.412	-1.347
Single carriageway – 3 lanes	-2.229	.337	-2.889	-1.569
Single carriageway – 2 lanes	1.177	.157	.868	1.485
Single carriageway – single track	-1.764	.270	-2.294	-1.234
Dual carriageway – 3+ lanes	-1.936	.285	-2.495	-1.377
Dual carriageway – 2 lanes	-1.322	.227	-1.766	-.878
One way street	-1.176	.221	-1.609	-.743
Roundabout	1.551	.402	.764	2.338

Table M-5.8: Estimated Marginal Means for Junction Detail

Junction Detail	**Mean**	**Std. Error**	**95% Wald Confidence Interval**	
			Lower	**Upper**
Other junction	-1.209	.264	-1.726	-.693
Private drive or entrance	-1.495	.300	-2.083	-.907
Multiple junction	-1.801	.333	-2.453	-1.149
Crossroads	-.140	.184	-.500	.220
Slip road	-2.657	.509	-3.655	-1.658
T, Y or staggered junction	1.115	.143	.835	1.394
Mini-roundabout	-3.152	.640	-4.407	-1.897
Roundabout	-1.991	.325	-2.629	-1.354
Not at junction or within 20 metres	1.305	.140	1.031	1.579

Appendix M-6: Negative Binomial Regression Model for Seriously Injured (SI) during Non-Prayer Time.

Table M-6.1: Model Information

Data set	Non-Prayer Time
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	140

Table M-6.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	36.766	118	.312
Scaled Deviance	36.766	118	
Pearson Chi-Square	40.740	118	.345
Scaled Pearson Chi-Square	40.740	118	
Log Likelihood[b]	-345.710		
Akaike's Information Criterion (AIC)	735.421		
Finite Sample Corrected AIC (AICC)	744.070		
Bayesian Information Criterion (BIC)	800.137		
Consistent AIC (CAIC)	822.137		

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Table M-6.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
228.341	21	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table M-6.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	3.376	1	.066
Major land use	34.873	5	.000
Road Type	109.036	8	.000
Junction Detail	80.447	8	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-6.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	3.187	.7541	1.709	4.665	17.864	1	.000
Agriculture	-1.214	.5306	-2.254	-.174	5.238	1	.022
Government Offices	-1.991	.8595	-3.675	-.306	5.364	1	.021
Accommodation	.994	.3333	.341	1.647	8.891	1	.003
Commercial	.849	.3247	.213	1.486	6.843	1	.009
Residential	.705	.3359	.047	1.363	4.404	1	.036
Religious	0[a]	.	.	.	.	.	.
Unknown	-2.706	.8219	-4.317	-1.095	10.838	1	.001
Single carriageway –4+ lanes	-2.312	.7458	-3.774	-.850	9.612	1	.002
Single carriageway – 3 lanes	-2.563	.7739	-4.080	-1.046	10.968	1	.001
Single carriageway – 2 lanes	.116	.6849	-1.226	1.459	.029	1	.865
Single carriageway – single track	-2.286	.7763	-3.807	-.764	8.670	1	.003
Dual carriageway – 3+ lanes	-2.422	.7770	-3.945	-.899	9.715	1	.002
Dual carriageway – 2 lanes	-1.843	.7216	-3.257	-.428	6.520	1	.011
One way street	-1.684	.7335	-3.122	-.247	5.274	1	.022
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.645	.4249	-2.478	-.812	14.988	1	.000
Private drive or entrance	-2.151	.4883	-3.108	-1.194	19.404	1	.000
Multiple junction	-2.310	.4806	-3.252	-1.368	23.104	1	.000
Crossroads	-.992	.3348	-1.648	-.336	8.777	1	.003

Slip road	-3.021	.6496	-4.294	-1.747	21.622	1	.000
T, Y or staggered junction	-.107	.2724	-.641	.426	.156	1	.693
Mini-roundabout	-3.382	.8158	-4.981	-1.783	17.186	1	.000
Roundabout	-2.268	.5175	-3.282	-1.253	19.199	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table M-6.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-1.535	.492	-2.500	-.570
Government Offices	-2.312	.855	-3.987	-.636
Accommodation (Hostels or Hotels)	.673	.225	.232	1.114
Commercial	.528	.230	.078	.979
Residential	.384	.251	-.107	.875
Religious	-.321	.298	-.906	.264

Table M-6.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-1.392	.511	-2.394	-.389
Single carriageway –4+ lanes	-.998	.397	-1.776	-.220
Single carriageway – 3 lanes	-1.249	.472	-2.175	-.323
Single carriageway – 2 lanes	1.430	.232	.975	1.886
Single carriageway – single track	-.972	.436	-1.827	-.117
Dual carriageway – 3+ lanes	-1.108	.441	-1.972	-.244
Dual carriageway – 2 lanes	-.529	.349	-1.213	.156
One way street	-.371	.361	-1.079	.338
Roundabout	1.314	.644	.052	2.576

Table M-6.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.311	.424	-1.143	.520
Private drive or entrance	-.818	.492	-1.783	.147
Multiple junction	-.977	.486	-1.929	-.024
Crossroads	.342	.336	-.316	.999
Slip road	-1.687	.660	-2.981	-.393
T, Y or staggered junction	1.226	.253	.730	1.723
Mini-roundabout	-2.049	.786	-3.588	-.509
Roundabout	-.934	.472	-1.860	-.009
Not at junction or within 20 metres	1.333	.252	.840	1.827

Appendix M-7: Poisson Regression Model for Killed during Non-Prayer Time.

Table M-7.1: Model Information

Data set	Non-Prayer Time
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	65

Table M-7.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	24.299	44	.552
Scaled Deviance	41.119	44	
Pearson Chi-Square	26.002	44	.591
Scaled Pearson Chi-Square	44.000	44	
Log Likelihood[b,c]	-98.756		
Adjusted Log Likelihood[d]	-167.116		
Akaike's Information Criterion (AIC)	239.512		
Finite Sample Corrected AIC (AICC)	261.001		
Bayesian Information Criterion (BIC)	285.174		
Consistent AIC (CAIC)	306.174		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

c. The log likelihood is based on a scale parameter fixed at 1.

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table M-7.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
597.120	20	.000

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table M-7.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.

(Intercept)	33.670	1	.000
Major land use	67.493	5	.000
Road Type	389.319	8	.000
Junction Detail	161.203	7	.000

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-7.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	1.652	.9542	-.218	3.522	2.997	1	.083
Agriculture	-2.345	.7843	-3.882	-.808	8.940	1	.003
Government Offices	-2.344	.5629	-3.447	-1.241	17.339	1	.000
Accommodation	.732	.1704	.398	1.066	18.431	1	.000
Commercial	.793	.1696	.461	1.125	21.873	1	.000
Residential	.525	.1752	.182	.868	8.981	1	.003
Religious	0[a]	.	.	.	.	.	.
Unknown	-.915	1.2286	-3.323	1.493	.554	1	.457
Single carriageway –4+ lanes	-2.176	1.0923	-4.316	-.035	3.967	1	.046
Single carriageway – 3 lanes	-2.000	1.0447	-4.047	.048	3.664	1	.056
Single carriageway – 2 lanes	.693	.9415	-1.152	2.538	.542	1	.462
Single carriageway – single track	-2.035	.9821	-3.960	-.110	4.294	1	.038
Dual carriageway – 3+ lanes	-2.084	.9944	-4.033	-.136	4.395	1	.036
Dual carriageway – 2 lanes	-1.182	.9558	-3.055	.692	1.529	1	.216
One way street	-1.300	.9584	-3.179	.578	1.840	1	.175
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.766	.2860	-2.327	-1.206	38.140	1	.000
Private drive or entrance	-2.415	.3953	-3.189	-1.640	37.316	1	.000
Multiple junction	-1.486	.3295	-2.132	-.840	20.327	1	.000
Crossroads	-1.262	.1721	-1.599	-.925	53.750	1	.000
T, Y or staggered junction	-.003	.1081	-.215	.209	.001	1	.980
Mini-roundabout	-2.345	.7843	-3.882	-.808	8.940	1	.003
Roundabout	-2.445	.5548	-3.532	-1.358	19.422	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	.591[b]						

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table M-7.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-3.380	.800	-4.948	-1.813
Government Offices	-3.379	.583	-4.522	-2.236
Accommodation (Hostels or Hotels)	-.304	.215	-.726	.118
Commercial	-.242	.211	-.656	.171
Residential	-.510	.205	-.912	-.108
Religious	-1.035	.238	-1.502	-.568

Table M-7.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-1.168	.813	-2.761	.425
Single carriageway –4+ lanes	-2.429	.592	-3.589	-1.268
Single carriageway – 3 lanes	-2.253	.499	-3.230	-1.275
Single carriageway – 2 lanes	.440	.210	.028	.852
Single carriageway – single track	-2.288	.350	-2.973	-1.603
Dual carriageway – 3+ lanes	-2.338	.382	-3.087	-1.588
Dual carriageway – 2 lanes	-1.435	.265	-1.954	-.915
One way street	-1.553	.271	-2.085	-1.021
Roundabout	-.253	.926	-2.067	1.561

Table M-7.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.776	.363	-2.489	-1.064
Private drive or entrance	-2.425	.454	-3.314	-1.535
Multiple junction	-1.496	.400	-2.279	-.713
Crossroads	-1.272	.270	-1.801	-.744

T, Y or staggered junction	-.013	.241	-.485	.460
Mini-roundabout	-2.355	.812	-3.947	-.763
Roundabout	-2.455	.540	-3.513	-1.397
Not at junction or within 20 metres	-.010	.233	-.468	.448

Appendix M-8: Negative Binomial Regression Model for Killed during Non-Prayer Time.

Table M-8.1: Model Information

Data set	Non-Prayer Time
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	65

Table M-8.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	6.085	44	.138
Scaled Deviance	6.085	44	
Pearson Chi-Square	5.978	44	.136
Scaled Pearson Chi-Square	5.978	44	
Log Likelihood[b]	-131.963		
Akaike's Information Criterion (AIC)	305.926		
Finite Sample Corrected AIC (AICC)	327.414		
Bayesian Information Criterion (BIC)	351.588		
Consistent AIC (CAIC)	372.588		

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.

Table M-8.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
58.630	20	.000

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table M-8.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	6.276	1	.012
Major land use	10.284	5	.068
Road Type	38.008	8	.000
Junction Detail	15.172	7	.034

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-8.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	1.723	1.9475	-2.094	5.540	.783	1	.376
Agriculture	-2.416	1.5142	-5.384	.551	2.546	1	.111
Government Offices	-2.448	1.1218	-4.647	-.250	4.763	1	.029
Accommodation	.358	.5499	-.719	1.436	.425	1	.515
Commercial	.397	.5614	-.704	1.497	.499	1	.480
Residential	.281	.5542	-.805	1.367	.257	1	.612
Religious	0[a]	.	.	.	.	.	.
Unknown	-1.024	2.4061	-5.740	3.692	.181	1	.670

Single carriageway –4+ lanes	-2.036	2.1587	-6.267	2.195	.890	1	.346
Single carriageway – 3 lanes	-1.710	2.0811	-5.788	2.369	.675	1	.411
Single carriageway – 2 lanes	.693	1.8708	-2.974	4.360	.137	1	.711
Single carriageway – single track	-1.861	1.9662	-5.715	1.993	.896	1	.344
Dual carriageway – 3+ lanes	-1.866	1.9819	-5.750	2.019	.886	1	.347
Dual carriageway – 2 lanes	-1.000	1.9284	-4.780	2.779	.269	1	.604
One way street	-1.039	1.9321	-4.826	2.748	.289	1	.591
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.248	.7480	-2.714	.218	2.785	1	.095
Private drive or entrance	-2.101	.9499	-3.962	-.239	4.890	1	.027
Multiple junction	-1.216	.7678	-2.721	.289	2.507	1	.113
Crossroads	-.980	.5011	-1.962	.002	3.824	1	.051
T, Y or staggered junction	.064	.3860	-.692	.821	.028	1	.868
Mini-roundabout	-2.416	1.5142	-5.384	.551	2.546	1	.111
Roundabout	-2.120	1.3026	-4.673	.433	2.648	1	.104
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Fixed at the displayed value.

Table M-8.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-3.039	1.521	-6.020	-.058
Government Offices	-3.071	1.129	-5.284	-.858
Accommodation (Hostels or Hotels)	-.264	.478	-1.201	.672
Commercial	-.226	.475	-1.156	.704
Residential	-.342	.440	-1.203	.520
Religious	-.623	.563	-1.727	.481

Table M-8.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper

Unknown	-1.191	1.544	-4.218	1.836
Single carriageway –4+ lanes	-2.203	1.142	-4.442	.036
Single carriageway – 3 lanes	-1.877	.985	-3.808	.055
Single carriageway – 2 lanes	.526	.418	-.294	1.346
Single carriageway – single track	-2.028	.720	-3.440	-.616
Dual carriageway – 3+ lanes	-2.033	.759	-3.521	-.544
Dual carriageway – 2 lanes	-1.167	.599	-2.342	.007
One way street	-1.206	.589	-2.361	-.051
Roundabout	-.167	1.817	-3.727	3.393

Table M-8.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.257	.835	-2.893	.379
Private drive or entrance	-2.109	1.026	-4.121	-.098
Multiple junction	-1.224	.861	-2.912	.464
Crossroads	-.989	.585	-2.135	.157
T, Y or staggered junction	.055	.512	-.948	1.059
Mini-roundabout	-2.425	1.554	-5.472	.622
Roundabout	-2.128	1.228	-4.534	.277
Not at junction or within 20 metres	-.009	.468	-.925	.908

Appendix M-9: Poisson Regression Model for Seriously Injured (SI) during Weekends.

Table M-9.1: Model Information

Data set	Weekends
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	98

Table M-9.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	83.419	76	1.098
Scaled Deviance	57.014	76	
Pearson Chi-Square	111.197	76	1.463
Scaled Pearson Chi-Square	76.000	76	
Log Likelihood[b,c]	-180.689		
Adjusted Log Likelihood[d]	-123.497		
Akaike's Information Criterion (AIC)	405.379		

Finite Sample Corrected AIC (AICC)	418.872		
Bayesian Information Criterion (BIC)	462.248		
Consistent AIC (CAIC)	484.248		

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.
c. The log likelihood is based on a scale parameter fixed at 1.
d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table M-9.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
841.481	21	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table M-9.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	34.426	1	.000
Major land use	78.316	5	.000
Road Type	489.403	8	.000
Junction Detail	249.476	8	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-9.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	3.379	.5248	2.350	4.408	41.454	1	.000
Agriculture	-1.531	.4144	-2.343	-.719	13.648	1	.000
Government Offices	-2.265	.8727	-3.975	-.555	6.737	1	.009
Accommodation	.949	.1808	.594	1.303	27.547	1	.000

Commercial	.887	.1818	.530	1.243	23.787	1	.000
Residential	.856	.1839	.496	1.217	21.684	1	.000
Religious	0[a]	.	.	.	.	.	.
Unknown	-3.817	.8643	-5.511	-2.123	19.498	1	.000
Single carriageway –4+ lanes	-2.681	.5833	-3.824	-1.537	21.123	1	.000
Single carriageway – 3 lanes	-3.653	.6608	-4.948	-2.358	30.562	1	.000
Single carriageway – 2 lanes	-.203	.5035	-1.190	.784	.163	1	.686
Single carriageway – single track	-2.912	.5726	-4.035	-1.790	25.865	1	.000
Dual carriageway – 3+ lanes	-3.418	.6015	-4.597	-2.239	32.295	1	.000
Dual carriageway – 2 lanes	-2.796	.5509	-3.876	-1.716	25.760	1	.000
One way street	-2.505	.5436	-3.571	-1.440	21.239	1	.000
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-2.294	.2692	-2.822	-1.767	72.648	1	.000
Private drive or entrance	-3.360	.5477	-4.433	-2.286	37.635	1	.000
Multiple junction	-3.080	.4111	-3.886	-2.274	56.130	1	.000
Crossroads	-1.354	.1724	-1.692	-1.016	61.657	1	.000
Slip road	-3.176	1.2208	-5.569	-.783	6.767	1	.009
T, Y or staggered junction	-.277	.1118	-.496	-.057	6.118	1	.013
Mini-roundabout	-4.243	.7888	-5.789	-2.697	28.933	1	.000
Roundabout	-3.028	.3966	-3.805	-2.250	58.280	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1.463[b]						

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table M-9.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-2.907	.444	-3.777	-2.037
Government Offices	-3.641	.887	-5.379	-1.903
Accommodation (Hostels or Hotels)	-.427	.222	-.863	.009
Commercial	-.489	.224	-.928	-.051
Residential	-.520	.232	-.975	-.065
Religious	-1.376	.256	-1.878	-.875

Table M-9.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-2.934	.745	-4.393	-1.475
Single carriageway –4+ lanes	-1.798	.384	-2.550	-1.046
Single carriageway – 3 lanes	-2.770	.498	-3.747	-1.794
Single carriageway – 2 lanes	.679	.247	.196	1.163
Single carriageway – single track	-2.029	.367	-2.748	-1.311
Dual carriageway – 3+ lanes	-2.535	.411	-3.342	-1.729
Dual carriageway – 2 lanes	-1.913	.334	-2.567	-1.260
One way street	-1.623	.320	-2.249	-.996
Roundabout	.883	.494	-.085	1.850

Table M-9.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.542	.331	-2.191	-.893
Private drive or entrance	-2.608	.582	-3.749	-1.466
Multiple junction	-2.328	.452	-3.213	-1.443
Crossroads	-.602	.258	-1.107	-.097
Slip road	-2.424	1.234	-4.843	-.004
T, Y or staggered junction	.476	.208	.069	.883
Mini-roundabout	-3.491	.789	-5.036	-1.945
Roundabout	-2.275	.404	-3.067	-1.484
Not at junction or within 20 metres	.752	.211	.339	1.166

Appendix M-10: Negative Binomial Regression Model for Seriously Injured (SI) during Weekends.

Table M-10.1: Model Information

Data set	Weekends
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	98

Table M-10.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	20.978	76	.276
Scaled Deviance	20.978	76	
Pearson Chi-Square	21.887	76	.288
Scaled Pearson Chi-Square	21.887	76	
Log Likelihood[b]	-220.293		
Akaike's Information Criterion (AIC)	484.585		
Finite Sample Corrected AIC (AICC)	498.078		
Bayesian Information Criterion (BIC)	541.454		
Consistent AIC (CAIC)	563.454		

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.

Table M-10.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
127.267	21	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table M-10.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	6.802	1	.009
Major land use	11.636	5	.040
Road Type	69.912	8	.000
Junction Detail	42.065	8	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-10.5: Parameter Estimates							
Parameter	**B**	**Std. Error**	**95% Wald Confidence Interval**		**Hypothesis Test**		
			Lower	**Upper**	**Wald Chi-Square**	**df**	**Sig.**
(Intercept)	2.929	.8402	1.282	4.576	12.151	1	.000
Agriculture	-1.231	.7377	-2.677	.215	2.784	1	.095
Government Offices	-1.858	1.2152	-4.239	.524	2.337	1	.126
Accommodation	.520	.4330	-.328	1.369	1.444	1	.229
Commercial	.496	.4237	-.334	1.327	1.371	1	.242
Residential	.430	.4438	-.440	1.300	.940	1	.332
Religious	0[a]	.	.	.	.	.	.
Unknown	-2.796	1.1918	-5.132	-.460	5.505	1	.019
Single carriageway –4+ lanes	-1.726	.9322	-3.553	.101	3.428	1	.064
Single carriageway – 3 lanes	-2.814	.9164	-4.610	-1.018	9.429	1	.002
Single carriageway – 2 lanes	.131	.7730	-1.385	1.646	.029	1	.866
Single carriageway – single track	-2.059	.9235	-3.869	-.248	4.968	1	.026
Dual carriageway – 3+ lanes	-2.597	.9082	-4.377	-.817	8.177	1	.004
Dual carriageway – 2 lanes	-1.929	.8414	-3.578	-.280	5.255	1	.022
One way street	-1.745	.8623	-3.435	-.055	4.096	1	.043
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.734	.5335	-2.780	-.689	10.569	1	.001
Private drive or entrance	-2.924	.7977	-4.488	-1.361	13.441	1	.000
Multiple junction	-2.134	.6373	-3.383	-.885	11.210	1	.001
Crossroads	-.823	.4237	-1.654	.007	3.775	1	.052
Slip road	-3.059	1.4766	-5.953	-.165	4.293	1	.038
T, Y or staggered junction	-.270	.3257	-.908	.369	.685	1	.408
Mini-roundabout	-3.485	1.0175	-5.479	-1.490	11.729	1	.001
Roundabout	-2.212	.6514	-3.488	-.935	11.530	1	.001
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table M-10.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-1.877	.707	-3.262	-.492
Government Offices	-2.504	1.199	-4.854	-.154
Accommodation (Hostels or Hotels)	-.126	.331	-.776	.524
Commercial	-.150	.328	-.793	.493
Residential	-.216	.379	-.959	.527
Religious	-.646	.410	-1.450	.157

Table M-10.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-1.990	.954	-3.861	-.120
Single carriageway - 4+ lanes	-.920	.609	-2.114	.274
Single carriageway - 3 lanes	-2.008	.633	-3.249	-.767
Single carriageway - 2 lanes	.937	.322	.306	1.568
Single carriageway - single track	-1.252	.576	-2.382	-.123
Dual carriageway - 3+ lanes	-1.791	.577	-2.921	-.661
Dual carriageway - 2 lanes	-1.123	.470	-2.044	-.201
One way street	-.939	.493	-1.905	.027
Roundabout	.806	.744	-.652	2.265

Table M-10.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.805	.556	-1.894	.284
Private drive or entrance	-1.995	.828	-3.617	-.373
Multiple junction	-1.205	.603	-2.387	-.022
Crossroads	.106	.445	-.766	.977
Slip road	-2.130	1.492	-5.055	.794
T, Y or staggered junction	.659	.326	.020	1.299
Mini-roundabout	-2.556	.989	-4.494	-.617
Roundabout	-1.283	.610	-2.477	-.088
Not at junction or within 20 metres	.929	.346	.251	1.607

Appendix M-11: Poisson Regression Model for Killed during Weekends.

Table M-11.1: Model Information

Data set	Weekends
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	36

Table M-11.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	13.804	19	.727
Scaled Deviance	17.592	19	
Pearson Chi-Square	14.908	19	.785
Scaled Pearson Chi-Square	19.000	19	
Log Likelihood[b,c]	-53.147		
Adjusted Log Likelihood[d]	-67.735		
Akaike's Information Criterion (AIC)	140.295		
Finite Sample Corrected AIC (AICC)	174.295		
Bayesian Information Criterion (BIC)	167.215		
Consistent AIC (CAIC)	184.215		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

c. The log likelihood is based on a scale parameter fixed at 1.

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table M-11.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
110.233	16	.000

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table M-11.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.

(Intercept)	5.645	1	.018
Major land use	11.886	4	.018
Road Type	62.247	6	.000
Junction Detail	30.152	5	.000

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-11.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-.894	.9546	-2.765	.977	.877	1	.349
Government Offices	-1.411	.9458	-3.265	.442	2.227	1	.136
Accommodation	.701	.3620	-.008	1.411	3.754	1	.053
Commercial	.894	.3560	.196	1.592	6.306	1	.012
Residential	.614	.3663	-.104	1.332	2.811	1	.094
Religious	0[a]	.	.	.	.	.	.
Unknown	-1.779E-016	1.2527	-2.455	2.455	.000	1	1.000
Single carriageway –4+ lanes	.363	1.2937	-2.173	2.898	.079	1	.779
Single carriageway – 3 lanes	2.475	1.5681	-.598	5.549	2.492	1	.114
Single carriageway – 2 lanes	2.388	.9079	.609	4.168	6.920	1	.009
Dual carriageway – 3+ lanes	.536	1.1112	-1.642	2.714	.233	1	.629
Dual carriageway – 2 lanes	.817	.9332	-1.012	2.646	.767	1	.381
One way street	.814	.9676	-1.083	2.710	.707	1	.400
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.287	.5546	-2.374	-.200	5.385	1	.020
Private drive or entrance	-2.297	.6491	-3.569	-1.024	12.516	1	.000
Multiple junction	-2.196	.9107	-3.981	-.411	5.813	1	.016
Crossroads	-.871	.2772	-1.414	-.328	9.874	1	.002
T, Y or staggered junction	-.083	.2061	-.487	.321	.162	1	.687
Roundabout	0[a]	.	.	.	.	.	.
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	.785[b]						

Dependent Variable: Count_Killed; Model: (Intercept)
Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Computed based on the Pearson chi-square.

Table M-11.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Government	-2.343	.941	-4.188	-.498
Accommodation	-.230	.310	-.838	.377
Commercial	-.038	.298	-.621	.546
Residential	-.317	.297	-.901	.266
Religious	-.932	.421	-1.757	-.106

Table M-11.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-1.696	.936	-3.530	.138
Single carriageway - 4+ lanes	-1.334	.951	-3.198	.531
Single carriageway - 3 lanes	.779	1.212	-1.597	3.155
Single carriageway - 2 lanes	.692	.260	.183	1.202
Dual carriageway - 3+ lanes	-1.160	.698	-2.528	.208
Dual carriageway - 2 lanes	-.879	.363	-1.590	-.168
One way street	-.882	.427	-1.720	-.045
Roundabout	-1.696	.936	-3.530	.138

Table M-11.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.097	.630	-2.331	.137
Private drive or entrance	-2.107	.717	-3.512	-.701
Multiple junction	-2.006	.848	-3.668	-.344
Crossroads	-.681	.401	-1.467	.104
T, Y or staggered junction	.107	.338	-.556	.770
Roundabout	.190	.346	-.489	.868
Not at junction or within 20 metres	.190	.346	-.489	.868

Appendix M-12: Negative Binomial Regression Model for Killed during Weekends.

Table M-12.1: Model Information

Data set	Weekends
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details

Observation Used (N)	36

Table M-12.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	3.852	19	.203
Scaled Deviance	3.852	19	
Pearson Chi-Square	3.726	19	.196
Scaled Pearson Chi-Square	3.726	19	
Log Likelihood[b]	-70.138		
Akaike's Information Criterion (AIC)	174.276		
Finite Sample Corrected AIC (AICC)	208.276		
Bayesian Information Criterion (BIC)	201.196		
Consistent AIC (CAIC)	218.196		

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.

Table M-12.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
19.337	16	.252

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
Compares the fitted model against the intercept-only model.

Table M-12.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	1.365	1	.243
Major land use	2.277	4	.685
Road Type	11.106	6	.085
Junction Detail	6.111	5	.296

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-12.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-.533	1.6241	-3.716	2.650	.108	1	.743
Government Offices	-1.553	1.6063	-4.702	1.595	.935	1	.334
Accommodation	.419	.7929	-1.135	1.973	.279	1	.597
Commercial	.533	.7986	-1.032	2.098	.446	1	.504
Residential	.466	.7612	-1.026	1.958	.374	1	.541
Religious	0[a]	.	.	.	.	.	.
Unknown	4.158E-016	2.0000	-3.920	3.920	.000	1	1.000
Single carriageway –4+ lanes	.141	2.1930	-4.157	4.439	.004	1	.949
Single carriageway – 3 lanes	2.113	2.6059	-2.994	7.220	.658	1	.417
Single carriageway – 2 lanes	2.160	1.5335	-.846	5.166	1.984	1	.159
Dual carriageway – 3+ lanes	.502	1.8777	-3.178	4.183	.072	1	.789
Dual carriageway – 2 lanes	.705	1.5830	-2.397	3.808	.198	1	.656
One way street	.743	1.6534	-2.497	3.984	.202	1	.653
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-.970	1.1139	-3.154	1.213	.759	1	.384
Private drive or entrance	-2.103	1.1212	-4.300	.095	3.517	1	.061
Multiple junction	-2.046	1.5333	-5.051	.960	1.780	1	.182
Crossroads	-.776	.6753	-2.100	.547	1.321	1	.250
T, Y or staggered junction	-.074	.5533	-1.158	1.011	.018	1	.894
Roundabout	0[a]	.	.	.	.	.	.
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Fixed at the displayed value.

Table M-12.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Government	-2.143	1.556	-5.194	.907
Accommodation (Hostels or Hotels)	-.171	.590	-1.327	.984
Commercial	-.057	.567	-1.169	1.055

Residential	-.124	.549	-1.201	.952
Religious	-.590	.769	-2.097	.917

Table M-12.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-1.413	1.549	-4.449	1.623
Single carriageway - 4+ lanes	-1.272	1.596	-4.401	1.857
Single carriageway - 3 lanes	.700	1.996	-3.212	4.613
Single carriageway - 2 lanes	.747	.451	-.136	1.631
Dual carriageway - 3+ lanes	-.910	1.192	-3.247	1.426
Dual carriageway - 2 lanes	-.708	.674	-2.028	.613
One way street	-.670	.749	-2.138	.799
Roundabout	-1.413	1.549	-4.449	1.623

Table M-12.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.735	1.148	-2.984	1.514
Private drive or entrance	-1.867	1.187	-4.195	.460
Multiple junction	-1.810	1.405	-4.564	.944
Crossroads	-.541	.756	-2.022	.941
T, Y or staggered junction	.162	.592	-.998	1.322
Roundabout	.235	.613	-.966	1.437
Not at junction or within 20 metres	.235	.613	-.966	1.437

Appendix M-13: Poisson Regression Model for Seriously Injured (SI) during Working Days

Table M-13.1: Model Information

Data set	Working Days
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	142

Table M-13.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	152.707	120	1.273
Scaled Deviance	58.359	120	
Pearson Chi-Square	314.004	120	2.617
Scaled Pearson Chi-Square	120.000	120	
Log Likelihood[b,c]	-288.378		
Adjusted Log Likelihood[d]	-110.207		
Akaike's Information Criterion (AIC)	620.757		
Finite Sample Corrected AIC (AICC)	629.261		
Bayesian Information Criterion (BIC)	685.785		
Consistent AIC (CAIC)	707.785		

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

c. The log likelihood is based on a scale parameter fixed at 1.
d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table M-13.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
1182.340	21	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table M-13.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	34.324	1	.000
Major land use	113.641	5	.000
Road Type	662.431	8	.000
Junction Detail	361.241	8	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-13.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	4.338	.5749	3.211	5.465	56.940	1	.000
Agriculture	-2.153	.4693	-3.073	-1.233	21.044	1	.000
Government Offices	-2.186	.5303	-3.225	-1.147	16.989	1	.000
Accommodation	.888	.1609	.572	1.203	30.442	1	.000
Commercial	.969	.1587	.658	1.280	37.304	1	.000
Residential	.735	.1645	.412	1.057	19.953	1	.000
Religious	0[a]	.	.	.	.	.	.
Unknown	-3.989	.6624	-5.288	-2.691	36.276	1	.000
Single carriageway –4+ lanes	-3.647	.6192	-4.861	-2.434	34.696	1	.000
Single carriageway – 3 lanes	-3.993	.6721	-5.310	-2.676	35.291	1	.000
Single carriageway – 2 lanes	-.485	.5525	-1.568	.598	.770	1	.380
Single carriageway – single track	-3.463	.6120	-4.662	-2.263	32.008	1	.000
Dual carriageway – 3+ lanes	-3.759	.6363	-5.006	-2.512	34.901	1	.000

Dual carriageway – 2 lanes	-2.842	.5811	-3.981	-1.703	23.920	1	.000
One way street	-2.859	.5851	-4.006	-1.713	23.883	1	.000
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-2.627	.2995	-3.214	-2.040	76.950	1	.000
Private drive or entrance	-2.676	.3092	-3.282	-2.070	74.896	1	.000
Multiple junction	-2.854	.3317	-3.504	-2.204	74.042	1	.000
Crossroads	-1.406	.1655	-1.730	-1.082	72.164	1	.000
Slip road	-3.700	.5169	-4.714	-2.687	51.241	1	.000
T, Y or staggered junction	-.161	.1031	-.363	.041	2.446	1	.118
Mini-roundabout	-4.293	.7055	-5.676	-2.910	37.023	1	.000
Roundabout	-3.505	.4403	-4.368	-2.642	63.348	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	2.617[b]						

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table M-13.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-2.955	.475	-3.885	-2.024
Government Offices	-2.988	.537	-4.040	-1.935
Accommodation (Hostels or Hotels)	.086	.159	-.225	.397
Commercial	.167	.157	-.141	.476
Residential	-.067	.166	-.391	.258
Religious	-.802	.197	-1.187	-.417

Table M-13.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-2.300	.405	-3.093	-1.508
Single carriageway - 4+ lanes	-1.958	.330	-2.605	-1.312
Single carriageway - 3 lanes	-2.304	.422	-3.130	-1.477
Single carriageway - 2 lanes	1.204	.174	.864	1.545
Single carriageway - single track	-1.774	.315	-2.392	-1.155

Dual carriageway - 3+ lanes	-2.070	.361	-2.777	-1.363
Dual carriageway - 2 lanes	-1.153	.253	-1.650	-.656
One way street	-1.170	.257	-1.674	-.667
Roundabout	1.689	.518	.673	2.705

Table M-13.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.362	.332	-2.013	-.711
Private drive or entrance	-1.411	.340	-2.078	-.744
Multiple junction	-1.589	.362	-2.298	-.880
Crossroads	-.141	.215	-.563	.281
Slip road	-2.435	.537	-3.489	-1.382
T, Y or staggered junction	1.104	.165	.780	1.427
Mini-roundabout	-3.028	.701	-4.401	-1.655
Roundabout	-2.239	.420	-3.063	-1.416
Not at junction or within 20 metres	1.265	.163	.947	1.584

Appendix M-14: Negative Binomial Regression Model for Seriously Injured (SI) during Working Days

Table M-14.1: Model Information

Data set	Working Days
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	142

Table M-14.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	41.642	120	.347
Scaled Deviance	41.642	120	
Pearson Chi-Square	47.731	120	.398
Scaled Pearson Chi-Square	47.731	120	
Log Likelihood[b]	-344.655		
Akaike's Information Criterion (AIC)	733.309		
Finite Sample Corrected AIC (AICC)	741.813		
Bayesian Information Criterion (BIC)	798.337		
Consistent AIC (CAIC)	820.337		

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Table M-14.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.

225.587	21	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table M-14.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	1.105	1	.293
Major land use	24.997	5	.000
Road Type	111.715	8	.000
Junction Detail	76.117	8	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-14.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	3.339	.7941	1.783	4.896	17.681	1	.000
Agriculture	-1.192	.5835	-2.335	-.048	4.171	1	.041
Government Offices	-1.444	.7962	-3.005	.116	3.290	1	.070
Accommodation	.818	.3267	.177	1.458	6.265	1	.012
Commercial	.735	.3198	.108	1.362	5.282	1	.022
Residential	.635	.3315	-.015	1.285	3.668	1	.055
Religious	0[a]	.	.	.	.	.	.
Unknown	-2.803	.8354	-4.440	-1.166	11.259	1	.001
Single carriageway –4+ lanes	-2.523	.7893	-4.070	-.976	10.214	1	.001
Single carriageway – 3 lanes	-2.747	.8278	-4.369	-1.124	11.009	1	.001
Single carriageway – 2 lanes	-.076	.7310	-1.508	1.357	.011	1	.917
Single carriageway – single track	-2.352	.8054	-3.930	-.773	8.525	1	.004
Dual carriageway – 3+ lanes	-2.636	.8274	-4.258	-1.014	10.148	1	.001
Dual carriageway – 2 lanes	-1.764	.7484	-3.230	-.297	5.553	1	.018
One way street	-1.785	.7804	-3.315	-.255	5.231	1	.022
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.581	.4424	-2.449	-.714	12.775	1	.000
Private drive or entrance	-1.989	.4646	-2.900	-1.078	18.329	1	.000
Multiple junction	-2.091	.4705	-3.013	-1.168	19.743	1	.000
Crossroads	-.922	.3332	-1.575	-.269	7.661	1	.006
Slip road	-2.514	.6051	-3.700	-1.328	17.266	1	.000
T, Y or staggered junction	-.135	.2723	-.668	.399	.244	1	.621

Mini-roundabout	-3.108	.7336	-4.545	-1.670	17.946	1	.000
Roundabout	-2.472	.5420	-3.534	-1.410	20.801	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table M-14.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-1.352	.545	-2.419	-.285
Government Offices	-1.604	.784	-3.141	-.068
Accommodation (Hostels or Hotels)	.657	.227	.212	1.102
Commercial	.575	.231	.123	1.026
Residential	.475	.238	.008	.941
Religious	-.160	.297	-.743	.422

Table M-14.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-1.184	.463	-2.092	-.276
Single carriageway –4+ lanes	-.904	.390	-1.668	-.140
Single carriageway – 3 lanes	-1.128	.482	-2.072	-.184
Single carriageway – 2 lanes	1.543	.229	1.094	1.992
Single carriageway – single track	-.733	.412	-1.541	.075
Dual carriageway – 3+ lanes	-1.017	.452	-1.904	-.130
Dual carriageway	-.145	.342	-.814	.525
One way street	-.166	.344	-.841	.508
Roundabout	1.619	.702	.244	2.994

Table M-14.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.171	.438	-1.029	.687
Private drive or entrance	-.578	.465	-1.489	.332
Multiple junction	-.680	.473	-1.606	.246
Crossroads	.488	.327	-.153	1.130
Slip road	-1.104	.606	-2.290	.083
T, Y or staggered junction	1.276	.247	.791	1.761
Mini-roundabout	-1.697	.724	-3.116	-.277
Roundabout	-1.061	.495	-2.031	-.092
Not at junction or within 20 metres	1.411	.252	.916	1.905

Appendix M-15: Poisson Regression Model for Killed during Working Days

Table M-15.1: Model Information

Data set	Working Days
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details

Observation Used (N)	65

Table M-15.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	41.329	44	.939
Scaled Deviance	38.689	44	
Pearson Chi-Square	47.001	44	1.068
Scaled Pearson Chi-Square	44.000	44	
Log Likelihood[b,c]	-106.396		
Adjusted Log Likelihood[d]	-99.601		
Akaike's Information Criterion (AIC)	254.791		
Finite Sample Corrected AIC (AICC)	276.280		
Bayesian Information Criterion (BIC)	300.454		
Consistent AIC (CAIC)	321.454		

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.
c. The log likelihood is based on a scale parameter fixed at 1.
d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table M-15.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
328.280	20	.000

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table M-15.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	20.091	1	.000
Major land use	28.405	5	.000
Road Type	197.639	8	.000
Junction Detail	113.570	7	.000

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-15.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	1.816	1.1735	-.484	4.116	2.394	1	.122
Agriculture	-1.848	.7560	-3.329	-.366	5.974	1	.015
Government Offices	-1.848	.7560	-3.329	-.366	5.974	1	.015
Accommodation	.557	.2184	.129	.985	6.511	1	.011
Commercial	.629	.2140	.210	1.048	8.642	1	.003
Residential	.402	.2198	-.028	.833	3.353	1	.067
Religious	0[a]	.	.	.	.	.	.
Unknown	-1.795	1.3821	-4.504	.914	1.687	1	.194
Single carriageway –4+ lanes	-2.218	1.5641	-5.284	.847	2.011	1	.156
Single carriageway – 3 lanes	-2.102	1.2713	-4.593	.390	2.733	1	.098
Single carriageway – 2 lanes	.725	1.1579	-1.544	2.995	.392	1	.531
Single carriageway – single track	-1.809	1.2065	-4.174	.556	2.248	1	.134
Dual carriageway – 3+ lanes	-2.117	1.2729	-4.611	.378	2.765	1	.096
Dual carriageway – 2 lanes	-1.243	1.1835	-3.562	1.077	1.103	1	.294
One way street	-1.182	1.1856	-3.506	1.142	.994	1	.319
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-2.134	.3436	-2.807	-1.460	38.555	1	.000
Private drive or entrance	-2.482	.5309	-3.522	-1.441	21.857	1	.000
Multiple junction	-1.876	.3832	-2.627	-1.125	23.977	1	.000
Crossroads	-1.170	.2212	-1.604	-.737	27.999	1	.000
T, Y or staggered junction	-.148	.1504	-.443	.147	.964	1	.326
Mini-roundabout	-2.541	1.0515	-4.602	-.480	5.840	1	.016
Roundabout	-2.445	.5313	-3.486	-1.403	21.170	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1.068[b]						

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table M-15.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-2.936	.790	-4.484	-1.388
Government Offices	-2.936	.790	-4.484	-1.388
Accommodation (Hostels or Hotels)	-.531	.294	-1.107	.045
Commercial	-.459	.279	-1.006	.088
Residential	-.686	.277	-1.229	-.143
Religious	-1.088	.310	-1.695	-.481

Table M-15.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-1.930	.785	-3.469	-.391
Single carriageway - 4+ lanes	-2.353	1.075	-4.460	-.246
Single carriageway - 3 lanes	-2.236	.579	-3.371	-1.102
Single carriageway - 2 lanes	.590	.245	.111	1.070
Single carriageway - single track	-1.944	.417	-2.761	-1.127
Dual carriageway - 3+ lanes	-2.251	.580	-3.389	-1.114
Dual carriageway - 2 lanes	-1.377	.355	-2.073	-.682
One way street	-1.317	.353	-2.009	-.625
Roundabout	-.135	1.155	-2.399	2.130

Table M-15.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.974	.437	-2.830	-1.117
Private drive or entrance	-2.322	.595	-3.489	-1.155
Multiple junction	-1.716	.470	-2.638	-.794
Crossroads	-1.010	.345	-1.686	-.335
T, Y or staggered junction	.012	.303	-.581	.605
Mini-roundabout	-2.381	1.083	-4.503	-.258
Roundabout	-2.285	.547	-3.357	-1.213
Not at junction or within 20 metres	.160	.278	-.386	.706

Appendix M-16: Negative Binomial Regression Model for Killed during Working Days

Table M-16.1: Model Information

Data set	Working Days
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	65

Table M-16.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	11.774	44	.268
Scaled Deviance	11.774	44	
Pearson Chi-Square	11.719	44	.266
Scaled Pearson Chi-Square	11.719	44	
Log Likelihood[b]	-133.284		
Akaike's Information Criterion (AIC)	308.567		
Finite Sample Corrected AIC (AICC)	330.056		
Bayesian Information Criterion (BIC)	354.230		
Consistent AIC (CAIC)	375.230		

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.

Table M-16.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
55.988	20	.000

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table M-16.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	4.174	1	.041
Major land use	4.942	5	.423
Road Type	36.542	8	.000
Junction Detail	17.475	7	.015

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-16.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	1.501	1.7035	-1.838	4.840	.776	1	.378
Agriculture	-1.659	1.3172	-4.241	.923	1.586	1	.208
Government Offices	-1.659	1.3172	-4.241	.923	1.586	1	.208
Accommodation	.326	.5443	-.741	1.393	.358	1	.549
Commercial	.435	.5277	-.599	1.470	.681	1	.409
Residential	.185	.5260	-.846	1.216	.124	1	.725
Religious	0[a]	.	.	.	.	.	.
Unknown	-1.294	1.9849	-5.185	2.596	.425	1	.514
Single carriageway –4+ lanes	-1.686	2.2171	-6.031	2.659	.578	1	.447

Single carriageway – 3 lanes	-1.588	1.8114	-5.138	1.962	.769	1	.381
Single carriageway – 2 lanes	.851	1.6436	-2.370	4.073	.268	1	.605
Single carriageway – single track	-1.294	1.7292	-4.683	2.095	.560	1	.454
Dual carriageway – 3+ lanes	-1.692	1.8098	-5.239	1.855	.874	1	.350
Dual carriageway – 2 lanes	-.833	1.6719	-4.110	2.444	.248	1	.618
One way street	-.616	1.7082	-3.964	2.732	.130	1	.719
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.632	.6345	-2.875	-.388	6.612	1	.010
Private drive or entrance	-1.839	.9225	-3.648	-.031	3.976	1	.046
Multiple junction	-1.270	.7006	-2.643	.103	3.286	1	.070
Crossroads	-.783	.5197	-1.802	.235	2.272	1	.132
T, Y or staggered junction	-.021	.4108	-.826	.784	.003	1	.959
Mini-roundabout	-2.352	1.4950	-5.282	.578	2.476	1	.116
Roundabout	-1.936	.8953	-3.691	-.182	4.678	1	.031
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table M-16.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-2.293	1.342	-4.924	.338
Government Offices	-2.293	1.342	-4.924	.338
Accommodation (Hostels or Hotels)	-.308	.506	-1.300	.684
Commercial	-.199	.448	-1.076	.679
Residential	-.449	.435	-1.302	.403
Religious	-.634	.538	-1.689	.421

Table M-16.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper

Unknown	-1.418	1.154	-3.679	.843
Single carriageway - 4+ lanes	-1.810	1.532	-4.813	1.193
Single carriageway - 3 lanes	-1.712	.858	-3.394	-.030
Single carriageway - 2 lanes	.728	.400	-.057	1.512
Single carriageway - single track	-1.418	.667	-2.724	-.111
Dual carriageway - 3+ lanes	-1.815	.859	-3.498	-.132
Dual carriageway - 2 lanes	-.957	.587	-2.108	.194
One way street	-.739	.606	-1.926	.448
Roundabout	-.124	1.639	-3.336	3.089

Table M-16.8: Estimated Marginal Means for Junction Detail

Junction Detail	**Mean**	**Std. Error**	**95% Wald Confidence Interval**	
			Lower	**Upper**
Other junction	-1.432	.732	-2.867	.003
Private drive or entrance	-1.639	.995	-3.590	.311
Multiple junction	-1.070	.793	-2.625	.485
Crossroads	-.584	.620	-1.799	.632
T, Y or staggered junction	.179	.537	-.874	1.231
Mini-roundabout	-2.152	1.539	-5.169	.864
Roundabout	-1.737	.899	-3.498	.025
Not at junction or within 20 metres	.200	.438	-.659	1.059

Appendix M-17: Poisson Regression Model for Seriously Injured (SI) during High Season.

Table M-17.1: Model Information

Data set	High Season
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	139

Table M-17.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	128.754	117	1.100
Scaled Deviance	57.283	117	
Pearson Chi-Square	262.981	117	2.248
Scaled Pearson Chi-Square	117.000	117	
Log Likelihood[b,c]	-274.578		
Adjusted Log Likelihood[d]	-122.160		
Akaike's Information Criterion (AIC)	593.156		
Finite Sample Corrected AIC (AICC)	601.880		
Bayesian Information Criterion (BIC)	657.714		
Consistent AIC (CAIC)	679.714		

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

c. The log likelihood is based on a scale parameter fixed at 1.

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table M-17.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
1579.183	21	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table M-17.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	44.855	1	.000
Major land use	153.428	5	.000
Road Type	818.673	8	.000
Junction Detail	486.140	8	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-17.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	4.234	.4544	3.343	5.124	86.802	1	.000
Agriculture	-1.809	.3486	-2.493	-1.126	26.930	1	.000
Government Offices	-2.830	.6242	-4.053	-1.606	20.551	1	.000
Accommodation	.811	.1431	.531	1.092	32.164	1	.000
Commercial	1.051	.1379	.781	1.321	58.082	1	.000
Residential	.688	.1459	.402	.974	22.267	1	.000
Religious	0[a]	.	.	.	.	.	.
Unknown	-4.312	.6888	-5.662	-2.962	39.181	1	.000
Single carriageway –4+ lanes	-3.458	.5113	-4.460	-2.456	45.735	1	.000
Single carriageway – 3 lanes	-3.771	.5511	-4.851	-2.691	46.821	1	.000
Single carriageway – 2 lanes	-.183	.4362	-1.038	.672	.176	1	.675
Single carriageway – single track	-3.194	.4943	-4.162	-2.225	41.749	1	.000
Dual carriageway – 3+ lanes	-3.440	.5253	-4.470	-2.411	42.899	1	.000
Dual carriageway – 2 lanes	-2.745	.4692	-3.664	-1.825	34.216	1	.000
One way street	-2.576	.4677	-3.493	-1.659	30.339	1	.000
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-2.676	.2610	-3.188	-2.165	105.156	1	.000
Private drive or entrance	-2.860	.2854	-3.419	-2.300	100.399	1	.000
Multiple junction	-3.181	.3257	-3.820	-2.543	95.431	1	.000
Crossroads	-1.704	.1584	-2.014	-1.394	115.710	1	.000
Slip road	-3.994	.5038	-4.981	-3.007	62.851	1	.000
T, Y or staggered junction	-.299	.0919	-.479	-.119	10.575	1	.001
Mini-roundabout	-4.487	.6803	-5.820	-3.153	43.494	1	.000
Roundabout	-3.233	.3314	-3.883	-2.584	95.217	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.

(Scale)	2.248[b]						

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table M-17.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-2.699	.359	-3.403	-1.995
Government Offices	-3.720	.632	-4.958	-2.481
Accommodation	-.079	.157	-.387	.230
Commercial	.161	.149	-.130	.453
Residential	-.202	.160	-.516	.113
Religious	-.890	.182	-1.247	-.533

Table M-17.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-2.919	.559	-4.015	-1.823
Single carriageway –4+ lanes	-2.065	.317	-2.685	-1.444
Single carriageway – 3 lanes	-2.378	.378	-3.118	-1.638
Single carriageway – 2 lanes	1.210	.168	.880	1.540
Single carriageway – single track	-1.801	.286	-2.362	-1.239
Dual carriageway – 3+ lanes	-2.047	.338	-2.710	-1.385
Dual carriageway – 2 lanes	-1.352	.243	-1.828	-.876
One way street	-1.183	.237	-1.647	-.719
Roundabout	1.393	.411	.587	2.199

Table M-17.8: Estimated Marginal Means for Junction Details

Junction Details	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper

Other junction	-1.421	.300	-2.009	-.834
Private drive or entrance	-1.605	.321	-2.234	-.976
Multiple junction	-1.927	.358	-2.628	-1.226
Crossroads	-.449	.213	-.867	-.032
Slip road	-2.739	.525	-3.769	-1.709
T, Y or staggered junction	.956	.165	.633	1.278
Mini-roundabout	-3.232	.676	-4.557	-1.907
Roundabout	-1.979	.330	-2.626	-1.331
Not at junction or within 20 metres	1.255	.159	.942	1.567

Appendix M-18: Negative Binomial Regression Model for Seriously Injured (SI) during High Season.

Table M-18.1: Model Information

Data set	High Season
Probability Distribution	Negative binomial (1)

Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	139

Table M-18.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	33.946	117	.290
Scaled Deviance	33.946	117	
Pearson Chi-Square	42.671	117	.365
Scaled Pearson Chi-Square	42.671	117	
Log Likelihood[b]	-338.979		
Akaike's Information Criterion (AIC)	721.957		
Finite Sample Corrected AIC (AICC)	730.681		
Bayesian Information Criterion (BIC)	786.516		
Consistent AIC (CAIC)	808.516		

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Table M-18.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
244.119	21	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table M-18.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	3.658	1	.056
Major land use	31.342	5	.000
Road Type	117.831	8	.000
Junction Detail	81.950	8	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-18.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	2.992	.6900	1.640	4.345	18.809	1	.000
Agriculture	-.964	.5114	-1.966	.039	3.550	1	.060
Government Offices	-1.953	.8731	-3.664	-.241	5.001	1	.025
Accommodation	.838	.3251	.200	1.475	6.638	1	.010
Commercial	.961	.3135	.347	1.575	9.399	1	.002
Residential	.711	.3310	.063	1.360	4.618	1	.032
Religious	0[a]	.	.	.	.	.	.
Unknown	-2.992	.8547	-4.667	-1.316	12.251	1	.000
Single carriageway –4+ lanes	-2.127	.7127	-3.524	-.730	8.908	1	.003
Single carriageway – 3 lanes	-2.412	.7311	-3.845	-.979	10.884	1	.001
Single carriageway – 2 lanes	.413	.6339	-.829	1.656	.425	1	.514
Single carriageway – single track	-1.989	.7091	-3.379	-.600	7.873	1	.005
Dual carriageway – 3+ lanes	-2.203	.7649	-3.702	-.704	8.295	1	.004
Dual carriageway – 2 lanes	-1.564	.6592	-2.856	-.272	5.630	1	.018
One way street	-1.403	.6865	-2.749	-.058	4.178	1	.041
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.846	.4657	-2.759	-.934	15.716	1	.000
Private drive or entrance	-2.225	.4789	-3.164	-1.286	21.583	1	.000
Multiple junction	-2.404	.4767	-3.339	-1.470	25.447	1	.000
Crossroads	-1.224	.3398	-1.890	-.558	12.975	1	.000
Slip road	-2.862	.6225	-4.082	-1.642	21.147	1	.000
T, Y or staggered junction	-.210	.2806	-.759	.340	.558	1	.455
Mini-roundabout	-3.153	.7602	-4.643	-1.663	17.206	1	.000
Roundabout	-2.160	.4940	-3.129	-1.192	19.127	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table M-18.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-1.345	.481	-2.288	-.402
Government Offices	-2.334	.867	-4.033	-.635
Accommodation	.456	.246	-.026	.939
Commercial	.580	.226	.137	1.022
Residential	.330	.256	-.172	.832
Religious	-.381	.291	-.953	.190

Table M-18.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-1.854	.625	-3.079	-.629
Single carriageway –4+ lanes	-.990	.419	-1.812	-.168
Single carriageway – 3 lanes	-1.275	.476	-2.208	-.342
Single carriageway – 2 lanes	1.551	.234	1.093	2.009
Single carriageway – single track	-.852	.403	-1.643	-.061
Dual carriageway – 3+ lanes	-1.066	.495	-2.036	-.096
Dual carriageway – 2 lanes	-.427	.335	-1.083	.229
One way street	-.266	.353	-.958	.426
Roundabout	1.137	.602	-.042	2.317

Table M-18.8: Estimated Marginal Means for Junction Details

Junction Details	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.508	.469	-1.428	.412
Private drive or entrance	-.887	.486	-1.840	.066
Multiple junction	-1.066	.484	-2.015	-.118
Crossroads	.114	.339	-.550	.779
Slip road	-1.524	.627	-2.753	-.296
T, Y or staggered junction	1.129	.262	.615	1.643
Mini-roundabout	-1.815	.741	-3.267	-.363
Roundabout	-.822	.450	-1.703	.059
Not at junction or within 20 metres	1.338	.251	.845	1.831

Appendix M-19: Poisson Regression Model for Killed during High Season.

Table M-19.1: Model Information

Data set	High Season
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	62

Table M-19.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	31.662	42	.754
Scaled Deviance	32.380	42	
Pearson Chi-Square	41.069	42	.978
Scaled Pearson Chi-Square	42.000	42	
Log Likelihood[b,c]	-99.056		
Adjusted Log Likelihood[d]	-101.301		
Akaike's Information Criterion (AIC)	238.112		
Finite Sample Corrected AIC (AICC)	258.600		
Bayesian Information Criterion (BIC)	280.655		
Consistent AIC (CAIC)	300.655		

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.
c. The log likelihood is based on a scale parameter fixed at 1.
d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table M-19.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
381.689	19	.000

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table M-19.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	24.154	1	.000
Major land use	43.131	5	.000
Road Type	236.232	8	.000
Junction Detail	120.409	6	.000

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-19.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	1.685	1.1235	-.517	3.888	2.250	1	.134
Agriculture	-2.469	1.0075	-4.443	-.494	6.004	1	.014
Government Offices	-1.776	.7254	-3.197	-.354	5.991	1	.014
Accommodation	.646	.2180	.218	1.073	8.771	1	.003
Commercial	.944	.2072	.538	1.350	20.746	1	.000
Residential	.526	.2200	.095	.957	5.718	1	.017
Religious	0[a]	.	.	.	.	.	.
Unknown	-2.629	1.4874	-5.544	.286	3.125	1	.077

Single carriageway –4+ lanes	-1.971	1.4965	-4.905	.962	1.736	1	.188
Single carriageway – 3 lanes	-2.103	1.2157	-4.486	.279	2.993	1	.084
Single carriageway – 2 lanes	.783	1.1074	-1.387	2.954	.500	1	.479
Single carriageway – single track	-1.888	1.1583	-4.158	.382	2.657	1	.103
Dual carriageway – 3+ lanes	-2.238	1.2166	-4.623	.146	3.385	1	.066
Dual carriageway – 2 lanes	-.994	1.1241	-3.197	1.210	.781	1	.377
One way street	-1.483	1.1386	-3.715	.748	1.697	1	.193
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-2.030	.3020	-2.622	-1.438	45.185	1	.000
Private drive or entrance	-2.397	.4560	-3.291	-1.503	27.632	1	.000
Multiple junction	-2.071	.5861	-3.219	-.922	12.481	1	.000
Crossroads	-1.316	.2202	-1.748	-.885	35.718	1	.000
T, Y or staggered junction	-.240	.1401	-.515	.035	2.936	1	.087
Roundabout	-2.629	.5066	-3.622	-1.636	26.936	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	.978[b]						

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table M-19.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-3.701	1.026	-5.712	-1.690
Government Offices	-3.008	.751	-4.480	-1.536
Accommodation	-.586	.270	-1.116	-.057
Commercial	-.288	.254	-.787	.210
Residential	-.706	.261	-1.217	-.195
Religious	-1.232	.308	-1.837	-.628

Table M-19.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-2.825	1.030	-4.843	-.806
Single carriageway –4+ lanes	-2.167	1.030	-4.186	-.148

Single carriageway – 3 lanes	-2.299	.559	-3.394	-1.204
Single carriageway – 2 lanes	.588	.245	.107	1.069
Single carriageway – single track	-2.083	.418	-2.902	-1.265
Dual carriageway – 3+ lanes	-2.434	.560	-3.531	-1.337
Dual carriageway – 2 lanes	-1.189	.321	-1.818	-.560
One way street	-1.679	.362	-2.387	-.970
Roundabout	-.195	1.103	-2.357	1.966

Table M-19.8: Estimated Marginal Means for Junction Details

Junction Details	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-2.091	.421	-2.916	-1.265
Private drive or entrance	-2.458	.544	-3.524	-1.392
Multiple junction	-2.131	.656	-3.417	-.845
Crossroads	-1.377	.367	-2.096	-.658
T, Y or staggered junction	-.301	.315	-.919	.317
Roundabout	-2.690	.540	-3.748	-1.632
Not at junction or within 20 metres	-.061	.303	-.654	.532

Appendix M-20: Negative Binomial Regression Model for Killed during High Season.

Table M-20.1: Model Information

Data set	High Season
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	62

Table M-20.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	9.334	42	.222
Scaled Deviance	9.334	42	
Pearson Chi-Square	10.230	42	.244
Scaled Pearson Chi-Square	10.230	42	
Log Likelihood[b]	-128.766		
Akaike's Information Criterion (AIC)	297.532		
Finite Sample Corrected AIC (AICC)	318.020		
Bayesian Information Criterion (BIC)	340.075		
Consistent AIC (CAIC)	360.075		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Table M-20.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
57.101	19	.000

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table M-20.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	4.953	1	.026
Major land use	7.231	5	.204
Road Type	38.543	8	.000
Junction Detail	15.600	6	.016

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-20.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	1.645	1.7028	-1.692	4.983	.934	1	.334
Agriculture	-2.465	1.5097	-5.424	.494	2.666	1	.102
Government Offices	-1.772	1.3338	-4.386	.842	1.765	1	.184
Accommodation	.332	.5492	-.744	1.409	.366	1	.545
Commercial	.583	.5383	-.473	1.638	1.171	1	.279
Residential	.187	.5457	-.883	1.256	.117	1	.733
Religious	0[a]	.	.	.	.	.	.
Unknown	-2.228	2.1841	-6.509	2.053	1.040	1	.308
Single carriageway –4+ lanes	-1.558	2.2126	-5.895	2.779	.496	1	.481
Single carriageway – 3 lanes	-1.652	1.8066	-5.193	1.889	.836	1	.360
Single carriageway – 2 lanes	.820	1.6358	-2.386	4.026	.251	1	.616
Single carriageway – single track	-1.481	1.7242	-4.860	1.899	.738	1	.390
Dual carriageway – 3+ lanes	-1.831	1.8014	-5.361	1.700	1.033	1	.309
Dual carriageway – 2 lanes	-.600	1.6614	-3.857	2.656	.130	1	.718
One way street	-1.003	1.7065	-4.348	2.341	.346	1	.557
Roundabout	0[a]	.	.	.	.	.	.

Other junction	-1.471	.6307	-2.707	-.235	5.441	1	.020
Private drive or entrance	-1.827	.8957	-3.582	-.071	4.159	1	.041
Multiple junction	-1.704	1.0254	-3.714	.306	2.762	1	.097
Crossroads	-1.029	.5600	-2.127	.068	3.377	1	.066
T, Y or staggered junction	-.274	.4017	-1.061	.513	.465	1	.495
Roundabout	-2.228	.8777	-3.948	-.508	6.443	1	.011
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table M-20.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-3.098	1.518	-6.073	-.123
Government Offices	-2.405	1.343	-5.037	.228
Accommodation	-.300	.477	-1.236	.635
Commercial	-.050	.424	-.880	.780
Residential	-.446	.456	-1.340	.447
Religious	-.633	.590	-1.789	.523

Table M-20.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-2.324	1.547	-5.356	.707
Single carriageway - 4+ lanes	-1.654	1.520	-4.634	1.326
Single carriageway - 3 lanes	-1.748	.867	-3.447	-.049
Single carriageway - 2 lanes	.724	.409	-.079	1.526
Single carriageway - single track	-1.577	.672	-2.895	-.259
Dual carriageway - 3+ lanes	-1.927	.862	-3.617	-.237
Dual carriageway - 2 lanes	-.696	.567	-1.808	.415

One way street	-1.099	.628	-2.330	.131
Roundabout	-.096	1.627	-3.285	3.093

Table M-20.8: Estimated Marginal Means for Junction Details

Junction Details	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.408	.740	-2.858	.043
Private drive or entrance	-1.763	.988	-3.700	.174
Multiple junction	-1.641	1.102	-3.800	.519
Crossroads	-.966	.688	-2.314	.383
T, Y or staggered junction	-.210	.532	-1.253	.832
Roundabout	-2.164	.900	-3.928	-.401
Not at junction or within 20 metres	.064	.470	-.858	.985

Appendix M-21: Poisson Regression Model for Seriously Injured (SI) during Low Season.

Table M-21.1: Model Information

Data set	Low Season
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	95

Table M-21.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	78.860	73	1.080
Scaled Deviance	56.359	73	
Pearson Chi-Square	102.146	73	1.399
Scaled Pearson Chi-Square	73.000	73	
Log Likelihood[b,c]	-166.457		
Adjusted Log Likelihood[d]	-118.961		
Akaike's Information Criterion (AIC)	376.915		
Finite Sample Corrected AIC (AICC)	390.970		
Bayesian Information Criterion (BIC)	433.100		
Consistent AIC (CAIC)	455.100		

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

c. The log likelihood is based on a scale parameter fixed at 1.

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table M-21.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
584.823	21	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table M-21.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	33.329	1	.000

Major land use	77.910	5	.000
Road Type	366.720	8	.000
Junction Detail	154.348	8	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-21.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	2.396	.8202	.788	4.004	8.533	1	.003
Agriculture	-1.914	.8591	-3.598	-.230	4.964	1	.026
Government Offices	-1.682	.5621	-2.784	-.580	8.954	1	.003
Accommodation	1.235	.2074	.829	1.642	35.477	1	.000
Commercial	.655	.2233	.218	1.093	8.610	1	.003
Residential	1.064	.2122	.648	1.480	25.109	1	.000
Religious	0[a]	.	.	.	.	.	.
Unknown	-2.546	.8744	-4.260	-.832	8.478	1	.004
Single carriageway –4+ lanes	-2.218	.8508	-3.886	-.551	6.797	1	.009
Single carriageway – 3 lanes	-3.117	.9996	-5.076	-1.158	9.724	1	.002
Single carriageway – 2 lanes	.109	.8003	-1.459	1.678	.019	1	.891
Single carriageway – single track	-2.595	.8598	-4.280	-.910	9.112	1	.003
Dual carriageway – 3+ lanes	-2.836	.8790	-4.559	-1.114	10.413	1	.001
Dual carriageway – 2 lanes	-2.012	.8247	-3.628	-.395	5.950	1	.015
One way street	-2.212	.8360	-3.851	-.573	7.000	1	.008
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-2.233	.3304	-2.880	-1.585	45.665	1	.000
Private drive or entrance	-2.784	.5394	-3.841	-1.727	26.638	1	.000
Multiple junction	-2.301	.3706	-3.027	-1.575	38.559	1	.000
Crossroads	-.777	.1749	-1.120	-.434	19.736	1	.000
Slip road	-2.062	.8533	-3.735	-.390	5.841	1	.016
T, Y or staggered junction	.091	.1286	-.161	.343	.497	1	.481
Mini-roundabout	-3.282	.7918	-4.834	-1.730	17.181	1	.000
Roundabout	-2.971	.6886	-4.321	-1.621	18.615	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1.399[b]						

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Computed based on the Pearson chi-square.

Table M-21.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-3.268	.863	-4.960	-1.576
Government Offices	-3.036	.569	-4.150	-1.921
Accommodation (Hostels or Hotels)	-.118	.195	-.500	.263
Commercial	-.698	.220	-1.130	-.267
Residential	-.290	.210	-.701	.121
Religious	-1.354	.253	-1.849	-.858

Table M-21.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-2.070	.428	-2.908	-1.232
Single carriageway –4+ lanes	-1.743	.378	-2.484	-1.001
Single carriageway – 3 lanes	-2.641	.646	-3.908	-1.375
Single carriageway – 2 lanes	.585	.246	.102	1.068
Single carriageway – single track	-2.120	.400	-2.904	-1.335
Dual carriageway – 3+ lanes	-2.361	.439	-3.221	-1.501
Dual carriageway – 2 lanes	-1.536	.323	-2.169	-.903
One way street	-1.736	.338	-2.398	-1.074
Roundabout	.476	.740	-.974	1.926

Table M-21.8: Estimated Marginal Means for Junction Details

Junction Details	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.880	.387	-2.638	-1.123
Private drive or entrance	-2.431	.576	-3.560	-1.302
Multiple junction	-1.948	.420	-2.771	-1.126
Crossroads	-.424	.264	-.942	.093
Slip road	-1.710	.873	-3.421	.001

T, Y or staggered junction	.443	.225	.002	.885
Mini-roundabout	-2.929	.777	-4.453	-1.406
Roundabout	-2.618	.657	-3.907	-1.330
Not at junction or within 20 metres	.353	.224	-.087	.792

Appendix M-22: Negative Binomial Regression Model for Seriously Injured (SI) during Low Season.

Table M-22.1: Model Information

Data set	Low Season
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	95

Table M-22.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	23.624	73	.324
Scaled Deviance	75.704	73	
Pearson Chi-Square	22.780	73	.312
Scaled Pearson Chi-Square	73.000	73	
Log Likelihood[b]	-201.683		
Akaike's Information Criterion (AIC)	-646.295		
Finite Sample Corrected AIC (AICC)	447.366		
Bayesian Information Criterion (BIC)	461.422		
Consistent AIC (CAIC)	503.552		

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Table M-22.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
328.323	21	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table M-22.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	20.668	1	.000
Major land use	47.031	5	.000
Road Type	169.534	8	.000
Junction Detail	94.778	8	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-22.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	1.959	.6389	.707	3.211	9.402	1	.002
Agriculture	-1.584	.6410	-2.841	-.328	6.110	1	.013
Government Offices	-1.586	.4866	-2.540	-.632	10.623	1	.001
Accommodation	.838	.2366	.374	1.302	12.536	1	.000
Commercial	.242	.2415	-.231	.715	1.003	1	.316
Residential	.612	.2397	.142	1.082	6.521	1	.011
Religious	0[a]	.	.	.	.	.	.
Unknown	-1.586	.6905	-2.940	-.233	5.277	1	.022
Single carriageway –4+ lanes	-1.408	.6676	-2.717	-.100	4.449	1	.035
Single carriageway – 3 lanes	-2.255	.7513	-3.728	-.783	9.012	1	.003
Single carriageway – 2 lanes	.392	.6151	-.813	1.598	.407	1	.524
Single carriageway – single track	-1.853	.6756	-3.177	-.528	7.520	1	.006
Dual carriageway – 3+ lanes	-2.041	.6753	-3.365	-.718	9.137	1	.003
Dual carriageway – 2 lanes	-1.323	.6285	-2.555	-.091	4.430	1	.035
One way street	-1.327	.6524	-2.606	-.048	4.138	1	.042
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.550	.2962	-2.131	-.970	27.386	1	.000
Private drive or entrance	-2.199	.4298	-3.042	-1.357	26.191	1	.000
Multiple junction	-1.277	.3465	-1.957	-.598	13.590	1	.000
Crossroads	-.334	.2289	-.782	.115	2.124	1	.145
Slip road	-1.798	.6078	-2.989	-.606	8.747	1	.003
T, Y or staggered junction	.185	.1887	-.184	.555	.966	1	.326
Mini-roundabout	-2.623	.6087	-3.816	-1.430	18.575	1	.000
Roundabout	-2.228	.5678	-3.341	-1.115	15.399	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	.312[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table M-22.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper

Agriculture	-2.206	.633	-3.446	-.966
Government Offices	-2.207	.477	-3.142	-1.272
Accommodation	.216	.166	-.109	.542
Commercial	-.380	.197	-.767	.007
Residential	-.009	.188	-.378	.359
Religious	-.621	.217	-1.047	-.196

Table M-22.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-1.187	.353	-1.879	-.496
Single carriageway –4+ lanes	-1.009	.319	-1.634	-.385
Single carriageway – 3 lanes	-1.856	.472	-2.782	-.931
Single carriageway – 2 lanes	.791	.194	.412	1.171
Single carriageway – single track	-1.454	.340	-2.120	-.788
Dual carriageway – 3+ lanes	-1.642	.337	-2.303	-.981
Dual carriageway – 2 lanes	-.924	.269	-1.451	-.397
One way street	-.928	.265	-1.447	-.410
Roundabout	.399	.564	-.707	1.505

Table M-22.8: Estimated Marginal Means for Junction Details

Junction Details	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.104	.314	-1.721	-.488
Private drive or entrance	-1.753	.447	-2.630	-.877
Multiple junction	-.832	.337	-1.493	-.170
Crossroads	.112	.243	-.364	.589
Slip road	-1.352	.622	-2.570	-.133
T, Y or staggered junction	.631	.190	.260	1.003
Mini-roundabout	-2.178	.593	-3.340	-1.015
Roundabout	-1.782	.529	-2.818	-.746
Not at junction or within 20 metres	.446	.196	.061	.831

Appendix M-23: Poisson Regression Model for Killed during Low Season.

Table M-23.1: Model Information

Data set	Low Season
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	37

Table M-23.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	13.451	18	.747
Scaled Deviance	18.773	18	
Pearson Chi-Square	12.897	18	.717
Scaled Pearson Chi-Square	18.000	18	
Log Likelihood[b,c]	-52.564		
Adjusted Log Likelihood[d]	-73.362		
Akaike's Information Criterion (AIC)	143.128		
Finite Sample Corrected AIC (AICC)	187.834		
Bayesian Information Criterion (BIC)	173.736		
Consistent AIC (CAIC)	192.736		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.
c. The log likelihood is based on a scale parameter fixed at 1.
d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table M-23.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
90.569	18	.000

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table M-23.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	3.678	1	.055
Major land use	13.664	4	.008
Road Type	42.919	7	.000
Junction Detail	27.623	6	.000

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-23.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-.446	.9091	-2.228	1.336	.241	1	.624
Agriculture	-1.271	.8939	-3.023	.481	2.023	1	.155
Accommodation	.881	.3026	.288	1.474	8.480	1	.004
Commercial	.446	.3317	-.204	1.096	1.807	1	.179
Residential	.502	.3236	-.132	1.137	2.412	1	.120
Religious	0[a]	.	.	.	.	.	.
Unknown	.192	1.0759	-1.917	2.301	.032	1	.858
Single carriageway –4+ lanes	-.057	1.2264	-2.460	2.347	.002	1	.963
Single carriageway – 3 lanes	1.487	1.2961	-1.053	4.027	1.316	1	.251
Single carriageway – 2 lanes	1.717	.8809	-.009	3.444	3.800	1	.051
Single carriageway – single track	-.147	1.2471	-2.591	2.298	.014	1	.906
Dual carriageway – 3+ lanes	.284	1.0794	-1.831	2.400	.069	1	.792

Dual carriageway – 2 lanes	-.019	.9695	-1.919	1.881	.000	1	.985
One way street	.485	.9307	-1.339	2.309	.272	1	.602
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-.542	.9240	-2.353	1.269	.344	1	.558
Private drive or entrance	-2.152	.8718	-3.861	-.444	6.095	1	.014
Multiple junction	-1.544	.4145	-2.356	-.731	13.871	1	.000
Crossroads	-.581	.2663	-1.103	-.059	4.751	1	.029
T, Y or staggered junction	.090	.2198	-.341	.521	.168	1	.682
Mini-roundabout	-1.271	.8939	-3.023	.481	2.023	1	.155
Roundabout	0[a]	.	.	.	.	.	.
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	.717[b]						

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Computed based on the Pearson chi-square.

Table M-23.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-2.029	.913	-3.819	-.239
Accommodation	.124	.331	-.525	.772
Commercial	-.312	.355	-1.008	.385
Residential	-.255	.301	-.845	.335
Religious	-.758	.375	-1.492	-.024

Table M-23.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-.892	.681	-2.226	.442
Single carriageway - 4+ lanes	-1.141	.912	-2.928	.647
Single carriageway - 3 lanes	.403	.957	-1.472	2.278
Single carriageway - 2 lanes	.633	.265	.114	1.152
Single carriageway - single track	-1.231	.909	-3.013	.551
Dual carriageway - 3+ lanes	-.800	.674	-2.121	.522
Dual carriageway - 2 lanes	-1.103	.478	-2.039	-.167

One way street	-.599	.389	-1.361	.163
Roundabout	-1.084	.911	-2.870	.702

Table M-23.8: Estimated Marginal Means for Junction Details

Junction Details	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.438	.952	-2.303	1.428
Private drive or entrance	-2.048	.908	-3.828	-.269
Multiple junction	-1.440	.456	-2.333	-.547
Crossroads	-.477	.360	-1.182	.228
T, Y or staggered junction	.194	.326	-.444	.832
Mini-roundabout	-1.167	.922	-2.975	.640
Roundabout	.104	.299	-.482	.689
Not at junction or within 20 metres	.104	.299	-.482	.689

Appendix M-24: Negative Binomial Regression Model for Killed during Low Season.

Table M-24.1: Model Information

Data set	Low Season
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	37

Table M-24.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	3.598	18	.200
Scaled Deviance	3.598	18	
Pearson Chi-Square	3.445	18	.191
Scaled Pearson Chi-Square	3.445	18	
Log Likelihood[b]	-68.834		
Akaike's Information Criterion (AIC)	175.668		
Finite Sample Corrected AIC (AICC)	220.374		
Bayesian Information Criterion (BIC)	206.275		
Consistent AIC (CAIC)	225.275		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Table M-24.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.

16.268	18	.574

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table M-24.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	1.032	1	.310
Major land use	1.943	4	.746
Road Type	8.785	7	.268
Junction Detail	5.237	6	.514

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table M-24.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-.415	1.6309	-3.611	2.782	.065	1	.799
Agriculture	-1.270	1.5718	-4.351	1.811	.653	1	.419
Accommodation	.593	.7221	-.822	2.008	.675	1	.411
Commercial	.415	.8122	-1.177	2.007	.261	1	.610
Residential	.436	.7617	-1.057	1.929	.328	1	.567
Religious	0[a]	.	.	.	.	.	.
Unknown	.192	1.8909	-3.514	3.898	.010	1	.919
Single carriageway –4+ lanes	-.022	2.1055	-4.148	4.105	.000	1	.992
Single carriageway – 3 lanes	1.265	2.2630	-3.171	5.700	.312	1	.576
Single carriageway – 2 lanes	1.684	1.5624	-1.378	4.747	1.162	1	.281
Single carriageway – single track	-.140	2.1905	-4.434	4.153	.004	1	.949
Dual carriageway – 3+ lanes	.332	1.9036	-3.399	4.063	.030	1	.862
Dual carriageway – 2 lanes	.138	1.7460	-3.284	3.560	.006	1	.937
One way street	.564	1.6255	-2.622	3.749	.120	1	.729
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-.585	1.6342	-3.788	2.617	.128	1	.720
Private drive or entrance	-1.863	1.5278	-4.857	1.132	1.487	1	.223
Multiple junction	-1.287	.8229	-2.900	.326	2.445	1	.118

Crossroads	-.428	.6404	-1.683	.828	.446	1	.504
T, Y or staggered junction	.119	.6108	-1.078	1.316	.038	1	.846
Mini-roundabout	-1.270	1.5718	-4.351	1.811	.653	1	.419
Roundabout	0[a]	.	.	.	.	.	.
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table M-24.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-1.903	1.584	-5.007	1.202
Accommodation	-.040	.673	-1.359	1.279
Commercial	-.218	.726	-1.641	1.204
Residential	-.197	.535	-1.245	.852
Religious	-.633	.740	-2.083	.817

Table M-24.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-.852	1.206	-3.216	1.511
Single carriageway - 4+ lanes	-1.066	1.593	-4.188	2.057
Single carriageway - 3 lanes	.221	1.634	-2.981	3.423
Single carriageway - 2 lanes	.640	.467	-.274	1.555
Single carriageway - single track	-1.184	1.581	-4.284	1.915
Dual carriageway - 3+ lanes	-.712	1.182	-3.029	1.604
Dual carriageway - 2 lanes	-.906	.879	-2.629	.817
One way street	-.480	.706	-1.864	.903
Roundabout	-1.044	1.590	-4.161	2.073

Table M-24.8: Estimated Marginal Means for Junction Details

Junction Details	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.519	1.662	-3.777	2.738
Private drive or entrance	-1.797	1.563	-4.861	1.267
Multiple junction	-1.221	.836	-2.859	.418
Crossroads	-.361	.716	-1.765	1.042
T, Y or staggered junction	.185	.655	-1.098	1.468
Mini-roundabout	-1.204	1.595	-4.330	1.922
Roundabout	.066	.544	-1.001	1.133
Not at junction or within 20 metres	.066	.544	-1.001	1.133

Appendix V-1: Poisson Regression Model for Seriously Injured (SI) during Prayer Time.

Table V-1.1: Model Information

Data set	Prayer Time
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	36

Table V-1.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	22.021	19	1.159
Scaled Deviance	12.445	19	
Pearson Chi-Square	33.620	19	1.769
Scaled Pearson Chi-Square	19.000	19	
Log Likelihood[b,c]	-58.267		
Adjusted Log Likelihood[d]	-32.929		
Akaike's Information Criterion (AIC)	150.533		
Finite Sample Corrected AIC (AICC)	184.533		
Bayesian Information Criterion (BIC)	177.453		
Consistent AIC (CAIC)	194.453		

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.
c. The log likelihood is based on a scale parameter fixed at 1.
d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table V-1.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
70.844	16	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table V-1.4: Tests of Model Effects

Source	Type III

	Wald Chi-Square	df	Sig.
(Intercept)	.948	1	.330
Major land use	5.258	4	.262
Road Type	27.497	6	.000
Junction Detail	27.186	6	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-1.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	1.982	1.3877	-.738	4.702	2.040	1	.153
Agriculture	-.308	1.4302	-3.111	2.495	.047	1	.829
Accommodation	.881	.4032	.091	1.671	4.774	1	.029
Commercial	.538	.4122	-.270	1.346	1.706	1	.192
Residential	.645	.4272	-.192	1.482	2.281	1	.131
Religious	0[a]	.	.	.	.	.	.
Single carriageway –4+ lanes	-1.876	1.4823	-4.781	1.029	1.602	1	.206
Single carriageway – 2 lanes	-.177	1.3411	-2.805	2.452	.017	1	.895
Single carriageway – single track	-1.823	1.4973	-4.758	1.111	1.483	1	.223
Dual carriageway – 3+ lanes	-2.406	1.8973	-6.124	1.313	1.608	1	.205
Dual carriageway – 2 lanes	-2.128	1.4532	-4.976	.720	2.144	1	.143
One way street	-1.811	1.5498	-4.848	1.227	1.365	1	.243
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.472	.8177	-3.075	.131	3.241	1	.072
Private drive or entrance	-1.858	.6288	-3.090	-.625	8.729	1	.003
Crossroads	-1.497	.4624	-2.403	-.591	10.481	1	.001
T, Y or staggered junction	-.115	.2712	-.647	.416	.180	1	.671
Mini-roundabout	-1.805	1.3786	-4.507	.897	1.715	1	.190
Roundabout	-2.575	.9667	-4.470	-.681	7.098	1	.008
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1.769[b]						

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table V-1.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper

Agriculture	-1.118	1.434	-3.928	1.692
Accommodation (Hostels or Hotels)	.071	.459	-.828	.971
Commercial	-.271	.419	-1.093	.550
Residential	-.164	.452	-1.051	.722
Religious	-.810	.485	-1.759	.140

Table V-1.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 4+ lanes	-.874	.722	-2.289	.540
Single carriageway - 2 lanes	.825	.384	.072	1.578
Single carriageway - single track	-.822	.782	-2.354	.711
Dual carriageway - 3+ lanes	-1.404	1.408	-4.163	1.356
Dual carriageway - 2 lanes	-1.126	.668	-2.435	.182
One way street	-.809	.876	-2.527	.909
Roundabout	1.002	1.299	-1.544	3.548

Table V-1.8: Estimated Marginal Means for Junction Detail

Junction Details	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.599	.905	-2.372	1.175
Private drive or entrance	-.984	.749	-2.453	.484
Crossroads	-.624	.553	-1.708	.461
T, Y or staggered junction	.758	.455	-.133	1.650
Mini-roundabout	-.932	1.432	-3.739	1.875
Roundabout	-1.702	.915	-3.495	.091
Not at junction or within 20 metres	.873	.467	-.041	1.788

Appendix V-2: Negative Binomial Regression Model for Seriously Injured (SI) during Prayer Time.

Table V-2.1: Model Information

Data set	Prayer Time
Probability Distribution	Negative binomial (1)

Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	36

Table V-2.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	6.409	19	.337
Scaled Deviance	6.409	19	
Pearson Chi-Square	8.038	19	.423
Scaled Pearson Chi-Square	8.038	19	
Log Likelihood[b]	-73.327		
Akaike's Information Criterion (AIC)	180.653		
Finite Sample Corrected AIC (AICC)	214.653		
Bayesian Information Criterion (BIC)	207.573		
Consistent AIC (CAIC)	224.573		

Dependent Variable: Count_SI

Model: (Intercept), Landuse, RoadType, JunctionDetail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Table V-2.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
23.447	16	.102

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-2.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	.485	1	.486
Major land use	1.072	4	.899
Road Type	9.737	6	.136
Junction Detail	9.410	6	.152

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-2.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	1.805	1.5630	-1.258	4.869	1.334	1	.248
Agriculture	-.663	1.6075	-3.814	2.488	.170	1	.680
Accommodation	.396	.7242	-1.024	1.815	.299	1	.585
Commercial	.533	.6806	-.802	1.867	.612	1	.434
Residential	.300	.7783	-1.226	1.825	.148	1	.700
Religious	0[a]	.	.	.	.	.	.
Single carriageway –4+ lanes	-1.066	1.6709	-4.341	2.209	.407	1	.524
Single carriageway – 2 lanes	.068	1.4526	-2.779	2.915	.002	1	.962
Single carriageway – single track	-1.518	1.6991	-4.848	1.812	.799	1	.372
Dual carriageway – 3+ lanes	-2.206	2.0613	-6.246	1.834	1.145	1	.285
Dual carriageway – 2 lanes	-1.677	1.5985	-4.810	1.456	1.100	1	.294
One way street	-1.637	1.7351	-5.037	1.764	.890	1	.346
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.119	1.1312	-3.336	1.098	.978	1	.323
Private drive or entrance	-1.550	.8510	-3.218	.118	3.317	1	.069
Crossroads	-1.211	.7475	-2.676	.255	2.622	1	.105
T, Y or staggered junction	-.131	.5622	-1.233	.970	.055	1	.815
Mini-roundabout	-1.873	1.5520	-4.915	1.168	1.457	1	.227
Roundabout	-2.221	1.1107	-4.398	-.044	3.999	1	.046
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Fixed at the displayed value.

Table V-2.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-1.164	1.595	-4.290	1.963
Accommodation (Hostels or Hotels)	-.105	.716	-1.509	1.299

Commercial	.032	.487	-.922	.985
Residential	-.201	.680	-1.533	1.131
Religious	-.501	.646	-1.766	.765

Table V-2.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 4+ lanes	-.305	.952	-2.172	1.561
Single carriageway - 2 lanes	.829	.438	-.029	1.687
Single carriageway - single track	-.758	1.028	-2.772	1.256
Dual carriageway - 3+ lanes	-1.446	1.572	-4.526	1.635
Dual carriageway - 2 lanes	-.916	.766	-2.417	.585
One way street	-.876	1.083	-3.000	1.247
Roundabout	.760	1.411	-2.005	3.526

Table V-2.8: Estimated Marginal Means for Junction Detail

Junction Details	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.348	1.172	-2.646	1.949
Private drive or entrance	-.779	.941	-2.624	1.065
Crossroads	-.440	.730	-1.871	.991
T, Y or staggered junction	.639	.582	-.502	1.779
Mini-roundabout	-1.103	1.605	-4.250	2.043
Roundabout	-1.451	1.016	-3.443	.541
Not at junction or within 20 metres	.770	.614	-.433	1.973

Appendix V-3: Poisson Regression Model for Killed during Prayer Time.

Table V-3.1: Model Information

Data set	Prayer Time
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	15

Table V-3.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	.535	3	.178
Scaled Deviance	2.973	3	
Pearson Chi-Square	.540	3	.180
Scaled Pearson Chi-Square	3.000	3	
Log Likelihood[b,c]	-17.180		
Adjusted Log Likelihood[d]	-95.391		
Akaike's Information Criterion (AIC)	58.360		
Finite Sample Corrected AIC (AICC)	214.360		
Bayesian Information Criterion (BIC)	66.857		
Consistent AIC (CAIC)	78.857		

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.
c. The log likelihood is based on a scale parameter fixed at 1.
d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table V-3.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
22.843	11	.019

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table V-3.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	.801	1	.371
Major land use	7.221	3	.065
Road Type	2.237	4	.692
Junction Detail	9.818	4	.044

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-3.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	.740	.8831	-.991	2.470	.702	1	.402
Accommodation	-.134	.4010	-.919	.652	.111	1	.739
Commercial	.513	.3607	-.194	1.220	2.023	1	.155
Residential	-.047	.3866	-.804	.711	.014	1	.904
Religious	0[a]	.	.	.	.	.	.
Single carriageway – 3 lanes	5.628E-017	.6002	-1.176	1.176	.000	1	1.000
Single carriageway – 2 lanes	-.047	.7139	-1.446	1.353	.004	1	.948
Single carriageway – single track	-.740	.9797	-2.660	1.181	.570	1	.450
Dual carriageway – 2 lanes	.272	.8667	-1.427	1.971	.098	1	.754

One way street	0[a]	.	.	.	.	.	.
Private drive or entrance	-.693	.5198	-1.712	.326	1.778	1	.182
Crossroads	-.336	.2485	-.824	.151	1.833	1	.176
Slip road	-.740	.9797	-2.660	1.181	.570	1	.450
T, Y or staggered junction	-.965	.3475	-1.646	-.284	7.711	1	.005
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	.180[b]						

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table V-3.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Accommodation	-.044	.333	-.697	.610
Commercial	.603	.279	.057	1.149
Residential	.043	.247	-.440	.527
Religious	.090	.278	-.455	.635

Table V-3.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 3 lanes	.276	.574	-.849	1.401
Single carriageway - 2 lanes	.230	.265	-.289	.748
Single carriageway - single track	-.464	.635	-1.708	.781
Dual carriageway - 2 lanes	.548	.561	-.553	1.649
One way street	.276	.507	-.718	1.270

Table V-3.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std.	95% Wald Confidence Interval

		Error	Lower	Upper
Private drive or entrance	.027	.370	-.698	.752
Crossroads	.384	.368	-.338	1.105
Slip road	-.020	.810	-1.608	1.569
T, Y or staggered junction	-.245	.406	-1.041	.551
Not at junction or within 20 metres	.720	.303	.127	1.314

Appendix V-4: Negative Binomial Regression Model for Killed during Prayer Time.

Table V-4.1: Model Information

Data set	Prayer Time
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	15

Table V-4.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	.208	3	.069
Scaled Deviance	.208	3	
Pearson Chi-Square	.213	3	.071
Scaled Pearson Chi-Square	.213	3	
Log Likelihood[b]	-24.194		
Akaike's Information Criterion (AIC)	72.389		
Finite Sample Corrected AIC (AICC)	228.389		
Bayesian Information Criterion (BIC)	80.885		
Consistent AIC (CAIC)	92.885		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Table V-4.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
1.572	11	1.000

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table V-4.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	.057	1	.811
Major land use	.414	3	.937
Road Type	.180	4	.996
Junction Detail	.706	4	.951

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-4.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	.702	3.3065	-5.778	7.183	.045	1	.832
Accommodation	-.123	1.5884	-3.236	2.990	.006	1	.938
Commercial	.529	1.5381	-2.486	3.543	.118	1	.731
Residential	-.009	1.5599	-3.066	3.048	.000	1	.995
Religious	0[a]	.	.	.	.	.	.
Single carriageway – 3 lanes	-1.889E-017	2.0000	-3.920	3.920	.000	1	1.000
Single carriageway – 2 lanes	-.009	2.5364	-4.980	4.962	.000	1	.997
Single carriageway – single track	-.702	3.5963	-7.751	6.346	.038	1	.845
Dual carriageway – 2 lanes	.260	3.0233	-5.666	6.186	.007	1	.931
One way street	0[a]	.	.	.	.	.	.
Private drive or entrance	-.693	1.8708	-4.360	2.974	.137	1	.711
Crossroads	-.403	1.0209	-2.404	1.598	.155	1	.693
Slip road	-.702	3.5963	-7.751	6.346	.038	1	.845
T, Y or staggered junction	-.953	1.2808	-3.463	1.557	.554	1	.457
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.

(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table V-4.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Accommodation	-.061	1.233	-2.477	2.355
Commercial	.591	1.092	-1.549	2.731
Residential	.053	.909	-1.730	1.835
Religious	.062	1.061	-2.017	2.140

Table V-4.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 3 lanes	.251	2.001	-3.671	4.173
Single carriageway - 2 lanes	.242	.943	-1.607	2.091
Single carriageway - single track	-.451	2.332	-5.022	4.120
Dual carriageway - 2 lanes	.511	1.908	-3.229	4.251
One way street	.251	1.790	-3.257	3.760

Table V-4.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Private drive or entrance	.018	1.311	-2.552	2.588
Crossroads	.309	1.355	-2.347	2.964
Slip road	.009	2.979	-5.830	5.847
T, Y or staggered junction	-.242	1.480	-3.144	2.660
Not at junction or within 20 metres	.711	1.081	-1.408	2.830

Appendix E: Poisson Regression Model for Seriously Injured (SI) during Non-Prayer Time.

Table V-5.1: Model Information

Data set	Non-Prayer Time
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	69

Table V-5.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	44.565	48	.928
Scaled Deviance	36.384	48	
Pearson Chi-Square	58.793	48	1.225
Scaled Pearson Chi-Square	48.000	48	
Log Likelihood[b,c]	-109.223		
Adjusted Log Likelihood[d]	-89.173		
Akaike's Information Criterion (AIC)	260.447		
Finite Sample Corrected AIC (AICC)	280.106		
Bayesian Information Criterion (BIC)	307.363		
Consistent AIC (CAIC)	328.363		

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

c. The log likelihood is based on a scale parameter fixed at 1.

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table V-5.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
301.380	20	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-5.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	7.920	1	.005
Major land use	30.503	5	.000
Road Type	188.047	8	.000
Junction Detail	98.046	7	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-5.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	2.407	.8977	.648	4.167	7.191	1	.007
Agriculture	2.516	1.4322	-.291	5.323	3.086	1	.079
Government Offices	-2.153	.8161	-3.752	-.553	6.958	1	.008
Accommodation	.805	.2687	.279	1.332	8.986	1	.003
Commercial	1.014	.2582	.508	1.520	15.421	1	.000
Residential	.763	.2733	.227	1.298	7.788	1	.005
Religious	0[a]	.	.	.	.	.	.
Unknown	-2.840	1.4007	-5.585	-.095	4.111	1	.043
Single carriageway –4+ lanes	-2.413	.9183	-4.213	-.613	6.905	1	.009
Single carriageway – 3 lanes	-3.133	1.0682	-5.226	-1.039	8.600	1	.003
Single carriageway – 2 lanes	-.086	.8494	-1.750	1.579	.010	1	.920
Single carriageway – single track	-2.361	.9024	-4.129	-.592	6.844	1	.009
Dual carriageway – 3+ lanes	-2.756	.9507	-4.619	-.892	8.402	1	.004
Dual carriageway – 2 lanes	-2.020	.8982	-3.780	-.259	5.056	1	.025
One way street	-2.425	.9316	-4.251	-.599	6.776	1	.009
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-2.341	.4345	-3.193	-1.490	29.031	1	.000
Multiple junction	-2.585	.5671	-3.696	-1.473	20.770	1	.000
Crossroads	-1.496	.2507	-1.987	-1.005	35.621	1	.000
Slip road	-2.498	.7977	-4.062	-.935	9.808	1	.002
T, Y or staggered junction	-.373	.1639	-.694	-.051	5.168	1	.023
Mini-roundabout	-2.522	.7973	-4.085	-.960	10.009	1	.002
Roundabout	-2.629	.6532	-3.910	-1.349	16.200	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.

(Scale)	1.225[b]						

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table V-5.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	1.114	1.364	-1.560	3.788
Government Offices	-3.555	.831	-5.183	-1.926
Accommodation (Hostels or Hotels)	-.596	.256	-1.099	-.094
Commercial	-.388	.266	-.909	.133
Residential	-.639	.291	-1.210	-.068
Religious	-1.402	.347	-2.081	-.722

Table V-5.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-1.747	1.157	-4.015	.520
Single carriageway –4+ lanes	-1.320	.442	-2.186	-.454
Single carriageway – 3 lanes	-2.040	.709	-3.429	-.651
Single carriageway – 2 lanes	1.007	.287	.444	1.570
Single carriageway – single track	-1.268	.417	-2.085	-.451
Dual carriageway – 3+ lanes	-1.663	.513	-2.669	-.657
Dual carriageway – 2 lanes	-.927	.425	-1.759	-.095
One way street	-1.333	.418	-2.152	-.513
Roundabout	1.093	.840	-.553	2.738

Table V-5.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper

Other junction	-1.447	.537	-2.499	-.394
Multiple junction	-1.690	.649	-2.961	-.419
Crossroads	-.601	.396	-1.378	.175
Slip road	-1.604	.727	-3.029	-.178
T, Y or staggered junction	.522	.335	-.135	1.179
Mini-roundabout	-1.628	.858	-3.310	.054
Roundabout	-1.735	.656	-3.020	-.449
Not at junction or within 20 metres	.895	.336	.237	1.553

Appendix V-6: Negative Binomial Regression Model for Seriously Injured (SI) during Non-Prayer Time.

Table V-6.1: Model Information

Data set	Non-Prayer Time
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	69

Table V-6.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	13.347	48	.278
Scaled Deviance	13.347	48	
Pearson Chi-Square	14.839	48	.309
Scaled Pearson Chi-Square	14.839	48	
Log Likelihood[b]	-134.670		
Akaike's Information Criterion (AIC)	311.340		
Finite Sample Corrected AIC (AICC)	330.999		
Bayesian Information Criterion (BIC)	358.256		
Consistent AIC (CAIC)	379.256		

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.

Table V-6.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
59.356	20	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table V-6.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	1.728	1	.189
Major land use	7.291	5	.200
Road Type	34.175	8	.000
Junction Detail	16.362	7	.022

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-6.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval	Hypothesis Test

			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	2.130	1.4116	-.637	4.897	2.277	1	.131
Agriculture	1.341	1.9838	-2.547	5.229	.457	1	.499
Government Offices	-2.094	1.1154	-4.280	.092	3.525	1	.060
Accommodation	.555	.5535	-.530	1.640	1.005	1	.316
Commercial	.521	.5174	-.494	1.535	1.012	1	.314
Residential	.513	.5710	-.606	1.632	.807	1	.369
Religious	0[a]	.	.	.	.	.	.
Unknown	-2.573	1.9125	-6.322	1.175	1.811	1	.178
Single carriageway –4+ lanes	-1.891	1.3624	-4.562	.779	1.927	1	.165
Single carriageway – 3 lanes	-2.588	1.5021	-5.532	.356	2.968	1	.085
Single carriageway – 2 lanes	.020	1.2508	-2.432	2.471	.000	1	.987
Single carriageway – single track	-1.903	1.3361	-4.522	.715	2.030	1	.154
Dual carriageway – 3+ lanes	-2.083	1.3933	-4.814	.647	2.236	1	.135
Dual carriageway – 2 lanes	-1.610	1.2860	-4.131	.910	1.568	1	.211
One way street	-1.839	1.3798	-4.543	.866	1.776	1	.183
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.834	.7735	-3.350	-.318	5.621	1	.018
Multiple junction	-1.840	.8973	-3.599	-.082	4.207	1	.040
Crossroads	-.904	.4747	-1.835	.026	3.627	1	.057
Slip road	-1.632	1.2176	-4.019	.754	1.797	1	.180
T, Y or staggered junction	-.112	.4006	-.897	.673	.078	1	.780
Mini-roundabout	-1.755	1.1847	-4.077	.567	2.194	1	.139
Roundabout	-1.975	.9354	-3.808	-.141	4.457	1	.035
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table V-6.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	.607	1.865	-3.049	4.263
Government Offices	-2.828	1.117	-5.017	-.639
Accommodation (Hostels or Hotels)	-.179	.393	-.950	.592

Commercial	-.213	.426	-1.047	.621
Residential	-.221	.451	-1.104	.662
Religious	-.734	.591	-1.893	.425

Table V-6.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-1.561	1.527	-4.554	1.433
Single carriageway - 4+ lanes	-.879	.618	-2.090	.332
Single carriageway - 3 lanes	-1.575	.945	-3.428	.278
Single carriageway - 2 lanes	1.033	.415	.219	1.847
Single carriageway - single track	-.891	.628	-2.121	.339
Dual carriageway - 3+ lanes	-1.071	.727	-2.496	.355
Dual carriageway - 2 lanes	-.597	.642	-1.856	.662
One way street	-.826	.573	-1.949	.298
Roundabout	1.013	1.243	-1.423	3.448

Table V-6.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.172	.870	-2.878	.534
Multiple junction	-1.179	.979	-3.098	.741
Crossroads	-.242	.579	-1.378	.893
Slip road	-.970	1.073	-3.073	1.132
T, Y or staggered junction	.550	.484	-.399	1.499
Mini-roundabout	-1.093	1.264	-3.569	1.384
Roundabout	-1.313	.903	-3.083	.457
Not at junction or within 20 metres	.662	.512	-.342	1.666

Appendix F: Poisson Regression Model for Killed during Non-Prayer Time.

Table V-7.1: Model Information

Data set	Non-Prayer Time
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	25

Table V-7.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	5.800	12	.483
Scaled Deviance	10.992	12	
Pearson Chi-Square	6.332	12	.528
Scaled Pearson Chi-Square	12.000	12	
Log Likelihood[b,c]	-32.732		
Adjusted Log Likelihood[d]	-62.027		
Akaike's Information Criterion (AIC)	91.464		
Finite Sample Corrected AIC (AICC)	124.555		
Bayesian Information Criterion (BIC)	107.309		
Consistent AIC (CAIC)	120.309		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

c. The log likelihood is based on a scale parameter fixed at 1.

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table V-7.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
84.875	12	.000

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-7.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	1.163	1	.281
Major land use	14.884	3	.002
Road Type	32.972	4	.000
Junction Detail	35.329	5	.000

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-7.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-.085	.5279	-1.119	.950	.026	1	.873
Accommodation	1.075	.3265	.435	1.715	10.848	1	.001
Commercial	.474	.3459	-.203	1.152	1.882	1	.170
Residential	.308	.3623	-.402	1.018	.723	1	.395
Religious	0[a]	.	.	.	.	.	.
Single carriageway – 3 lanes	1.466	.9168	-.331	3.263	2.556	1	.110
Single carriageway – 2 lanes	1.396	.4561	.502	2.290	9.365	1	.002
Single carriageway – single track	-.288	.9001	-2.052	1.476	.102	1	.749
Dual carriageway – 3+ lanes	-.388	.5860	-1.537	.761	.438	1	.508
Dual carriageway – 2 lanes	0[a]	.	.	.	.	.	.
Other junction	-1.619	.7666	-3.122	-.117	4.461	1	.035
Multiple junction	-1.311	.7837	-2.847	.225	2.799	1	.094
Crossroads	-1.689	.3521	-2.379	-.999	23.009	1	.000
T, Y or staggered junction	-.703	.2371	-1.168	-.238	8.789	1	.003
Mini-roundabout	-1.576	.5503	-2.655	-.498	8.205	1	.004
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	.528[b]						

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Computed based on the Pearson chi-square.

Table V-7.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Accommodation (Hostels or Hotels)	.278	.351	-.410	.966
Commercial	-.323	.372	-1.052	.406
Residential	-.489	.335	-1.145	.167
Religious	-.797	.397	-1.575	-.019

Table V-7.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway – 3 lanes	.696	.827	-.925	2.316
Single carriageway – 2 lanes	.626	.204	.226	1.026
Single carriageway – single track	-1.058	.780	-2.586	.471
Dual carriageway – 2 lanes	-1.158	.429	-1.998	-.318
One way street	-.770	.489	-1.728	.188

Table V-7.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.802	.809	-2.387	.783
Multiple junction	-.494	.794	-2.050	1.061
Crossroads	-.872	.360	-1.578	-.167
T, Y or staggered junction	.114	.297	-.468	.697
Mini-roundabout	-.759	.578	-1.893	.374
Not at junction or within 20 metres	.817	.278	.272	1.362

Appendix H: Negative Binomial Regression Model for Killed during Non-Prayer Time.

Table V-8.1: Model Information

Data set	Non-Prayer Time
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	25

Table V-8.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	2.260	12	.188
Scaled Deviance	2.260	12	
Pearson Chi-Square	2.250	12	.188
Scaled Pearson Chi-Square	2.250	12	
Log Likelihood[b]	-44.444		
Akaike's Information Criterion (AIC)	114.888		
Finite Sample Corrected AIC (AICC)	147.979		
Bayesian Information Criterion (BIC)	130.733		
Consistent AIC (CAIC)	143.733		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Table V-8.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
11.230	12	.509

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-8.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	.162	1	.687
Major land use	1.182	3	.757
Road Type	4.716	4	.318
Junction Detail	4.582	5	.469

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-8.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	.068	1.2033	-2.290	2.427	.003	1	.955
Accommodation	.868	.9058	-.908	2.643	.918	1	.338
Commercial	.477	.8854	-1.259	2.212	.290	1	.590
Residential	.234	.9296	-1.588	2.056	.064	1	.801
Religious	0[a]	.	.	.	.	.	.
Single carriageway – 3 lanes	1.129	1.8415	-2.481	4.738	.376	1	.540
Single carriageway – 2 lanes	1.184	1.0023	-.781	3.148	1.394	1	.238
Single carriageway – single track	-.348	1.9068	-4.085	3.390	.033	1	.855
Dual carriageway – 2 lanes	-.325	1.2727	-2.820	2.169	.065	1	.798
One way street	0[a]	.	.	.	.	.	.
Other junction	-1.486	1.5637	-4.551	1.579	.903	1	.342
Multiple junction	-1.252	1.6116	-4.411	1.907	.603	1	.437
Crossroads	-1.432	.7922	-2.984	.121	3.266	1	.071
T, Y or staggered junction	-.588	.6897	-1.940	.763	.728	1	.394
Mini-roundabout	-1.490	1.1759	-3.795	.814	1.606	1	.205
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Fixed at the displayed value.

Table V-8.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Accommodation (Hostels or Hotels)	.222	.800	-1.346	1.791
Commercial	-.168	.855	-1.844	1.507
Residential	-.411	.698	-1.778	.957
Religious	-.645	.893	-2.395	1.104

Table V-8.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway – 3 lanes	.550	1.663	-2.710	3.811
Single carriageway – 2 lanes	.605	.423	-.224	1.434
Single carriageway – single track	-.926	1.583	-4.029	2.177
Dual carriageway – 2 lanes	-.904	.896	-2.660	.853
One way street	-.578	1.029	-2.595	1.438

Table V-8.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.695	1.656	-3.940	2.550
Multiple junction	-.461	1.581	-3.560	2.638
Crossroads	-.641	.718	-2.048	.767
T, Y or staggered junction	.203	.666	-1.104	1.509
Mini-roundabout	-.699	1.154	-2.962	1.563
Not at junction or within 20 metres	.791	.654	-.491	2.073

Appendix V-9: Poisson Regression Model for Seriously Injured (SI) during Weekends.

Table V-9.1: Model Information

Data set	Weekends
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	39

Table V-9.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	17.605	23	.765
Scaled Deviance	22.387	23	
Pearson Chi-Square	18.087	23	.786
Scaled Pearson Chi-Square	23.000	23	
Log Likelihood[b,c]	-56.345		
Adjusted Log Likelihood[d]	-71.650		
Akaike's Information Criterion (AIC)	144.690		
Finite Sample Corrected AIC (AICC)	169.417		
Bayesian Information Criterion (BIC)	171.307		
Consistent AIC (CAIC)	187.307		

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

c. The log likelihood is based on a scale parameter fixed at 1.

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table V-9.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
152.562	15	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-9.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	4.019	1	.045

Major land use	14.848	3	.002
Road Type	70.725	7	.000
Junction Detail	57.968	4	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-9.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-1.169	.6004	-2.346	.007	3.793	1	.051
Accommodation	1.272	.3350	.616	1.929	14.423	1	.000
Commercial	1.151	.3430	.479	1.824	11.262	1	.001
Residential	1.074	.3448	.399	1.750	9.712	1	.002
Religious	0[a]	.	.	.	.	.	.
Unknown	.729	1.0544	-1.337	2.796	.478	1	.489
Single carriageway –4+ lanes	1.375	.7083	-.013	2.763	3.768	1	.052
Single carriageway – 3 lanes	.850	1.0536	-1.215	2.915	.651	1	.420
Single carriageway – 2 lanes	2.634	.5284	1.598	3.669	24.845	1	.000
Single carriageway – single track	.591	.6141	-.613	1.794	.925	1	.336
Dual carriageway – 3+ lanes	1.746	1.0766	-.364	3.856	2.631	1	.105
Dual carriageway – 2 lanes	.899	.6573	-.389	2.187	1.872	1	.171
One way street	.899	.6546	-.384	2.182	1.886	1	.170
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-2.643	.6434	-3.904	-1.382	16.870	1	.000
Crossroads	-1.651	.2959	-2.231	-1.071	31.151	1	.000
T, Y or staggered junction	-.832	.2150	-1.253	-.411	14.979	1	.000
Mini-roundabout	-2.291	.6478	-3.560	-1.021	12.502	1	.000
Roundabout	0[a]	.	.	.	.	.	.
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	.786[b]						

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table V-9.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Accommodation	-.053	.276	-.593	.487
Commercial	-.174	.295	-.751	.404
Residential	-.251	.289	-.817	.316
Religious	-1.325	.390	-2.089	-.561

Table V-9.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-.802	.929	-2.623	1.019
Single carriageway - 4+ lanes	-.156	.491	-1.118	.806
Single carriageway - 3 lanes	-.681	.923	-2.489	1.128
Single carriageway - 2 lanes	1.103	.174	.762	1.443
Single carriageway - single track	-.940	.383	-1.692	-.189
Dual carriageway - 3+ lanes	.215	.942	-1.630	2.061
Dual carriageway - 2 lanes	-.632	.429	-1.472	.208
One way street	-.632	.434	-1.483	.219
Roundabout	-1.531	.548	-2.606	-.456

Table V-9.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.857	.675	-3.180	-.534
Crossroads	-.866	.319	-1.490	-.241
T, Y or staggered junction	-.047	.245	-.527	.434
Mini-roundabout	-1.505	.673	-2.823	-.187
Roundabout	.786	.238	.319	1.252
Not at junction or within 20 metres	.786	.238	.319	1.252

Appendix K: Negative Binomial Regression Model for Seriously Injured (SI) during Weekends.

Table V-10.1: Model Information

Data set	Weekends
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	39

Table V-10.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	4.945	23	.215
Scaled Deviance	4.945	23	
Pearson Chi-Square	4.772	23	.207
Scaled Pearson Chi-Square	4.772	23	
Log Likelihood[b]	-71.884		
Akaike's Information Criterion (AIC)	175.769		
Finite Sample Corrected AIC (AICC)	200.496		
Bayesian Information Criterion (BIC)	202.386		
Consistent AIC (CAIC)	218.386		

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.

Table V-10.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
25.077	15	.049

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table V-10.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	.706	1	.401
Major land use	2.044	3	.563
Road Type	12.130	7	.096
Junction Detail	8.979	4	.062

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-10.5: Parameter Estimates							
Parameter	**B**	**Std. Error**	**95% Wald Confidence Interval**		**Hypothesis Test**		
			Lower	**Upper**	**Wald Chi-Square**	**df**	**Sig.**
(Intercept)	-.860	1.0430	-2.904	1.185	.679	1	.410
Accommodation	.863	.7122	-.533	2.259	1.468	1	.226
Commercial	1.006	.7399	-.444	2.457	1.850	1	.174
Residential	.709	.7446	-.750	2.169	.907	1	.341
Religious	0[a]	.	.	.	.	.	.
Unknown	.778	1.7568	-2.665	4.222	.196	1	.658
Single carriageway –4+ lanes	1.256	1.2404	-1.176	3.687	1.025	1	.311
Single carriageway – 3 lanes	.635	1.7505	-2.796	4.066	.132	1	.717
Single carriageway – 2 lanes	2.419	.9349	.587	4.251	6.696	1	.010
Single carriageway – single track	.609	1.0327	-1.415	2.633	.348	1	.555
Dual carriageway – 3+ lanes	1.501	1.8070	-2.041	5.043	.690	1	.406
Dual carriageway – 2 lanes	.901	1.1116	-1.278	3.079	.656	1	.418
One way street	.931	1.1261	-1.277	3.138	.683	1	.409
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-2.346	1.1031	-4.508	-.184	4.522	1	.033
Crossroads	-1.351	.6548	-2.634	-.067	4.255	1	.039
T, Y or staggered junction	-.782	.5495	-1.859	.295	2.023	1	.155
Mini-roundabout	-1.991	1.1353	-4.216	.234	3.076	1	.079
Roundabout	0[a]	.	.	.	.	.	.
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table V-10.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Accommodation (Hostels or Hotels)	-.072	.530	-1.110	.967
Commercial	.072	.559	-1.024	1.168
Residential	-.225	.545	-1.293	.843
Religious	-.935	.703	-2.312	.442

Table V-10.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-.515	1.528	-3.511	2.481
Single carriageway - 4+ lanes	-.037	.867	-1.737	1.662
Single carriageway - 3 lanes	-.658	1.517	-3.631	2.314
Single carriageway - 2 lanes	1.126	.331	.478	1.774
Single carriageway - single track	-.684	.687	-2.030	.662
Dual carriageway - 3+ lanes	.208	1.563	-2.856	3.272
Dual carriageway - 2 lanes	-.392	.713	-1.790	1.005
One way street	-.363	.748	-1.829	1.104
Roundabout	-1.293	.915	-3.086	.500

Table V-10.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.557	1.118	-3.749	.634
Crossroads	-.562	.569	-1.678	.553
T, Y or staggered junction	.007	.456	-.887	.900
Mini-roundabout	-1.203	1.126	-3.409	1.004
Roundabout	.788	.468	-.130	1.706
Not at junction or within 20 metres	.788	.468	-.130	1.706

Appendix J: Poisson Regression Model for Killed during Weekends.

Table V-11.1: Model Information

Data set	Weekends
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	13

Table V-11.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	1.387	4	.347
Scaled Deviance	3.752	4	
Pearson Chi-Square	1.479	4	.370
Scaled Pearson Chi-Square	4.000	4	
Log Likelihood[b,c]	-16.157		
Adjusted Log Likelihood[d]	-43.707		
Akaike's Information Criterion (AIC)	50.314		
Finite Sample Corrected AIC (AICC)	110.314		
Bayesian Information Criterion (BIC)	55.399		
Consistent AIC (CAIC)	64.399		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

c. The log likelihood is based on a scale parameter fixed at 1.

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table V-11.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
16.621	8	.034

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-11.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.

(Intercept)	.107	1	.744
Major land use	1.407	2	.495
Road Type	6.458	2	.040
Junction Detail	6.114	2	.047

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-11.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	5.792E-017	.6080	-1.192	1.192	.000	1	1.000
Accommodation	.101	.9187	-1.700	1.901	.012	1	.913
Commercial	-.309	.9375	-2.146	1.528	.109	1	.742
Residential	-4.956E-017	.8599	-1.685	1.685	.000	1	1.000
Religious	0[a]	.	.	.	.	.	.
Single carriageway – 3 lanes	4.534E-017	.8599	-1.685	1.685	.000	1	1.000
Single carriageway – 2 lanes	1.211	.6710	-.104	2.526	3.256	1	.071
Dual carriageway – 2 lanes	.284	.7868	-1.258	1.826	.130	1	.718
One way street	0[a]	.	.	.	.	.	.
Private drive or entrance	0[a]	.	.	.	.	.	.
Crossroads	-.463	.3151	-1.080	.155	2.157	1	.142
Slip road	0[a]	.	.	.	.	.	.
T, Y or staggered junction	-.917	.3991	-1.699	-.134	5.275	1	.022
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	.370[b]						

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Computed based on the Pearson chi-square.

Table V-11.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Accommodation	.198	.332	-.452	.849
Commercial	-.211	.396	-.988	.565

Residential	.098	.274	-.439	.634
Religious	.098	.793	-1.457	1.653

Table V-11.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 3 lanes	-.328	.671	-1.643	.987
Single carriageway - 2 lanes	.883	.270	.354	1.411
Dual carriageway - 2 lanes	-.044	.503	-1.029	.941
One way street	-.328	.515	-1.337	.681

Table V-11.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Private drive or entrance	.322	.257	-.183	.826
Crossroads	-.141	.379	-.883	.601
Slip road	.322	.257	-.183	.826
T, Y or staggered junction	-.595	.427	-1.433	.242
Not at junction or within 20 metres	.322	.257	-.183	.826

Appendix V-12: Negative Binomial Regression Model for Killed during Weekends.

Table V-12.1: Model Information

Data set	Weekends
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details

Observation Used (N)	13

Table V-12.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	.466	4	.116
Scaled Deviance	.466	4	
Pearson Chi-Square	.511	4	.128
Scaled Pearson Chi-Square	.511	4	
Log Likelihood[b]	-22.528		
Akaike's Information Criterion (AIC)	63.055		
Finite Sample Corrected AIC (AICC)	123.055		
Bayesian Information Criterion (BIC)	68.140		
Consistent AIC (CAIC)	77.140		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Table V-12.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
2.037	8	.980

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-12.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	.030	1	.862
Major land use	.122	2	.941
Road Type	.783	2	.676
Junction Detail	.659	2	.719

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-12.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	3.758E-017	1.4142	-2.772	2.772	.000	1	1.000
Accommodation	-.060	2.2271	-4.425	4.305	.001	1	.979
Commercial	-.353	2.2811	-4.824	4.118	.024	1	.877
Residential	1.002E-017	2.0000	-3.920	3.920	.000	1	1.000
Religious	0[a]	.	.	.	.	.	.
Single carriageway – 3 lanes	-6.357E-017	2.0000	-3.920	3.920	.000	1	1.000
Single carriageway – 2 lanes	1.236	1.7077	-2.111	4.583	.524	1	.469
Dual carriageway – 2 lanes	.448	1.8997	-3.275	4.171	.056	1	.814
One way street	0[a]	.	.	.	.	.	.
Private drive or entrance	0[a]	.	.	.	.	.	.
Crossroads	-.402	.9575	-2.278	1.475	.176	1	.675
Slip road	0[a]	.	.	.	.	.	.
T, Y or staggered junction	-.836	1.0516	-2.898	1.225	.633	1	.426
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table V-12.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Accommodation	.114	.935	-1.719	1.946
Commercial	-.180	1.071	-2.278	1.919
Residential	.173	.642	-1.086	1.432
Religious	.173	1.847	-3.447	3.794

Table V-12.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 3 lanes	-.351	1.608	-3.502	2.800
Single carriageway - 2 lanes	.886	.722	-.530	2.301
Dual carriageway - 2 lanes	.097	1.210	-2.274	2.468
One way street	-.351	1.259	-2.818	2.116

Table V-12.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Private drive or entrance	.318	.646	-.949	1.585
Crossroads	-.084	1.031	-2.105	1.937
Slip road	.318	.646	-.949	1.585
T, Y or staggered junction	-.519	1.028	-2.534	1.497
Not at junction or within 20 metres	.318	.646	-.949	1.585

Appendix V-13: Poisson Regression Model for Seriously Injured (SI) during Working Days

Table V-13.1: Model Information

Data set	Working Days
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	69

Table V-13.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	42.561	48	.887
Scaled Deviance	33.383	48	
Pearson Chi-Square	61.196	48	1.275
Scaled Pearson Chi-Square	48.000	48	
Log Likelihood[b,c]	-109.204		
Adjusted Log Likelihood[d]	-85.656		
Akaike's Information Criterion (AIC)	260.409		
Finite Sample Corrected AIC (AICC)	280.068		
Bayesian Information Criterion (BIC)	307.325		
Consistent AIC (CAIC)	328.325		

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

c. The log likelihood is based on a scale parameter fixed at 1.

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table V-13.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
318.560	20	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-13.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	12.698	1	.000
Major land use	25.152	5	.000
Road Type	170.525	7	.000
Junction Detail	119.397	8	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-13.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.

(Intercept)	2.558	.8622	.868	4.248	8.800	1	.003
Agriculture	-.308	.8536	-1.981	1.365	.130	1	.718
Government Offices	-2.434	.8245	-4.050	-.818	8.716	1	.003
Accommodation	.622	.2444	.143	1.101	6.476	1	.011
Commercial	.741	.2365	.277	1.204	9.813	1	.002
Residential	.618	.2495	.129	1.107	6.128	1	.013
Religious	0[a]	.	.	.	.	.	.
Single carriageway –4+ lanes	-2.395	.8928	-4.145	-.645	7.197	1	.007
Single carriageway – 3 lanes	-3.189	1.1511	-5.445	-.933	7.675	1	.006
Single carriageway – 2 lanes	-.068	.8270	-1.689	1.553	.007	1	.934
Single carriageway – single track	-2.316	.8983	-4.076	-.555	6.645	1	.010
Dual carriageway – 3+ lanes	-2.707	.9345	-4.539	-.876	8.392	1	.004
Dual carriageway – 2 lanes	-2.066	.8794	-3.790	-.343	5.520	1	.019
One way street	-2.603	.9336	-4.433	-.773	7.772	1	.005
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-2.218	.4170	-3.035	-1.401	28.298	1	.000
Private drive or entrance	-2.508	.5201	-3.528	-1.489	23.263	1	.000
Multiple junction	-2.524	.5787	-3.658	-1.390	19.021	1	.000
Crossroads	-1.532	.2702	-2.062	-1.002	32.134	1	.000
Slip road	-2.110	.6702	-3.424	-.797	9.915	1	.002
T, Y or staggered junction	-.113	.1605	-.428	.201	.500	1	.480
Mini-roundabout	-.573	1.2190	-2.962	1.817	.221	1	.639
Roundabout	-2.835	.5183	-3.851	-1.820	29.929	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1.275[b]						

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table V-13.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-1.270	.859	-2.953	.413
Government Offices	-3.396	.841	-5.045	-1.748
Accommodation (Hostels or Hotels)	-.340	.258	-.845	.165
Commercial	-.221	.251	-.713	.271
Residential	-.344	.275	-.883	.194
Religious	-.962	.316	-1.581	-.342

Table V-13.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 4+ lanes	-1.566	.426	-2.401	-.731
Single carriageway - 3 lanes	-2.360	.848	-4.023	-.697
Single carriageway - 2 lanes	.761	.268	.235	1.286
Single carriageway - single track	-1.486	.442	-2.353	-.620
Dual carriageway - 3+ lanes	-1.878	.509	-2.876	-.880
Dual carriageway - 2 lanes	-1.237	.412	-2.044	-.430
One way street	-1.774	.465	-2.686	-.862
Roundabout	.829	.837	-.811	2.469

Table V-13.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.705	.487	-2.661	-.750
Private drive or entrance	-1.996	.578	-3.129	-.863
Multiple junction	-2.011	.634	-3.253	-.770
Crossroads	-1.019	.335	-1.676	-.363
Slip road	-1.597	.709	-2.987	-.208
T, Y or staggered junction	.399	.278	-.146	.944
Mini-roundabout	-.060	1.226	-2.463	2.343
Roundabout	-2.323	.517	-3.335	-1.310
Not at junction or within 20 metres	.513	.277	-.031	1.056

Appendix V-14: Negative Binomial Regression Model for Seriously Injured (SI) during Working Days

Table V-14.1: Model Information

Data set	Working Days
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	69

Table V-14.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	14.017	48	.292
Scaled Deviance	14.017	48	
Pearson Chi-Square	14.735	48	.307
Scaled Pearson Chi-Square	14.735	48	
Log Likelihood[b]	-136.860		
Akaike's Information Criterion (AIC)	315.721		
Finite Sample Corrected AIC (AICC)	335.380		
Bayesian Information Criterion (BIC)	362.637		
Consistent AIC (CAIC)	383.637		

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Information criteria are in small-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.

Table V-14.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
63.280	20	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Compares the fitted model against the intercept-only model.

Table V-14.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	2.242	1	.134
Major land use	7.247	5	.203
Road Type	32.909	7	.000
Junction Detail	23.188	8	.003

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-14.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	2.385	1.2769	-.118	4.887	3.488	1	.062
Agriculture	-.279	1.3567	-2.938	2.380	.042	1	.837
Government Offices	-2.303	1.1045	-4.467	-.138	4.346	1	.037
Accommodation	.316	.5113	-.686	1.318	.381	1	.537
Commercial	.385	.4859	-.568	1.337	.626	1	.429
Residential	.401	.5568	-.690	1.493	.520	1	.471
Religious	0[a]	.	.	.	.	.	.
Single carriageway –4+ lanes	-1.917	1.2564	-4.380	.545	2.329	1	.127
Single carriageway – 3 lanes	-2.717	1.5293	-5.714	.280	3.157	1	.076
Single carriageway – 2 lanes	-.064	1.1404	-2.300	2.171	.003	1	.955

Single carriageway – single track	-1.944	1.2674	-4.428	.540	2.354	1	.125
Dual carriageway – 3+ lanes	-2.234	1.3107	-4.803	.335	2.906	1	.088
Dual carriageway – 2 lanes	-1.500	1.2124	-3.876	.877	1.530	1	.216
One way street	-2.131	1.3082	-4.695	.433	2.653	1	.103
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.734	.7280	-3.161	-.307	5.672	1	.017
Private drive or entrance	-1.984	.8006	-3.553	-.415	6.140	1	.013
Multiple junction	-1.866	.8919	-3.615	-.118	4.379	1	.036
Crossroads	-1.032	.5006	-2.013	-.050	4.247	1	.039
Slip road	-.984	1.1217	-3.182	1.215	.769	1	.380
T, Y or staggered junction	-.035	.4100	-.839	.768	.007	1	.931
Mini-roundabout	-.655	1.5897	-3.771	2.460	.170	1	.680
Roundabout	-2.336	.7400	-3.786	-.886	9.966	1	.002
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Fixed at the displayed value.

Table V-14.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	-.639	1.295	-3.176	1.899
Government Offices	-2.662	1.094	-4.806	-.518
Accommodation (Hostels or Hotels)	-.044	.408	-.843	.755
Commercial	.025	.377	-.713	.764
Residential	.042	.441	-.823	.907
Religious	-.359	.514	-1.367	.648

Table V-14.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 4+ lanes	-.960	.600	-2.136	.216
Single carriageway - 3 lanes	-1.760	1.088	-3.893	.373
Single carriageway - 2 lanes	.893	.376	.157	1.629

Single carriageway - single track	-.987	.660	-2.282	.307
Dual carriageway - 3+ lanes	-1.277	.715	-2.679	.125
Dual carriageway - 2 lanes	-.542	.604	-1.725	.641
One way street	-1.173	.613	-2.375	.028
Roundabout	.957	1.155	-1.307	3.221

Table V-14.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-1.159	.766	-2.661	.343
Private drive or entrance	-1.409	.838	-3.053	.234
Multiple junction	-1.292	.935	-3.125	.541
Crossroads	-.457	.509	-1.454	.540
Slip road	-.409	1.037	-2.441	1.622
T, Y or staggered junction	.539	.429	-.301	1.379
Mini-roundabout	-.081	1.594	-3.205	3.044
Roundabout	-1.762	.707	-3.146	-.377
Not at junction or within 20 metres	.574	.445	-.298	1.447

Appendix V-15: Poisson Regression Model for Killed during Working Days

Table V-15.1: Model Information

Data set	Working Days
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	24

Table V-15.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	3.435	10	.344
Scaled Deviance	9.964	10	
Pearson Chi-Square	3.448	10	.345
Scaled Pearson Chi-Square	10.000	10	
Log Likelihood[b,c]	-31.129		
Adjusted Log Likelihood[d]	-90.285		
Akaike's Information Criterion (AIC)	90.258		
Finite Sample Corrected AIC (AICC)	136.925		
Bayesian Information Criterion (BIC)	106.751		
Consistent AIC (CAIC)	120.751		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

c. The log likelihood is based on a scale parameter fixed at 1.

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table V-15.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
106.502	13	.000

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-15.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	.935	1	.334
Major land use	11.779	3	.008
Road Type	35.011	4	.000
Junction Detail	40.768	6	.000

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-15.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	.245	.4437	-.625	1.115	.305	1	.581
Accommodation	.776	.2487	.289	1.264	9.743	1	.002
Commercial	.381	.2563	-.121	.883	2.209	1	.137
Residential	.177	.2791	-.370	.724	.401	1	.527
Religious	0[a]	.	.	.	.	.	.
Single carriageway – 3 lanes	.709	.7780	-.816	2.234	.830	1	.362
Single carriageway – 2 lanes	1.207	.3817	.459	1.955	9.998	1	.002
Single carriageway – single track	-.278	.5870	-1.429	.872	.225	1	.636
Dual carriageway – 2 lanes	-.192	.5283	-1.228	.843	.133	1	.716
One way street	0[a]	.	.	.	.	.	.
Other junction	-1.629	.6229	-2.849	-.408	6.836	1	.009
Private drive or entrance	-1.064	.4594	-1.965	-.164	5.364	1	.021
Multiple junction	-1.452	.6231	-2.673	-.231	5.430	1	.020
Crossroads	-1.131	.3286	-1.775	-.487	11.841	1	.001
T, Y or staggered junction	-.712	.1918	-1.087	-.336	13.760	1	.000
Mini-roundabout	-1.660	.4416	-2.526	-.795	14.135	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	.345[b]						

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table V-15.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Accommodation	.218	.287	-.344	.780
Commercial	-.177	.295	-.755	.400
Residential	-.382	.256	-.883	.120
Religious	-.558	.281	-1.110	-.007

Table V-15.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 3 lanes	.195	.694	-1.166	1.556
Single carriageway - 2 lanes	.693	.161	.378	1.008
Single carriageway - single track	-.792	.462	-1.698	.114
Dual carriageway - 2 lanes	-.706	.392	-1.475	.063
One way street	-.514	.386	-1.271	.244

Table V-15.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.761	.658	-2.050	.528
Private drive or entrance	-.196	.471	-1.119	.726
Multiple junction	-.584	.635	-1.829	.660
Crossroads	-.263	.294	-.839	.312
T, Y or staggered junction	.156	.237	-.308	.621
Mini-roundabout	-.793	.463	-1.700	.115
Not at junction or within 20 metres	.868	.212	.451	1.284

Appendix V-16: Negative Binomial Regression Model for Killed during Working Days

Table V-16.1: Model Information

Data set	Working Days
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Main Land use; Road Type; Junction Details
Observation Used (N)	24

Table V-16.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	1.208	10	.121
Scaled Deviance	1.208	10	
Pearson Chi-Square	1.185	10	.119
Scaled Pearson Chi-Square	1.185	10	
Log Likelihood[b]	-43.505		
Akaike's Information Criterion (AIC)	115.010		
Finite Sample Corrected AIC (AICC)	161.676		
Bayesian Information Criterion (BIC)	131.502		
Consistent AIC (CAIC)	145.502		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Table V-16.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
10.010	13	.693

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-16.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	.105	1	.746
Major land use	.948	3	.814
Road Type	4.015	4	.404
Junction Detail	3.905	6	.690

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-16.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	.268	1.3404	-2.359	2.896	.040	1	.841
Accommodation	.870	.9095	-.912	2.653	.915	1	.339
Commercial	.438	.8442	-1.216	2.093	.270	1	.603
Residential	.349	.9350	-1.483	2.182	.139	1	.709
Religious	0[a]	.	.	.	.	.	.
Single carriageway – 3 lanes	.421	1.9787	-3.457	4.299	.045	1	.832
Single carriageway – 2 lanes	1.057	1.0968	-1.092	3.207	.929	1	.335
Single carriageway – single track	-.354	1.6008	-3.491	2.784	.049	1	.825
Dual carriageway – 2 lanes	-.326	1.4484	-3.165	2.513	.051	1	.822
One way street	0[a]	.	.	.	.	.	.
Other junction	-1.675	1.6176	-4.845	1.496	1.072	1	.301
Private drive or entrance	-.972	1.2606	-3.442	1.499	.594	1	.441
Multiple junction	-1.326	1.5601	-4.383	1.732	.722	1	.396
Crossroads	-1.038	.9741	-2.948	.871	1.136	1	.286
T, Y or staggered junction	-.699	.7023	-2.076	.677	.992	1	.319
Mini-roundabout	-1.545	1.1404	-3.780	.690	1.835	1	.176
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table V-16.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Accommodation (Hostels or Hotels)	.262	.884	-1.471	1.995
Commercial	-.170	.902	-1.937	1.597
Residential	-.259	.656	-1.545	1.027
Religious	-.608	.812	-2.200	.983

Table V-16.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 3 lanes	.067	1.823	-3.506	3.640
Single carriageway - 2 lanes	.704	.439	-.158	1.565
Single carriageway - single track	-.707	1.164	-2.988	1.574
Dual carriageway - 2 lanes	-.680	1.042	-2.722	1.363
One way street	-.354	1.023	-2.359	1.652

Table V-16.8: Estimated Marginal Means for Junction Detail

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.832	1.720	-4.204	2.540
Private drive or entrance	-.129	1.255	-2.589	2.330
Multiple junction	-.483	1.570	-3.560	2.594
Crossroads	-.196	.770	-1.706	1.314
T, Y or staggered junction	.143	.702	-1.233	1.519
Mini-roundabout	-.702	1.147	-2.951	1.546
Not at junction or within 20 metres	.842	.631	-.395	2.079

Appendix V-17: Poisson Regression Model for Seriously Injured (SI) during High Season.

Table V-17.1: Model Information

Data set	High Season
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	68

Table V-17.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	47.850	47	1.018
Scaled Deviance	34.772	47	
Pearson Chi-Square	64.678	47	1.376
Scaled Pearson Chi-Square	47.000	47	
Log Likelihood[b,c]	-110.734		
Adjusted Log Likelihood[d]	-80.468		
Akaike's Information Criterion (AIC)	263.468		
Finite Sample Corrected AIC (AICC)	283.555		
Bayesian Information Criterion (BIC)	310.077		
Consistent AIC (CAIC)	331.077		

Dependent Variable: Count_SI; Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

c. The log likelihood is based on a scale parameter fixed at 1.

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table V-17.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
311.381	20	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-17.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	14.201	1	.000
Major land use	25.434	5	.000
Road Type	170.918	7	.000
Junction Detail	121.239	8	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-17.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	2.674	.7852	1.135	4.213	11.595	1	.001
Agriculture	-.558	.9903	-2.499	1.383	.318	1	.573
Government Offices	-2.509	1.1958	-4.853	-.165	4.403	1	.036
Accommodation	.726	.2638	.209	1.243	7.567	1	.006
Commercial	1.008	.2516	.514	1.501	16.034	1	.000
Residential	.733	.2667	.210	1.256	7.548	1	.006
Religious	0[a]	.	.	.	.	.	.
Single carriageway –4+ lanes	-2.532	.8274	-4.153	-.910	9.362	1	.002
Single carriageway – 3 lanes	-3.341	1.0109	-5.323	-1.360	10.925	1	.001
Single carriageway – 2 lanes	-.165	.7426	-1.620	1.291	.049	1	.825
Single carriageway – single track	-2.556	.8103	-4.144	-.968	9.949	1	.002
Dual carriageway – 3+ lanes	-3.413	1.0944	-5.558	-1.268	9.725	1	.002
Dual carriageway – 2 lanes	-2.353	.8070	-3.935	-.772	8.505	1	.004
One way street	-2.459	.8323	-4.090	-.828	8.729	1	.003
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-2.285	.4076	-3.084	-1.486	31.426	1	.000
Private drive or entrance	-2.901	.5988	-4.074	-1.727	23.464	1	.000
Multiple junction	-2.980	.6894	-4.332	-1.629	18.685	1	.000
Crossroads	-1.797	.2883	-2.362	-1.232	38.831	1	.000
Slip road	.161	1.0957	-1.987	2.308	.022	1	.883
T, Y or staggered junction	-.435	.1669	-.762	-.108	6.800	1	.009
Mini-roundabout	-2.006	.8539	-3.680	-.333	5.522	1	.019
Roundabout	-2.994	.5363	-4.045	-1.943	31.163	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1.376[b]						

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Computed based on the Pearson chi-square.

Table V-17.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	.19	.178	.03	1.21
Government	.03	.032	.00	.28
Accommodation	.67	.175	.40	1.12
Commercial	.89	.215	.56	1.43
Residential	.68	.181	.40	1.14
Religious	.33	.100	.18	.59

Table V-17.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 4+ lanes	.19	.089	.08	.48
Single carriageway - 3 lanes	.09	.064	.02	.37
Single carriageway - 2 lanes	2.05	.597	1.16	3.62
Single carriageway - single track	.19	.081	.08	.44
Dual carriageway - 3+ lanes	.08	.066	.02	.40
Dual carriageway - 2 lanes	.23	.099	.10	.53
One way street	.21	.092	.09	.49
Roundabout	2.41	1.830	.55	10.67

Table V-17.8: Estimated Marginal Means for Junction Details

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	.16	.084	.06	.45
Private drive or entrance	.09	.060	.02	.33
Multiple junction	.08	.062	.02	.36
Crossroads	.27	.106	.12	.58
Slip road	1.88	1.886	.26	13.42
T, Y or staggered junction	1.04	.359	.53	2.04
Mini-roundabout	.22	.194	.04	1.26
Roundabout	.08	.045	.03	.24
Not at junction or within 20 metres	1.60	.531	.84	3.07

Appendix V-18: Negative Binomial Regression Model for Seriously Injured (SI) during High Season.

Table V-18.1: Model Information

Data set	High Season
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	68

Table V-18.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	14.524	47	.309
Scaled Deviance	14.524	47	
Pearson Chi-Square	16.628	47	.354
Scaled Pearson Chi-Square	16.628	47	
Log Likelihood[b]	-135.511		
Akaike's Information Criterion (AIC)	313.022		
Finite Sample Corrected AIC (AICC)	333.109		
Bayesian Information Criterion (BIC)	359.632		
Consistent AIC (CAIC)	380.632		

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Table V-18.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
64.251	20	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-18.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	4.386	1	.036
Major land use	6.664	5	.247
Road Type	33.388	7	.000
Junction Detail	25.102	8	.001

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-18.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	2.382	1.1353	.157	4.607	4.401	1	.036
Agriculture	-1.012	1.3105	-3.581	1.556	.597	1	.440
Government Offices	-2.332	1.4959	-5.264	.600	2.430	1	.119
Accommodation	.433	.5122	-.571	1.437	.714	1	.398
Commercial	.683	.4901	-.277	1.644	1.943	1	.163
Residential	.394	.5401	-.664	1.453	.533	1	.465
Religious	0[a]	.	.	.	.	.	.
Single carriageway –4+ lanes	-1.917	1.1466	-4.164	.331	2.794	1	.095
Single carriageway – 3 lanes	-2.835	1.3199	-5.422	-.248	4.614	1	.032
Single carriageway – 2 lanes	-.050	.9996	-2.009	1.910	.002	1	.960
Single carriageway – single track	-2.125	1.1176	-4.315	.066	3.614	1	.057
Dual carriageway – 3+ lanes	-2.915	1.3906	-5.640	-.189	4.393	1	.036
Dual carriageway – 2 lanes	-1.704	1.0886	-3.838	.429	2.451	1	.117
One way street	-1.847	1.1580	-4.117	.423	2.544	1	.111
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-1.722	.7100	-3.114	-.330	5.883	1	.015
Private drive or entrance	-2.251	.8454	-3.908	-.594	7.090	1	.008
Multiple junction	-2.508	.9877	-4.444	-.572	6.448	1	.011
Crossroads	-1.150	.5097	-2.149	-.151	5.094	1	.024
Slip road	.308	1.3877	-2.412	3.028	.049	1	.824
T, Y or staggered junction	-.219	.4072	-1.017	.579	.290	1	.590
Mini-roundabout	-1.630	1.1395	-3.864	.603	2.047	1	.152
Roundabout	-2.417	.7384	-3.864	-.970	10.715	1	.001
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Fixed at the displayed value.

Table V-18.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Agriculture	.20	.253	.02	2.33
Government Offices	.05	.081	.00	1.02
Accommodation	.86	.351	.39	1.91
Commercial	1.11	.392	.55	2.22
Residential	.83	.360	.35	1.94
Religious	.56	.272	.22	1.45

Table V-18.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 4+ lanes	.32	.214	.09	1.18
Single carriageway - 3 lanes	.13	.121	.02	.81
Single carriageway - 2 lanes	2.09	.788	1.00	4.38
Single carriageway - single track	.26	.162	.08	.88
Dual carriageway - 3+ lanes	.12	.120	.02	.86
Dual carriageway - 2 lanes	.40	.238	.12	1.28
One way street	.35	.214	.10	1.16
Roundabout	2.20	2.236	.30	16.14

Table V-18.8: Estimated Marginal Means for Junction Details

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	.27	.211	.06	1.26
Private drive or entrance	.16	.144	.03	.94
Multiple junction	.12	.130	.01	.99
Crossroads	.47	.262	.16	1.40
Slip road	2.03	2.524	.18	23.14
T, Y or staggered junction	1.20	.592	.46	3.16
Mini-roundabout	.29	.343	.03	2.92
Roundabout	.13	.100	.03	.58
Not at junction or within 20 metres	1.49	.683	.61	3.66

Appendix Table V-19: Poisson Regression Model for Killed during High Season.

Table V-19.1: Model Information

Data set	High Season
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	19

Table V-19.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	1.245	5	.249
Scaled Deviance	4.868	5	
Pearson Chi-Square	1.279	5	.256
Scaled Pearson Chi-Square	5.000	5	
Log Likelihood[b,c]	-25.567		
Adjusted Log Likelihood[d]	-99.942		
Akaike's Information Criterion (AIC)	79.133		
Finite Sample Corrected AIC (AICC)	184.133		
Bayesian Information Criterion (BIC)	92.356		
Consistent AIC (CAIC)	106.356		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

c. The log likelihood is based on a scale parameter fixed at 1.

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table V-19.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
149.947	13	.000

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-19.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	.315	1	.574
Major land use	13.888	3	.003
Road Type	28.662	3	.000
Junction Detail	69.984	6	.000

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-19.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-1.370E-017	.5058	-.991	.991	.000	1	1.000
Accommodation	.749	.2537	.251	1.246	8.708	1	.003
Commercial	.421	.2690	-.106	.948	2.452	1	.117
Residential	.111	.2886	-.454	.677	.149	1	.700
Religious	0[a]	.	.	.	.	.	.
Single carriageway – 3 lanes	1.173	.8082	-.411	2.757	2.107	1	.147
Single carriageway – 2 lanes	1.602	.5503	.524	2.681	8.478	1	.004
Single carriageway – single track	.034	.6328	-1.206	1.274	.003	1	.957
Dual carriageway – 2 lanes	.216	.6803	-1.117	1.549	.101	1	.751
One way street	0[a]	.	.	.	.	.	.
Other junction	-1.714	.5393	-2.771	-.657	10.099	1	.001
Private drive or entrance	-1.602	.5503	-2.681	-.524	8.478	1	.004
Multiple junction	-1.602	.5503	-2.681	-.524	8.478	1	.004
Crossroads	-1.284	.2532	-1.781	-.788	25.731	1	.000
Slip road	0[a]	.	.	.	.	.	.
T, Y or staggered junction	-.818	.1803	-1.171	-.464	20.572	1	.000
Mini-roundabout	-2.024	.5293	-3.061	-.986	14.618	1	.000
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	.256[b]						

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table V-19.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Accommodation	.223	.289	-.343	.789
Commercial	-.104	.297	-.687	.478
Residential	-.414	.264	-.932	.104
Religious	-.525	.258	-1.031	-.019

Table V-19.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 3 lanes	.363	.592	-.798	1.523
Single carriageway - 2 lanes	.792	.134	.530	1.055
Single carriageway - single track	-.776	.405	-1.569	.017
Dual carriageway - 2 lanes	-.594	.412	-1.402	.214
One way street	-.810	.566	-1.919	.299

Table V-19.8: Estimated Marginal Means for Junction Details

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.788	.579	-1.922	.345
Private drive or entrance	-.677	.590	-1.834	.480
Multiple junction	-.677	.590	-1.834	.480
Crossroads	-.359	.257	-.863	.145
Slip road	.925	.201	.532	1.319
T, Y or staggered junction	.108	.230	-.344	.559
Mini-roundabout	-1.098	.547	-2.171	-.026
Not at junction or within 20 metres	.925	.201	.532	1.319

Appendix V-20: Negative Binomial Regression Model for Killed during High Season.

Table V-20.1: Model Information

Data set	High Season
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	19

Table V-20.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	.385	5	.077
Scaled Deviance	.385	5	
Pearson Chi-Square	.381	5	.076
Scaled Pearson Chi-Square	.381	5	
Log Likelihood[b]	-37.107		
Akaike's Information Criterion (AIC)	102.214		
Finite Sample Corrected AIC (AICC)	207.214		
Bayesian Information Criterion (BIC)	115.437		
Consistent AIC (CAIC)	129.437		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Table V-20.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
9.494	13	.735

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-20.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	.024	1	.878
Major land use	.527	3	.913
Road Type	2.601	3	.457
Junction Detail	4.425	6	.619

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-20.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-1.519E-017	1.4142	-2.772	2.772	.000	1	1.000
Accommodation	.675	1.1906	-1.658	3.009	.322	1	.571
Commercial	.450	1.2960	-2.090	2.991	.121	1	.728
Residential	.054	1.3206	-2.534	2.643	.002	1	.967
Religious	0[a]	.	.	.	.	.	.
Single carriageway – 3 lanes	1.163	2.5848	-3.903	6.229	.202	1	.653
Single carriageway – 2 lanes	1.589	1.7158	-1.774	4.952	.858	1	.354
Single carriageway – single track	.034	1.8208	-3.535	3.602	.000	1	.985
Dual carriageway – 2 lanes	.317	2.1469	-3.891	4.525	.022	1	.883
One way street	0[a]	.	.	.	.	.	.
Other junction	-1.644	1.6556	-4.889	1.601	.986	1	.321
Private drive or entrance	-1.589	1.7158	-4.952	1.774	.858	1	.354
Multiple junction	-1.589	1.7158	-4.952	1.774	.858	1	.354
Crossroads	-1.217	1.0770	-3.328	.894	1.277	1	.258
Slip road	0[a]	.	.	.	.	.	.
T, Y or staggered junction	-.742	.8140	-2.338	.853	.832	1	.362
Mini-roundabout	-2.040	1.6439	-5.262	1.182	1.540	1	.215
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_Killed
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Fixed at the displayed value.

Table V-20.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Accommodation	.193	1.085	-1.933	2.319
Commercial	-.032	1.163	-2.311	2.248
Residential	-.428	.925	-2.240	1.384
Religious	-.482	.882	-2.211	1.247

Table V-20.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 3 lanes	.355	1.901	-3.370	4.080
Single carriageway - 2 lanes	.782	.409	-.020	1.583
Single carriageway - single track	-.774	1.236	-3.196	1.648
Dual carriageway - 2 lanes	-.491	1.302	-3.043	2.061
One way street	-.808	1.755	-4.247	2.631

Table V-20.8: Estimated Marginal Means for Junction Details

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-.728	1.796	-4.249	2.792
Private drive or entrance	-.674	1.888	-4.375	3.027
Multiple junction	-.674	1.888	-4.375	3.027
Crossroads	-.302	.871	-2.008	1.405
Slip road	.916	.721	-.498	2.329
T, Y or staggered junction	.173	.780	-1.355	1.701
Mini-roundabout	-1.124	1.584	-4.228	1.980
Not at junction or within 20 metres	.916	.721	-.498	2.329

Appendix V-21: Poisson Regression Model for Seriously Injured (SI) during Low Season.

Table V-21.1: Model Information

Data set	Low Season
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	34

Table V-21.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	10.549	16	.659
Scaled Deviance	15.948	16	
Pearson Chi-Square	10.583	16	.661
Scaled Pearson Chi-Square	16.000	16	
Log Likelihood[b,c]	-48.199		
Adjusted Log Likelihood[d]	-72.872		
Akaike's Information Criterion (AIC)	132.399		
Finite Sample Corrected AIC (AICC)	177.999		
Bayesian Information Criterion (BIC)	159.873		
Consistent AIC (CAIC)	177.873		

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

c. The log likelihood is based on a scale parameter fixed at 1.

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table V-21.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
134.670	17	.000

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-21.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	9.776	1	.002
Major land use	20.472	4	.000
Road Type	58.766	6	.000
Junction Detail	33.751	6	.000

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-21.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-1.020	.8670	-2.719	.679	1.384	1	.239
Government Offices	-1.465	.8600	-3.150	.221	2.900	1	.089
Accommodation	1.020	.3004	.431	1.609	11.525	1	.001
Commercial	.387	.3124	-.226	.999	1.533	1	.216
Residential	.642	.3081	.038	1.246	4.340	1	.037
Religious	0[a]	.	.	.	.	.	.
Unknown	-.038	1.1683	-2.328	2.252	.001	1	.974
Single carriageway –4+ lanes	.770	.9494	-1.091	2.630	.657	1	.418
Single carriageway – 2 lanes	2.446	.8345	.811	4.082	8.592	1	.003
Single carriageway – single track	.826	.9365	-1.009	2.662	.778	1	.378
Dual carriageway – 3+ lanes	1.124	.9800	-.796	3.045	1.316	1	.251
Dual carriageway – 2 lanes	.516	.9170	-1.281	2.314	.317	1	.574
One way street	1.246	1.0312	-.775	3.267	1.460	1	.227
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-2.446	.8345	-4.082	-.811	8.592	1	.003
Private drive or entrance	-1.813	.8443	-3.468	-.158	4.612	1	.032
Multiple junction	-.391	.9409	-2.236	1.453	.173	1	.677
Crossroads	-.905	.2722	-1.439	-.372	11.061	1	.001
T, Y or staggered junction	.038	.2054	-.364	.441	.035	1	.852
Mini-roundabout	-2.446	.8345	-4.082	-.811	8.592	1	.003
Roundabout	0[a]	.	.	.	.	.	.
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	.661[b]						

Dependent Variable: Count_SI
Model: (Intercept), Major land use, Road Type, Junction Detail
a. Set to zero because this parameter is redundant.
b. Computed based on the Pearson chi-square.

Table V-21.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Government Offices	-2.619	.878	-4.340	-.897
Accommodation (Hostels or Hotels)	-.134	.291	-.704	.436
Commercial	-.767	.327	-1.408	-.127
Residential	-.512	.320	-1.139	.114
Religious	-1.154	.380	-1.898	-.410

Table V-21.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-1.937	.883	-3.667	-.207
Single carriageway –4+ lanes	-1.129	.461	-2.033	-.226
Single carriageway – 2 lanes	.548	.276	.006	1.089
Single carriageway – single track	-1.072	.520	-2.092	-.053
Dual carriageway – 3+ lanes	-.774	.555	-1.862	.313
Dual carriageway – 2 lanes	-1.382	.473	-2.309	-.455
One way street	-.653	.648	-1.922	.617
Roundabout	-1.899	.879	-3.621	-.176

Table V-21.8: Estimated Marginal Means for Junction Details

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-2.488	.871	-4.195	-.781
Private drive or entrance	-1.855	.874	-3.568	-.142
Multiple junction	-.433	.934	-2.264	1.397
Crossroads	-.947	.335	-1.604	-.291
T, Y or staggered junction	-.004	.259	-.512	.504
Mini-roundabout	-2.488	.871	-4.195	-.781
Roundabout	-.042	.300	-.630	.546
Not at junction or within 20 metres	-.042	.300	-.630	.546

Appendix V-22: Negative Binomial Regression Model for Seriously Injured (SI) during Low Season.

Table V-22.1: Model Information

Data set	Low Season
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Seriously Injured (SI)
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	34

Table V-22.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	2.396	16	.150
Scaled Deviance	2.396	16	
Pearson Chi-Square	2.287	16	.143
Scaled Pearson Chi-Square	2.287	16	
Log Likelihood[b]	-64.331		
Akaike's Information Criterion (AIC)	164.662		
Finite Sample Corrected AIC (AICC)	210.262		
Bayesian Information Criterion (BIC)	192.137		
Consistent AIC (CAIC)	210.137		

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Table V-22.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
20.749	17	.238

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-22.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	2.106	1	.147
Major land use	2.633	4	.621
Road Type	9.846	6	.131
Junction Detail	5.844	6	.441

Dependent Variable: Count_SI

Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-22.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-.823	1.6525	-4.062	2.416	.248	1	.618
Government Offices	-1.439	1.6143	-4.603	1.725	.795	1	.373
Accommodation	.823	.8549	-.852	2.498	.927	1	.336
Commercial	.301	.7699	-1.208	1.810	.152	1	.696
Residential	.437	.7997	-1.130	2.005	.299	1	.584
Religious	0[a]	.	.	.	.	.	.
Unknown	.110	2.1163	-4.038	4.258	.003	1	.958
Single carriageway –4+ lanes	.811	1.8329	-2.781	4.404	.196	1	.658
Single carriageway – 2 lanes	2.373	1.5704	-.705	5.451	2.283	1	.131
Single carriageway – single track	.937	1.8102	-2.611	4.485	.268	1	.605
Dual carriageway – 3+ lanes	1.055	1.8933	-2.656	4.766	.310	1	.577
Dual carriageway – 2 lanes	.590	1.7193	-2.780	3.960	.118	1	.732
One way street	1.004	1.9197	-2.759	4.766	.273	1	.601
Roundabout	0[a]	.	.	.	.	.	.
Other junction	-2.373	1.5704	-5.451	.705	2.283	1	.131
Private drive or entrance	-1.850	1.5699	-4.927	1.227	1.389	1	.239
Multiple junction	-.426	1.7954	-3.945	3.093	.056	1	.813
Crossroads	-.662	.7741	-2.179	.855	.731	1	.393
T, Y or staggered junction	-.110	.6919	-1.466	1.246	.025	1	.873
Mini-roundabout	-2.373	1.5704	-5.451	.705	2.283	1	.131
Roundabout	0[a]	.	.	.	.	.	.
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_SI
Model: (Intercept), Landuse, RoadType, JunctionDetail
a. Set to zero because this parameter is redundant.
b. Fixed at the displayed value.

Table V-22.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Government Offices	-2.377	1.611	-5.534	.780
Accommodation	-.114	.566	-1.224	.996
Commercial	-.637	.710	-2.028	.755
Residential	-.500	.683	-1.838	.839
Religious	-.937	.840	-2.584	.709

Table V-22.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Unknown	-1.663	1.643	-4.884	1.559
Single carriageway –4+ lanes	-.962	.865	-2.657	.733
Single carriageway – 2 lanes	.600	.510	-.399	1.598
Single carriageway – single track	-.836	1.142	-3.074	1.402
Dual carriageway – 3+ lanes	-.718	1.028	-2.732	1.297
Dual carriageway – 2 lanes	-1.183	.894	-2.936	.570
One way street	-.769	1.152	-3.028	1.489
Roundabout	-1.773	1.643	-4.994	1.448

Table V-22.8: Estimated Marginal Means for Junction Details

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Other junction	-2.311	1.617	-5.480	.857
Private drive or entrance	-1.789	1.578	-4.883	1.305
Multiple junction	-.364	1.684	-3.666	2.937
Crossroads	-.601	.657	-1.889	.688
T, Y or staggered junction	-.049	.495	-1.020	.922
Mini-roundabout	-2.311	1.617	-5.480	.857
Roundabout	.061	.710	-1.331	1.453
Not at junction or within 20 metres	.061	.710	-1.331	1.453

Appendix V-23: Poisson Regression Model for Killed during Low Season.

Table V-23.1: Model Information

Data set	Low Season
Probability Distribution	Poisson
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	17

Table V-23.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	1.890	7	.270
Scaled Deviance	6.951	7	
Pearson Chi-Square	1.903	7	.272
Scaled Pearson Chi-Square	7.000	7	
Log Likelihood[b,c]	-19.055		
Adjusted Log Likelihood[d]	-70.080		
Akaike's Information Criterion (AIC)	58.109		
Finite Sample Corrected AIC (AICC)	94.776		
Bayesian Information Criterion (BIC)	66.441		
Consistent AIC (CAIC)	76.441		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

c. The log likelihood is based on a scale parameter fixed at 1.

d. The adjusted log likelihood is based on an estimated scale parameter and is used in the model fitting omnibus test.

Table V-23.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
5.045	9	.830

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-23.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	.001	1	.974
Major land use	2.838	3	.417
Road Type	2.999	2	.223
Junction Detail	.062	3	.996

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-23.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-.383	.5345	-1.430	.665	.513	1	.474
Accommodation	.671	.4025	-.118	1.460	2.779	1	.096
Commercial	.298	.3904	-.467	1.064	.585	1	.445
Residential	.425	.3996	-.358	1.208	1.132	1	.287
Religious	0[a]	.	.	.	.	.	.
Single carriageway – 3 lanes	-.042	.6708	-1.357	1.272	.004	1	.950
Single carriageway – 2 lanes	.385	.4191	-.437	1.206	.842	1	.359
Dual carriageway – 2 lanes	-.183	.5461	-1.253	.888	.112	1	.738
One way street	0[a]	.	.	.	.	.	.
Private drive or entrance	0[a]	.	.	.	.	.	.
Crossroads	.040	.3216	-.590	.670	.015	1	.901
T, Y or staggered junction	-.048	.2967	-.629	.534	.026	1	.872
Mini-roundabout	-.002	.6254	-1.228	1.224	.000	1	.998
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	.272[b]						

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Computed based on the Pearson chi-square.

Table V-23.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Accommodation	.326	.324	-.309	.961
Commercial	-.046	.324	-.680	.588
Residential	.080	.260	-.430	.590
Religious	-.345	.345	-1.020	.331

Table V-23.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 3 lanes	-.078	.579	-1.214	1.057
Single carriageway - 2 lanes	.349	.159	.037	.660
Dual carriageway - 2 lanes	-.219	.358	-.921	.484
One way street	-.036	.403	-.825	.753

Table V-23.8: Estimated Marginal Means for Junction Details

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Private drive or entrance	.006	.233	-.452	.463
Crossroads	.046	.313	-.568	.660
T, Y or staggered junction	-.042	.286	-.602	.519
Mini-roundabout	.004	.600	-1.172	1.180
Not at junction or within 20 metres	.006	.233	-.452	.463

Appendix V-24: Negative Binomial Regression Model for Killed during Low Season.

Table V-24.1: Model Information

Data set	Low Season
Probability Distribution	Negative binomial (1)
Link Function	Log
Dependent Variable	Count_Killed
Explanatory Variables	Major land use; Road Type; Junction Details
Observation Used (N)	17

Table V-24.2: Goodness of Fit[a]

	Value	df	Value/df
Deviance	.722	7	.103
Scaled Deviance	.722	7	
Pearson Chi-Square	.722	7	.103
Scaled Pearson Chi-Square	.722	7	
Log Likelihood[b]	-25.838		
Akaike's Information Criterion (AIC)	71.676		
Finite Sample Corrected AIC (AICC)	108.342		
Bayesian Information Criterion (BIC)	80.008		
Consistent AIC (CAIC)	90.008		

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Information criteria are in small-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

Table V-24.3: Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
.582	9	1.000

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Compares the fitted model against the intercept-only model.

Table V-24.4: Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig.
(Intercept)	.000	1	.991
Major land use	.317	3	.957
Road Type	.357	2	.836
Junction Detail	.003	3	1.000

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

Table V-24.5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-.395	1.4787	-3.293	2.503	.071	1	.789
Accommodation	.658	1.1759	-1.647	2.962	.313	1	.576
Commercial	.301	1.0954	-1.846	2.448	.076	1	.783
Residential	.438	1.1319	-1.780	2.657	.150	1	.699
Religious	0[a]	.	.	.	.	.	.
Single carriageway – 3 lanes	-.043	1.8454	-3.660	3.574	.001	1	.981
Single carriageway – 2 lanes	.373	1.1733	-1.927	2.672	.101	1	.751
Dual carriageway – 2 lanes	-.200	1.5682	-3.274	2.873	.016	1	.898
One way street	0[a]	.	.	.	.	.	.
Private drive or entrance	0[a]	.	.	.	.	.	.
Crossroads	.051	.9464	-1.804	1.906	.003	1	.957
T, Y or staggered junction	.016	.8974	-1.743	1.775	.000	1	.986
Mini-roundabout	.022	1.7117	-3.333	3.377	.000	1	.990
Not at junction or within 20 metres	0[a]	.	.	.	.	.	.
(Scale)	1[b]						
(Negative binomial)	1[b]						

Dependent Variable: Count_Killed

Model: (Intercept), Major land use, Road Type, Junction Detail

a. Set to zero because this parameter is redundant.

b. Fixed at the displayed value.

Table V-24.6: Estimated Marginal Means for Major land use

Major land use	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Accommodation	.313	.951	-1.551	2.177
Commercial	-.044	.922	-1.851	1.764
Residential	.093	.716	-1.311	1.497
Religious	-.345	.957	-2.221	1.532

Table V-24.7: Estimated Marginal Means for Road Type

Road Type	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Single carriageway - 3 lanes	-.071	1.602	-3.210	3.068
Single carriageway - 2 lanes	.345	.466	-.568	1.257
Dual carriageway - 2 lanes	-.228	1.027	-2.241	1.785
One way street	-.028	1.113	-2.209	2.153

Table V-24.8: Estimated Marginal Means for Junction Details

Junction Detail	Mean	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Private drive or entrance	-.013	.659	-1.306	1.279
Crossroads	.037	.890	-1.707	1.782
T, Y or staggered junction	.003	.813	-1.592	1.597
Mini-roundabout	.009	1.631	-3.187	3.205
Not at junction or within 20 metres	-.013	.659	-1.306	1.279

Appendix P

We review here the sections of the suggested form. Any necessary explanation will be provided if required.

1- Date and time:

Time and Date	Time	Minute	Hour
	Time of accident		
	Time of reporting		
	Time of investigation		

Date
Day □ Night □
Date: / / 14 Hijri
Date of report completion:

2- Location:

location													
	City/Governorate/District									Type of location			
	Reading of coordinates									0		North- N	
										0		East- E	
	Name and number of road												
	Name and number of the crossing road or the name of a mark												
	Distance in meter from the crossing or mark					Direction		Reading of the kilometric mark					

N.B. In the case where the two readings of coordinates are recorded, the last line which includes distance and direction becomes unnecessary.

3- Vehicles:

Vehicles	Vehicle	Traffic direction	Registration Number	Type of registration	Issuing country	colour	Model	Make	Type of vehicle

There is a supplement to other vehicles if more than one vehicle is involved in the accident.

4- Parties:

	Vehicle	Name	Nationality	ID number	Type of party	Health status	Percent (%)
Parties							
		Phone:		Address:			

N.B. Witnesses' addresses are recorded separately.

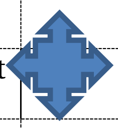
There is a supplement to record the highest number of involved parties when required.

5- Information:

Road surface	Lighting status	Accident cause	Point of collision	Weather status	Type of accident	Private damage	Public damage
Dry □ Wet □	Clear □ Dark □						

6- Description and outline of the accident:

Accident outline



7- Summary of the Accident:

Summary of the accident:

8- Administrative information:

Information	**Name**	**ID Number**										**Signature**
Accident investigator												
Report writer												
Report receiver												
Date and time of report submission: / / 14 Hijri Min: Hour:												Day □ Night □
Conservation No.												