ROAD TRAFFIC ACCIDENTS IN MALAWI: INFERENCE ANALYSIS, INTERPRETATIONS AND INTERVENTIONS

Master of Science in Infrastructure Development and Management

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CERTIFICATION OF APPROVAL

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I, **GIBSON MPOKONYOKA NGWIRA**, declare that this thesis is my own original work and shall not or has not been presented to any other university for a similar or any other degree award.

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Date: August 30, 2012

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DEDICATION

The study is devoted to my late mother, Tryness Nyabiti, who died on June 18, 2011 while I was writing research proposal for this study also to my wife, Elina Ngwira and two sons namely Gibson Ngwira Junior and Mahala Ngwira.

ABSTRACT

This is a case study investigating road traffic accidents in Malawi. Apart from assessing risks to road accidents and burden of crash injuries the study also identifies significant risk factors or safety factors that have more than standard influence on road accidents. Each and every road safety factor has an affect on crash involvement and injury but some of them have risk above normal or benchmark threat.

Road crash injuries impact huge human and economic cost worldwide including Malawi and the crisis is predicted to increase if road safety is not adequately addressed by Member States. Therefore, the study was instigated in response to WHO call for all Member States to address their road safety problems.

A secondary sourced data of road traffic accidents for 2010 was sampled from database managed by NRSCM and empirical analysis was carried out. Sample size was settled at a whole year crash data of 2,472 road accidents. After that, based on crash data variables, hypotheses were formulated and statistical methods namely Cross-tabulation and Chi-square (χ^2) test, integrated in computer package, SPSS 16.0, analysed crash data. While cross-tabulation assessed split of crash injuries in road safety factors, Chi-square (χ^2) tested hypotheses for statistical significance. Speed, BAC level, seatbelt/helmet use, road user type, road user behaviour, road user gender, road user age, vehicle type, time, day, district, accident type, road geometry, surrounding, other factors and light condition are among many crash data variables and attributes or road safety factors identified significant to road accidents.

Based on findings and their discussions, the study concludes that Malawi roads kill more than injury and pedestrians, bicyclists and passengers are more vulnerable. Over-speeding is at the core of road safety problems, followed by the growing motorisation and enhanced traffic mix with high speed traffic.

With one origin of crash data, that is police, road accidents are under-reported. Police also rarely record seatbelt/helmet use, BAC level and behaviour safety problems in bicycle drivers. Consequently, crash risks and injury burden are inadequately assessed, policy-makers and decision-makers are provided with insufficient information, safety problems are partially treated and, road safety awareness is not developed and raised accordingly.

The study proposes interventions on road safety issues raised in findings and their discussions and so recommend for national policy promoting walking, cycling and public transport, for intensive road safety awareness campaigns and publicity as well as enforcement of road traffic laws and regulations and, for capacity improvements in pre-hospital, hospital and physiotherapy care in order to minimise risk, casualty including preventable deaths and disability. However, interventions should prioritise significant road safety factors in order to maximise crash injury reductions or crash injury reductions per unit cost of prevention.

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LIST OF ACRONYMS OR ABBREVIATIONS

BAC	Blood Alcohol Content
COF	Certificate of Fitness
DALY	Disability Adjusted Life Years
GDP	Gross Domestic Product
LC	Local Councils
MALTIS	Malawi Transport Information System
MOT&PI	Ministry of Transport and Public Infrastructure
mv	Motor Vehicle
NRSCM	National Road Safety Council of Malawi
ped	Pedestrian
QECH	Queen Elizabeth Central Hospital
RA	Roads Authority
RFA	Roads Fund Administration
RSA	Republic of South Africa
RSPIs	Road Safety Performance Indicators
RTD	Road Traffic Directorate
RTSA	Road Traffic and Safety Agency
SADC	Southern African Development Community
SIDA	Swedish International Development Cooperation Agency
SPSS	Statistic Package for Social Science
TP	Traffic Police
UNIMA	University of Malawi
WHO	World Health Organisation
VSO	Volunteer Service Organisation

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The role that transportation plays in society is more complex than carrying people and goods for proprietors. Transportation is responsible for facilitating production, distribution and consumption of goods and services through transport of resources, knowledge and skills. This is the economic role that transportation plays to the society (Sussman, 2000). Transportation also plays social role to the society by influencing the formation, size, pattern and development of societies and settlements. In addition, the world is divided into numerous political units which are formed for mutual protection, economic advantages and development of common culture. Transportation plays an important role in the functioning of such political units. Furthermore, transportation directly or indirectly affects many other areas of societal environment. The negative effects of transportation on the environment is more dominating than its useful aspects and can be categorised among others as safety (accidents), air pollution, noise pollution and energy consumption (Rodrigue, 1998).

Road transport sector remains the most dangerous medium for transportation, accounting for, on average 90% of all transport accidents (Rodrigue, 1998). Globally, road traffic accidents kill and injure approximately 1.2 million and 50 million people respectively each year (Worley, 2006). Despite having only 35% of the World's vehicle population, developing countries account for 85-90% of all world annual road traffic deaths and 90% of global disability adjusted life years (DALYs) due to road traffic injuries (SIDA, 2006; Worley, 2006). Africa is an extreme case, despite having only 2% of the total global vehicle population it accounts for 11% of all road traffic fatalities (SIDA, 2006).

Road crash injuries remain a major global public health problem. Currently, global road crash mortality risk stands at 20.95 deaths in 100,000 habitants (Mortality caused by Road Traffic Injury by Country, 2009) in addition road crash injuries rank 11th and 9th among leading causes of global deaths and disabilities (WHO, 2002; World Bank & WHO, 2004). Unless the current crash injury trend is reversed, road traffic injuries are projected moving to third position on top worldwide burden of diseases in 2020 (Murray & Lopez, 1996; WHO, 2004; World Bank & WHO, 2004).

Globally, pedestrians, cyclists and motorcyclists are the most vulnerable road users (World Bank & WHO, 2004). They account for almost half of all people killed in road traffic crashes every year (WHO, 2009). While crash deaths and injuries in high-income countries occur most in car occupants, majority of road accident deaths in low-income countries happen in other road user groups mainly pedestrians, cyclists, motorcyclists and public transport passengers, followed by drivers and children (SIDA, 2006). Young adults in the productive ages (15-44years) account for between 50-75% of all (global) road accident deaths (SIDA, 2006) while children under 15 years in the developing countries share about 20% of the total road crash fatalities and of all children killed in 2002, 96% were from poor and emerging economy countries (World Bank & WHO, 2004).

Road Accidents are a major public health problem in Malawi too. Crash injuries ranked 9th on top ten causes of deaths in all ages in 2002 (WHO, 2002; WHO, 2006). The same, in low-income countries, crash injuries are estimated to rank 3rd among leading causes of deaths in all ages in 2020, surpassing HIV/AIDS (SIDA, 2006). Similar casualty groups (pedestrians, cyclists and passengers) except motorcyclists are killed more the same with road users in productive age group (25-44years) and males in addition private motor vehicles lead in crash involvement and fatality peak in rural bitumen roads (National Road Safety Council of Malawi, 2007, 2008, 2009, 2010; WHO, 2011). Besides, 15.5% of all wounds treated at the Casualty Department of QECH in Blantyre in every fortnight originate from road accidents (Virich & Lavy, 2005).

According to statistics presented in Mortality Caused by Road Traffic Injury by Country (2009) and reported in WHO (2009), Malawi has worse fatality risk (31.57) if compared to global average status (20.95) and to most neighbouring and SADC countries for example Zambia (17.72), Mozambique (17.94), Zimbabwe (20.41) and Botswana (20.96). Fatality risk counts number of crash deaths in every 100,000 inhabitants. Besides, Malawi follows Ethiopia and Uganda having the highest fatality rate worldwide (Jacobs & Aeron-Thomas (n.d.); Jacobs, Aeron-Thomas & Astrop, 2000; World Bank & WHO, 2004). Fatality rate is number of crash deaths per 10,000 motor vehicles.

Consecutive crash data reports fault drivers for high mortality rate. Failure to comply traffic rules and signs has been a major challenge for most drivers such that over-speeding claims more deaths and injuries, followed by careless overtaking, failure by drivers to keep onto the left when driving or not give way or deliberately ignoring traffic signs and drunken driving (NRSCM, 2007, 2008, 2009, 2010).

Road safety in Malawi is under performance of several organizations but major agencies include NRSCM, TP, RTD, RA, RFA, LC and MOT&PI. NRSCM inform and educate the public on road safety in addition carry out crash data analysis while TP record crash data, enforce road safety laws and rescue crash victims. RTD register motor vehicles, inspect vehicles, test and licence drivers besides regulate public and freight transport sectors while LC set and enforce traffic bylaws. RA supervises designs, construction, rehabilitation and maintenance of roads while RFA fund road projects including some for road safety. MOT&PI provide political leadership for the operation and success of National Transport Policy (2004).

Demographic population for Malawi by the end of 2007 was estimated at 14 million people (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2007) while total number of registered motor vehicles by the end of the same year was about 130,000 and with class split of saloons: 41%, light commercial vehicles: 30%, trucks: 16%, motor cycles: 8% and buses: 5% (WHO, 2011).

1.2 CONCEPT OF ROAD TRAFFIC ACCIDENTS

In road traffic, the safety outcome can be described in three dimensions namely exposure, crash and consequence or outcome of injury (Figure 1.2.1). Every road accident undergoes a risk process involving the three dimensions mentioned above and each phase has own risk factors that influence occurrence (Figure 1.2.2). However, no single road traffic accident is influenced by a single risk factor (World Bank & WHO, 2004).

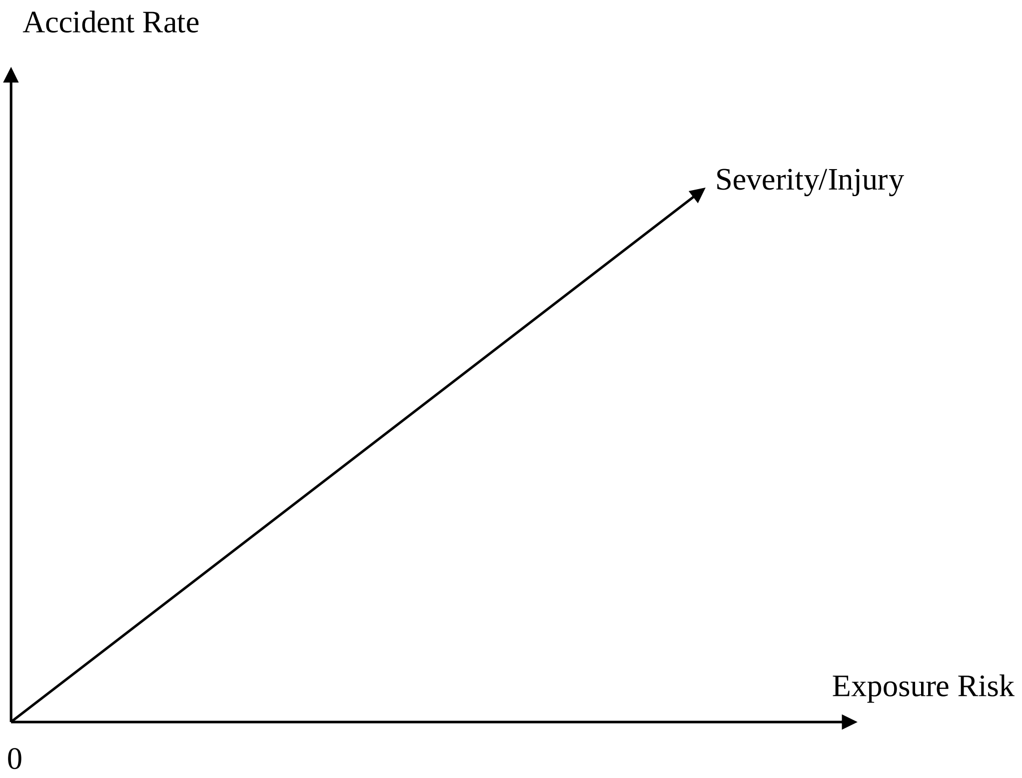

Figure 1.2.1: Three Dimensions Affecting Road Safety. Source: Elvic & Vaa, 2004; Nilsson, 2002, 2004.

Exposure is the amount of traffic or travel made by different road users and trips are generated by social and economic demands. As motorisation grows, exposure to risk crash involvement increase too. When a crash occurs, the outcome is either an injury or not. As for an injury, it can be either fatal or non-fatal. However, with poor pre-hospital care and medical treatment, non-fatal injuries may also lead to death.

Economic factors, demographic factors, land use and road function are major contributors to exposure (World Bank & WHO, 2004).

When road users travel for their mobility demands, interface with motor vehicles and are thus exposed to road accidents. Global wealth and household income controls motorisation then exposure to risk too. Motorisation rate rise with income (Kopits; Cropper & World Bank, 2003) correspondingly growth in global wealth and household income increased also vehicle population. But, the growing number of motor vehicles contributed to an increase in global road crash injuries (World Bank & WHO, 2004). Apart from Smeed (1949) was first to demonstrate the relationship between fatality rates and motorisation, many studies followed and found the same. Likewise, with an increase in household income, family travel demands along with trip production step up and exposure to risk road accidents too.

Different groups of people have different exposures to risk (World Bank & WHO, 2004). Young drivers and riders dominate per capita vehicle mileage travel on social trips and lead to high exposure to risk crash injuries. The same with young adult road users, they travel more for economic activities outside home or farm and are thus more exposed to road accidents (SIDA, 2006). Besides, rapid urbanisation of demographic and motorisation which is widespread in low-income countries expose a larger population to road accidents.

With sprawled and rarely mixed residential, work, business and social (schools, health) attractions, travel is dependent on car and lead to an increase in per capita vehicle ownership and mileage travel as well as exposure to road accidents. In addition, high presence of motorised traffic in residential plots increases vulnerability in pedestrians and cyclists, mainly children.

Most urban roads mainly in Africa cities are not used for their designated function (de Langen et al., 2006). Minibuses, delivery vans and heavy trucks often violate access and speed limits in residential plots worse traffic mix with high speed traffic in major arteries of low-income countries and both set-ups lead to high vulnerability in on-foot and pedal road users.

Social, technical and environmental risk factors influence crash involvement.

Inappropriate or excessive driving speed, under influence of alcohol and drugs, fatigue, poor vision, vulnerable road users and young drivers are some of social risk factors.

Saving travel time is a common norm in transport however attracts over-speeding. At high speed the vehicle becomes difficult to handle and may end into a crash (de Langen et al., 2006).

Globally, young drivers have higher crash risk than older drivers (Mayhew, Simpson & Traffic Injury Research Foundation of Canada, 1990) and road crash injury is a leading cause of death in young drivers and riders (Peden, McGee, & Krug, 2002; WHO, 2002). Young age and inexperience is at the core of crash injury problems (Elvic and Vaa, 2004; World Bank & WHO, 2004) and factors to that include late night drive, driving a borrowed vehicle he/she is not knowledgeable, drunken driving, use of drugs and driving for fun and thrill. Studies by Williams (2003) found night time drive-risk among drivers aged 20 to 44 years is four times higher than daytime risk. Young drivers have greater alcohol risk too because of being less tolerant to alcohol compared to older drivers and driving for fun and thrill risks over-speeding while a borrowed vehicle requires a learning curve on controls which affect driving ability and safety in most inexperienced drivers.

Crash risk enlarges with an increase in BAC level. Drivers and motorcyclists with any level of BAC greater than zero are at higher risks of crash than whose BAC level is zero (World Bank & WHO, 2004). For example, risk of crash involvement is 1.83 times greater at a BAC of 0.05g/dl than at a BAC of zero (McLean & Holubowycz, 1980). In EU, while a small percentage of drivers drive with excess alcohol, they are responsible for at least 20% of the serious and fatal traffic injuries (European Transport Safety Council, 2001). Alcohol affects driving ability and safety. Drivers under influence often violate traffic rules.

Alcohol is a safety problem in pedestrians too (WHO, 2004). At BAC levels above 0.1g/dl, pedestrians have significant risk of fatality relative to zero alcohol (Clayton, Colgan & Tunbridge, 2000). Incorrect judgement of vehicle approach speed, crossing the road carelessly and mixing with motor traffic dangerously are core safety problems of drunken pedestrians.

Fatigued drivers sleep while driving and often lose vehicle control. Fatigue or sleepiness in driver builds up from sleep deprivation, sickness and tiredness. Young age (up to 25 years), old age (over 50 years), gender (males), shift work, long haul drive, medical condition, alcohol consumption and long drive without rest and sleep are core factors of fatigue or sleepiness in drivers (Hartley, Arnold & Murdoch University, 1996). Young inexperienced drivers often tire soon when driving while old age associates with body weakness and tiredness because of poor health the same with alcohol or drug. Shift work, long haul and male drivers deprive sleeping which is a cause of tiredness and sleep-driving in them. Male drivers like driving for a long distance without rest and sleep.

Drivers with poor eye sight often miss traffic signs thus act contrary to posted command, regulation and information. Risk is greater in junctions/intersections, pedestrian crossing, keeping lane and following distance.

In low-income countries, pedestrians and riders are more vulnerable to crash injuries. Traffic mix with high speed traffic (Tiwari, Mohan & Fazio, 1998) and poor lighting in night as they are not seen by traffic (World Bank and WHO, 2004) risk more casualties in them. Lack of access to retro-reflective equipment, absence of bicycle lamp fitment and use of darkly coloured bicycle helmets are factors for not seen by motor traffic in poor or zero visibility and accelerate already unsafe conditions (European Transport Safety Council, 2000; World Bank & WHO, 2004).

Technical risk factors are vehicle defects, poor road designs and pavement defects.

Vehicle defects enhance vehicle factors to crash involvement. Faulty brakes, worn out/burst tyres, defective suspension/steering systems and others affect vehicle stability and control while faulty headlights reduce driver visibility at night or dazzle other road users.

In developing countries, to minimise construction costs, road designs regularly neglect safety features such as traffic calming measures, safe pedestrian crossings and separate paths for vulnerable road users. Consequently, pedestrians and bicyclists risk mixing with high speed traffic (Tiwari, Mohan & Fazio, 1998).

Pavement defect factors such as potholes, cut edges and worn out surfacing material increase risk to crash. A big pothole is likely to impact a hazardous vehicle defect such as tyre burst or make vehicle suspension resonate leading to vehicle loss control. While, worn out surfaces are predominantly slippery which affect traction and braking efficiency.

Environmental risk factors affect vehicle stability and control, and driver fore-sight visibility. Wet earth surface is usually slippery the same with wet and worn out bitumen surface but slippery condition reduces traction and braking efficiency. While, poor visibility in darkness, fog and dust lead to road users not had seen each other prior to crash involvement.

Crash involvement may impact injuries to car occupants or people outside the car or both. Severity depends on crash speed, vehicle crashworthiness, protective devices available in the vehicle, use of safety helmets and roadside objects.

Speed of the vehicle is at the core of the crash injury problem (World Bank & WHO, 2004). The probability of a crash involving injury is proportional to square of speed-V^2, while serious injury is cube –V^3 and fatal is fourth power-V^4 (Nilsson, 1982; Nilsson, 1997; World Bank & WHO, 2004). With advanced engine technology, modern vehicles accelerate to high speeds within shortest travel distance. Besides, speed is at the core of safety problems in good/fair road condition, drunken driving, drug use and young inexperience drivers.

For car occupants in a crash with an impact speed of 80 Km/h, the likelihood of death is 20 times what it would have been at impact speed of 32 Km/h (Insurance Institute for Highway Safety, 1987; World Bank & WHO, 2004). Similarly, pedestrians have a 90% chance of surviving car crashes at 30Km/h or below but less than a 50% chance of surviving impacts at 45Km/h or above (Ashton and Mackay, 1983; Pasanen, 1991; World Bank and WHO, 2004).

Car occupants, unlike pedestrians, motorcyclists and bicyclists, are protected by car hood. Crashworthiness is the ability for a car body/hood to resist extreme deformation at high crash impact. For better safety of car occupants, crash deformation should hardly extend into car interior and is achieved by reinforcing doors panel interiors, chassis frames and joints, roof hardtops and hardtop support pillars. However, occupants in cars manufactured before 1984 have approximately three times the risk of a car crash injury compared with occupants of newer vehicles (Blows, 2003; World Bank & WHO, 2004).

Seatbelts and air bags are the core protective devices available in vehicle interior. Air bags are caution balloons activated by crash impact. Seatbelts, if worn, restrain body shift while air bags, when activated, prevent car occupants colliding with solid interiors or fixtures. Without air bags, crash victims impact fatal head and chest injuries while non-use of seatbelt risks fatal head, spinal cord and abdomen injuries.

Non-use of seatbelts is a major injury risk factor in car occupants (World Bank & WHO, 2004) and in event of road accident, car occupants collide into each other or against vehicle interior or solid objects outside the vehicle if ejected. Incorrect use of both adult seatbelts and child restrains which is in substantial amount noticeably also cutback their potential to reduce injury (Koch, Medgyesi & Landry, 1995; Schoon, Heijkamp & Huijskens, 1992; World Bank & WHO, 2004). The same with safety helmet use in riders of motorcycle and bicycle, if not used, lead to fatal head injuries.

Loose objects and sharp or rough edge car interiors impact non-crash injuries. In event of crash, sharp or rough interiors can pierce or bruise car occupants while loose objects, if catapulted by crash momentum, may cause severe injury on car occupants.

Solid roadside hazards such as road furniture and trees contribute between 18% and 45% of global fatal crashes (Forgiving Roadsides, 1998; Kloeden, South Australia & NHMRC Road Accident Research Unit, 1999). When crashed into, solid roadside objects can impact non-crash injuries from hitting and piercing, and crash injuries from gravitational force.

Risk factors influencing severity of post-crash injuries include delay in detecting crash, presence of fire resulting from crash, leakage of hazardous materials, presence of alcohol and other drugs, difficulty evacuating and extracting people from crashed vehicles, difficulty evacuating passengers from buses and coaches involved in crash, lack of pre-hospital care and lack of care in the hospital emergency rooms (World Bank & WHO, 2004).

Evacuation, emergency trauma or pre-hospital care, hospital care and rehabilitation follow crash involvement. In both developed and developing countries, vast majority of deaths occur in the pre-hospital phase and slightly reduces for those patients taken to hospital (Moch, Jurkovich, nii-Amon-Kotei, Arreola-Risa, & Maier, 1998; World Bank & WHO, 2004).

Crashes involved during night or in remote locations are regularly detected and reported late. The delay is longer when crash vehicle ditches or ends into the bush leaving behind no trace of crash occurrence. Poor communication link between crash scene and emergency rescue provider delays reporting and response too. But, delay risk more preventable deaths because of late access to emergency trauma care.

Leaking fuel or flammable hazardous materials, when exposed to electric spark or exhaust heat, ablaze the crash vehicle including the scene leading to fatalities of fire and casualty increases if crash victims are trapped or rescue time is limited. Besides, direct exposure to some hazardous materials impact death or injury.

In low-income countries, lack of equipment and expertise delays extraction of crash victims which affects golden hour. Golden hour is the first hour of the post-crash phase in which crash victims must access pre-hospital care otherwise preventable deaths increase. Stampede delays evacuation in buses and coaches involved in a crash as passengers scramble for narrow emergency exits and stampede severe crash injuries.

In low-income countries, access to emergency medical services is generally poor. Evacuation of crash victims is mostly by on-lookers, relatives, other motorists and police instead of emergency rescue specialists (Forjuoh, Friedman, Mock & Quansah, 1999). Worse, private vehicles not emergency rescue ambulances or designated rescue vehicles are largely used for transporting crash victims to hospitals. Evidently, an African study conducted in Kenya found police and hospital ambulances evacuated only 5.5% and 2.9% of total crash victims (Nantulya & Reich, 2002). As a result, non-fatal injuries kill because of unprofessional handling of crash injuries and lack of pre-medical care.

With critical shortage of trauma specialists and equipment, crash victims do not receive adequate emergency trauma care. In low-income countries, trauma victims are treated predominantly by general practitioners and nursing staff who lack formal training in trauma handling. Besides, health staff levels do not match with the demand as such emergency trauma rooms like other health rooms are overloaded with patients.

Inadequate number of surgeons and equipment delay emergency life saving procedures such as surgery. In the late 1980s, Africa had 0.5 surgeons in every 100,000 inhabitants (MacGowan, 1987). With this poor ratio, a study of 2,000 trauma admissions in the main hospital of Kumasi in Ghana found a mean 12-hour delay before the start of emergency surgery (Moch, Nii-Amon-Kotei & Maier, 1997). Another study in Ghana hospitals by the same researcher found low rates of usage of key equipment though it was because of poor organisation not cost. Similar to Ghana, most African hospitals lack essential low-cost and reusable equipment such as chest tubes and airway cleaners which probable is among core factors of high fatality in post-crash phase.

1.3 PROBLEM STATEMENT / BURDEN OF CRASH INJURIES IN MALAWI

Road accidents impact vast human capital cost. Malawi roads claim more deaths in every 100,000 inhabitants compared to most neighbouring and SADC countries, and global average fatality risk (Mortality Caused by Road Traffic Injury by Country, 2009; WHO, 2009). Besides, crash injuries rank 9th position on top ten causes of deaths in all ages (WHO, 2002; WHO, 2006) and are projected to move to third position among leading causes of deaths in all ages in 2020, surpassing HIV/AIDS (SIDA, 2006). Among killed or disabled are engineers, doctors, nurses, scientists, technicians, agriculturist, teachers and other professionals. While human resource is already scarce, further losses to road accidents pinch the shortfall to extreme and replacement is not easy as takes years and huge resources to train a single professional.

With high fatality risk of 31.57 deaths in every 100,000 Malawi inhabitants, more families are traumatised. A large population live with permanent pain, grief and suffering because of losing their loved ones or they have survived crash injuries but are disabled therefore can not live normal life again in addition plight of orphans exacerbated with more families become poor (SIDA, 2006). Sooner after a parent or guardian mainly male family member is killed, family plunges into poverty. Males are generally bread winners of their families (SIDA, 2006).

Apart from huge human capital loss, road accident deaths consume massive financial resources (Jacobs & Aeron-Thomas, n.d.). According to Overseas Development Administration & Transport Research Laboratory (1995), annual cost of road accidents for Malawi is about 5 percent of her GDP. For example, in 2010, with GDP of US$5.2 billion (World Bank, 2010), Malawi lost approximately US$256 million to road accidents. The cost was incurred in unplanned health delivery services including funeral, capital re-investment or premature replacement of damaged vehicles and road infrastructures, insurance claims on life and property loss and others.

Notably, nearly all new road crash trauma patients are referred to government hospitals. Public hospitals become a priority may be because clinical services are on cost free or the public believe government hospitals offer better emergency trauma care. But, with already diminishing resources in public institutions since Malawi is poor, this unplanned expenditure and workload burden the public health service. Apart from overloading the workforce due to chronic shortage of health staff (von Bothmer, 2009; VSO Programme Area Summary, 2010) also contributes to persistent short supply of drugs in public hospitals.

Economical loss is remarkable in the tourism industry too. Alerts by foreign governments like that of British Foreign and Commonwealth Office (2010) to their nationals about poor road safety in Malawi scares potential cross-boarder and overseas visitors to Malawi and affects income from tourism.

1.4 JUSTIFICATION OR IMPORTANCE OF THE STUDY

The study target remarkable road crash injury reductions besides economic gain. With less human cost and fewer injuries, smaller number of families shall live with poverty, pain, grief and suffering as well as less burden in hospitals and households. Gain in GDP can be used for, example, purchasing learning materials sufficient for the free primary education. With fewer alerts, more visitors are to travel to Malawi leading to boost in tourism along with GDP in transport and tourism industry.

1.5 RESEARCH OBJECTIVES

1.5.1 Main Objective

- To analyse road traffic accidents in Malawi. The study follows WHO call for Member States to address road safety problems in their respective countries (World Bank & WHO, 2004).

1.5.2 Specific Objectives

- To identify factors contribute to road traffic accidents in Malawi.
- To investigate risks associated with road traffic accidents in Malawi.
- To assess countermeasures that can contribute to reduction of road accidents in Malawi.

1.5.3 Research Questions

Road accidents are preventable. Evidently, high-income countries have achieved significant crash injury reductions despite higher motorisation. In long term, with tactical and strategic interventions, crash injury trend in low-income countries can reverse or slow down too. With this vision, the author believes setting and finding solutions to under-listed research questions probable can maximise crash injury reductions or crash injury reductions per unit cost of intervention in Malawi. Hence, following research questions:

- Which are the significant risk factors of crash injury?
- What are countermeasures to the significant risk factors?
- How to maximise crash injury reductions?

1.6 SCOPE AND LIMITATION

The study looks at the broad overview of road accidents in Malawi and the empirical analysis of crash data limits to assessment of risks and burden of crash injuries. For the appraisal of true road safety situation in Malawi, the study opt for the analysis of a large sample probable a full year crash data. But, handling a large sample is normally tedious.

1.7 RESEARCH DIRECTION

This is a case study aim to assess true risks and burden of crash injuries in Malawi. Since very little is written about road safety in Malawi, literature review on road safety shall dwell mainly on policies, legislative laws and regulations, and operation philosophy in core road safety agencies.

A secondary sourced data of road traffic accidents for the year 2010 to be sampled from the database managed by NRSCM and to undergo empirical analysis. Independent variables of crash data to cross-tabulate with crash injury while hypotheses developed from key variables of crash data to be tested for statistical significance. Cross-tabulation to come up with crash injury split in road safety factors while hypothesis testing to identify core safety factors.

Lastly, to interpret statistical findings of the study followed by discussion of significant results and making conclusions based on significant findings. Finally, to propose interventions to core risk factors identified in the test. Any literature used in the study to be listed in the reference section while support documents to be attached in the appendices.

CHAPTER TWO

2.0 LITERATURE REVIEW ON ROAD SAFETY

2.1 INTRODUCTION

Road crash injuries are a global public health problem and the crisis is critical in low-income countries. The growing concern of road accidents on global public health has influenced many researchers to write on road safety risks, burden of crash injuries, accidents cost on national GDP, prevention, crash injury projection and many others. However, very little is written about road safety in Malawi. For this reason, literature review on road safety dwell mainly on policies, legislative laws and regulations, and operation philosophy in core road safety agencies.

2.2 DISCUSSIONS

While RSPIs preview road safety and aid in setting crash injury reductions, only seatbelt use rate (45%) and crash data indicators are made known for Malawi (WHO, 2011). But, seatbelt wearing rate (45%) is questionerable as data source is not available (WHO, 2011) and does not specify whether 45% wearing compliance is for car occupants in all vehicle classes.

Key RSPIs are crash data also known as direct RSPIs and risk factors commonly called indirect RSPIs. Direct RSPIs include total number of crashes, total fatal accidents, total injury accidents, total fatalities and total severe injuries while percentage of examined drivers above permitted blood alcohol limit, percentage of cars above speed limit, percentage of cars not stopping at stop sign, percentage of cars running red light, percentage of car occupants wearing safety belts, percentage of children sitting in children constrain seat, percentage of motorcyclists wearing helmets and percentage of bicyclists wearing helmets are indirect RSPIs (European Transport Safety Council, 2001; Svensson, 2007; Varhelyi, 2007).

Casual link exists between indirect RSPIs (risk factors) and direct RSPIs (crash data). Since only that is measured is controlled, interventions on road safety is never precise without indirect RSPIs hence a few or nil crash injury reductions as shown in Table 2.2.1. It is possible minor threats are ones accorded with attention and resource priority.

Table 2.2.1: Road Accidents Trend

Category	Number of Victims			
	2007	2008	2009	2010
Crashes	4473	3174	2824	2540
Killed	902	974	1013	976
Serious Injured	764	773	742	864
Minor Injured	2190	1470	1431	1479

Source: National Road Safety Council of Malawi, 2007, 2008, 2009, 2010.

Speed of the vehicle is at the core of crash injury problems (World Bank and WHO, 2004). To curtail over-speeding and its greater share on crash injuries, TP regularly perform speed spot checks using speed guns. Despite speed cameras reduce fatal and injury crashes by 6% in rural area (Elvik & Vaa, 2004), they are in very short supply as a result their impact on road safety is negligible. Use of visible single, stationary police vehicle on high risk stretches mainly in rural can compliment speed guns. The strategy seem cost-effective and Leggett, Transport Tasmania & Australian Road Research Board (1988) found reduce speeding behaviour, overall average speed and, serious and fatal crashes.

Seatbelt use law is not mandatory to all vehicle categories as trucks, buses, minibuses and tractors are exempted likewise use of child seat restrain and helmet use in bicyclists are not regulated despite higher fatality in them (Road Traffic Act, 1997). But, non-use of seatbelt in car occupants more than doubles the risk of crash injuries while non-use of crash helmets in two-wheeler users almost doubles the risk of crash injuries and non-use of child seat restraint more than doubles the risk of crash injuries in children (World Bank and WHO, 2004). When used, seatbelts reduce risk of serious and fatal injury by between 40% and 65% (World Bank & WHO,

2004) while bicycle helmet use reduce risk of head and brain injuries by between 63% and 88% (Thompson, Rivara & Thompson, 1996) and safety seats for children passenger in cars minimise infant deaths in cars by about 71% and deaths of small children by 54% (National Highway Traffic Safety Administration, 2002).

NRSCM perform descriptive analysis of crash data using excel computer package (National Road Safety Council of Malawi, 2007, 2008, 2009, 2010). Frequency diagrams, bar charts, pie charts and histograms are constructed describing the distribution of crash injuries. However, with excel package, NRSCM can hardly determine the relationship between two road safety factors on crash injury or test more than two variables or test for statistical significance hence motivated for this study. In this study, crash data analysis is by SPSS and statistical methods namely Cross-tabulation and Chi-square (χ^2) are used to test more than two variables and examine the causal relationship between or amongst road safety factor(s) and crash injury respective thus having better insight of risks and burden of crash injuries in Malawi.

Malawi follows Ethiopia and Uganda having highest global fatality rate (Jacobs & Aeron-Thomas, n.d.; Jacobs, Aeron-Thomas & Astrop, 2000). However, if motorisation is critically analysed, Malawi probable leads, surpassing Ethiopia and Uganda. For instance, in 2007, based on 839 (for data error = 3614) fatalities and 130,000 licenced vehicles (WHO, 2011), fatality rate was 278 deaths in every motorisation of 10,000 vehicles (Mortality Caused by Road Traffic Injury by Country, 2009). However, number of 130,000 vehicles was the total population since start of e-database. May be unlike Ethiopia and Uganda, Malawi is largely importing and registering used vehicles (MALTIS, 2000). But, used vehicles are old so they have more technical defects and shorter life span (Elvic & Vaa, 2004). For this reason, actual motorisation must have been far below reported volume of 130,000 vehicles evidently number plates licenced about five or more years ago are rarely seen on the road. Thus, may be true fatality rate exceeds 278 deaths per 10,000 vehicles and that of Ethiopia and Uganda respective.

Similar to fatality rate, fatality risk (31.57 deaths/100,000 people) is probable higher than recorded and reported. Studies from a number of countries have shown wide variation between police statistics and other sources (Jacobs, Aeron-Thomas & Astrop, 2000; Mackay, 2003;

World Bank & WHO, 2004). For example, in the Philippines only one of the five medically reported road deaths were included in Police statistics (WHO, 1996). Similarly, in China, the Beijing Research Institute of Traffic Engineering estimated that the actual number of people killed in road accidents in 1994 was over 40% greater than reported officially by the police (Liren, 1996). Besides, in developing countries, errors of margin for those numbers reported by Police were found to be between 25% and 50% (Gururaj, Thomas & Reddi, 2000; Jacobs, Aeron-Thomas & Astrop, 2000; World Bank & WHO, 2004). Correspondingly, police is under-reporting crashes and fatalities in Malawi. With this unreliable data, the public, stakeholders, policy makers and decision makers (MOT&PI) and international partners (World Bank, WHO and others) are misinformed on the burden of crash injuries while priorities for road traffic injury prevention can hardly be rationally or satisfactory determined (World Bank & WHO, 2004). Nevertheless, reliability and quality of data can improve if police statistics are verified with entries from other sources such as hospital, insurance companies and other government departments (World Bank & WHO, 2004).

While fatality globally and in developing countries lead in pedestrians, cyclists, motorcyclists and public transport passengers (SIDA, 2006; WHO, 2004), similar road user groups except motorcyclists are killed more in Malawi (National Road Safety Council of Malawi, 2007, 2008, 2009, 2010; WHO, 2011). Save for high compliance of helmet wearing and use of headlights in daytime has improved road safety in motorcyclists. Correspondingly, casualty in pedestrians, bicyclists and passengers can lessen if their road safety performance indicators improve.

Hostile insurance policies are sinking many crash victims and their families into extreme poverty. Despite high casualty in minibus transport (National Road Safety Council of Malawi, 2007, 2008, 2009, 2010) minibuses are restricted to third party insurance policy cover. Old vehicles also are limited to third party insurance policy cover. Since imported used vehicles dominate licencing (MALTIS, 2000), majority vehicles are old and covered with third party insurance policy. But, third party insurance premiums are very low per se crash victims or their families are compensated with very little money or left without compensation for the injury, loss of life and property (SIDA, 2006). With this mean compensation, crash victims can not afford good medical care consequently fatalities and disabilities increase (SIDA, 2006). Worse, the little compensation rarely reaches the real beneficiaries as fraud is deeply rooted in the insurance industry. Habitually, crooks claim damages without the knowledge and authority of crash victims or their families.

BAC legal limit for general population in Malawi is 0.08g/dl or 0.8g/l (Road Traffic Act, 1997; WHO, 2011). But, driving under influence of alcohol most likely increases risk of road accidents more than any other forms of traffic violation (Elvic & Vaa, 2004) and drivers or motorcyclists with any level of BAC greater than zero are at higher risks of crash than whose BAC level is zero (World Bank & WHO, 2004). For example, the risk of crash involvement was found to be 1.83 times greater at a BAC level of 0.05g/dl than at a BAC level of zero (McLean & Holubowycz, 1980) and the risk of crash is about 2.8 times greater at BAC level of 0.08g/dl than at zero BAC (Compton et al., 2002; Moskowitz et al., 2002; World Bank & WHO, 2004). Therefore, allowing BAC level of 0.08g/dl is extreme hazardous. Epidemiological research also does not support a legal limit for BAC level above 0.05g/dl (European Transport Safety Council, 2001).

BAC legal limit for young or novice drivers also is at 0.08g/dl (Road Traffic Act, 1997; WHO, 2011). But, young inexperienced drivers also have a higher risk of accident involvement after drinking alcohol (European Transport Safety Council, 2001). Since young drivers are less tolerant to alcohol than old drivers, crash risk start to increase substantially at lower BAC level than old experienced drivers (World Bank & WHO, 2004). For example, Mathijssen (1998) found young inexperienced drivers with BAC level of 0.05g/dl have 2.5 times risk of crash involvement compared with more experienced drivers and Keall, Frith & Patterson (2004) found teenage drivers with a BAC level of 0.03g/d carrying two or more passengers were 34 times more at risk of crash than drivers aged 30 or more with zero BAC level. But, 0.08g/dl is well above 0.05g/dl and 0.03g/d clearly 0.08g/dl has risk much above 2.5 times and 34 times. For this reason, setting BAC legal limit for young or novice drivers at 0.08g/dl is extreme risky and shocking but if revised to 0.02g/dl can reduce crashes between 4% and 24% (Shults et al., 2001).

Majority Commonwealth countries including Malawi, similar to United Kingdom, their colonial master, allow BAC legal limit of 0.08g/dl for general population (World Bank & WHO, 2004).

Surely, choice for that did not base on alcohol safety problems in their countries but plagiarism from United Kingdom, their mentor. Regrettably, most of these countries have poor road safety as indicated in Mortality Caused by Road Traffic Injury by Country (2009) & WHO (2009) and probable hazardous BAC legal limit (0.08g/dl) is a core safety problem. However, unlike other Commonwealth Member States, United Kingdom command better road safety (6.37 fatalities per 100,000 inhabitants) worldwide (Mortality Caused by Road Traffic Injury by Country, 2009; WHO, 2009). Improvements in enforcement of traffic rules on drunken driving and connected violations along with better road designs possible suppress the negative impact of hazardous BAC legal limit of 0.08g/dl in the United Kingdom.

As explained in the Section 1.1, Malawi has poor road safety compared to most countries in SADC (Mortality Caused by Road Traffic Injury by Country, 2009; WHO, 2009). While road safety bureaus or agencies in most countries are semi-autonomous (with minimal government hand) and under single significant authority, a lead agency, major road safety agencies in Malawi are under full government control (are government departments) besides report to different government ministries. With this complexity, policy-making and decision-making is normally slow because of bureaucratic nature of administration in government besides agencies lack common priority, commitment and responsibility as each and every arm of road safety has own challenges and priorities. Thus, fragmented institutional framework affects road safety.

With fragmented institutional framework, road safety awareness campaigns and publicity does not balance with abating road safety as it is carried out in isolation of legislation and law enforcement therefore does not deliver tangible and sustained reductions in deaths and serious injuries (Trinca et al., 1988; O'Neill, Mohan, Breen, Koonstra, Mackay, Roberts & Ryan, 2002). However, effective only in changing behaviour mainly in pedestrian and cycle education for school children (Duperrex, Roberts & Bunn, 2002).

Without curriculum and instruction manual, driver training lack official reference for knowledge. Since driver training depends on mentorship, tuition is inadequate and inconsistence. As a result, despite enrolling with driving schools which is enforced, drivers graduate more like informal drivers hence hazardous. Informal drivers might have good driving skills but lack good knowledge and a good understanding of risk (Elvic & Vaa, 2004). A number of studies done in high-income countries (USA, UK, Sweden, Finland, Australia and New Zealand) cited in Elvic & Vaa (2004), their combined results also found that drivers who have not undergone formal training have 2% more accidents per driver than drivers who have undertaken formal training. Feasible, risk is greater than 2% in low-income countries.

Driving test too suits for informal drivers as only driving skills with oral knowledge of Highway Code is assessed. But, basic driver training is ideally intended to give new drivers the knowledge and skills they need to drive safely (Elvic & Vaa, 2004). Thus, without theory test in addition lacking driver training manual, driver graduates lack knowledge required to balance safe driving. Though studies have shown drivers who take a theory test have exactly the same accident rate as drivers who do not take a theory test (Elvic & Vaa, 2004; McKnight & Edwards, 1982; Stoke, 1979, 1980; Stock et al., 1983), experiments were carried out in USA obvious sample drivers had basic knowledge acquired from state or private driving schools. But, if similar studies were carried out on driver samples with and without basic knowledge or training, the later sample, though pass skill test, is likely to have higher accident rates.

Examiners who graduate drivers also lack formal training and driving test criteria is not detailed or provided. Similar with driver training, driver examiner training base on mentorship knowledge and skill but not all mentors have the same attributes and apply to examiners too. For this reason, examination of driving test is not standardised and examiners coached by mentors with lower persona are likely to graduate and licence drivers with lower skills who are perilous to other road users.

Health requirements for drivers have been ignored despite regulated in Road Traffic Act: Regulations (2000). Drivers are licenced without formal medical check-up on main health requirements such as sight, hearing, epilepsy and heart diseases, diabetes, high blood pressure, alcohol and drug addict, mental illness, temperament, locomotion and others. But, drivers who do not fulfil health requirements have higher accident rates than drivers who fulfil (Elvic & Vaa, 2004). Studies by various authors cited in Elvic & Vaa (2004) also found effects or risks of different illnesses and health problems on driver accident rates were more than 1.0 in average while standard risk for a healthy driver is 1.0. No doubt, many drivers amid health risks greater than 1.0 are licenced. Health risk is greater in older drivers since old age is linked with diseases including sight problem.

Roadside surveys of vehicles in general show that older vehicles have more technical defects than newer vehicles (Elvic & Vaa, 2004). A study on passenger cars in Norway also found number of defects per vehicle increases from less than 1 for vehicles less than 4 years old to more than 5.5 for vehicles 13 years old or more (Elvic & Vaa, 2004). With used vehicles dominating new vehicle registration in Malawi (MALTIS, 2000), majority vehicle population is old and with more technical defects.

Periodic motor vehicle inspection for road worthiness is another road safety concern in Malawi. Despite vehicle defects have negligible influence on crash and injury (National Road Safety Council of Malawi, 2007, 2008, 2009, 2010) supported by other studies also found in general no evidence that periodic motor vehicle inspections reduce crash rates except in commercial heavy vehicles where brake failure is acknowledged risk (Jones & Stein, 1989; World Bank & WHO, 2004), with only four inspection pits available nationwide against a population of over 300,000 vehicles, many vehicles apply on public roads without undergo COF examination. But, vehicles that miss periodic inspections are usually not roadworthy and risk more vehicle factors.

Vehicle examination too is only by feel of touch and visual inspection. Unless assisted by equipments, precision to certify inspected vehicle components and systems such as brakes, steering, suspension, headlights and others within prescribed safe limits or standards is hardly achieved. As such, vehicles with component wear and settings outer prescribed safe limits also pass periodic inspection and drive on public roads but risk more vehicle factors.

Without formal and publicly available pre-hospital care system and lack of national universal access or call number (WHO, 2011), similar to research findings by Moch, Jurkovich, nii-Amon-Kotei, Arreola-Risa, & Maier (1998), vast majority of crash deaths occur in the pre-hospital phase. With no public call centres and emergency call numbers in police, hospital and fire service, crashes are often reported late which delays also evacuation and pre-hospital care, and risk more preventable deaths. Police have emergency call numbers such as 997, 990 and others however you can hardly be connected through nowadays in addition the facility is available in cities only. Even if rescue call request reach police or hospital in time, response is generally slow because of lack of transport.

Delay is much longer in rural correspondingly fatality is high. Besides rural areas lack call services, immediate vehicle to transport crash victim(s) to hospital is often not available because of low vehicular traffic and health services are generally many kilometres apart for this reason crash victims access emergency trauma care very late.

In Malawi, similar to findings by Forjuoh, Friedman, Mock & Quansah (1999), on-lookers, relatives and other motorists often evacuate crash victims. Delay response generally by police, hospital and fire along with national culture of sympathising with and readiness to offer help to colleagues in problems and pain believed source of public involvement in evacuation of crash victims. Worse, similar to Nantulya (2002) findings in Kenya, crash victims on way to hospital are transported largely in vehicles of other motorists other than police and hospital ambulances. In related development, despite police is responsible for rescuing crash victims, own only two ambulances then evacuation by police also is common in general transport vehicles. Since public lack skills in extracting victims and knowledge in trauma care, crash injuries are generally poorly handled while non-ambulance transport lack injury control fixtures and facilities similar to ones fitted in emergency rescue vehicles as a result crash injuries severe leading to high fatality in pre-hospital phase. As recommended by Hussain & Redmond (1994), bystanders and other motorists can be involved in rescuing victims but restricted to help jobs only.

Malawi health services suffer chronic understaffing (VSO Programme Area Summary, 2010). With one doctor for every 65,000 population (von Bothmer, 2009) and one orthopaedic surgeon to about 1,500,000 population or 0.06 orthopaedic surgeons per 100,000 population (Kollias, Banza & Mkandawire, 2010; Mkandawire, Ngulube & Lavy, 2008) and only 29 (4 Malawians) general surgeons for 14 million people or 0.2 general surgeons per 100,000 inhabitants (Kollias, Banza & Mkandawire, 2010), patients have limited access to specialist doctors and surgeons. If Ghana, with 0.5 surgeons per 100,000 populations has a mean 12-hour delay before the start of emergency surgery (Moch, Nii-Amon-Kotei & Maier, 1997), delay in Malawi hospitals should be longer than that with 0.2 surgeons per 100,000 populations. Thus, more patients die despite taken to the hospital and contradict with findings of Moch, Jurkovich, nii-Amon-Kotei, Arreola-Risa, & Maier (1998).

Road traffic injuries ranked 7th among Malawi top ten causes of physical disability or years of life lost in all ages in 2002 (WHO, 2002; WHO, 2006). While road traffic injuries are projected to be 3rd leading cause of deaths in all ages by 2020, burden of years of life lost (disability) from crash injuries also will soar unless effective disability treatment is provided. But, with only one major public disability rehabilitation centre, Kachere in Blantyre, many crash injuries are not rehabilitated adequately. Cure international also in Blantyre is another centre of distinctive disability healing. Though, children are treated at free cost, charges for the adults are prohibitive. Rooms for physiotherapy are available in most public hospitals but lack human resource and technical capacity. Like hospital care, disability physiotherapy is a challenge.

Without national policies to promote walking, cycling and public transport (WHO, 2011), travelling is much dependent on private cars. Evidently, both ownership and crashes lead in private vehicles while least in buses (MALTIS, 2000; National Road Safety Council of Malawi, 2007, 2008, 2009, 2010; WHO, 2011). With more private cars on road, population of basic drivers and young inexperience drivers has increased too. But, young drivers have greater crash risk than older drivers (Mayhew, Simpson & Traffic Injury Research Foundation of Canada, 1990) and road crash injury is a leading cause of death in young drivers and riders (Peden, McGee, & Krug, 2002; WHO, 2002).

Walking and cycling promotion goes together with provision of many and good quality sidewalks, crosswalks, paths and bicycle lanes (Litman, Steele & Victoria Transport Policy Institute, 2009). Correspondingly, without national policies to promote walking or cycling, provisions for pedestrians and cyclists are scarcely available and majority of existing non-motorised structures are in poor condition. As a result, unprotected road users involuntary mix with high speed traffic (Tiwari, Mohan & Fazio, 1998).

Travel in cities is mostly by driving because of rarely mixed attractions. But, if town planning authority adopt smart growth land use policy when developing new residential areas, the creation of clustered and mixed use community services cut the distances between commonly used destinations thus curtailing the need to travel and reducing dependence on private cars as well as exposure to risk road accidents (Litman, 2003). Smart growth is the development of high density, compact buildings with easily accessible services and amenities (World Bank & WHO, 2004).

In low-income countries including Malawi, fatality is leading in pedestrians (Odero, Garner & Zwi, 1997; National Road Safety Council of Malawi, 2007, 2008, 2009, 2010; SIDA, 2006). Apart from behaviour safety problems in drivers, road geometry designs also contribute to high fatality rate in pedestrians. Besides traffic mix with high speed traffic, the classic pedestrian crossing design is more perilous. Since drivers stop or give way for a pedestrians voluntary, often ignore right of way for pedestrians. When raised or with chicanes, kills vehicle approach speed (Johansson & Svenska kommunfo̍rbundet, 1993). Drivers are forced to reduce approach speed otherwise the ride becomes rough causing discomfort to car occupants and may impact damages to the vehicle. At low crash speed, for example, 30Km/h or below, pedestrians have a 90% chance of surviving car crashes (Ashton & Mackay, 1983; Pasanen, 1991; World Bank & WHO, 2004) besides drivers slow down or stop more often for crossing pedestrians (Katz, Elgrishi & Zaidel, 1975; Varhelyi, 1996).

Despite speed is at the core of safety problems at crosswalks in busy places such as schools and markets in urban, pedestrian crossings lack speed control measures. Remedies include provision of chicanes or raising it or split it into two with a traffic island so that pedestrians cross in two stages. While provision of chicanes and raising it kills vehicle approach speed, a short crossing reduce time pedestrians expose to vehicles and are thus more convenient and safer to elderly and child pedestrians (Johansson & Svenska kommunfo̍rbundet, 1993).

Contrary to requirements, most intersections, bus stops, pedestrian crosswalks, residential plot locals and high risk stretches in rural roads lack physical traffic calming measures such as roundabouts, road narrowing, humps and chicanes respective. When used, reduce road accidents between 15% and 80% (Institution of Highways and Transportation, 1990; Kjemtrup & Herrstedt, 1992).

While passengers of minibus transport and other two-rear wheeled vehicles are among leading casualties in road accidents, buses have least crash fatality rate (National Road Safety Council of Malawi, 2007, 2008, 2009, 2010; WHO, 2011). Therefore, promoting transit in big buses can solve safety problems in lower buses. However, if to attract more investment in heavy buses, requires incentives such as duty exemption on new buses and surtax rebate on fuel, spare parts and tyres. With more buses, because of competition, trip fares drop while transit demand improves.

Over-speeding is at the core of poor road safety in minibuses. Minibus drivers predominantly compete for passengers and so often violate traffic rules including over-speeding. However, minibuses can be fixed with engine governors which limit vehicle speed (World Bank & WHO, 2004). When used, could be valuable means of improving road safety mainly in rural roads (Afukaar, Antwi & Ofosu-Amaah, 2003).

Regulations prohibit dangerous drivers from public road only that lacks enforcement. Road Traffic Act (1997) stipulates that serious offence(s) committed by a driver must be endorsed on his/her driver licence or warrants his/her driver licence suspended or cancelled or ordered not to hold driver licence. Judiciary through courts issues orders while RTD effect changes in driver licence database and enforce it. Since no court order had been relayed to RTD for appropriate action, dangerous drivers remain licenced and are thus allowed on public road and claim more lives.

Legally, solid roadside objects need to be forgiving. Despite solid roadside hazards contribute between 18% and 45% of global fatal crashes (Forgiving Roadsides, 1998; Kloeden, South Australia & NHMRC Road Accident Research Unit, 1999) and Ross et al. (1991) stress road designs and networks should accommodate human characteristics and be more forgiving if an error is made, unforgiving solid objects mainly trees, street light poles made of concrete or wood and heavy billboards position close to carriageway besides they are not marked. Unless removed or fixed at a safer distance way and marked, risk is pertinent. Moving roadside obstacle away about 5 meters reduce road accidents by around 20% while between 5 metres to around 9 metres by a further 40% (Cirillo, 1967; Elvik & Vaa, 2004; Zegeer et al., 1988) and removing them down size crashes by 2% (Corben et al., 1997). When marked, they are more visible in night and lead to a 23% reduction in injury accidents (Corben et al., 1997).

2.3 CONCLUSION

Based on discussions in the literature review, road safety has many shortfalls and risk is large in all phases of crash involvement including exposure. Unless gaps and safety problems raised in the review are revised or corrected, crash injuries remain a core economic and public health concern.

CHAPTER THREE

3.0 RESEARCH DESIGN AND METHODOLOGY

3.1 HYPOTHESES, CONCEPTUALISATION AND KEY VARIABLES

As stated in Section 1.2, road accidents undergo three phases namely exposure, crash and injury. Behind these phases, are factors influence their existence or occurrence. Thus, each and every road safety factor controls crash involvement alternatively causal relationship exists between risk factors and road crashes. Same factors of exposure, crash and injury are used for developing crash database and stand for independent variables of crash data while crash injuries dependent variables. Speed, BAC, road condition, surrounding, accident type, weather, road condition, surface type, light condition, time and weekday are some of key independent variables of crash data while fatal and non-fatal injuries dependent variables. Classification of variables is important for developing hypotheses and testing variables.

The study came up with and tested two hypotheses. Hypothesis H1 tested the causal link between road safety factor and crash severity while hypothesis H2 examined the relationship between two road safety factors and crash injury.

H1: Is the observed relationship between road safety factor and crash severity statistically significant?

Null hypothesis (H_0): The relationship between road safety factor and crash severity is not statistically significant. Therefore, tested road safety factor has standard causal link with crash injury.

Alternative hypothesis (H_1): The relationship between road safety factor and crash severity is statistically significant. Thus, road safety factor has risk greater than normal.

H2: Is the observed relationship between two road safety factors and crash severity statistically significant?

Null hypothesis (H_0): The relationship between two road safety factors and crash severity is not statistically significant. So, tested road safety factors have standard influence on each other.

Alternative hypothesis (H_1): The relationship between two road safety factors and crash severity is statistically significant. Thus, tested road safety factors have above standard influence on each other.

3.2 MEASUREMENT ISSUES

Police is the authentic source of crash data. When road accident happens, police fill crash details in a prescribed form which is sent to NRSCM offices for entry in the database. People and vehicles involved are major units of measurement.

3.3 RESEARCH DESIGN

3.3.1 Research Philosophy

A Positivism Philosophy since the study adopted scientific method as a means of knowledge generation. Hypotheses were formulated and tested to establish causal link between road safety risk factors and outcome (severity) of the crash.

3.3.2 Research Approach

A deductive research approach since involved scientific principles as hypotheses were formulated and tested. The essence of the study was to test the theory that there is causal link between road safety risk factors and outcome (severity) of the crash.

3.3.3 Research Strategy

A case study and through empirical analysis of crash data investigated split of crash injuries in road safety factors and the causal link between road safety risk factors and outcome (severity) of the crash.

3.3.4 Ethic Consideration

No official support document is available and attached as UNIMA including the Polytechnic lack policy on ethical issues. Names of crash victims and officials involved in management of road accidents are not disclosed besides crash data do not record names of people.

3.4 SAMPLE DESIGN

3.4.1 Sampling Technique/Method

The sample was non-randomly selected and is the crash data recorded from January through December in the year 2010 by the Police though sampled from NRSCM.

3.4.2 Sample Size

The most recent crash data was studied in order to appreciate and combat latest road safety problems. A total population of 2,472 road accidents were recorded and reported in the year 2010. So, for a population of 3,000 (close to and greater than 2,472), at ±3% precision and 95% confidence level, normal sample size is about 811 (Israel, 1992). However, with alleged 25% to 50% less reported crash data by police (Jacobs, Aeron-Thomas & Astrop, 2000), precise population is hardly determined. As assumption of normal population is poor, Yamane (1967) recommends sampling entire population. Similarly, as NRSCM normally evaluate crash data of full year, for minimal errors between the two studies (this and NRSCM), opted sampling the entire crash population. Besides, crash data already exists and consolidating a large sample size is no longer much tedious. Quest for assessing true risks and crash injury burden also motivated choice for sampling whole population. Therefore, sample size was settled at 2,472 crashes.

3.5 DATA COLLECTION

3.5.1 Method and Source

A secondary sourced data of road traffic accidents for the year 2010 was sampled from the database managed by NRSCM in Lilongwe. Excel spreadsheets containing crash statistics and descriptors or attributes of data variables were retrieved from the database and copied or burnt onto my disc. Database store crash data in tables titled crash involvement, road users involved, motor vehicles involved, driver characteristics, behaviour safety problems, vehicle requirements and more.

3.5.2 Data Quality and Reliability

Crash data has adequate number of characteristics (variables and attributes) necessary for the holistic assessment of risks and crash injury burden. In addition, TP officers who collect crash data and NRSCM officers who manage database were trained by the database developer and have long experience in their respective tasks. Again, the database was developed and commissioned by SweRoad, an international agency on road safety projects contracted to many countries in East Europe, Asia and Africa, including RSA and Uganda. SweRoad is part of Swedish Road Administration, a kingpin of outstanding road safety in Sweden (SweRoad Ongoing Projects, n.d.). By the way, as sourced from Mortality Caused by Road Traffic Injury by Country (2009), Sweden has very low fatality risk (5.77 road deaths in every 100,000 inhabitants). Therefore, the three reasons stated above guarantee quality and reliability of crash data used and findings.

3.5.3 Data Capturing

Crash data in Microsoft excel tables obtained from NRSCM was recaptured into the computer but now in SPSS format, followed by assigning of attributes to corresponding variables while ordinal attributes such as age, time and days were converted into range for example time interval (6am-9am), month time (month-start) and road user age group (25-44 years).

3.6 DATA ANALYSIS TECHNIQUE/METHOD

3.6.1 Statistical Methods

Statistical methods namely Cross-tabulation and Chi-square (χ^2) test, integrated in computer package, SPSS 16.0, were used for analysing crash data. Choice was made based on fact both statistical methods are easy to follow and understand thus giving more insight of testing process and findings to decision makers, stakeholders or big hand and other readers.

3.6.2 Testing

From crash data, one or two independent variable(s) or road safety factor(s) was/were cross-tabulated with dependent variable or crash injury and the outcome is the share of crash injuries in risk factors while Chi-square (χ^2) tested formulated hypotheses for statistical significance and identified core safety factors.

The philosophy in hypothesis testing is to accept the null hypothesis or reject it and accept the alternative hypothesis. While null hypothesis is a status quo statement (thought to be true), alternative hypothesis opposes what believed to be true.

A significant level also known alpha level (α) and probability value (ρ) are factors for accepting or rejecting null hypothesis. A significant level is set in computer while p-value is based on empirical (statistical) data and is SPSS output number. Choice of confidence level determines the value of significant level to use. Since confidence level of 95% is commonly used in research, the same value was set for this study.

At confidence level of 95%, significant level is $\alpha = 0.05$ and all probability values of less than or equal to significant level value or $\rho \leq 0.05$ warranted null hypothesis rejection and accepted alternative hypothesis. Similarly, for probability values, $\rho > 0.05$, null hypothesis were accepted and alternative hypothesis rejected.

Each and every road safety factor has an effect on road safety though some have greater risk or risk above the normal or benchmark magnitude. Thus, for values of $\rho \leq 0.05$, tested road safety factor or variable/attribute in crash data has regular risk to road accidents while, for values of $\rho > 0.05$, risk exceeds standard values.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 SAMPLE PROFILE

For holistic approach on road safety, crash data contain many independent variables standing for risk factors. Unquestionably, each and every road safety factor or independent variable is significant and affect road safety. For this reason, it was found necessary to test nearly all variables in the crash data and have their influence on road safety made known.

4.2 PRESENTATION OF RESULTS

Cross-tabulation and Chi-square (χ^2) test produced SPSS outputs however only significant findings have been documented. Hence, came up with tables of summarised results which have been presented together with their discussions and interpretations.

4.3 RESULTS: DISCUSSIONS AND INTERPRETATIONS

While answers to research question # 2 and # 3 are concluded in the recommendations, cross-tabulation and hypothesis testing provide solutions to question # 1 and following are the findings and, their discussions and interpretations.

4.3.1 Analysis of Crash Involvement Data

Table 4.2.1: Relationship between Single Factors and Severity

Factor	**Time**	**Day**	**Month**	**Month Time**	**District**	**Accident Type**	**Road Geometry**	**Surrounding**
Crash & Fatal Top in	**3pm-6pm (23.3%; 22.2%)** **6am to 9pm**	**Saturday (16.0%; 19.0%)**	**April to September & January to March**	**Mid (36.7%; 37.5%)**	**Blantyre (23.2%; 14.6%)** **Lilongwe (19.7%; 15.9%)**	**mv/ pedestrian (43.3%; 51.3%)**	**Straight (73.4%; 75.9%)**	**Rural (48.7%; 64.6%)**
ρ-value	**0.000**	**0.090**	**0.453**	**0.803**	**0.000**	**0.000**	**0.000**	**0.000**
Factor	**Surface Type**	**Road Condition**	**Weather**	**Other Factor**	**Animal**	**Obstruction**	**Speed**	**Light Condition**
Crash & Fatal Top in	**Bitumen (91.9%; 91.7%)**	**Good/ fair (97.4%; 97.7%)**	**Dry (99.0%; 98.7%)**	**Hit & run (4.2%; 4.2%)**	**Stationary in Road (1)**	**Dropped cargo & others (3)**	**Over Limit (93.9%; 94.4%)**	**Daylight (69.5%; 61.7%)**
ρ-value	**0.480**	**0.263**	**0.137**	**0.000**	**0.067**	**0.795**	**0.039**	**0.000**

In Table 4.2.1, crash and fatal incidents peak in 3pm to 6pm (23.3%; 22.2%) but in general they occur more during 6am to 9pm. Crash and fatal occurrences also lead in Saturdays (16.0%; 19.0%), April to March excluding October through February, month-mid (36.7%; 37.5%), mv/pedestrian collisions (43.3%; 51.3%), straight road (73.4%; 75.9%), rural (48.7%; 64.6%), bitumen surface (91.9%; 91.7%), good/fair road condition (97.4%; 97.7%), dry weather (99.0%; 98.7%), hit and run (4.2%; 7.6%), above legal speed limit (93.9%; 94.4%) and daylight (69.5%; 61.7%). In addition, crashes lead in Blantyre (23.2%) while fatal in Lilongwe (15.9%) and animal stationary on the road, dropped cargo, rocks/landside and other obstructions involved crashes respective.

Enhanced motorisation and exposure (Smeed, 1949) risk more road accidents in 6am to 9pm, urban districts, April through September and daylight while improved driving and crash speed (Nilsson, 1982; Nilsson, 1997) lead to higher risk of crash involvement and injury in Saturdays, October through March, month-mid, straight road, rural area, bitumen surface, good/fair condition, hit and run and dry weather, and because of lack of many and good quality sidewalks, crosswalks, paths and bicycle lanes (Litman, Steele & Victoria Transport Policy Institute, 2009), traffic mix with high speed traffic increase risk of casualty in unprotected road users (Tiwari, Mohan & Fazio, 1998). Speed of vehicle is at the core of safety problems in animal and obstructions worse driving above speed limit risk extra crashes and injuries (Ashton & Mackay, 1983; de Langen et al., 2006; McLean & Kloeden, 2002; Nilsson, 1982; Nilsson, 1997; Pasanen, 1991).

Reduced traffic in rural, weekend days, October through March and month-mid improve mean free, driving and crash speed similarly better road factors in straight road, bitumen surface, good/fair condition and dry weather allow more driving and crash speed while more economic activities in urban districts and April through September increase motorisation and exposure. October through March is a planting season and economic activities as well as national and household income, and travelling decline but improve in April to September because of increased market of farm produce.

The statistical relationship with crash severity is significant in time ($\rho = 0.00 < 0.05$), districts ($\rho = 0.000 < 0.05$), accident type ($\rho = 0.000 < 0.05$), road geometry ($\rho = 0.000 < 0.05$), surrounding ($\rho = 0.000 < 0.05$), other factors ($\rho = 0.000 < 0.05$), speed ($\rho = 0.039 < 0.05$) and light condition ($\rho = 0.00 < 0.05$) thus risk is greater than normal in above stated safety factors. While, not statistically significant in weekdays ($\rho = 0.090 > 0.05$), month ($\rho = 0.453 > 0.05$), month time ($\rho = 0.803 > 0.05$), surface type ($\rho = 0.480 > 0.05$), road condition ($\rho=0.263 > 0.05$), weather ($\rho = 0.137 > 0.05$), animals ($\rho = 0.067 > 0.05$) and obstructions ($\rho = 0.795 > 0.05$ therefore threat is standard in the later variables.

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Table 4.2.2A: Relationship between Co-factors of Time and Severity

Co-factor	Factor (Time)	6am-9am	9am-12pm	12pm-3pm	3pm-6pm	6pm-9pm	9pm-12am	12am-3am	3am-6am
Day	Crash & Fatal Top in	Crash: Thursday (18.4%) Fatal: Saturday (16.8%)	Saturday (19.0%; 22.7%)	Saturday (17.1%; 19.1%)	Crash: Sunday (17.9%) Fatal: Saturday (18.8%)	Sunday (16.7%; 18.7%)	Crash: Saturday (19.4%) Fatal: Friday (20.0%)	Sunday (25.0%; 24.5%) Saturday (17.4%; 24.5%)	Crash: Sunday /Wednesday/Thursday (15.5%) Fatal: Friday (20.0%)
	ρ-value	0.946	0.635	0.551	0.110	0.930	0.711	0.496	0.466
Month Time	Crash & Fatal Top in	Mid (39.4%; 41.1%)	Mid (37.5%; 40.0%)	Mid (37.9%; 43.4%)	End (35.2%; 35.9%)	Crash: Mid/ End (35.1%) Fatal: Mid (35.3%)	Crash: Mid (37.9%) Fatal: End (43.3%)	End (37.0%; 36.7%)	Mid (44.0%; 42.9%)
	ρ-value	0.892	0.790	0.202	0.780	0.076	0.247	0.986	0.259
Accident Type	Crash & Fatal Top in	mv/ped (40.8%; 53.7%)	mv/ped (42.1%; 50.0%)	mv/ped (46.0%; 50.0%)	mv/ped (45.7%; 47.9%)	mv/ped (46.3%; 56.7%)	mv/ped (46.0%; 58.3%)	mv/ped (37.0%; 55.1%)	mv/ped (17.9%; 25.7%)
	ρ-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Road Geometry	Crash & Fatal Top in	Straight (74.0%; 75.8%)	Straight (70.8%; 69.1%)	Straight (73.6%; 80.9%)	Straight (72.2%; 74.0%)	Straight (77.2%; 80.7%)	Straight (77.4%; 80.0%)	Straight (73.9%; 71.4%)	Straight (61.9%; 62.9%)
	ρ-value	0.026	0.736	0.024	0.049	0.006	0.125	0.724	0.145

Reference is made to Table 4.2.2A for findings and their discussions explained just below.

During 6am to 9am, crashes (18.4%) peak in Thursdays while fatal (16.8%) in Saturdays. High motorisation and exposure (Smeed, 1949) with improved mean free and driving speed (Nilsson, 1982; Nilsson, 1997) lead to higher risk of crash involvement in Thursdays while greater mean free, driving and crash speed (Nilsson, 1982; Nilsson, 1997) is at the core of road safety problems in Saturdays. Traffic is normally slightly less in Thursdays and more reduced in weekend days.

The relationship between weekdays and severity is not statistically significant (ρ = 0.946 > 0.05) therefore threat is standard in all weekdays during 6am to 9am.

Crash and fatal incidents peak in Saturdays in 9am to 12pm (19.0%; 22.7%) and 12pm to 3pm (17.1%; 19.1%). Because of reduced traffic, more allowed driving and crash speed (Nilsson, 1982; Nilsson, 1997) with notable alcohol risk (Compton et al., 2002; Elvic & Vaa, 2004; Moskowitz et al., 2002; World Bank & WHO, 2004) is at the core of crash and injury problems.

The relationship between weekdays and severity is not statistically significant in 9am to 12pm (ρ = 0.635 > 0.05) and 12pm to 3pm (ρ = 0.551 > 0.05) hence threat is normal in all weekdays in 9am to 3pm.

In 3pm to 6pm, crashes (17.9%) lead in Sundays while fatal (18.8%) in Saturdays. Reduced traffic in weekend days improve mean free, driving and crash speed too risk of road accidents (Nilsson, 1982; Nilsson, 1997) also drunken driving is a major risk factor (Compton et al., 2002; Elvic & Vaa, 2004; Moskowitz et al., 2002; World Bank & WHO, 2004).

The relationship between weekdays and severity is not statistically significant (ρ = 0.110 > 0.05) so risk is normal in all weekdays during 3pm to 6pm.

Crash (16.7%) and fatal (18.7%) involved in 6pm to 9pm lead in Sundays. Greater mean free, driving and crash speed risk more crashes and injuries (Nilsson, 1982; Nilsson, 1997).

The relationship between weekdays and severity is not statistically significant (ρ = 0.930 > 0.05) therefore peril is ordinary in all weekdays in 6pm to 9pm.

In 9pm to 12am, crash involvement (19.4%) peak in Saturdays while fatal (20.0%) in Fridays. Improved mean free, driving and crash speed (Nilsson, 1982; Nilsson, 1997) is at the core of crash problems in Saturdays while more drunken driving (Compton et al., 2002; Elvic & Vaa, 2004; Moskowitz et al., 2002; World Bank & WHO, 2004) and fatigue (World Bank & WHO, 2004) lead to higher fatality in Friday nights.

The relationship between weekdays and severity is not statistically significant (ρ = 0.711 > 0.05) so peril is regular in all weekdays in 9pm to 12am.

During 12am to 3am, crashes (25.0%) peak in Sundays while fatal in Sundays (24.5%) and Saturdays (24.5%). Greater mean free, driving and crash speed (Nilsson, 1982; Nilsson, 1997) along with significant drunken driving (Compton et al., 2002; Elvic & Vaa, 2004; Moskowitz et al., 2002; World Bank & WHO, 2004) and fatigue (World Bank & WHO, 2004) risk more crashes and injuries in weekend nights.

The relationship between weekdays and severity is not statistically significant ($\rho = 0.496 > 0.05$) thus hazard is ordinary in all weekdays within 12am to 3am.

Within 3am to 6am, crashes lead in Sundays (15.5%), Wednesdays (15.5%) and Thursdays (15.5%) while fatal (20.0%) in Fridays. Growing motorisation and exposure (Smeed, 1949), improved mean free, driving and crash speed (Nilsson, 1982; Nilsson, 1997) and fatigue (World Bank & WHO, 2004) lead to poor road safety in the early hours of most weekdays.

The relationship between days and severity is not statistically significant ($\rho = 0.466 > 0.05$) so hazard is normal in all weekdays in 3am to 6am.

Crash and fatal lead in month-mid in 6am to 9am (39.4%; 41.1%), 9am to 12pm (37.5%; 40.0%), 12pm to 3pm (37.9%; 43.4%) and 3am to 6am (44.0%; 42.9%). Reduced traffic improve mean free, driving and crash speed as well as risk to road accidents (Nilsson, 1982; Nilsson, 1997).

The relationship between month time and severity is not statistically significant in 6am to 9am ($\rho = 0.892 > 0.05$), 9am to 12pm ($\rho = 0.790 > 0.05$), 12pm to 3pm ($\rho = 0.202 > 0.05$) and 3am to 6am ($\rho = 0.259 > 0.05$) so peril is regular in all month times in 6am to 6pm.

Crash and fatal incidents peak in month-end during 3pm to 6pm (35.2%; 35.9%) and 12am to 3am (37.0%; 36.7%). Improved motorisation and exposure (Smeed, 1949) and alcohol risk (Compton et al., 2002; Elvic & Vaa, 2004; Moskowitz et al., 2002; World Bank & WHO, 2004) generally are major safety problems in month-end however more allowed driving and crash speed (Nilsson, 1982; Nilsson, 1997), drunken driving (Compton et al., 2002; Elvic & Vaa, 2004; Moskowitz et al., 2002; World Bank & WHO, 2004) and fatigue (World Bank & WHO, 2004) lead to higher risk of crash and injury in 12am to 3am.

The relationship between month time and severity is not statistically significant in 3pm to 6pm (ρ = 0.780 > 0.05) and 12am to 3am (ρ = 0.986 > 0.05) therefore threat is classic in all month times in 3pm to 6pm and 12am to 3am.

Within 6pm to 9pm, crashes peak in month-mid (35.1%) and month-ends (35.1%) while fatal (35.3%) in month-mid. More allowed driving and crash speed (Nilsson, 1982; Nilsson, 1997) risk more crashes and injuries in month-mid while improved motorisation and exposure (Smeed, 1949) lead to higher risk of crash involvement in month-end.

The relationship between month time and severity is not statistically significant (ρ = 0.076 > 0.05) so risk is standard in all month times during 6pm to 9pm.

During 9pm to 12am, crashes (37.9%) lead in month-mid while fatal (43.3%) in month-ends. More allowed driving and crash speed (Nilsson, 1982; Nilsson, 1997) is at the core of crash problems in month-mid while improved motorisation and exposure (Smeed, 1949) and enhanced drunken driving (Compton et al., 2002; Elvic & Vaa, 2004; Moskowitz et al., 2002; World Bank & WHO, 2004) risk extra fatal incidents in month-end.

The relationship between month time and severity is not statistically significant (ρ = 0.247 > 0.05) thus peril is normal in all month times during 9pm to 12am.

Crash and fatal peak in mv/pedestrian collisions in 6am to 9am (40.8%; 53.7%), 9am to 12pm (42.1%; 50.0%), 12pm to 3pm (46.0%; 50.0%), 3pm to 6pm (45.7%; 47.9%), 6pm to 9pm (46.3%; 56.7%), 9pm to 12am (46.0%; 58.3%), 12am to 3am (37.0%; 55.1%) and 3am to 6am (17.9%; 25.7%).

Traffic mix with high speed traffic (Tiwari, Mohan & Fazio, 1998), lack of retro-reflective equipment at night (European Transport Safety Council, 2000; World Bank & WHO, 2004) and alcohol risk (Clayton, Colgan & Tunbridge, 2000; WHO, 2004) lead to more casualties in unprotected road users. Though speed of the vehicle is low in traffic peak hours (6am to 9am and 3pm to 6pm), casualty in pedestrians remain high as they have less chance of surviving impacts even at lower crash speed (Ashton & Mackay, 1983; Pasanen, 1991).

The relationship between accident type and severity is statistically significant in 6am to 9am ($\rho = 0.00 < 0.05$), 9am to 12pm ($\rho = 0.00 < 0.05$), 12pm to 3pm ($\rho = 0.00 < 0.05$), 3pm to 6pm ($\rho = 0.00 < 0.05$), 6pm to 9pm ($\rho = 0.00 < 0.05$), 9pm to 12am ($\rho = 0.00 < 0.05$), 12am to 3am ($\rho = 0.00 < 0.05$) and 3am to 6am ($\rho = 0.00 < 0.05$) thus threat varies with accident type or other collision types have greater risk of crash involvement and injury in all periods.

Crash and fatal lead in straight road in 6am to 9am (74.0%; 75.8%), 9am to 12pm (70.8%; 69.1%), 12pm to 3pm (73.6%; 80.9%), 3pm to 6pm (72.2%; 74.0%), 6pm to 9pm, (77.2%; 80.7%), 9pm to 12am (77.4%; 80.0%), 12am to 3am (73.9%; 71.4%) and 3am to 6am (61.9%; 62.9%). Improved driving and crash speed is at the hub of crash and injury problems (Nilsson, 1982; Nilsson, 1997).

The relationship between road geometry and severity is statistically significant in 6am to 9am ($\rho = 0.026 < 0.05$), 12pm to 3pm ($\rho = 0.024 < 0.05$), 3pm to 6pm ($\rho = 0.049 < 0.05$) and 6pm to 9pm ($\rho = 0.006 < 0.05$) while not statistically significant in 9am to 12pm ($\rho = 0.736 > 0.05$), 9pm to 12am ($\rho = 0.125 > 0.05$), 12am to 3am ($\rho = 0.724 > 0.05$) and 3am to 6am ($\rho = 0.145 > 0.05$) so risk changes with road geometry in 6am to 9am and 12pm to 9pm while normal in 9am to 12pm and 9pm to 6am.

Table 4.2.2B: Relationship between Co-factors of Time and Severity – Continued

Co-factor	Factor (Time)	6am-9am	9am-12pm	12pm-3pm	3pm-6pm	6pm-9pm	9pm-12am	12am-3am	3am-6am
Surrounding	**Crash & Fatal Top in**	**Crash: Urban (50.3%)** **Fatal: Rural (56.8%)**	**Rural (46.6%; 63.6%)**	**Rural (52.3%; 64.0%)**	**Rural (47.0%; 61.5%)**	**Rural (50.9%; 67.4%)**	**Rural (53.2%; 65.0%)**	**Rural (55.4%; 77.5%)**	**Rural (63.1%; 77.1%)**
	ρ-value	**0.037**	**0.000**	**0.000**	**0.000**	**0.000**	**0.061**	**0.018**	**0.032**
Surface Type	**Crash & Fatal Top in**	**Bitumen (91.6%; 93.7%)**	**Bitumen (90.3%; 89.1%)**	**Bitumen (89.5%; 89.7%)**	**Bitumen (90.8%; 87.0%)**	**Bitumen (94.5%; 95.7%)**	**Bitumen (94.4%; 95.0%)**	**Bitumen (98.9%; 100.0%)**	**Bitumen (92.9%; 88.6%)**
	ρ-value	**0.427**	**0.297**	**0.524**	**0.005**	**0.441**	**0.514**	**0.303**	**0.523**
Road Condition	**Crash & Fatal Top in**	**Good (98.3%; 97.9%)**	**Good (97.6%; 98.2%)**	**Good (96.3%; 97.1%)**	**Good (96.7%; 96.4%)**	**Good (97.8%; 98.4%)**	**Good (97.6%; 100.0%)**	**Good (100.0%; 100.0%)**	**Good (96.4%; 94.3%)**
	ρ-value	**0.827**	**0.384**	**0.440**	**0.346**	**0.284**	**0.091**	**-**	**0.304**

Findings and their discussions described just below refer to Table 4.2.2B.

Crashes (50.3%) lead in urban while fatal (56.8%) in rural in 6am to 9am but both peak in rural in 9am to 12pm (46.6%; 63.6%), 12pm to 3pm (52.3%; 64.0%), 3pm to 6pm (47.0%; 61.5%), 6pm to 9pm (50.9%; 67.4%), 9pm to 12am (53.2%; 65.0%), 12am to 3am (55.4%; 75.5%) and 3am to 6am (63.1%; 77.1%). Enhanced motorisation and exposure (Smeed, 1949) during 6am to 9am risk more crashes in urban while improved mean free, driving and crash speed (Nilsson, 1982; Nilsson, 1997) increase risk of crash and injury in rural.

The relationship between surrounding and severity is statistically significant in 6am to 9am ($\rho = 0.037 < 0.05$), 9am to 12pm ($\rho = 0.00 < 0.05$), 12pm to 3pm ($\rho = 0.00 < 0.05$), 3pm to 6pm ($\rho = 0.000 < 0.05$), 6pm to 9pm ‘($\rho = 0.00 < 0.05$), 12am to 3am ($\rho = 0.018 < 0.05$) and 3am to 6am ($\rho = 0.032 < 0.05$) but not statistically significant in 9pm to 12am ($\rho = 0.061 > 0.05$) so threat varies with surrounding in 6am to 6am except in 9pm to 12am when it is normal in all surroundings.

Crash and fatal occur most in bitumen surface in 6am to 9am (91.6%; 93.7%), 9am to 12pm (90.3%; 89.1%), 12pm to 3pm (89.5%; 89.7%), 3pm to 6pm (90.8%; 87.0%), 6pm to 9pm (94.5%; 95.7%), 9pm to 12am (94.4%; 95.0%), 12am to 3am (98.9%; 100.0%) and 3am to 6am (92.9%; 88.6%). More allowed driving and crash speed (Nilsson, 1982; Nilsson, 1997) with improved motorisation and exposure (Smeed, 1949) is at the core of crash and injury problems.

The relationship between surface type and severity is not statistically significant in 6am to 9am ($\rho = 0.427 > 0.05$), 9am to 12pm ($\rho = 0.297 > 0.05$), 12pm to 3pm ($\rho = 0.524 > 0.05$), 6pm to 9pm ($\rho = 0.441 > 0.05$), 9pm to 12am ($\rho = 0.514 > 0.05$), 12am to 3am ($\rho = 0.303 > 0.05$) and 3am to 6am ($\rho = 0.523 > 0.05$) while statistically significant during 3pm to 6pm ($\rho = 0.005 < 0.05$) thus risk is normal in all surface types in 6am to 6am except in 3pm to 6pm when it varies with surface type or risk is greater in other surface types during 3pm to 6pm.

Crash and fatal occur most in good/fair condition in 6am to 9am (98.3%; 97.9%), 9am to 12pm (97.6%; 98.2%), 12pm to 3pm (96.3%; 97.1%), 3pm to 6pm (96.7%; 96.4%), 6pm to 9pm (97.8%; 98.4%), 9pm to 12am (97.6%; 100.0%), 12am to 3am (100.0%; 100.0%) and 3am to 6am (96.4%; 94.3%). More allowed driving and crash speed (Nilsson, 1982; Nilsson, 1997) with improved motorisation and exposure (Smeed, 1949) risk more crashes and injuries.

The relationship between road condition and severity is not statistically significant in 6am to 9am ($\rho = 0.827 > 0.05$), 9am to 12pm ($\rho = 0.384 > 0.05$), 12pm to 3pm ($\rho = 0.440 > 0.05$), 3pm to 6pm ($\rho = 0.346 > 0.05$), 6pm to 9pm ($\rho = 0.284 > 0.05$), 9pm to 12am ($\rho = 0.091 > 0.05$) and 3am to 6am ($\rho = 0.304 > 0.05$) therefore threat is standard in all road conditions in 6am to 6am.

Table 4.2.2C: Relationship between Co-factors of Time and Severity - Continued

Co-factor	**Factor (Time)**	**6am-9am**	**9am-12pm**	**12pm-3pm**	**3pm-6pm**	**6pm-9pm**	**9pm-12am**	**12am-3am**	**3am-6am**
Wea-ther	**Crash & Fatal Top in**	**Dry (98.9%; 100.0%)**	**Dry (99.7%; 99.1%)**	**Dry (99.8%; 100.0%)**	**Dry (98.4%; 96.9%)**	**Dry (98.9%; 98.4%)**	**Dry (98.3%; 98.4%)**	**Dry (98.9%; 100.0%)**	**Dry (98.8%; 100.0%)**
	ρ-value	**0.701**	**0. 494**	**0.419**	**0.026**	**0.470**	**0.423**	**0.216**	**0.025**
Other Fact-ors	**Crash & Fatal Top in**	**Hit & run (1)**	**Hit & run (1.1%; 0.9%)**	**Hit & run (2.2%; 4.4%)**	**Hit & run (2.3%; 2.1%)**	**Hit & run (8.6%; 13.9%)**	**Hit &run (12.1%; 18.3%)**	**Hit & run (17.4%; 28.6%)**	**Hit & run (7.1%; 11.4%)**
	ρ-value	**0.699**	**0.089**	**0.156**	**0.378**	**0.021**	**0.100**	**0.018**	**0.567**
Spe-ed	**Crash & Fatal Top in**	**Over limit (91.3%; 91.6%)**	**Over limit (95.2%; 95.5%)**	**Over limit (95.1%; 97.1%)**	**Over limit (93.1%; 92.2%)**	**Over limit (94.7%; 95.2%)**	**Over limit (96.8%; 98.3%)**	**Over limit (91.3%; 91.8%)**	**Over limit (92.9%; 94.3%)**
	ρ-value	**0.900**	**0.066**	**0.385**	**0.830**	**0.003**	**0.188**	**0.624**	**0.853**

Results and their discussions illustrated just below refer to Table 4.2.2C.

Crash and fatal occur most in dry weather in 6am to 9am (98.9%; 100.0%), 3pm to 6pm (98.4%; 96.9%), 6pm to 9pm (98.9%; 98.4%), 9pm to 12am (98.3%; 98.4%), 12am to 3am (98.9%; 100.0%) and 3am to 6am (98.8%; 100.0%) while only in dry weather in 9am to 12pm (99.7%; 99.1%) and 12pm to 3pm (99.8%; 100.0%). Improved driving and crash speed is a major safety problem (Nilsson, 1982; Nilsson, 1997). Clear visibility and good traction in dry weather attract higher driving speed.

The relationship between weather and severity is not statistically significant in 6am to 9am ($\rho = 0.701 > 0.05$), 9am to 12pm (ρ = 0. 494 > 0.05), 12pm to 3pm ($\rho = 0.419 > 0.05$), 6pm to 9pm ($\rho = 0.470 > 0.05$, 9pm to 12am ($\rho = 0.423 > 0.05$), 12am to 3am ($\rho=0.216 > 0.05$) while statistically significant in 3pm to 6pm ($\rho = 0.026 < 0.05$) and 3am to 6am ($\rho = 0.025 < 0.05$) thus hazard is normal in all weather in 6am to 3pm and 6pm to 3am but changes with weather during 3pm to 6pm and 3am to 6am.

Only hit and run crash happened in 6am to 9am likewise only hit and run crash and fatal incidents were involved in 12pm to 3pm (2.2%; 4.4%), 9pm to 12am (12.1%; 18.3%), 12am to

3am (17.4%; 28.6%) and 3am to 6am (7.1%; 11.4%) besides they lead in 9am to 12pm (1.1%; 0.9%), 3pm to 6pm (2.3%; 2.1%) and 6pm to 9pm (8.6%; 13.9%). Speed of vehicle is at the core of hit and run crash and injury problems (Nilsson, 1982; Nilsson, 1997).

The relationship between other factors and accident severity is not statistically significant in 6am to 9am ($\rho = 0.699 > 0.05$), 9am to 12pm ($\rho = 0.089 > 0.05$), 12pm to 3pm ($\rho = 0.156 > 0.05$), 3pm to 6pm ($\rho = 0.378 > 0.05$), 9pm to 12am ($\rho = 0.100 > 0.05$) and 3am to 6am ($\rho = 0.567 > 0.05$) but statistically significant in 6pm to 9pm ($\rho = 0.021 < 0.05$) and 12am to 3am ($\rho = 0.018 < 0.05$). Thus, hazard is normal in all other factors in 6am to 6am except in 6pm to 9pm and 12am to 3am when it varies with other factors or risk is greater in other factors.

Crash and fatal occur most in above legal speed limit in 6am to 9am (91.3%; 91.6%), 9am to 12pm (95.2%; 95.5%), 12pm to 3pm (95.1%; 97.1%), 3pm to 6pm (93.1%; 92.2%), 6pm to 9pm (94.7%; 95.2%), 9pm to 12am (96.8%; 98.3%), 12am to 3am (91.3%; 91.8%) and 3am to 6am (92.9%; 94.3%). Higher the driving speed, less marginal for taking action to avoid accident also more likely a high collision speed and the accident becomes more severe (de Langen et al., 2006; Svensson, 2007).

The relationship between speed and severity is not statistically significant in 6am to 9am ($\rho = 0.900 > 0.05$), 9am to 12pm ($\rho = 0.066 > 0.05$), 12pm to 3pm ($\rho = 0.385 > 0.05$), 3pm to 6pm ($\rho = 0.830 > 0.05$), 9pm to 12am ($\rho = 0.188 > 0.05$), 12am to 3am ($\rho = 0.624 > 0.05$), and 3am to 6am ($\rho = 0.853 > 0.05$) while statistically significant during 6pm to 9pm ($\rho = 0.003 < 0.05$). So, risk is regular in all speeds in 6am to 6am except in 6pm to 9pm when it changes with speed or speed risk is more in 6pm to 9pm.

Table 4.2.3A: Relationship between Co-factors of Day and Severity

Co-factor	Factor (Day)	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Month Time	**Crash & Fatal Top in**	**Mid (39.3%; 37.1%)**	**Mid (37.5%; 40.7%)**	**Crash: End (36.8%)** **Fatal: Mid (38.0%)**	**Crash: Mid (36.3%)** **Fatal: Start (42.6%)**	**Mid (36.5%; 38.7%)**	**Crash: Mid (37.2%)** **Fatal: End (38.2%)**	**Mid (36.7%; 38.4%)**
	ρ-value	**0.836**	**0.946**	**0.610**	**0.114**	**0.586**	**0.884**	**0.647**
Accident Type	**Crash & Fatal Top in**	**mv/ped (45.6%; 55.0%)**	**mv/ped (43.8%; 52.7%)**	**mv/ped (41.9%; 50.9%)**	**mv/ped (45.0%; 49.5%)**	**mv/ped (42.3%; 52.4%)**	**mv/ped (39.5%; 48.5%)**	**mv/ped (45.3%; 50.0%)**
	ρ-value	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Road Geometry	**Crash & Fatal Top in**	**Straight (73.1%; 73.6%)**	**Straight (72.6%; 70.3%)**	**Straight (74.3%; 77.8%)**	**Straight (74.0%; 77.2%)**	**Straight (74.6%; 78.2%)**	**Straight (72.4%; 72.8%)**	**Straight (74.9%; 79.9%)**
	ρ-value	**0.019**	**0.474**	**0.036**	**0.001**	**0.022**	**0.787**	**0.018**
Surrounding	**Crash & Fatal Top in**	**Rural (52.8%; 68.6%)**	**Crash: Urban (46.7%)** **Fatal: Rural (56.0%)**	**Rural (51.8%; 68.5%)**	**Rural (47.3%; 59.4%)**	**Crash: Urban (48.3%)** **Fatal: Rural (68.5%)**	**Rural (52.2%; 63.2%)**	**Rural (47.3%; 64.6%)**
	ρ-value	**0.000**	**0.020**	**0.002**	**0.027**	**0.000**	**0.054**	**0.000**

Findings and their discussions expressed just below refer to Table 4.2.3A.

Crash and fatal lead in month-mid in Sundays (39.3%; 37.1), Mondays (37.5%; 40.7%), Thursdays (36.5%; 38.7%) and Saturdays (36.7%; 38.4%) while crashes peak in month-end in Tuesdays (36.8%), in month-mid in Wednesdays (36.3%) and in month-end in Fridays (38.2%) but fatal top in month-mid in Tuesdays (38.0%), in month-start in Wednesdays (42.6%) and in month-end in Fridays (38.2%).

Lesser traffic in month-mid improve driving and crash speed too risk of crash and injury (Nilsson, 1982; Nilsson, 1997) while increased motorisation and exposure (Smeed, 1949) risk more crashes in month-end and month-start, and drunken driving (Compton et al., 2002; Elvic &

Vaa, 2004; Moskowitz et al., 2002; World Bank & WHO, 2004) believed a core safety problem in Fridays of month-end.

The relationship between month time and severity is not statistically significant in Sundays ($\rho = 0.836 > 0.05$), Mondays ($\rho = 0.946 > 0.05$), Tuesdays ($\rho = 0.610 > 0.05$), Wednesdays ($\rho = 0.114 > 0.05$), Thursdays ($\rho = 0.586 > 0.05$), Fridays ($\rho = 0.884 > 0.05$) and Saturdays ($\rho = 0.647 > 0.05$) so hazard is normal in all month times in each and every weekday.

Crash and fatal occurrence lead in mv/pedestrian collisions in Sundays (45.6%; 55.0%), Mondays (43.8%; 52.7%), Tuesdays (41.9%; 50.9%), Wednesdays (45.0%; 49.5%), Thursdays (42.3%; 52.4%), Fridays (39.5%; 48.5%) and Saturdays (45.3%; 50.0%). Traffic mix with high speed traffic is a daily core safety problem in on-foot and pedal road users (Tiwari, Mohan & Fazio, 1998).

The relationship between accident type and severity is statistically significant in Sundays ($\rho = 0.000 < 0.05$), Mondays ($\rho = 0.000 < 0.05$), Tuesdays ($\rho = 0.000 < 0.05$), Wednesdays ($\rho = 0.000 < 0.05$), Thursdays ($\rho = 0.000 < 0.05$), Fridays ($\rho = 0.000 < 0.05$) and Saturdays ($\rho = 0.000 < 0.05$) thus peril changes with collision type in each and every weekday or risk is greater in other accident types.

Crash and fatal peak in straight road in Sundays (73.1%; 73.6%), Mondays (72.6%; 70.3%), Tuesdays (74.3%; 77.8%), Wednesdays (74.0%; 77.2%), Thursdays (74.6%; 78.2%), Fridays (72.4%; 72.8%) and Saturdays (74.9%; 79.9%). More allowed driving and crash speed risk more crashes and injuries (Nilsson, 1982; Nilsson, 1997).

The relationship between road geometry and severity is statistically significant in Sundays ($\rho = 0.019 < 0.05$), Tuesdays ($\rho = 0.036 < 0.05$), Wednesdays ($\rho = 0.001 < 0.05$), Thursdays ($\rho = 0.022 < 0.05$) and Saturdays ($\rho = 0.018 < 0.05$) while not statistically significant in Mondays ($\rho = 0.474 > 0.05$) and Fridays ($\rho = 0.787 > 0.05$). Therefore, risk varies with road geometry in each and every weekday except in Mondays and Fridays when it is normal in all road geometry.

Crash and fatal lead in rural in Sundays (52.8%; 68.6%), Tuesdays (51.8%; 68.5%), Wednesdays (47.3%; 59.4%), Fridays (52.2%; 63.2%) and Saturdays (47.3%; 64.6%) while crashes peak in urban in Mondays (46.7%) and Thursdays (48.3%) but fatal top in rural in Mondays (56.0%) and Thursdays (68.5%). Improved mean free, driving and crash speed (Nilsson, 1982; Nilsson, 1997) is at the core of crash and injury problems in rural while enhanced motorisation and exposure (Smeed, 1949) risk more crashes in urban.

The relationship between surrounding and severity is statistically significant in Sundays ($\rho = 0.000 < 0.05$), Mondays ($\rho = 0.020 < 0.05$), Tuesday ($\rho = 0.002 < 0.05$), Wednesdays ($\rho = 0.027 < 0.05$), Thursdays ($\rho = 0.000 < 0.05$) and Saturdays ($\rho = 0.000 < 0.05$) while not statistically significant in Fridays ($\rho = 0.054 > 0.05$) so risk varies with surrounding in each and every weekday except in Fridays when it is ordinary in all surroundings.

Table 4.2.3B: Relationship between Co-factors of Day and Severity – Continued

Co-factor	Factor (Day)	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Surface Type	**Crash & Fatal Top in**	**Bitumen (94.2%; 94.3%)**	**Bitumen (90.5%; 90.1%)**	**Bitumen (93.4%; 94.4%)**	**Bitumen (90.3%; 93.1%)**	**Bitumen (92.3%; 88.7%)**	**Bitumen (91.0%; 91.2%)**	**Bitumen (91.1%; 90.2%)**
	ρ-value	**0.678**	**0.377**	**0.739**	**0.093**	**0.267**	**0.425**	**0.105**
Road Condition	**Crash & Fatal Top in**	**Good (97.1%; 97.1%)**	**Good (95.3%; 95.6%)**	**Good (99.1%; 100.0%)**	**Good (97.7%; 98.0%)**	**Good (97.2%; 97.6%)**	**Good (97.2%; 96.3%)**	**Good (98.0%; 98.8%)**
	ρ-value	**0.812**	**0.797**	**0.872**	**0.436**	**0.507**	**0.377**	**0.669**
Weather	**Crash & Fatal Top in**	**Dry (99.7%; 100%)**	**Dry (98.7%; 96.7%)**	**Dry (99.7%; 99.1%)**	**Dry (99.7%; 100.0%)**	**Dry (98.6%; 99.2%)**	**Dry (98.2%; 97.8%)**	**Dry (98.7%; 98.2%)**
	ρ-value	**0.482**	**0.254**	**0.718**	**0.029**	**0.502**	**0.267**	**0.613**
Other Factors	**Crash & Fatal Top in**	**Hit & run (5.3%; 9.3%)**	**Hit & run (2.2%; 6.6%)**	**Hit & run (2.7%; 6.5%)**	**Hit & run (5.0%; 7.9%)**	**Hit & run (5.2%; 9.7%)**	**Hit & run (3.1%; 4.4%)**	**Hit & run (5.3%; 8.5%)**
	ρ-value	**0.153**	**0.020**	**0.065**	**0.181**	**0.034**	**0.160**	**0.010**

Results and their discussions stated just below refer to Table 4.2.3B.

Crash and fatal occur most in bitumen surface in Sundays (94.2%; 94.3%), Mondays (90.5%; 90.1%), Tuesdays (93.4%; 94.4%), Wednesdays (90.3%; 93.1%), Thursdays (92.3%; 88.7%), Fridays (91.0%; 91.2%) and Saturdays (91.1%; 90.2%). More allowed driving and crash speed (Nilsson, 1982; Nilsson, 1997) with improved motorisation and exposure (Smeed, 1949) risk more crashes and injuries.

The relationship between surface type and severity is not statistically significant in Sundays ($\rho = 0.678 > 0.05$), Mondays ($\rho = 0.377 > 0.05$), Tuesdays ($\rho = 0.739 > 0.05$), Wednesdays ($\rho = 0.093 > 0.05$), Thursdays ($\rho = 0.267 > 0.05$), Fridays ($\rho = 0.425 > 0.05$) and Saturdays ($\rho = 0.105 > 0.05$) thus hazard is normal in all surface types in each and every weekday.

Crash and fatal occur most in good/fair condition in Sundays (97.1%; 97.1%), Mondays (95.3%; 95.6%), Tuesdays (99.1%; 100.0%), Wednesdays (97.7%; 98.0%), Thursdays (97.2%; 97.6%), Fridays (97.2%; 96.3%) and Saturdays (98.0%; 98.8%). More allowed driving and crash speed (Nilsson, 1982; Nilsson, 1997) with improved motorisation and exposure (Smeed, 1949) lead to higher risk of road accidents.

The relationship between road condition and severity is not statistically significant in Sundays ($\rho = 0.812 > 0.05$), Mondays ($\rho = 0.797 > 0.05$), Tuesdays ($\rho = 0.872 > 0.05$), Wednesdays ($\rho = 0.436 > 0.05$), Thursdays ($\rho = 0.507 > 0.05$), Fridays ($\rho = 0.377 > 0.05$) and Saturdays ($\rho = 0.669 > 0.05$) so peril is standard in all road conditions in each and every weekday.

Crash and fatal occur only in dry weather in Sundays (99.7%; 100.0%) while most in dry weather in Mondays (98.7%; 96.7%), Tuesdays (99.7%; 99.1%), Wednesdays (99.7%; 100.0%), Thursdays (98.6%; 99.2%), Fridays (98.2%; 97.8%) and Saturdays (98.7%; 98.2%). Clear visibility and better tyre grip in dry weather attract higher driving speed therefore improved driving and crash speed is a core safety problem (Nilsson, 1982; Nilsson, 1997).

The relationship between weather and severity is not statistically significant in Sundays ($\rho = 0.482 > 0.05$), Mondays ($\rho = 0.254 > 0.05$), Tuesdays ($\rho = 0.718 > 0.05$), Thursdays ($\rho = 0.502 > 0.05$), Fridays ($\rho = 0.267 > 0.05$) and Saturdays ($\rho = 0.613 > 0.05$) while statistically significant in Wednesdays (ρ = 0.029 < 0.05). So, threat is ordinary in all weather in each and every weekday except in Wednesdays when it changes with weather.

Hit and run crash and fatal incidents lead in Sundays (5.3%; 9.3%), Fridays (3.1%; 4.4%) and Saturdays (5.3%; 8.5%) while only hit and run crash and fatal incidents in Mondays (2.2%; 6.6%), Tuesdays (2.7%; 6.5%), Wednesdays (5.0%; 7.9%) and Thursdays (5.2%; 9.7%). More allowed driving and crash speed (Nilsson, 1982; Nilsson, 1997) in weekend days, and enhanced motorisation and exposure (Smeed, 1949) along with dense traffic mix with high speed traffic (Tiwari, Mohan & Fazio, 1998) in working days are core safety problems of hit and run.

The relationship between other factors and severity is not statistically significant in Sundays (ρ = 0.153 > 0.05), Tuesdays (ρ = 0.065 > 0.05), Wednesdays (ρ = 0.181 > 0.05) and Fridays (ρ = 0.160 > 0.05) while statistically significant in Mondays (ρ = 0.020 < 0.05), Thursdays (ρ = 0.034 < 0.05) and Saturdays (ρ = 0.010 < 0.05). So, risk is normal in all other factors in each and every weekday except in Mondays, Thursdays and Saturdays when it varies with other factors.

Table 4.2.3C: Relationship between Co-factors of Day and Severity – Continued

Co-factor	Factor (Day)	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Animals	**Crash & Fatal Top in**	-	-	-	**Damages Only (1)**	-	-	-
	ρ-value				**0.029**			
Speed	**Crash & Fatal Top in**	**Over limit (93.1%; 92.9%)**	**Over limit (93.7%; 93.4%)**	**Over limit (95.8%; 96.3%)**	**Over limit (94.7%; 95.0%)**	**Over limit (93.4%; 94.4%)**	**Over limit (93.8%; 94.1%)**	**Over limit (93.2%; 95.1%)**
	ρ-value	**0.157**	**0.896**	**0.219**	**0.548**	**0.594**	**0.013**	**0.008**
Light Condition	**Crash & Fatal Top in**	**Daylight (65.0%; 58.6%)**	**Daylight (72.6%; 69.2%)**	**Daylight (69.5%; 60.2%)**	**Daylight (71.0%; 59.4%)**	**Daylight (69.1%; 64.5%)**	**Daylight (70.0%; 58.8%)**	**Daylight (70.1%; 63.8%)**
	ρ-value	**0.255**	**0.369**	**0.053**	**0.016**	**0.543**	**0.007**	**0.192**

Reference is made to Table 4.2.3C for findings and discussions expressed just below.

Animal stationary on road involved a damages only crash in Wednesday. Speed of vehicle is a core risk factor (Nilsson, 1982; Nilsson, 1997).

The relationship between animal and severity is statistically significant in Wednesday ($\rho = 0.029 < 0.05$) and so animal risk is greater in Wednesdays.

Crash and fatal occur most in above legal speed limit in Sundays (93.1%; 92.9%), Mondays (93.7%; 93.4%), Tuesdays (95.8%; 96.3%), Wednesdays (94.7%; 95.0%), Thursdays (93.4%; 94.4%), Fridays (93.8%; 94.1%) and Saturdays (93.2%; 95.1%). Driving over legal speed limit has greater risk of crash involvement and injury (Ashton & Mackay, 1983; de Langen et al., 2006; McLean & Kloeden, 2002; Pasanen, 1991; Svensson, 2007; World Bank and WHO, 2004).

The relationship between speed and severity is not statistically significant in Sundays ($\rho = 0.157 > 0.05$), Mondays ($\rho = 0.896 > 0.05$), Tuesdays ($\rho = 0.219 > 0.05$), Wednesdays ($\rho = 0.548 > 0.05$) and Thursdays ($\rho = 0.594 > 0.05$) while statistically significant in Fridays ($\rho = 0.013 < 0.05$) and Saturdays ($\rho = 0.008 < 0.05$). Then, risk is normal in all speeds in each and every weekday except in Fridays and Saturdays when it varies with speed.

Crash and fatal incidents peak in daylight in Sundays (65.0%; 58.6%), Mondays (72.6%; 69.2%), Tuesdays (69.5%; 60.2%), Wednesdays (71.0%; 59.4%), Thursdays (69.1%; 64.5%), Fridays (70.0%; 58.8%) and Saturdays (70.1%; 63.8%). Improved motorisation and exposure is at the core of crash and injury problems (Smeed, 1949).

The relationship between light condition and severity is not statistically significant in Sundays ($\rho = 0.255 > 0.05$), Mondays ($\rho = 0.369 > 0.05$), Tuesdays ($\rho = 0.053 > 0.05$), Thursdays ($\rho = 0.543 > 0.05$) and Saturdays ($\rho = 0.192 > 0.05$) while statistically significant in Wednesdays ($\rho = 0.016 < 0.05$) and Fridays ($\rho = 0.007 < 0.05$). Thus, risk is standard in all light conditions in each and every weekday except in Wednesdays and Fridays when it varies light condition.

Table 4.2.4A: Relationship between Co-factors of Accident Type and Severity

Co-factor	**Factor**	**mv/mv head on**	**mv/mv rear end**	**mv/mv side**	**mv/mv overtake**	**mv/mv turn**	**Single mv Rollover**	**Single mv crash**
Road Geometry	**Crash & Fatal Top in**	**Straight (70.0%; 57.1%)**	**Straight (64.3%; 71.4%)**	**Straight (61.6.0%; 66.7%)**	**Straight (74.0%; 100.0%)**	**Straight (61.1%; 100.0%)**	**Straight (60.6%; 57.7%)**	**Straight (57.5%; 61.5%)**
	ρ-value	**0.264**	**0.061**	**0.131**	**0.449**	**0.637**	**0.865**	**0.899**
Surrou-nding	**Crash & Fatal Top in**	**Rural (48.6%; 71.4%)**	**Urban (66.7%; 28.6%)** **Rural (27.1%; 57.1%)**	**Urban (55.2%; 50.0%)** **Rural (40.1%; 50.0%)**	**Urban (54.0%; 37.5%)**	**Urban (61.1%; 0.0%)** **Rural (22.2%; 100.0%)**	**Rural (73.9%; 85.6%)**	**Rural (59.4%; 80.8%)**
	ρ-value	**0.182**	**0.018**	**0.352**	**0.394**	**0.660**	**0.051**	**0.446**
Co-factor	**Factor**	**mv/pedestrian**	**mv/bicyclist**	**mv/controlled Animal**	**mv/uncontrolled Animal**	**mv/other**	**Bicycle/pedestrian**	**Bicycle/other**
Road Geometry	**Crash & Fatal Top in**	**Straight (82.5%; 82.4%)**	**Straight (74.4%; 75.0%)**	**Straight (100.0%; 100.0%)**	**Straight (66.7%; 0.0%)**	**Straight (61.9%; 74.5%)**	**Straight (100.0%; 100.0%)**	**Straight (60.0%; 50.0%)**
	ρ-value	**0.015**	**0.476**	**_**	**0.827**	**0.459**	**_**	**0.659**
Surrou-nding	**Crash & Fatal Top in**	**Urban (49.8%; 28.2%)** **Rural (40.2%; 57.1%)**	**Rural (58.7%; 68.0%)**	**Rural (100.0%; 100.0%)**	**Rural (83.3%; 0.0%)**	**Rural (62.7%; 74.5%)**	**Rural (50.0%; 33.3%)** **Urban (40.0; 33.3%)** **Peri-urban (10.0%; 33.3%)**	**Rural (60.0%; 75.0%)**
	ρ-value	**0.000**	**0.166**	**_**	**0.050**	**0.142**	**0.612**	**0.171**

Results and discussions described just below refer to Table 4.2.4A.

Crash and fatal lead in straight road in mv/mv head on (70.0%; 57.1%), mv/mv rear-end (64.3%; 71.4%), mv/mv side (61.6.0%; 66.7%), mv/mv overtake (74.0%; 100.0%), mv/mv turn (61.1%; 100.0%), single mv rollover (60.6%; 57.7%), single mv (57.5%; 61.5%), mv/pedestrian (82.5%; 82.4%), mv/bicyclist (74.4%; 75.0%), mv/controlled animal (100.0%; 100.0%), mv/uncontrolled animal (66.7%; 0.0%), mv/other (61.9%; 74.5%), bicycle/pedestrian (100.0%; 100.0%) and bicycle/other (60.0%; 50.0%) collisions. More allowed driving and crash speed is a major safety problem (Ashton & Mackay, 1983; de Langen et al., 2006; Nilsson, 1982; Nilsson, 1997; Pasanen, 1991; Svensson, 2007).

The relationship between road geometry and severity is not statistically significant in mv/mv head on ($\rho = 0.264 > 0.05$), mv/mv rear end ($\rho = 0.061 > 0.05$), mv/mv side ($\rho = 0.131 > 0.05$), mv/mv overtake ($\rho = 0.449 > 0.05$), mv/mv turn ($\rho = 0.637 > 0.05$), single mv rollover ($\rho = 0.865 > 0.05$), single mv ($\rho = 0.899 > 0.05$), mv/bicyclist ($\rho = 0.476 > 0.05$), mv/uncontrolled animal ($\rho = 0.827 > 0.05$), mv/other ($\rho = 0.459 > 0.05$ and bicycle/other ($\rho = 0.659 > 0.05$) collisions while statistically significant in mv/pedestrian crashes ($\rho = 0.015 < 0.05$). Thus, threat is standard in all road geometry in all collision types except in mv/pedestrian where it changes with road geometry or risk of mv/pedestrian collision is greater in some road geometry.

Crash and fatal lead in rural in mv/mv head on (48.6%; 71.4%), single mv rollover (73.9%; 85.6%), single mv (59.4%; 80.8%), mv/bicyclist (58.7%; 68.0%), mv/uncontrolled animal (83.3%; 0.0%), mv/other (62.7%; 74.5%), bicycle/other (60.0%; 75.0%) and mv/controlled animal (100.0%; 100.0%) accident types while peak in urban in mv/mv overtake collision (54.0%; 37.5%). In addition, crashes peak in urban while fatal in rural in mv/mv rear end (66.7%; 57.1%), mv/mv turn (61.1%; 100.0%), mv/pedestrian (49.8%; 57.1%) and mv/mv side (55.2%; 50.0%) collisions in contrast crashes (50.0%) peak in rural while fatal in rural (33.3%), peri-urban (33.3%) and urban (33.3%) in bicycle/pedestrian collision type.

Improved mean free, driving and crash speed (Ashton & Mackay, 1983; Nilsson, 1982; Nilsson, 1997; Pasanen, 1991) is a core safety problem in rural while enhanced motorisation and exposure (Smeed, 1949) along with traffic mix (Tiwari, Mohan & Fazio, 1998) risk more crashes in urban.

The relationship between surrounding and severity is not statistically significant in mv/mv head on ($\rho = 0.182 > 0.05$), mv/mv side ($\rho = 0.352 > 0.05$), mv/mv overtake ($\rho = 0.394 > 0.05$), mv/mv turn ($\rho = 0.660 > 0.05$), single mv rollover ($\rho = 0.051 > 0.05$), single mv ($\rho = 0.446 > 0.05$), mv/bicyclist ($\rho = 0.166 > 0.05$), mv/other ($\rho = 0.142 > 0.05$), bicycle/pedestrian ($\rho = 0.612 > 0.05$) and bicycle/other ($\rho = 0.171 > 0.05$) collisions while statistically significant in mv/mv rear end ($\rho = 0.018 < 0.05$), mv/pedestrian ($\rho = 0.000 < 0.05$) and mv/uncontrolled animal ($\rho = 0.050 = 0.05$) accident types. Thus, risk is normal in all surroundings in all collision types except in mv/mv rear end, mv/pedestrian and mv/uncontrolled animal where it varies with surrounding.

Table 4.2.4B: Relationship between Co-factors of Accident Type and Severity – Continued

Co-factor	Factor	mv/mv head on	mv/mv rear end	mv/mv side	mv/mv overtake	mv/mv turn	Single mv Rollover	Single mv crash
Surface Type	Crash & Fatal Top in	Bitumen (98.6%; 100.0%)	Bitumen (95.3%; 92.9%)	Bitumen (94.2%; 100.0%)	Bitumen (98.0%; 100.0%)	Bitumen (100.0%; 100.0%)	Bitumen (85.9%; 84.6%)	Bitumen (90.6%; 88.5%)
	ρ-value	0.331	0.953	0.986	0.497	_	0.031	0.172
Road Condition	Crash & Fatal Top in	Good (98.6%; 100.0%)	Good (98.4%; 100.0%)	Good (95.9%; 100.0%)	Good (100.0%; 100.0%)	Good (100.0%; 100.0%)	Good (95.4%; 94.2%)	Good (96.2%; 96.2%)
	ρ-value	0.331	0.975	0.186	_	_	0.255	0.287
Co-factor	Factor	mv/pedestrian	mv/bicyclist	mv/controlled Animal	mv/uncontrolled Animal	mv/other	Bicycle/ pedestrian	Bicycle/ other
Surface Type	Crash & Fatal Top in	Bitumen (94.3%; 94.6%)	Bitumen (91.1%; 94.8%)	Bitumen (50.0%; 0.0%) Earth (50.0%; 100.0%)	Bitumen (100.0%; 0.0%)	Bitumen (78.4%; 70.9%)	Bitumen (60.0%; 66.7%)	Bitumen (80.0%; 75.0%)
	ρ-value	0.522	0.107	0.157	_	0.002	0.827	0.576
Road Condition	Crash & Fatal Top in	Good (98.1%; 98.2%)	Good (97.3%; 98.8%)	Good (100.0%; 100.0%)	Good (100.0%; 0.0%)	Good (95.5%; 96.4%)	Good (100.0%; 100.0%)	Good (80.0%; 75.0%)
	ρ-value	0.631	0.346	_	_	0.449	_	0.576

Findings and discussions described just below refer to Table 4.2.4B.

Crash and fatal occur most in bitumen surface in mv/mv head on (98.6%; 100.0%), mv/mv rear end (95.3%; 92.9%), mv/mv side (94.2%; 100.0%), mv/mv overtake (98.0%; 100.0%), mv/mv turn (100.0%; 100.0%), single mv rollover (85.9%; 84.6%), single mv (90.6%; 88.5%), mv/pedestrian (94.3%; 94.6%), mv/bicyclist (91.1%; 94.8%), mv/uncontrolled animal (100.0%;

0.0%), mv/other (78.4%; 70.9%), bicycle/pedestrian (60.0%; 66.7%) and bicycle/other (80.0%; 75.0%) collisions. Besides, crashes peak in bitumen (50.0%) and earth (50.0%) surfaces while fatal in earth surface (100.0%) in mv/controlled animal. More allowed driving and crash speed (Ashton & Mackay, 1983; Nilsson, 1982; Nilsson, 1997; Pasanen, 1991) with improved motorisation and exposure (Smeed, 1949) risk more crashes and injuries in bitumen surface.

The relationship between surface type and severity is not statistically significant in mv/mv head on ($\rho = 0.331 > 0.05$), mv/mv rear end ($\rho = 0.953 > 0.05$), mv/mv side ($\rho = 0.986 > 0.05$), mv/mv overtake ($\rho = 0.497 > 0.05$), single mv ($\rho = 0.172 > 0.05$), mv/pedestrian ($\rho = 0.522 > 0.05$), mv/bicyclist ($\rho = 0.107 > 0.05$), mv/controlled animal ($\rho = 0.157 > 0.05$), bicycle/pedestrian ($\rho = 0.827 > 0.05$) and bicycle/other ($\rho = 0.576 > 0.05$) collisions while statistically significant in single mv rollover ($\rho = 0.031 < 0.05$) and mv/other ($\rho = 0.002 < 0.05$) accident types. So, risk is normal in all surface types in all collision types except in single mv rollover and mv/other where it varies with surface type.

Crash and fatal occur only in good/fair condition in mv/mv head on collision (98.6%; 100.0%) while most in good/fair condition in mv/mv rear end (98.4%; 100.0%), mv/mv side (95.9%; 100.0%), mv/mv overtake (100.0%; 100.0%), mv/mv turn (100.0%; 100.0%), single mv rollover (95.4%; 94.2%), single mv (96.2%; 96.2%), mv/pedestrian (98.1%; 98.2%), mv/bicyclist (97.3%; 98.8%), mv/controlled animal (100.0%; 100.0%), mv/uncontrolled animal (100.0%; 0.0%), mv/other (95.5%; 96.4%) and bicycle/pedestrian (100.0%; 100.0%) collisions, and peak in bicycle/other (80.0%; 75.0%) collision type. More allowed driving and crash speed (Ashton & Mackay, 1983; Nilsson, 1982; Nilsson, 1997; Pasanen, 1991) collectively with improved motorisation and exposure (Smeed, 1949) risk more crashes and injuries in good/fair road condition.

The relationship between road condition and severity is not statistically significant in mv/mv head on ($\rho = 0.331 > 0.05$), mv/mv rear end ($\rho = 0.975 > 0.05$), mv/mv side ($\rho = 0.186 > 0.05$), single mv rollover ($\rho = 0.255 > 0.05$), single mv ($\rho = 0.287 > 0.05$), mv/pedestrian ($\rho = 0.631 > 0.05$), mv/bicyclist ($\rho = 0.346 > 0.05$), mv/other ($\rho = 0.449 > 0.05$) and bicycle/other ($\rho = 0.576 > 0.05$) collisions. Thus, threat is normal in all road conditions in all collision types.

Table 4.2.4C: Relationship between Co-factors of Accident Type and Severity – Continued

Co-factor	Factor	mv/mv head on	mv/mv rear end	mv/mv side	mv/mv overtake	mv/mv turn	Single mv Rollover	Single mv crash
Weather	Crash & Fatal Top in ρ-value	Dry (100.0%; 100.0%) _	Dry (97.7%; 100.0%) 0.993	Dry (99.4%; 100.0%) 0.816	Dry (100.0%; 100.0%) _	Dry (100.0%; 100.0%) _	Dry (98.2%; 97.1%) 0.549	Dry (97.2%; 96.2%) 0.429
Other Factors	Crash & Fatal Top in ρ-value	_	_	Hit & run (1.7%; 0.0%) 0.226	Hit & run (2.0%; 0.0%) 0.497	_	Road Works (0.4%; 0.0%) 0.003	Road Works (0.9%; 0.0%) 0.202
Co-factor	Factor	mv/pedestrian	mv/bicyclist	mv/controlled Animal	mv/uncontrolled Animal	mv/other	Bicycle/ pedestrian	Bicycle/ other
Weather	Crash & Fatal Top in ρ-value	Dry (98.9%; 99.2%) 0.273	Dry (99.5%; 98.8%) 0.419	Dry (100.0%; 100.0%) _	Dry (100.0%; 0.0%) _	Dry (99.3%; 100.0%) 0.001	Dry (100.0%; 100.0%) _	Dry (100.0%; 100.0%) _
Other Factors	Crash & Fatal Top in ρ-value	Hit & run (7.6%; 12.4%) 0.000	Hit & run (3.9%; 5.8%) 0.526	_	_	Hit & run (0.7%; 1.8%) 0.836	Hit & run (10.0%; 0.0%) 0.574	_

Findings and their discussions explained just below refer to Table 4.2.4C.

Crash and fatal occur most in dry weather in mv/mv rear end (97.7%; 100.0%), single mv rollover (98.2%; 97.1%), single mv (97.2%; 96.2%), mv/pedestrian (98.9%; 99.2%), mv/bicyclist (99.5%; 98.8%) and mv/other (99.3%; 100.0%) accident types while only in dry weather in mv/mv side (99.4%; 100.0%), mv/mv head on (100.0%; 100.0%), mv/mv turn (100.0%; 100.0%), mv/mv overtake (100.0%; 100.0%), mv/controlled animal (100.0%; 100.0%), mv/uncontrolled animal (100.0%; 0.0%), bicycle/pedestrian (100.0%; 100.0%) and bicycle/other (100.0%; 100.0%) collisions. Better visibility and traction in dry weather improve also driving and crash speed too risk of crash involvement and injury (Ashton & Mackay, 1983; Nilsson, 1982; Nilsson, 1997; Pasanen, 1991).

The relationship between weather and severity is not statistically significant in mv/mv rear end ($\rho = 0.993 > 0.05$), mv/mv side ($\rho = 0.816 > 0.05$), single mv rollover ($\rho = 0.549 > 0.05$), single mv ($\rho = 0.429 > 0.05$), mv/pedestrian ($\rho = 0.273 > 0.05$) and mv/bicyclist ($\rho = 0.419 > 0.05$) collisions while statistically significant in mv/other ($\rho = 0.001 < 0.05$) accident type. So, risk is normal in all weather in all collision types except in mv/other where it varies with weather.

Only hit and run crashes were involved in mv/mv side (1.7%), mv/mv overtake (2.0%), mv/other (0.7%) and bicycle/pedestrian (10.0%) accident types in contrast only road works crashes were involved in single mv rollover (0.4%) and single mv (0.9%) collisions while hit and run crash and fatal incidents lead in mv/pedestrian (7.6%; 12.4%) and mv/bicyclist (3.9%; 5.8%) collision types. Speed of vehicle is at the core of road safety problems (Ashton & Mackay, 1983; Nilsson, 1982; Nilsson, 1997; Pasanen, 1991).

The relationship between other factors and severity is not statistically significant in mv/mv side ($\rho = 0.226 > 0.05$), mv/mv overtake ($\rho = 0.497 > 0.05$), single mv ($\rho = 0.202 > 0.05$), mv/bicyclist ($\rho = 0.526 > 0.05$), mv/other ($\rho = 0.836 > 0.05$) and bicycle/pedestrian ($\rho = 0.574 > 0.05$) collisions while statistically significant in single mv rollover ($\rho = 0.003 < 0.05$) and mv/pedestrian ($\rho = 0.000 < 0.05$) accident types. Thus, threat is normal in all other factors in all collisions except in single mv rollover and mv/pedestrian where it varies with other factors.

Table 4.2.4D: Relationship between Co-factors of Accident Type and Severity – Continued

Co-factor	**Factor**	**mv/mv head on**	**mv/mv rear end**	**mv/mv side**	**mv/mv overtake**	**mv/mv turn**	**Single mv Rollover**	**Single mv crash**
Speed	**Crash & Fatal Top in**	**Over Limit (90.0%; 95.2%)**	**Over Limit (93.0%; 92.9%)**	**Over Limit (93.0%; 100.0%)**	**Over Limit (86.0%; 100.0%)**	**Over Limit (77.8%; 100.0%)**	**Over Limit (96.8%; 97.1%)**	**Over Limit (97.2%; 100.0%)**
	ρ-value	**0.006**	**0.868**	**0.774**	**0.388**	**0.804**	**0.399**	**0.190**
Light Condition	**Crash & Fatal Top in**	**Daylight (55.7%; 38.1%)** **Night (44.3%; 61.9%)**	**Daylight (70.5%; 28.6%)** **Night (29.5%; 71.4%)**	**Daylight (64.5%; 66.7%)**	**Daylight (82.0%; 100.0%)**	**Daylight (83.3%; 100.0%)**	**Daylight (67.3%; 63.5%)**	**Daylight (61.3%; 61.5%)**
	ρ-value	**0.007**	**0.002**	**0.988**	**0.304**	**0.934**	**0.540**	**0.695**
Co-factor	**Factor**	**mv/pedestrian**	**mv/bicyclist**	**mv/controlled Animal**	**mv/uncontrolled Animal**	**mv/other**	**Bicycle/ pedestrian**	**Bicycle/ other**
Speed	**Crash & Fatal Top in**	**Over Limit (93.0%; 92.3%)**	**Over Limit (95.9%; 97.1%)**	**Over Limit (100.0%; 100.0%)**	**Over Limit (100.0%; 0.0%)**	**Over Limit (94.0%; 92.7%)**	**Over Limit (100.0%; 100.0%)**	**Over Limit (100.0%; 100.0%)**
	ρ-value	**0.374**	**0.302**	**_**	**_**	**0.009**	**_**	**_**
Light Condition	**Crash & Fatal Top in**	**Daylight (70.5%; 60.0%)**	**Daylight (73.3%; 67.4%)**	**Daylight (50.0%; 100.0%)** **Night (50.0%; 0.0%)**	**Night (66.7%; 0.0%)**	**Daylight (67.5%; 60.0%)**	**Daylight (90.0%; 100.0%)**	**Daylight (80.0%; 75.0%)**
	ρ-value	**0.000**	**0.036**	**0.157**	**0.269**	**0.741**	**0.574**	**0.576**

Findings summarised in Table 4.2.4D are stated and discussed just below.

Crash and fatal occur most in above legal speed limit in mv/mv head on (90.0%; 95.2%), mv/mv rear end (93.0%; 92.9%), mv/mv side (93.0%; 100.0%), mv/mv overtake (86.0%; 100.0%), mv/mv turn (77.8%; 100.0%), single mv rollover (96.8%; 97.1%), single mv (97.2%; 100.0%), mv/pedestrian (93.0%; 92.3%), mv/bicycle (95.9%; 97.1%), mv/controlled animal (100.0%; 100.0%), mv/uncontrolled animal (100.0%; 0.0%), mv/other (94.0%; 92.7%), bicycle/pedestrian

(100.0%; 100.0%) and bicycle/other (100.0%; 100.0%) collisions. Driving speeds over legal limit risk extra crashes and injuries (Ashton & Mackay, 1983; McLean & Kloeden, 2002; Nilsson, 1982; Nilsson, 1997; Pasanen, 1991).

The relationship between speed and severity is statistically significant in mv/mv head on ($\rho = 0.006 < 0.05$) and mv/other ($\rho = 0.009 < 0.05$) collisions while not statistically significant in mv/mv rear end ($\rho = 0.868 > 0.05$), mv/mv side ($\rho = 0.774 > 0.05$), mv/mv overtake ($\rho = 0.388 > 0.05$), mv/mv turn ($\rho = 0.804 > 0.05$), single mv rollover ($\rho = 0.399 > 0.05$), single mv ($\rho = 0.190 > 0.05$), mv/pedestrian ($\rho = 0.374 > 0.05$) and mv/bicyclist ($\rho = 0.302 > 0.05$) accident types. Thus, risk is normal in all speeds in all collisions except in mv/mv head on and mv/other where it varies with speed.

Crashes peak in daylight while fatal in night in mv/mv head on (55.7%, 61.9%) and mv/mv rear end (70.5%; 71.4%) collisions on the contrary crashes peak in daylight (50.0%) and night (50.0%) while fatal in daylight (100.0%) in mv/controlled animal accident type. Besides, both top in daylight in mv/mv side (64.5%; 66.7%), mv/mv overtake (82.0%; 100.0%), mv/mv turn (83.3%; 100.0%), single mv rollover (67.3%; 63.5%), single mv (61.3%; 61.5%), mv/pedestrian (70.5%; 60.0%), mv/bicyclist (73.3%; 67.4%), mv/other (67.5%; 60.0%), bicycle/pedestrian (90.0%; 100.0%) and bicycle/other (80.0%; 75.0%) collisions though lead in night in mv/uncontrolled animal accident type (66.7%; 0.0%).

Enhanced motorisation and exposure (Smeed, 1949), and denser traffic mix with high speed traffic (Tiwari, Mohan & Fazio, 1998) lead to higher risk of crash involvement and injury in daylight while greater mean free, driving and crash speed (Nilsson, 1982; Nilsson, 1997) is a major risk factor during night.

The relationship between light condition and severity is statistically significant in mv/mv head on ($\rho = 0.007 < 0.05$), mv/mv rear end ($\rho = 0.002 < 0.05$), mv/pedestrian ($\rho = 0.000 < 0.05$) and mv/bicyclist ($\rho = 0.036 < 0.05$) accident types while not statistically significant in mv/mv side ($\rho = 0.988 > 0.05$), mv/mv overtake ($\rho = 0.304 > 0.05$), mv/mv turn ($\rho = 0.934 > 0.05$), single m/v rollover ($\rho = 0.540 > 0.05$), single mv ($\rho = 0.695 > 0.05$), mv/controlled animal ($\rho = 0.157 > 0.05$), mv/uncontrolled animal ($\rho = 0.269 > 0.05$), mv/other ($\rho = 0.741 > 0.05$), bicycle/pedestrian ($\rho = 0.574 > 0.05$) and bicycle/other ($\rho = 0.576 > 0.05$) collisions. Thus, threat is regular in all light conditions in all collision types except in mv/mv head on, mv/mv rear end, mv/pedestrian and mv/bicyclist where it changes with light condition.

Table 4.2.5A: Relationship between Co-factors of Road Geometry and Severity

Co-factor	**Factor**	**Straight Road**	**Curve**	**T-junction**	**Round About**	**Y-junction**	**X-junction**	**+-junction**	**Bridge**
Surrounding	**Crash & Fatal Top in**	**Rural (48.7%; 64.9%)**	**Rural (68.2%; 70.5%)**	**Urban (68.0%; 37.5%)** **Rural (21.1%; 42.5%)**	**Urban (100%; 100%)** **-**	**Urban (71.4%; 0.0%)** **Rural (21.4%; 100.0%)**	**Urban (66.7%; 0.0%)** **Rural (33.3%; 100.0%)**	**Urban (86.4%; 50%)**	**Rural (58%; 69.2%)**
	ρ-value	**0.000**	**0.076**	**0.000**		**0.520**	**0.223**	**0.093**	**0.721**
Surface Type	**Crash & Fatal Top in**	**Bitumen (92.5%; 92.2%)**	**Bitumen (87.5%; 87.1%)**	**Bitumen (94.3%; 97.5%)**	**Bitumen (100%; 100%)**	**Bitumen (92.9%; 100%)**	**Bitumen (100%; 100%)**	**Bitumen (100%; 100%)**	**Bitumen (87%; 92.3%)**
	ρ-value	**0.344**	**0.552**	**0.788**	**-**	**0.897**	**-**	**-**	**0.913**
Road Condition	**Crash & Fatal Top in**	**Good (97.9%; 97.4%)**	**Good (95.8%; 98.5%)**	**Good (97.4%; 100.0%)**	**Good (100%; 100%)**	**Good (100%; 100%)**	**Good (100%; 100%)**	**Good (100%; 100%)**	**Good (91.3%; 96.2%)**
	ρ-value	**0.694**	**0.108**	**0.516**	**-**	**-**	**-**	**-**	**0.739**
Weather	**Crash & Fatal Top in**	**Dry (99.2%; 99.1%)**	**Dry (97.9%; 97.0%)**	**Dry (99.5%; 97.5%)**	**Dry (100%; 100%)**	**Dry (100%; 100%)**	**Dry (100%; 100%)**	**Dry (100%; 100%)**	**Dry (97.1%; 100.0%)**
	ρ-value	**0.388**	**0.189**	**0.276**	**-**	**-**	**-**	**-**	**0.228**
Other Factors	**Crash & Fatal Top in**	**Hit &run (4.9%; 8.8%)** **Road Works (0.2%; 0.2%)**	**Hit &run (4.9%; 8.8%)**	**Hit &run (2.1%; 5.0%)**	**-**	**-**	**-**	**-**	**Hit & run (5.8%; 11.5%)**
	ρ-value	**0.000**	**0.921**	**0.411**					**0.519**

In Table 4.2.5A, crash and fatal incidents peak in rural in straight road (48.7%; 64.9%), curve (68.2%; 70.5%) and bridge (58.0%; 69.2%) on the contrary lead in urban in +-junction (86.4%; 50.0%) and roundabout (100.0%; 100.0%). In addition, crash and fatal occur most in bitumen surface in straight road (92.5%; 92.2%), curve (87.5%; 87.1%), T-junction (94.3%; 97.5%), roundabout (100.0%; 100.0%), y-junction (92.9%; 100.0%), x-junction (100.0%; 100.0%), +-junction (100.0%; 100.0%) and bridge (87.0%; 92.3%), and in good/fair road condition in straight road (97.9%; 97.4%), curve (95.8%; 98.5%), T-junction (97.4%; 100.0%), roundabout (100.0%; 100.0%), y-junction (92.9%; 100.0%), x-junction (100.0%; 100.0%), +-junction (100.0%; 100.0%) and bridge (91.3%; 96.2%). Alike, they happen most in dry weather in straight road (99.2%; 99.1%), curve (97.9%; 97.0%) and bridge (97.1%; 100.0%) though only in dry weather in T-junction (99.5%; 97.5%), roundabout (100.0%; 100.0%), y-junction (92.9%; 100.0%), x-junction (100.0%; 100.0%) and +-junction (100.0%; 100.0%). Besides, crash and fatal in hit and run (4.9%; 8.8%) are more than in road works (0.2%; 0.2%) in straight road while only hit and run in curve (4.9%; 8.8%), T-junction (2.1%; 5.0%) and bridge (5.8%; 11.5%).

More allowed driving and crash speed (Nilsson, 1982; Nilsson, 1997) in rural risk more crashes and injuries in straight road, curve and bridge while enhanced motorisation and exposure (Smeed, 1949) along with extreme traffic mix with high speed traffic (Tiwari, Mohan & Fazio, 1998) in urban area lead to higher risk of crash involvement and injury in junctions and roundabout. Similarly, improved driving and crash speed (Nilsson, 1982; Nilsson, 1997) and enhanced motorisation and exposure (Smeed, 1949) risk more crashes and injuries in bitumen surface and good/fair road condition while better visibility and traction in dry weather improve also driving and crash speed too risk of crash involvement and injury (Nilsson, 1982; Nilsson, 1997). As for other factors, improved driving and crash speed (Ashton & Mackay, 1983; Nilsson, 1982; Nilsson, 1997; Pasanen, 1991) in straight road, curve, T-junction and bridge risk more safety problems of hit and run. Driving speed is normally higher in main trunk of T-junction and two-way bridge.

The relationship between surrounding and severity is statistically significant in straight road ($\rho = 0.000 < 0.05$) and T-junction ($\rho = 0.000 < 0.05$) while not statistically significant in curve ($\rho = 0.076 > 0.05$), Y-junction ($\rho = 0.520 > 0.05$), +-junction ($\rho = 0.093 > 0.05$), x-junction ($\rho = 0.223$

> 0.05) and bridge (ρ = 0.721 > 0.05) thus hazard is standard in all surroundings in all road geometry except in straight road and T-junction where it varies with surrounding. Besides, the relationship between surface type and severity is not statistically significant in straight road (ρ = 0.344 > 0.05), curve (ρ = 0.552 > 0.05), T-junction (ρ = 0.788 > 0.05), y-junction (ρ = 0.897 > 0.05) and bridge (ρ = 0.913 > 0.05) so threat is regular in all surface types in all road geometry.

The relationship between road condition and severity is not statistically significant in straight road (ρ = 0.694 > 0.05), curve (ρ = 0.108 > 0.05), T-junction (ρ = 0.516 > 0.05) and bridge (ρ = 0.739 > 0.05) so risk is standard in all road conditions in all road geometry. Alike, the relationship between weather and severity is not statistically significant in straight road (ρ = 0.388 > 0.05), curve (ρ = 0.189 > 0.05), T-junction (ρ = 0.276 > 0.05) and bridge (ρ = 0.228 > 0.05) hence risk is normal in all weather in all road geometry. Also, the relationship between other factors and severity is statistically significant in straight road (ρ = 0.000 < 0.05) while not statistically significant in curve (ρ = 0.921 > 0.05), T-junction (ρ = 0.411 > 0.05) and bridge (ρ = 0.519 > 0.05) therefore peril is normal in all other factors in all road geometry except in straight road where it differs with other factors.

Table 4.2.5B: Relationship between Co-factors of Road Geometry and Severity - Continued

Co-factor	Factor	Straight Road	Curve	T-junction	Round About	Y-junction	X-junction	+-junction	Bridge
Animals	**Crash & Fatal Top in**	**Animal Stationary (1)**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	ρ-value	**0.045**							
Obstruction	**Crash & Fatal Top in**	**Dropped cargo (1)**	**Rocks (0.3%) & Others (0.3%)**	**-**	**-**	**-**	**-**	**-**	**-**
	ρ-value	**0.594**	**0.738**						
Speed	**Crash & Fatal Top in**	**Over limit (93.7%; 94.2%)**	**Over limit (96.4%; 95.5%)**	**Over limit (93.8%; 100.0%)**	**Over limit (92.9%; 75.0%)**	**Over limit (100%; 100%)**	**Over limit (100%; 100%)**	**Over limit (77.3%; 50.0%)** **Within (22.7%; 50.0%)**	**Over limit (94.2%; 96.2%)**
	ρ-value	**0.112**	**0.700**	**0.118**	**0.442**	**-**	**-**	**0.529**	**0.745**
Light Condition	**Crash & Fatal Top in**	**Day light (68.7%; 60.8%)**	**Day light (69.9%; 64.4%)**	**Day light (76.3%; 70.0%)**	**Day light (85.7%; 100.0%)**	**Day light (78.6%; 100.0%)**	**Day light (100%; 100%)**	**Day light (72.7%; 100.0%)**	**Day light (60.9%; 46.2%)** **Night (39.1%; 53.8%)**
	ρ-value	**0.000**	**0.013**	**0.642**	**0.241**	**0.190**	**-**	**0.095**	**0.075**

In Table 4.2.5B, animal stationary on the road involved damages only crash in straight road while dropped cargo, rocks/landslide and other obstructions involved crashes in straight road and curve respective. Besides, crash and fatal incidents occur most in above legal limit in straight road (93.7%; 94.2%), curve (96.4%; 95.5%), roundabout (92.9%; 75.0%), T-junction (93.8%; 100.0%), +-junction (77.3%; 50.0%) and bridge (94.2%; 96.2%) while peak in daylight in straight road (68.7%; 60.8%), curve (69.9%; 64.4%) roundabout (85.7%; 100.0%), T-junction (76.3%; 70.0%), y- junction (78.6%; 100.0%) and +-junction (72.7%; 100.0%). However, crashes (60.9%) peak in daylight while fatal (53.8%) in night in bridge.

Improved driving and crash speed (Nilsson, 1982; Nilsson, 1997) in straight road and curve increase risk of crash involvement with animals and in obstructions similarly driving and crash speeds above legal limit lead to higher risk of crash involvement and injury (Ashton & Mackay, 1983; McLean & Kloeden, 2002; Pasanen, 1991). While, enhanced motorisation and exposure (Smeed, 1949) with dense traffic mix with high speed traffic (Tiwari, Mohan & Fazio, 1998) risk more crashes and injuries in daylight in addition greater mean free, driving and crash speed during night (Nilsson, 1982; Nilsson, 1997), unforgiving guardrails or their supports (Forgiving Roadsides, 1998; Kloeden, South Australia & NHMRC Road Accident Research Unit, 1999) and missing guardrails because of vandalism risk more casualties in bridges.

The relationship between animal and severity is statistically significant in straight road ($\rho = 0.045 < 0.05$) thus animal risk is greater in straight road. Besides, the relationship between obstructions and severity is not statistically significant in straight road ($\rho = 0.594 > 0.05$) and curve ($\rho = 0.738 > 0.05$) and so risk is normal in all obstructions in all road geometry and the relationship between speed and severity is not statistically significant in straight road ($\rho = 0.112 > 0.05$), curve ($\rho = 0.700 > 0.05$), roundabout ($\rho = 0.442 > 0.05$), T-junction ($\rho = 0.118 > 0.05$), +-junction ($\rho = 0.529 > 0.05$) and bridge ($\rho = 0.745 > 0.05$) hence hazard is normal in all speeds in all road geometry.

The relationship between light condition and severity is statistically significant in straight road ($\rho = 0.000 < 0.05$) and curve ($\rho = 0.013 < 0.05$) but not statistically significant in roundabout ($\rho = 0.241 > 0.05$), T-junction ($\rho = 0.642 > 0.05$), y-junction ($\rho = 0.190 > 0.05$), +-junction ($\rho = 0.095 > 0.05$) and bridge ($\rho = 0.075 > 0.05$) thus risk is regular in all light conditions in all road geometry except in straight road and curve where it changes with light condition.

Table 4.2.6: Relationship between Co-factors of Surrounding and Severity

Co-factor	**Factor**	**Rural Area**	**Urban Area**	**Peril-urban**	**Farm/compound**
Surface Type	**Crash & Fatal Top in**	**Bitumen (88.3%; 90.9%)**	**Bitumen (96.9%; 95.6%)**	**Bitumen (93.3%; 95.5%)**	**Bitumen (47.8%; 46.2%) Earth (47.8%; 53.8%)**
	ρ-value	**0.011**	**0.918**	**0.114**	**0.056**
Road Condition	**Crash & Fatal Top in**	**Good/fair (96.5%; 97.5%)**	**Good/fair (98.3%; 98.5%)**	**Good/fair (100%; 100%)**	**Good/fair (87.0%; 84.6%)**
	ρ-value	**0.229**	**0.592**	**-**	**0.051**
Weather	**Crash & Fatal Top in**	**Dry (98.7%; 98.2%)**	**Dry (99.7%; 100%)**	**Dry (100%; 100%)**	**Dry (91.3%; 100%)**
	ρ-value	**0.502**	**0.337**	**0.690**	**0.031**
Other Factors	**Crash & Fatal Top in**	**Hit & run (5.3%; 8.2%)**	**Hit & run (3.1%; 6.9%)**	**Hit & run (3.1%; 5.7%)**	**Hit & run (4.3%; 7.7%)**
	ρ-value	**0.000**	**0.002**	**0.276**	**0.848**
Speed	**Crash & Fatal Top in**	**Above Limit (96.3%; 96.8%)**	**Above Limit (91.6%; 88.2%)**	**Above Limit (92.7%; 93.2%)**	**Above Limit (100%; 100%)**
	ρ-value	**0.795**	**0.000**	**0.682**	**-**
Light Condition	**Crash & Fatal Top in**	**Daylight (66.7%; 59.0%)**	**Daylight (73.3%; 68.0%)**	**Daylight (67.9%; 62.5%)**	**Daylight (60.9%; 76.9%)**
	ρ-value	**0.000**	**0.207**	**0.529**	**0.178**

Reference is made to findings summarised in Table 4.2.6.

Crash and fatal occur most in bitumen surface in rural (88.3%; 90.9%), urban (96.9%; 95.6%) and peri-urban (93.3%; 95.5%), in good/fair road condition in rural (96.5%; 97.5%), urban (98.3%; 98.5%) and farm/compound (87.0%; 84.6%), in dry weather in rural (98.7%; 98.2%), urban (99.7%; 100.0%), peri-urban (100.0%; 100.0%) and farm/compound (91.3%; 100.0%), and in above legal speed limit in rural (96.3%; 96.8%), urban (91.6%; 88.2%), peri-urban (92.7%; 93.2%) and farm/compound (100.0%; 100.0%) while peak in hit and run in rural (5.3%; 8.2%), urban (3.1%; 6.9%), peri-urban (3.1%; 5.7%) and farm/compound (4.3%; 7.7%), and in daylight in rural (66.7%; 59.0%), urban (73.3%; 68.0%), peri-urban (67.9%; 62.5%) and farm/compound (60.9%; 76.9%). As for farm/compound, crashes peak in bitumen (47.8%) and earth (47.8%) surfaces while fatal in earth surface (53.8%).

More allowed driving and crash speed (Nilsson, 1982; Nilsson, 1997) with improved motorisation and exposure (Smeed, 1949) risk more crashes and injuries in bitumen surface and good/fair road condition while clear visibly and good traction in dry weather improve also driving and crash speed as well as risk of road accidents (Nilsson, 1982; Nilsson, 1997). Similarly, more allowed driving and crash speed (Nilsson, 1982; Nilsson, 1997) in rural and peri-urban, and enhanced motorisation and exposure (Smeed, 1949) along with dense traffic mix with high speed traffic (Tiwari, Mohan & Fazio, 1998) in urban and peri-urban are core safety problems of hit and run. Besides, driving speeds above legal limit lead to higher risk of crash involvement and injury (Ashton & Mackay, 1983; McLean & Kloeden, 2002; Pasanen, 1991), and enhanced motorisation and exposure (Smeed, 1949) together with intense traffic mix with high speed traffic (Tiwari, Mohan & Fazio, 1998) is at the core of high crash involvement and injury in daylight.

The relationship between surface type and severity is statistically significant in rural ($\rho = 0.011 < 0.05$) but not statistically significant in urban ($\rho = 0.918 > 0.05$), peri-urban ($\rho = 0.114 > 0.05$) and farm/compound ($\rho = 0.056 > 0.05$) thus risk is normal in all surface types in all surroundings except in rural where it changes with surface type. While, the relationship between road condition and severity is not statistically significant in rural ($\rho = 0.229 > 0.05$), urban ($\rho = 0.592 > 0.05$) and farm/compound ($\rho = 0.051 > 0.05$) so threat is normal in all road conditions in all surroundings.

The relationship between weather and severity is not statistically significant in rural ($\rho = 0.502 > 0.05$), urban ($\rho = 0.337 > 0.05$) and peri-urban ($\rho = 0.690 > 0.05$) while statistically significant in farm/compound ($\rho = 0.031 < 0.05$) thus risk is normal in all weather in all surroundings except in farm/compound where it varies with weather. Likewise, the relationship between other factors and severity is statistically significant in rural ($\rho = 0.000 < 0.05$) and urban ($\rho = 0.002 < 0.05$) but not statistically significant in peri-urban ($\rho = 0.276 > 0.05$) and farm/compound ($\rho = 0.848 < 0.05$) therefore risk changes with other factors in all surroundings except in peri-urban and farm/compound where it is normal in all other factors.

The relationship between speed and severity is not statistically significant in rural (ρ = 0.795 > 0.05) and peri-urban (ρ = 0.682 > 0.05) while statistically significant in urban (ρ = 0.000 < 0.05) so hazard is normal in all speeds in all surroundings except in urban where it varies with speed. Similarly, the relationship between light condition and severity is statistically significant in rural (ρ = 0.000 < 0.05) while not statistically significant in urban (ρ = 0.207 > 0.05), peri-urban (ρ = 0.529 > 0.05) and farm/compound (ρ = 0.178 < 0.05) thus peril is standard in all light conditions in all surroundings except in rural where it varies with light condition.

Table 4.2.7: Relationship between Co-factors of Surface Type and Severity

Co-factor	**Factor**	**Bitumen**	**Gravel**	**Earth**
Road Condition	**Crash & Fatal Top in**	**Good/fair (99.5%; 99.7%)**	**Good/fair (69.4%; 60.0%)**	**Good/fair (75.5%; 70.0%)**
	ρ-value	**0.290**	**0.706**	**0.212**
Weather	**Crash & Fatal Top in**	**Dry (99.3%; 98.9%)**	**Dry (97.2%; 90.0%)**	**Dry (96.9%; 98.4%)**
	ρ-value	**0.106**	**0.445**	**0.120**
Other Factors	**Crash & Fatal Top in**	**Hit & run (4.4%; 8.2%)**	**Hit & run (2.8%)**	**Hit & run (4.4%; 8.2%)**
	ρ-value	**0.000**	**0.656**	**0.149**
Speed	**Crash & Fatal Top in**	**Over Legal Limit (93.7%; 94.7%)**	**Over Legal Limit (91.7%; 70.0%)**	**Over Legal Limit (98.7%; 96.7%)**
	ρ-value	**0.196**	**0.037**	**0.354**
Light Condition	**Crash & Fatal Top in**	**Daylight (68.5%; 60.1%)**	**Daylight (83.3%; 80.0%)**	**Daylight (80.5%; 78.7%)**
	ρ-value	**0.000**	**0.833**	**0.808**

Results summarised in Table 4.2.7 refers.

Crash and fatal peak in good/fair condition in bitumen (99.5%; 99.7%), gravel (69.4%; 60.0%) and earth (75.5%; 70.0%) surfaces, in hit and run in bitumen (4.4%; 8.2%), earth (1.9%; 1.6%) and gravel (2.8%; 0.0%) surfaces, and in daylight in bitumen (68.5%; 60.1%), gravel (83.3%; 80.0%) and earth (80.5%; 78.7%) surfaces while most in dry weather in bitumen (99.3%; 98.9%), gravel (97.2%; 90.0%) and earth (96.9%; 98.4%) surfaces, and in above legal speed limit in bitumen (93.7%; 94.7%), gravel (91.7%; 70.0%) and earth (98.7%; 96.7%) surfaces.

More allowed driving and crash speed (Nilsson, 1982; Nilsson, 1997) with improved motorisation and exposure (Smeed, 1949) lead to higher risk of crash involvement and injury in good/fair road condition while good traction and clear visibility in dry weather improve also driving and crash speed too risk of road accidents (Nilsson, 1982; Nilsson, 1997). Speed of vehicle is at the core of hit and run safety problems, and driving above legal speed limit lead to higher risk of crash involvement and injury (Ashton & Mackay, 1983; McLean & Kloeden, 2002; Nilsson, 1982; Nilsson, 1997; Pasanen, 1991). Besides, enhanced motorisation and exposure (Smeed, 1949) along with dense traffic mix with high speed traffic (Tiwari, Mohan & Fazio, 1998) risk more crashes and injuries in daylight.

The relationship between road condition and severity is not statistically significant in bitumen ($\rho = 0.290 > 0.05$), gravel ($\rho = 0.706 > 0.05$) and earth ($\rho = 0.212 > 0.05$) surfaces hence risk is normal in all road conditions in all surface types. Similarly, the relationship between weather and severity is not statistically significant in bitumen surface ($\rho = 0.106 > 0.05$), gravel surface ($\rho = 0.445 > 0.05$) and earth surface ($\rho = 0.120 > 0.05$) therefore threat is regular in all weather in all surface types.

The relationship between other factors and severity is statistically significant in bitumen surface ($\rho = 0.000 < 0.05$) while not statistically significant in gravel surface ($\rho = 0.656 > 0.05$) and earth surface ($\rho = 0.149 > 0.05$) so threat varies with other factors in all surface types except in gravel and earth surfaces where it is ordinary in all other factors. Similarly, the relationship between speed posted and severity is not statistically significant in bitumen surface ($\rho = 0.196 > 0.05$) and earth surface ($\rho = 0.354 > 0.05$) but statistically significant in gravel surface ($\rho = 0.037 < 0.05$) so risk is normal in all speeds in all surface types except in gravel where it changes with speed and the relationship between light condition and severity is statistically significant in bitumen surface ($\rho = 0.000 < 0.05$) while not statistically significant in gravel surface ($\rho = 0.833 > 0.05$) and earth surface ($\rho = 0.808 > 0.05$) thus risk is standard in all light conditions in all surface types except in bitumen where it varies with light condition.

Table 4.2.8: Relationship between Co-factors of Road Condition and Severity

Co-factor	Factor	Good/fair	Potholes	Corrugated	Slippery
Weather	Crash & Fatal Top in ρ-value	Dry (99.3%; 98.9%) 0.189	Dry (96.8%; 92.3%) 0.698	Dry (100%; 100%) -	rain (57.1%; 100.0%) 0.140
Other Factors	Crash & Fatal Top in ρ-value	Hit & run (4.2%; 7.8%) 0.000	-	-	-
Animal	Crash & Fatal Top in ρ-value	Stationary on Road (1) 0.068	-	-	-
Obstruction	Crash & Fatal Top in ρ-value	Dropped cargo /rocks/others (3) 0.718	Other (1) 0.651	-	-
Speed	Crash & Fatal Top in ρ-value	Above Limit (94.0%; 94.8%) 0.089	Above Limit (90.3%; 76.9%) 0.204	Above Limit (100%; 100%) -	Above Limit (100%; 100%) -
Light Condition	Crash & Fatal Top in ρ-value	Daylight (69.3%; 61.4%) 0.000	Daylight (77.4%; 76.9%) 0.790	Daylight (70%; 33.3%) Night (30.0%; 66.7%) 0.078	Daylight (71.4%; 100.0%) 0.646

Reference is made to Table 4.2.8. Crash and fatal incidents occur most in dry weather in good/fair road condition (99.3%; 98.9%) though only in dry weather in potholes (96.8%; 92.3%) and corrugated (100.0%; 100.0%) conditions, and in above legal speed limit in good/fair (94.0%; 94.8%), potholes (90.3%; 76.9%), corrugated (100.0%; 100.0%) and slippery (100.0%; 100.0%) conditions while peak in rain weather in slippery condition (57.1%; 100.0%), in hit and run in good/fair condition (4.2%; 7.8%) and in daylight in good/fair (69.3%; 61.4%), potholes (77.4%; 76.9%) and slippery conditions (71.4%; 100.0%). Animal stationary on road, dropped cargo and rocks/landslide obstructions also involved crashes in good/fair condition while other obstructions in pothole condition. However, crashes (70.0%) top in daylight but fatal (66.7%) during night in corrugated road condition.

More allowed driving and crash speed (Nilsson, 1982; Nilsson, 1997) in dry weather improve also risk of crash involvement and injury in most road conditions in contrast rain weather increase slippery condition leading to reduced vehicle traction and braking efficiency but higher risk of road accidents. Speed of vehicle is at the core of crash and injury problems in hit and run, animals and obstructions, and driving above legal speed limit risk extra crashes and injuries (de Langen, 2006; McLean & Kloeden, 2002; Nilsson, 1982; Nilsson, 1997) while enhanced motorisation and exposure (Smeed, 1949) in daylight lead to higher risk of crash involvement and injury in most road conditions.

The relationship between weather and severity is not statistically significant in good/fair condition ($\rho = 0.189 > 0.05$), potholes ($\rho = 0.698 > 0.05$) and slippery condition ($\rho = 0.140 > 0.05$) so threat is ordinary in all weather in all road conditions. Likewise, the relationship between animals and severity is not statistically significant in good/fair condition ($\rho = 0.068 > 0.05$) hence animal risk is regular in good/fair road condition while the relationship between other factors and severity is statistically significant in good/fair condition ($\rho = 0.000 < 0.05$) thus risk in other factors is greater in good/fair road condition.

The relationship between obstructions and severity is not statistically significant in good/fair condition ($\rho = 0.718 > 0.05$) and potholes ($\rho = 0.651 > 0.05$) therefore risk is normal in all obstructions in all road conditions. Equally, the relationship between speed and severity is not statistically significant in good/fair ($\rho = 0.089 > 0.05$) and potholes ($\rho = 0.204 > 0.05$) conditions thus hazard is standard in all speeds in all road conditions while the relationship between light condition and severity is statistically significant in good/fair road condition ($\rho = 0.000 < 0.05$) but not statistically significant in potholes ($\rho = 0.790 > 0.05$), corrugated condition ($\rho = 0.078 > 0.05$) and slippery condition ($\rho = 0.646 > 0.05$) therefore risk is normal in all light conditions in all road conditions except in good/fair condition where it changes with light condition.

Table 4.2.9: Relationship between Co-factors of Weather and Severity

Co-factor	Factor	Dry	Rain	Mist	Windy
Other factors	Crash & Fatal Top in	Hit & run (4.2%; 7.6%)	Hit & run (7.7%; 12.5%)	-	-
	ρ-value	0.000	0.879		
Speed	Crash & Fatal Top in	Over Legal Limit (94.0%; 94.5%)	Over Legal Limit (100.0%; 100.0%)	-	-
	ρ-value	0.096	-		
Light Condition	Crash & Fatal Top in	Daylight (69.6%; 61.7%)	Daylight (53.8%; 62.5%)	-	-
	ρ-value	0.000	0.428		

Findings summarised in Table 4.2.9 point out crash and fatal incidents peak in hit and run in dry (4.2%; 7.6%) and rain (7.7%; 12.5%) weather, and in daylight in dry (69.6%; 61.7%) and rain (53.8%; 62.5%) weather while occur most in above legal speed limit in dry (94.0%; 94.5%) and rain (100.0%; 100.0%) weather.

Good traction and clear visibility in dry weather improve also driving and crash speed too risk of road accidents (Ashton & Mackay, 1983; Nilsson, 1982; Nilsson, 1997; Pasanen, 1991) on the contrary reduced visibility in rain weather lead to road users not notice each other prior to crash involvement. Driving and crash speeds above legal limit generally risk extra crashes and injuries (Ashton & Mackay, 1983; McLean & Kloeden, 2002; Nilsson, 1982; Nilsson, 1997; Pasanen, 1991) while enhanced motorisation and exposure (Smeed, 1949) along with dense traffic mix with high speed traffic (Tiwari, Mohan & Fazio, 1998) increase also risk of crash involvement and injury in daylight.

The relationship between other factors and severity is statistically significant in dry weather ($\rho = 0.000 < 0.05$) while not statistically significant in rain weather ($\rho = 0.879 > 0.05$) so hazard varies with other factors in dry weather while it is normal in all other factors in rain weather. The same, the relationship between light condition and severity is statistically significant in dry weather ($\rho = 0.000 < 0.05$) but not statistically significant in rain weather ($\rho = 0.428 > 0.05$) therefore risk varies with light condition in dry weather while ordinary in all light conditions in rain weather. Also, the relationship between speed and severity is not statistically significant in dry weather ($\rho = 0.096 > 0.05$) thus peril is regular in all speeds in dry weather.

Table 4.2.10: Relationship between Co-factors of Other Factors and Severity

Co-factor	**Factor**	**Hit & run**	**Road Works**
Speed	**Crash & Fatal Top in**	**Over Legal Limit (90.3%; 92.4%)**	**Over Legal Limit (50.0%; 0.0%)** **Within Limit (50%; 100%)**
	ρ-value	**0.663**	**0.135**
Light Condition	**Crash & Fatal Top in**	**Night (72.8%; 81.8%)**	**Daylight (75.8%; 100.0%)**
	ρ-value	**0.015**	**0.135**

In Table 4.2.10, hit and run crash and fatal occur most in above legal speed limit (90.3%; 92.4%) and peak in night (72.8%; 81.8%) while crashes (50.0%) involved at road works lead in both above and within legal speed limit respective but fatal in below legal speed limit (100.0%) besides crash and fatal incidents involved at road works peak in daylight (75.8%; 100.0%).

Driving and crash speeds above legal limit generally lead to higher risk of crash involvement and injury (McLean & Kloeden, 2002; Nilsson, 1982; Nilsson, 1997; World Bank and WHO, 2004). Greater mean free, driving and crash speed (Ashton & Mackay, 1983; McLean & Kloeden, 2002; Nilsson, 1982; Nilsson, 1997; Pasanen, 1991; World Bank and WHO, 2004), enhanced drunken driving (Clayton, Colgan & Tunbridge, 2000; Compton et al., 2002; Elvic and Vaa, 2004; McLean & Holubowycz, 1980; Moskowitz et al., 2002) and lack of retro-reflective equipment in unprotected road users (European Transport Safety Council, 2000; World Bank & WHO, 2004) risk more hit and run road accidents during night while improved motorisation and exposure (Smeed, 1949) and intense traffic mix with high speed traffic (Tiwari, Mohan & Fazio, 1998) are core safety problems at road works in daylight.

The relationship between speed and severity is not statistically significant in hit and run ($\rho = 0.663 < 0.05$) and road works ($\rho = 0.135 > 0.05$) then threat is normal in all speeds in other factors. While, the relationship between light condition and severity is statistically significant in hit and run (ρ = 0.015 < 0.05) but not statistically significant in road works (ρ = 0.135 > 0.05) thus risk varies with light condition in hit and run while it is standard in all light conditions at road works.

Table 4.2.11: Relationship between Co-factor of Speed and Severity

Co-factor	**Factor**	**Unknown Speed**	**Below Speed Limit**	**Over Speed Limit**
Light Condition	**Crash & Fatal Top in**	**Daylight (78.6%; 80.0%)**	**Daylight (72.3%; 67.4%)**	**Daylight (69.3%; 61.3%)**
	ρ-value	**0.548**	**0.573**	**0.000**

In Table 4.2.11, crash and fatal occurrence peak in daylight in unknown (78.6%; 80.0%), within legal limit (72.3%; 67.4%) and above legal limit (69.3%; 61.3%) speeds. Enhanced motorisation and exposure (Smeed, 1949) together with dense traffic mix with high speed traffic (Tiwari, Mohan & Fazio, 1998) risk more road accidents in daylight. Since pedestrians have less chance of surviving impacts even at lower crash speed (Ashton & Mackay, 1983; Pasanen, 1991), mv/pedestrian collisions likely dominate in driving speeds below legal limit.

The relationship between light condition and severity is not statistically significant in unknown speed (ρ = 0.548 > 0.05), within legal speed limit (ρ = 0.573 < 0.05) while statistically significant in above legal speed limit (ρ = 0.000 < 0.05). Therefore, risk is standard in all light conditions in unknown speed and within legal speed limit while changes with light condition in over legal speed limit.

4.3.2 Analysis of Road Users Crash Injury Data

Table 4.2.12: Relationship between Road User Type and Injury

Road User	**Involved**	**Killed**	**Serious Injured**	**Minor Injured**	**Ratio (Fatal : Serious)**	**Ratio (Fatal: Minor)**
Pedestrians	**1195 (20.7%)**	**474 (48.0%)**	**374 (42.3%)**	**346 (22.6%)**	**1.27:1**	**1.37:1**
Passengers	**1276 (22.1%)**	**258 (26.1%)**	**300 (33.9%)**	**689 (45.1%)**	**0.86:1**	**0.44:1**
Bicyclists	**447 (7.7%)**	**176 (17.8%)**	**110 (12.4%)**	**138 (9.0%)**	**1.6:1**	**1.28:1**
Drivers	**2758 (47.7%)**	**68 (6.9%)**	**75 (8.5%)**	**316 (20.7%)**	**0.91:1**	**0.22:1**
Motorcyclists	**93 (1.6%)**	**10 (1.0%)**	**26 (2.9%)**	**38 (2.5%)**	**0.38:1**	**0.26:1**
Animal Drivers	**3 (0.1%)**	**1 (0.1%)**	**0 (0.0%)**	**1 (0.1%)**	**1:0**	**1:1**
Totals	**5772 + (5 unknown)**	**987**	**885**	**1528**	**1.12:1**	**0.65:1**
ρ-value	**0.000**					

As summarised in Table 4.2.12, about 5,777 people were involved in road accidents and fatality lead in pedestrians (48.0%), followed by passengers (26.1%), bicyclists (17.8%), drivers (6.9%), motorcyclists (1.0%) and animal drivers (0.1%). Pedestrians (fatal: 474; severe: 374 & minor: 346) and bicycle riders (fatal: 176; severe: 110 & minor: 138) are killed more than serious and minor injured, and fatality is generally 1.12 times greater than severe injuries while about 0.65 times of minor injuries.

Lack of traffic speed calming measures (World Bank and WHO, 2004), safe crosswalks (de Langen et al., 2006) and retro-reflective/protective equipment (European Transport Safety Council, 2000) together with intense traffic mix with high speed traffic (Tiwari, Mohan & Fazio, 1998) and negative behaviour of drivers towards non-motorised traffic (de Langen et al., 2006) lead to higher risk of crash and injury in pedestrians and bicyclists. While, high crash speed (Insurance Institute for Highway Safety, 1987; Nilsson, 1982; Nilsson, 1997) and low seatbelt use (Hill, Morris & Mackay, 1992) risk more crash injuries in car occupants. Save for high compliance in helmet use, fatality is low in motorcyclists.

The relationship between road user type and crash injury is statistically significant ($\rho = 0.00 < 0.05$) therefore other road users are more vulnerable to road accidents.

Table 4.2.13: Relationship between Road User Characteristics and Injury

Factor	**Road User Gender**	**Road User Age (years)**	**Seatbelt/helmet Use**
Crash & Fatality Lead in	**Males (87.2%; 84.4%)**	**25-44 (66.3%; 53.7%) 1-10 (5.5%; 12.5%) 18-24 (12.4%; 12.4%)**	**Unknown (75.0%; 81.7%) Fatality: Not Used (16.5%) Used (1.8%)**
ρ-value	**0.00**	**0.000**	**0.000**

Findings summarised in Table 4.2.13 express male road users (87.2%; 84.4%) are involved and killed more than females (12.6%; 15.5%) besides crash involvement (66.3%) and fatality (53.7%) lead in road user age group 25-44 years. Fatality follow second (12.5%) in age group 1-10 years (children) despite low crash involvement (5.5%) while peak third (12.4%) in age group 18-24 years though crash involvement is second highest (12.4%). Also, fatality in crash victims did not use seatbelt/helmet (16.5%) is greater than in those used (1.8%) correspondingly large fatality (81.7%) in crash victims not unknown whether used seatbelt/helmet inform majority did not and do not comply to seatbelt/helmet use.

Males in most low-income countries are bread winners for their families and so travels more for economic activities outside home or farm compared to females and are thus more exposed to the risk of road accidents also males are less concerned with safety and are thus more likely to violate traffic rules (SIDA, 2006). Similarly, road users in productive age group 18-24years & 25-44 years mainly males travel more on social-economic errands and are thus more exposed to risk of road accidents and males are less concerned with safety and are thus more likely to violate traffic rules (SIDA, 2006).

Lack of child seat restraint legislative law and regulations in the Road Traffic Act (1997), inadequate knowledge in road safety and less firm body anatomy risk more casualties in children. Children are at great risk as urban streets and roads are mostly their playground (SIDA, 2006) while non-use of child seat restraint more than doubles the risk of crash injuries in children (World Bank and WHO, 2004). Similarly, non-use of seatbelt in car occupants more than doubles the risk of crash injuries equally non-use of crash helmets in two-wheeler users almost doubles the risk of crash injuries (World Bank and WHO, 2004).

The relationship between road user gender and crash injury is statistically significant ($\rho = 0.00 < 0.05$) thus risk varies with road user gender and male road users are exposed more than females. Alike, the relationship between road user age group and crash injury is statistically significant ($\rho = 0.00 < 0.05$) so threat differ with road user age group and casualties are more in age group 25-44 years, and the relationship between helmet/belt use and crash injury is statistically significant ($\rho = 0.00 < 0.05$) and so danger in two-wheel riders and passengers adjust with helmet/belt use and crash injury is less severe in two-wheel riders put on crash helmet and passengers fasten seatbelt.

Table 4.2.14: Relationship between Co-factors of Road User Type and Injury

Co-factor	Factor	Drivers	Pedestrians	Passengers	Bicyclists	Motorcyclists	Animal Drivers
Gender	**Crash & Fatality Top in**	**Males (97.1%; 100.0%)**	**Males (78.7%; 82.7%)**	**Males (69.9%; 74.8%)**	**Males (97.5%; 96.6%)**	**Males (96.8%; 90.0%)**	**Males 100.0%; 100.0%)**
	ρ-value	**0.070**	**0.040**	**0.063**	**0.739**	**0.452**	**-**
Age (years)	**Crash & Fatality Top in**	**25-44 (79.7%; 80.9%)** **18-24 (7.2%; 10.3%)**	**25-44 (43.8%; 47.7%)** **1-10 (21.6%; 21.7%)** **18-24 (15.9%; 10.5%)**	**25-44 (62.0%; 55.6%)** **18-24 (18.3%; 15.1%)**	**25-44 (56.2%; 56.2%)** **18-24 (19.2%; 14.2%)**	**25-44 (72.0%; 60.0%)** **18-24 (9.7%; 10.0%).**	**11-17 (33.3%; 100.0%)** **Crashes: 25-44 (33.3%)** **Unknown (33.3%)**
	ρ-value	**0.000**	**0.025**	**0.018**	**0.321**	**0.864**	**0.199**
Seatbelt Use	**Fatality Top in**	**Used (13.2%)** **Not Used (10.3%)**	**N/A**	**Used (21.7%)** **Not Used (10.1%)**	**N/A**	**N/A**	**N/A**
	ρ-value	**0.000**		**0.006**			
Crash Helmet Use	**Fatality Top in**	**N/A**	**N/A**	**N/A**	**Not Used (42.6%)** **Used (25.0%)**	**Not Used (30.0%)** **Used (10.0%)**	**N/A**
	ρ-value				**0.144**	**0.060**	

As summarised in Table 4.2.14, males are involved and killed more than females in drivers (97.1%; 100.0%), motorcycle riders (96.8%; 90.0%), passengers (69.9%; 74.8%), pedestrians (78.7%; 82.7%) and bicycle riders (97.5%; 96.6%) besides crash and fatality lead in age group 25-44 years in drivers (79.7%; 80.9%), passengers (62.0%; 55.6%), pedestrians (43.8%; 47.7%), bicyclists (56.2%; 56.2%) and motorcyclists (72.0%; 60.0%), followed by age group 1-10 years (21.6%; 21.7%) and age group 18-24 years in drivers (7.2%; 10.3%), passengers (18.3%;

15.1%), pedestrians (15.9%; 10.5%), bicyclists (19.2%; 14.2%) and motorcyclists (9.7%; 10.0%). Also, fatality in seatbelt use peak in non-compliance in drivers (13.2%) and passengers (21.7%) the same with helmet use in bicycle (42.6%) and motorcycle (30.0%) riders.

Gender difference in crash and mortality rates is likely related to both exposure and risk taking behaviour (World Bank and WHO, 2004). Male road users travel more on social-economic errands and are thus more exposed to the risk of road accidents besides males are less concerned with safety and are thus more likely to violate traffic rules (SIDA, 2006). For example, male drivers and motorcycle riders are more likely to speed and engage in reckless driving, including drunken driving (SIDA, 2006).

Road users in productive age groups (18-24 & 25-44 years) travel more on social-economic activities and are therefore more exposed to risk of road accidents (SIDA, 2006). On the contrary to global status highlighted in Mayhew, Simpson & Traffic Injury Research Foundation of Canada (1990), for Malawi, young drivers crash less than older drivers though risk is significant in them. Apart from inexperience, young drivers (18-24 years) have greater fatigue risk because of more late night drives (Hartley, Arnold & Murdoch University, 1996) the same with alcohol risk (Elvic and Vaa, 2004; Keall, Frith & Patterson, 2004; Mathijssen, 1998) as they are less tolerant to alcohol (World Bank and WHO, 2004).

Children lack road safety knowledge and so crossing the road without thorough check and playing in busy streets and roads are their greatest risk (SIDA, 2006). Non-use of seat-belt in car occupants more than doubles the risk of crash injuries equally non-use of crash helmets in two-wheeler users almost doubles the risk of crash injuries (World Bank and WHO, 2004).

The relationship between gender and crash injury is not statistically significant in drivers ($\rho = 0.070 > 0.05$), passengers ($\rho = 0.063 > 0.05$), bicycle riders ($\rho = 0.739 > 0.05$) and motorcyclists ($\rho = 0.452 > 0.05$) while statistically significant in pedestrians ($\rho = 0.040 < 0.05$) therefore risk is the same and normal in both male and female drivers, passengers, bicycle riders and motorcyclists while it varies with pedestrian gender or male pedestrians are vulnerable more than females. Similarly, the relationship between road user age group and crash injury is statistically significant in drivers ($\rho = 0.000 < 0.05$), passengers ($\rho = 0.018 < 0.05$) and pedestrians ($\rho =$

0.025 < 0.05) while not statistically significant in bicyclists (ρ = 0.321 > 0.05), motorcyclists (ρ = 0.864 > 0.05) and animal drivers (ρ = 0.199 > 0.05) thus vulnerability differs with age in drivers, passengers and pedestrians or some age groups in drivers, passengers and pedestrians are more vulnerable while threat is standard in all age groups in bicyclists, motorcyclists and animal drivers.

The relationship between seatbelt use and crash injury is statistically significant in drivers (ρ = 0.000 < 0.05) and passengers (ρ = 0.006 < 0.05) thus risk varies with seatbelt/helmet use and is greater in non-compliance. While, the relationship between helmet use and crash injury is not statistically significant in bicyclists (ρ = 0.144 > 0.05) and motorcyclists (ρ = 0.060 > 0.05) so risk is the same and standard in helmet use compliance or not.

Table 4.2.15: Relationship between Road User Gender, Age and Injury

Co-factor	**Factor (years)**	**1-10**	**11-17**	**18-24**	**25-44**	**45-64**	**65 & Over**
Gender	**Crash & Fatality Top in**	**Males (66.9%; 73.2%)**	**Males (71.4%; 73.2%)**	**Males (86.9%; 87.7%)**	**Males (90.3%; 90.4%)**	**Males (87.3%; 77.4%)**	**Males (73.4%; 64.0%)**
	ρ-value	**0.034**	**0.555**	**0.000**	**0.000**	**0.000**	**0.038**

Findings in Table 4.2.15 inform, males are involved and killed more than females in age group 1-10 years (66.9%; 73.2%), 11-17 years (71.4%, 73.2%), 18-24 years (86.9%; 87.7%), 25-44 years (90.3%; 90.4%), 45-64 years (87.3%; 77.4%) and 65 years or above (73.4%; 64.0%).

Male children (1-10 years) have extra exposure as they hang out more and often play in busy streets and roads the same males in other age groups travel more on social-economic activities and are thus more exposed to the risk of road accidents in addition males are less concerned with safety and are thus more likely to violate traffic rules (SIDA, 2006).

The relationship between gender and crash injury is statistically significant in road user age group of 1-10 years (ρ = 0.034 < 0.05), 18-24 years (ρ = 0.000 < 0.05), 25-44 years (ρ = 0.000 < 0.05), 45-64 years (ρ = 0.000 < 0.05) and 65 years or over (ρ = 0.038 < 0.05) while not statistically significant in road user age group of 11-17 years (ρ = 0.555 > 0.05). Thus, vulnerability changes with road user gender or males are more exposed in all age groups except in 11-17 years wherein risk is equal and normal in both male and female road users.

4.3.3 Analysis of Pedestrian Behaviour Safety Problems Crash Data

Table 4.2.16: Relationship between Pedestrian Behaviour Safety Problems and Injury

Factor	**Pedestrian Behaviour**
Crash and Fatality peak in	**Crossing Road Carelessly (14.8%; 18.9%)** **Walking in Road (3.8%; 4.4%)**
ρ-value	**0.021**

In Table 4.2.16, crash and fatality lead in pedestrian behaviour safety problems of crossing road carelessly (14.8%; 18.9%), followed by walking in the road (3.8%; 4.4%).

Male road users are less concerned with safety and are thus more likely to violate traffic rules, including crossing road carelessly (SIDA, 2006). Evidently, this study finds male pedestrians and pedestrians in age group 25-44 years lead in casualty while crossing road carelessly. Likely, male pedestrians top in crossing road carelessly and must be the same with male pedestrians in age group 25-44 years. Also, in Africa, urban roads are full of people, more of them outside a motor vehicle than inside such that both carriageway and road shoulders are used intensively (de Langen et al., 2006) therefore competition for road space likely lead to higher risk taking and consequences are high mortality in unprotected road users (Tiwari, Mohan & Fazio, 1998).

The relationship between pedestrian behaviour and crash injury is statistically significant ($\rho = 0.021 < 0.05$) hence risk changes with pedestrian behaviour safety problems and crossing road carelessly risk more than other pedestrian behaviour safety problems.

Table 4.2.17: Relationship between Co-factors of Pedestrian Behaviour Safety Problems and Injury

Co-factor	Factor	Crossing Road Carelessly	Crossing Road at Crosswalk	Crossing Road Outside Pedestrian Crossing	Being Under the Influence of Alcohol	Walking in the Road	Other
Gender	**Crash & Fatality Top in**	**Males (82.4%; 90.6%)**	**Males (94.1%; 100.0%)**	**Males (1crash)**	**Males (19 crashes)**	**Males (95.2%; 90.0%)**	**Males (76.9%; 78.9%)**
	ρ-value	**0.017**	**0.178**	**-**	**-**	**0.615**	**0.533**
Age (years)	**Crash & Fatality Top in**	**25-44 (44.2%; 38.8%)**	**1-10 (41.2%; 40.0%)**	**45-64 (1 crash)**	**25-44 (73.7%; 85.7%)**	**25-44 (50.0%; 55.0%)**	**25-44 (35.9%; 42.1%)**
	ρ-value	**0.740**	**0.739**	**-**	**0.008**	**0.615**	**0.575**

In Table 4.2.17, male pedestrians are crash involved and killed more than females in behaviour safety problems of crossing road carelessly (82.4%; 90.6%), crossing road at crosswalk (94.1%; 100.0%), walking in road (95.2%; 90.0%) and other behaviour safety problems (76.9%; 78.9%) while only male pedestrians are crash involved while crossing road outside pedestrian crossing (1 crash) and being under influence of alcohol (19 crashes). Besides, crash and fatality lead in pedestrian age group 25-44 years while crossing road carelessly (44.2%; 38.8%), under the influence of alcohol (73.7%; 85.7%), walking in the road (50.0%; 55.0%) and other behaviour safety problems (35.9%; 42.1%) also peak in age group 1-10 years while crossing road at crosswalk (41.2%; 40.0%) and in age group 45-64 years while crossing road outside pedestrian crossing (a crash).

Male road users are generally less concerned with safety and are thus more likely to violate traffic rules (SIDA, 2006) while road users in productive age group 25-44 years travel more on social-economic errands and are thus more exposed to risk of road accidents besides males who dominate in the age group 25-44 years are less concerned with safety and are thus more likely to violate traffic rules (SIDA, 2006). Children generally judge vehicle approach speed incorrectly and often do not check for incoming traffic even once before or while crossing the road (Kandela, 1993) as they lack understanding of road safety (World Bank and WHO, 2004).

The relationship between pedestrian gender and crash injury is not statistically significant in crossing road at crosswalk (ρ = 0.178 > 0.05), walking in road (ρ = 0.615 > 0.05) and other behaviour safety problems (ρ = 0.533 > 0.05) while statistically significant in crossing road carelessly (ρ = 0.017 < 0.05) hence risk is equal and normal in gender in all pedestrian behaviour safety problems except in crossing road carelessly where it varies with gender and male pedestrians are more vulnerable while crossing road carelessly.

The relationship between pedestrian age group and crash injury is statistically significant in under influence of alcohol (ρ = 0.008 < 0.05) while not statistically significant in crossing road carelessly (ρ = 0.740 > 0.05), crossing road at crosswalk (ρ = 0.739 > 0.05), walking in the road (ρ = 0.615 > 0.05) and other behavioural safety problems (ρ = 0.575 > 0.05) therefore exposure is the same and standard in all pedestrian age groups in all behaviour safety problems except in under influence of alcohol where it varies with age group and alcohol risk lead in productive age (25-44 years).

4.3.4 Analysis of Vehicles Involved Crash Data

Table 4.2.18: Relationship between Motor Vehicle Characteristics and Injury

Factor	**Vehicle Class**	**Vehicle Defects**	**Vehicle Requirement**
Crash & Fatality Lead in	**Private cars (25.7%, 17.9%) Pick-ups (16.2%, 14.5%) Minibuses (11.6%, 11.1%) Heavy trucks (9.8%, 12.6%)**	**No Mechanical defects (91.3%, 90.5%)**	**Valid COF (85.3%; 82.8%)**
ρ-value	**0.000**	**0.582**	**0.000**

Findings in Table 4.2.18 inform crash and fatal peak in private cars (25.7%, 17.9%), followed by pick-ups (16.2%, 14.5%), minibuses (11.6%, 11.1%) and heavy trucks (9.8%, 12.6%). Similar to findings by Jones & Stein (1989), crash and fatal occur most in vehicles without mechanical defects (91.3%, 90.5%). Also, they lead in motor vehicles with valid COF (85.3%; 82.8%).

Vehicle population class split lead in private cars and pickups (WHO, 2011) correspondingly motorisation and exposure to road accidents (Smeed, 1949). Besides, most private cars and pick ups are owned and driven by drivers in age group 25-44 years found most perilous. Apart from cars and pickups have lower crashworthiness compared to bigger trucks and buses, greater mix of vehicle sizes in a carriageway also enlarge risk in small vehicles (World Bank and WHO, 2004). Impacts between cars and larger trucks, the power of the large vehicles increase rate of injury and fatality many times compared with an equivalent car-to-car crash (Joach, 2000; Mackay & Wodzin, 2002). In addition, use of pick-ups for transporting passengers, common in rural area, risk more crash deaths as passengers in open-back are often ejected and deadly crash into solid objects (Barss et al., 1998).

Drivers are often less cautious while driving a perfect motor vehicle and are thus more likely to violate traffic rules, including over-speeding but speed of vehicle is at the core of crash injury problems (Insurance Institute for Highway Safety, 1987; Nilsson, 1982; Nilsson, 1997). Also, vehicles with valid documents have greater per capita vehicle mileage travel and are thus more exposed to road accidents (Smeed, 1949). Unless vehicle has valid COF, is not allowed for other documents such as taxi licencing and insurance policy cover necessary for it to drive on public road (Road Traffic Act, 1997).

The relationship between vehicle class and severity is statistically significant ($\rho = 0.000 < 0.05$) so risk varies with vehicle class or some vehicle classes such as cars, pick ups and minibuses risk more road accidents. Similarly, the relationship between vehicle requirements and severity is statistically significant ($\rho = 0.000 < 0.05$) therefore risk is greater in vehicles with valid documents as they travel more and have greater exposure. While, the relationship between vehicle mechanical defects and severity is not statistically significant ($\rho = 0.582 > 0.05$) therefore mechanical defects have regular influence on road accidents.

4.3.5 Analysis of Motor Vehicle Drivers Crash Data

Table 4.2.19: Relationship between Driver Characteristics and Injury

Factor	**Driver Behaviour**	**BAC Level**	**Driving Licence**
Crash & Fatality Lead in	**Over-speeding (36.6%; 45.1%)**	**Unknown BAC level (96.5%; 96.9%)**	**Holders (96.3%; 95.4%)**
ρ-value	**0.000**	**0.002**	**0,004**

In reference to Table 4.2.19, crash and fatal injury lead in excess speed (36.6%; 45.1%) while occur most in unknown BAC level (96.5%; 96.9%) and licence drivers (96.3%; 95.4%).

Speed of vehicle is at the core of crash and injury problems (World Bank & WHO, 2004). The difficulty of the task of driving increases when driving speed increases (de Langen, 2006) and probability of a crash involving injury is proportional to square of speed-V^2 while serious injury to cube power-V^3 and fatal fourth to power-V^4 (Nilsson, 1982; Nilsson, 1997).

BAC level is rarely tested in crash victims mainly drivers and pedestrians as police lack equipment and the facility is available only in urban districts. In addition, as majority crash victims are evacuated by on-lookers and other motorists (Forjuoh, Friedman, Mock & Quansah, 1999), police has limited access for BAC level test.

With enhanced traffic checks and patrols by police, only graduate drivers have greater access to public roads and are thus more exposed to road accidents (Smeed, 1949) besides experience drivers often are less cautious and are thus more likely to violate traffic rules, including over-speeding and drunken driving.

The relationship between driver behaviour and severity is statistically significant ($\rho = 0.000 < 0.05$) hence risk changes with driver behaviour and peak in driver behaviour problem of over speeding. Likewise, the relationship between BAC level and severity is statistically significant (ρ

$= 0.002 < 0.05$) thus risk increase with BAC level also the relationship between driving licence and severity is statistically significant ($\rho = 0.04 < 0.05$) therefore threat changes with licence holding and licence drivers risk more road accidents.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Without national policies to promote walking and cycling (WHO, 2011), travelling is most dependent on motorised traffic, a high risk mode of transport, hence more road accidents despite very low vehicle population. Similarly, with lack of policies to promote public transport, travelling is most on private cars but private cars crash more and risk greater fatality.

Most collisions involve motorised traffic. Despite exposure, driver training and licencing share the blame. Relating to findings by Elvic & Vaa (2004), Malawi drivers may be more hazardous without driver training manual and check on health requirements as they lack good knowledge and a good understanding of risk as well their health risk may be greater than 1.0. Check on health requirements is not enforced in spite of enact in the Road Traffic Act, 1997.

Since crash data is sourced from police only, fatality is likely under-reported by gross margin (Gururaj, Thomas & Reddi, 2000; Jacobs, Aeron-Thomas & Astrop, 2000) therefore the assessment does not give the true burden of crash injury.

All road safety factors tested statistically significant ($\rho \leq 0.05$) to crash injury are major safety concerns and include speed, BAC level, seatbelt/helmet use, road user characteristics (type, gender, age and behaviour), vehicle type, time, day, district, accident type, road geometry, surrounding, other factors, light condition and more others. Unless intervened and their risk reduce to standard, crash injury trend continue rising and impact more economic and public health problems.

In contrast with global crash injury pattern (Worley, 2006) Malawi roads kill more than injury. Since Malawi lack formal and publicly available pre-hospital care system (WHO, 2011), similar to findings by Moch, Jurkovich, nii-Amon-Kotei, Arreola-Risa, & Maier (1998), probable vast majority of road accident deaths occur in the pre-hospital phase.

Speed of vehicle is at the core of crash involvement and injury problems, followed by growing motorisation and exposure, traffic mix with high speed traffic and non-use of seatbelt and helmet in car occupants and bicycle riders. Despite crash drivers are rarely tested for BAC level therefore alcohol risk is not well defined, legal limit of 0.08g/dl for both general population and young or novice drivers is suicidal and believed also a major safety problem.

Though competing for a space with high speed traffic is the core safety problem in pedestrians and bicyclists, lack of basic education and road safety knowledge also considered a significant contributor to their high vulnerability. Violation of traffic rules is common in them and often you see them naively not observing traffic control lights or crossing road carelessly or not keeping lane or changing course abruptly while turning or overtaking each other.

Crash and fatal occurrence is significant in collisions between motor vehicles leaving the road and solid roadside objects (mv/other). Unforgiving solid objects like concrete/wood made street light poles, trees, heavy billboards and others are seen located very close to carriageway besides most of them are not marked. Also, guard rails miss in most bridges and hazardous road geometry forms because of vandalism.

Rural roads are generally in poor condition and public transport is a problem as buses shun going there. Instead, pick ups do the service but pickups are not built for transporting passengers hence they are more perilous.

While carrying out interventions, with made known core safety problems, setting and achieve crash injury reduction target is now optimistic. By prioritising attention and resource allocation to significant risk factors, crash injury reduction or injury reduction per unit cost of intervention is likely to improve.

Road accidents are another core source of poverty in Malawi. With fatality occur most in pedestrians and bicycle riders whose majority are poor and in males in productive age group (18-44 years), similar to findings in SIDA, 2006, their families plunge into extreme poverty and more children are orphaned besides their plight exacerbate.

5.2 LIMITATIONS AND IMPLICATIONS

With one origin of crash data, that's police only, fatality is under-reported (Jacobs, Aeron-Thomas & Astrop, 2000). Police also rarely record seatbelt/helmet use, BAC level and behaviour safety problems in bicycle drivers. Consequently, statistical errors like that found in helmet use in motorcycle ($\rho = 0.060$) and bicycle ($\rho = 0.144$) riders. But, compliance in helmet use reduces injury risk (World Bank & WHO, 2004) then findings were supposed to be statistically significant. Besides, crash risks and injury burden are inadequately assessed while policy-makers and decision-makers are provided with insufficient information and safety problems are partially treated also road safety awareness is not developed and raised accordingly (World Bank & WHO, 2004).

Findings of the study outline the broad overview of road safety in Malawi as well as provide platform for cost effective approach while implement countermeasures. However, using crash data as means of measuring, monitoring and controlling road safety is unethical as is based on human cost. Best practice recommends for evaluate of key indirect RSPIs. Like in non-destructive test on machines, indirect RSPIs just inform the prevailing degree of risk and controlling indirect RSPIs reduce also road crash injuries. However, indirect RSPIs are yet evaluated therefore a menu for further studies. Pattern of crash deaths is another area requires thorough analysis. Unless scope of fatality in crash phases is determined, precise countermeasures can hardly be identified.

5.3 RECOMMENDATIONS

5.3.1 To minimise the abating road safety in pedestrians, bicycle riders and passengers National Transport Policy (2004) should promote walking, cycling and public transport in order to switch from higher risk to lower-risk modes of transport as well as to reduce traffic mix with high speed traffic and travel dependence on private cars.

5.3.2 Reduce risk in drivers and road factors to cut back road accidents of motorised traffic which are more perilous.

- RTD need to improve capacity in driver training (develop curriculum and manual), testing (include theory test) and licencing (enforce health requirements) and in vehicle inspection (more pits and equipment).
- TP should intensify traffic checks and patrols.
- NRSCM should conduct defensive driving courses regularly.
- RA should design and construct roads with minimal risk as well as rehabilitate and maintain roads for minimal risk.

5.3.3 Road safety agencies should step up speed management and enforcement as speed of the vehicle is found at the core of crash involvement and injury problems.

- Restrict road use to design function.
- Construct physical traffic calming measures such as roundabouts, road narrowing, humps and chicanes at intersections, bus stops, pedestrian crosswalks, access/locals roads and high risk stretches in rural roads respective.
- Raise pedestrian crossings as well as split pedestrian crossing with a traffic island in places of high risk in urban such as schools and market places so that pedestrians cross in two stages thus less exposed to vehicles.
- Purchase more speed radars and intensify random spot speed checks.
- Use visible single, stationary police vehicle on high risk stretches mainly in rural.
- Regulate and enforce use of speed governors in minibuses.

5.3.4 Regulate and enforce mandatory use of seatbelt in all car occupants, child seat restraint and helmet in two-wheel drivers, including bicycle riders to fall crash deaths.

5.3.5 Revise BAC legal limit (0.08g/dl) to most sanctioned limit of 0.05g/dl for general driver population and 0.02g/dl or below for young drivers and motorcycle riders in addition regulate BAC legal limit for pedestrians and bicycle riders.

5.3.6 RA should design roads and networks that accommodate human characteristics and are more forgiving if an error is made. Use only forgiving fixtures and, if not, remove them or fix them to a safer distance of about 5m to 9m or beyond also mark them for more visibility during night.

5.3.7 RA, MOT&PI, LC and communities should maintain rural roads regularly to reduce road factors and to improve access of buses which are safer compared with pickups.

5.3.8 To curtail preventable deaths, Malawi need a vibrant, autonomous emergency rescue agency with call free numbers along with more ambulances, equipment and trauma care specialists for standard practice in evacuation of crash victims and for better pre-hospital care. Capacity of health and physiotherapy care also needs improvements for satisfactory medical treatment and rehabilitation of survivors of road traffic crashes.

5.3.9 Legislative laws need to prohibit bystanders and other motorists taking part in evacuation of crash victims unless contacting the emergency services or calling for other forms of help, helping to put out any fire, securing crash scene from further crashes or harm to rescuers and bystanders, control of crowd gathered at scene and apply first aid. And so, drivers and locals living in crash prone sites like Lithipe 1 need training in first aid.

5.3.10 Police crash data must be supported by other sources preferably hospital or insurance firms for capturing nearly all road accidents in that case to assess true risks and burden of crash injuries.

5.3.11 To maximise crash injury reductions or reductions per unit cost of prevention, resource allocation and attention need prioritise significant risk factors while implementing road safety countermeasures and public awareness campaigns.

5.3.12 Perform advanced crash data analysis regularly for better planning, implementing, monitoring and evaluating interventions.

5.3.13 RA should not compromise road safety in designs, construction, rehabilitation and maintenance of roads. Though inclusion inflates project price, road safety problems cost more than the project so there are no savings.

5.3.14 Capacity of NRSCM need improved if road safety awareness campaign and publicity is to balance with deteriorating road safety. The same with RTD and TP for advanced enforcement of road traffic laws and regulations required to compliment effectiveness of road safety awareness campaign and publicity.

5.3.15 Malawi need a lead road safety agency with the authority and responsibility to make decisions, control resources and coordinate efforts by all sectors of road safety including those of health.

5.3.16 Road Safety agencies ought to evaluate indirect RSPIs for best practice in measuring, monitoring and controlling road safety.

5.3.17 Multinational Corporations, Donor Countries and Agencies, United Nation Agencies and Nongovernmental Organisations urgently need to declare more of its resources to helping low-income countries including Malawi improve road safety otherwise, with the level of assistance given to road safety which is far below that for other health problems of comparable magnitude like Malaria, TB and others, poor nations fight a lose battle.

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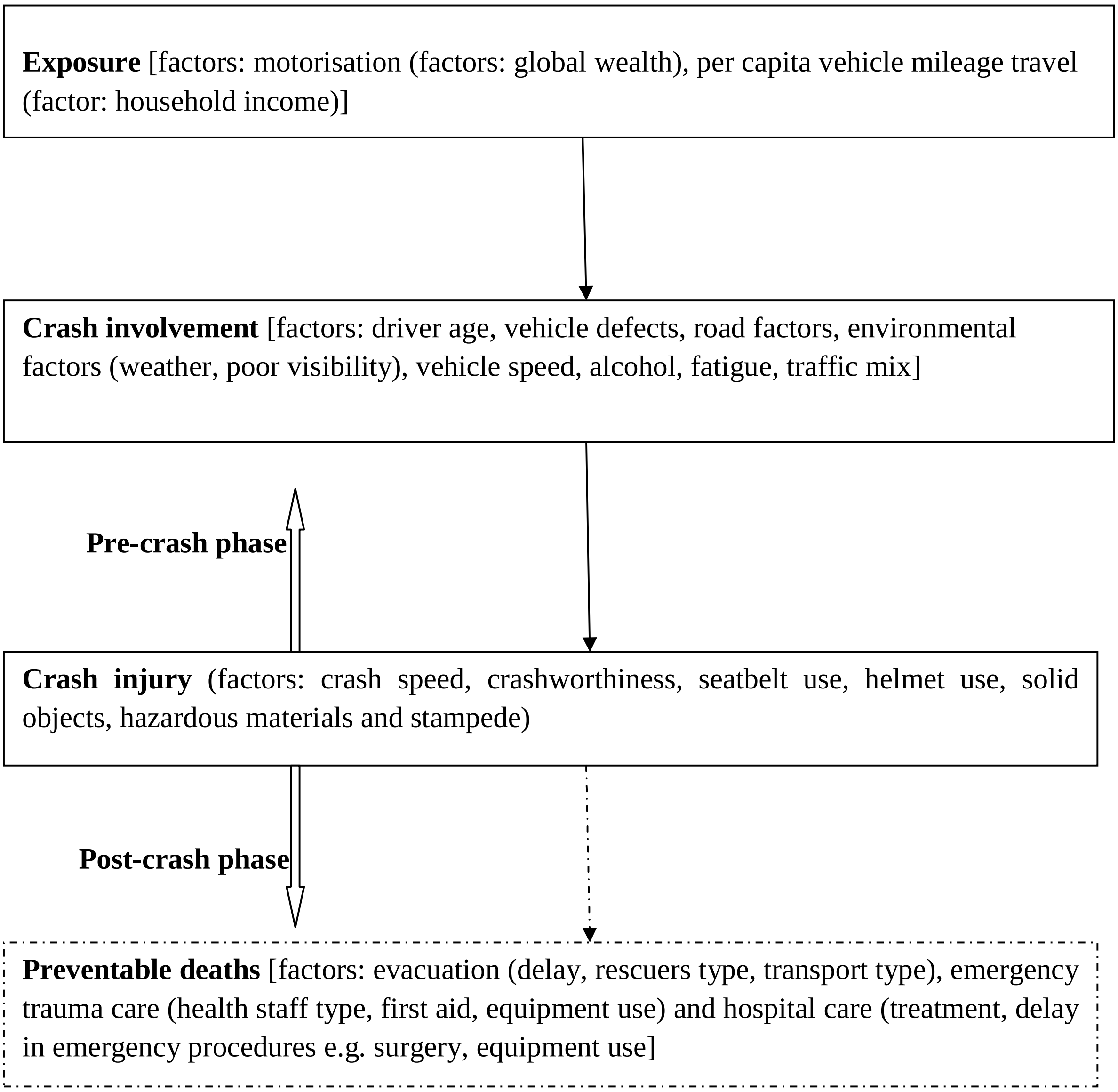
APPENDIX

Conceptualisation of Road Traffic Accidents



Exposure [factors: motorisation (factors: global wealth), per capita vehicle mileage travel (factor: household income)]

Crash involvement [factors: driver age, vehicle defects, road factors, environmental factors (weather, poor visibility), vehicle speed, alcohol, fatigue, traffic mix]

Crash injury (factors: crash speed, crashworthiness, seatbelt use, helmet use, solid objects, hazardous materials and stampede)

Preventable deaths [factors: evacuation (delay, rescuers type, transport type), emergency trauma care (health staff type, first aid, equipment use) and hospital care (treatment, delay in emergency procedures e.g. surgery, equipment use]

Figure 1.2.2: Concept Framework of Road Traffic Accidents