A Study of Road Accidents, Causalities and their Injury Patterns in Libya

By

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DECLARATION

The author declares that no part of the work presented in this thesis has been submitted in application for another degree in this or any other university or educational institution.

Abstract

This study examines the characteristics and details of road accidents that occurred in Libya between 1966 and 2000. The accident rate in Libya, on any comparable basis, is much larger than that in the Europe and USA and the culture of recording data and creating accident statistics is not well established. This work is the first attempt of any kind to collect and examine such data.

Information was obtained from several sources in Libya during three field trips by the author during the course of this study. The numbers of road traffic accidents and casualties were obtained from the office of the Libyan Directorate General of Traffic based in Tripoli and the details of licensed vehicles and population statistics were obtained from the Secretariat of Planning.

This data was examined using established methods used in the UE and USA to determine the utility of the accepted analysis methods in the Libyan situation.

The overall results indicated that motor vehicle accidents are the most common single cause of avoidable death and disabilities in Libya averaging 3.4 per day. The reason for this is based on several factors peculiar to Libya such as the poor state of the infrastructure, the lack of road safety features, the aging vehicle population and the lack of adequate medical facilities.

The data collected was divided into different categories to enable the examination of pedestrian casualties, the impact of vehicle occupancy, the age and condition of the vehicle involved and the age and sex of the victim. Each of these categories was further subdivided to provide a further detailed analysis.

The results obtained from the analysis showed the utility of the established analysis methods. The results broadly agreed with the findings of other workers but indicated a higher incident rate than had been recorded in developing countries such as South Africa and Saudi Arabia and were much larger than the USA and Europe.

This thesis concludes by suggesting ways in which pedestrian and traffic safety can be improved in Libya and makes recommendations with regard to improving the accident data collection and reporting methods. It is considered that this work, being the first of its kind to address road traffic accidents in Libya, has highlighted many contributory infrastructure aspects the effect of which can be reduced if the recommendations of this thesis are implemented.

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CHAPTER ONE

INTRODUCTION

1 Introduction

During the twentieth century road accidents have replaced infectious disease as a leading cause of death. However it is not only the numbers involved which are similar between accidents and disease. Gordon (1949) noted that three factors can be identified in the causation of disease and of accidents; these factors being the host, the agent and the human, the agent being the virus or bacteria responsible for the disease and environmental factors the mechanisms which bring the host and agent together. A similar situation applies to accidents where the host factors are the actions of persons leading to the accident, the agent that which causes the accident and the environmental factors are the location and time where the host and agent interact.

Orme (1965) suggested that accidents were a result of interactions between the roads, people and vehicles. These are the same factors that Gordon noted, but expressed in terms of road accidents. Haddon (1968) proposed that an accident can be divided into three stages; pre-crash, crash and post-crash. The pre-crash phase is concerned with driver characteristics such as being under the influence of alcohol or old age; the state of the vehicle and road, and the vehicle and occupant. The crash phase covers the interaction between the vehicle and road, and the vehicle and occupant. The post-crash phase covers the emergency and other services needed as a result of the accident.

1.2 The Magnitude of the Road Crash Problem in Libya

The Road Statistics Review of Libya M.O.I. (1996) showed that road accidents were the greatest single cause of death for those aged 25-35; representing 30% of all fatalities. The percentage of deaths caused by traffic accidents in relation to total deaths in Libya 1996 was 11% of total deaths (H.D.F. 1997). This is abnormally high compared with similar statistics for Great Britain, for example, which show that the average percentage of deaths through traffic accidents was only 3% (HMSO 1996). However fatalities are only a small part of the problem. For each person killed in the year 2000, approximately 3 people were seriously injured and 4 were slightly injured (Road Accidents Statistics, Libya, 2000); many of the seriously injured receiving permanent disabilities as a result of their accidents. According to the Special Need Medical Centre in Tripoli city in1996, it was reported that 255 persons were disabled as a result of traffic accidents in Tripoli alone. In the period between 1998 and 2002 there were 1,502 persons disabled as result of traffic accidents in Libya (Alyoum 2004).

Fatal accidents represent not only tragic family losses but also serious economic losses to the community in respect of their education and training. Property damage from traffic accidents cost the Libyan economy £8 million (16 million LD) annually (Road Accident Statistics, Libya, 2001). It is not only mortality that has to be considered, but also the temporary and permanent incapacity resulting from road traffic accidents. In addition to the pain and suffering caused and the tragedy of death or permanent disability, serious economic losses to the community arise from road traffic accidents. This is due to the actual costs of medical and surgical treatment, which tend to increase as techniques advance. These costs are explained in chapter four, as are the loss of the economic contributions of the injured persons, and the damage to property. Road traffic accidents now constitute a public health problem of substantial magnitude. Table 1.1 shows the major causes of death in the country during the year 1997, and it is clear that motor vehicle accidents rank second highest amongst the leading causes of death in Libya.

Cause of death	Percentage
Circular	37.4
Tumours	13
Road accidents	11
Diabetes and glands	5.8
Glandular Infections.	5.3

Table 1.1 The Main Causes of Death in Libya

1.3 Comparison Between Libya and Other Countries

To further the present research and gain a better understanding of motor vehicle accidents in Libya, it was necessary to compare some of Libya's statistical data with those of other countries.

Generally, in dealing with any country's traffic accident situation and to know its standing in relation to that of other countries, it has to be considered that every country decides on the basis of human and economic considerations whether or not the yearly numbers of traffic accidents and fatalities is tolerable, and can then consequently decide what investment is desirable in order to bring the number of accidents down to a satisfactory level. The making of such decisions is, of course, primarily political since they concern budgetary priorities. Establishing these priorities can nevertheless be influenced by a comparison with surrounding countries of similar circumstances, or with either developed or developing countries.

The division between developed and developing countries is by no means clear and many definitions have been used. An early definition of a developing country was one with a vehicle ownership level of less than 1,000 vehicles per 10,000 population.

In the past few years the World Health Organization has conducted a thorough study of road accidents in the developing countries (WHO 1999), and it was concluded that "Road accidents are a serious public health problem". In developing countries the problem was already severe and will increase as the use of motorized transport increases. Despite the lack of reliable data, there is evidence that in several developing countries, traffic accidents have tripled and fatalities doubled during the last ten years.

Libya is a rich and rapidly developing country. Yet it is still a developing country, and it has its own particular problems in respect of traffic accidents.

International traffic accident rates have been developed by concerned organizations such as the International Road Federation. These are published in their annual publication "World Road Statistics" and have been adopted for the purpose of making general comparisons of traffic accidents statistics. The 2000 publication included the following:

1. Fatality rates related to population (fatalities per 100,000 persons).
2. Rates related to vehicle population (fatalities per 10,000 motor vehicles)
3. Rates pertaining to vehicle ownership (vehicles per 10,000 persons).
4. Rates related to vehicle kilometerage (fatalities per 100 million driven kilometres).

In considering these rates, it should be noted that Libya depends totally on roads and vehicles for the transportation of goods and people. There is neither a railway system nor a rapid transit passenger train system. Table 1.2 consists of published data gathered to compare the changes in road accident rates, firstly in a number of developing countries which share the same culture as Libya, and secondly the rates in two developed countries.

	Country	Fatalities per100,000 people	Fatalities per10,000 vehicles
1	Libya	24	8.3
2	Egypt	7.4	20
3	Morocco	10.4	20.1
4	Jordan	12.8	18.8
5	Syria	10.5	36.2
6	Saudi Arabia	21	13.9
7	U.K	6.3	1.4
8	US	15.8	2

Table 1.2 Road Accident Rate Comparisons Between Libya and other Countries (1996)

The fatality rate per 100,000 populations for Libya was higher than the corresponding figures for all other Arabic countries. Compared with the rates for the U.K and it is very obvious that the fatalities per population in Libya were more than four times that of the U.K.

1.4 Overview of Libya

The Libyan Arab Jamahiriya has a surface area estimated at 1,775,500 km^2 with a population of 4.7 million in 1997. Most of the population, however, is concentrated in the main cities on the coastal plains, namely Tripoli and Benghazi.

About 85% of the population are urban. Population growth in urban centres is 7% per year. In 1995, the percentages of the populations below 15 years of age and above 65 years of age were 39% and 2.2%, respectively. In 1996, it was estimated that 82% of the total adult population and 74% of the female adult population were literate. The crude death rate was estimated at 7.0 per 1,000 population in 1996, and in the same year, the crude birth rate was estimated at 40 per 1,000 population. In 1995, infant mortality was 24.4 per 1,000 live births, maternal mortality was estimated at 4.0 per 10 000 live births, the total life expectancy was 66 years and the under-five mortality rate was estimated at 30.1 per 1,000 live births.

The motto of Libyan health policy is "health for all by all". The goal of this policy is to create a society in which every member can play a active role, both socially and economically, and in which services are equally distributed among the whole population.

1.4.1 Geography of Libya

Libya is located in the centre of North Africa with a Mediterranean coastline of close to 2,000 kilometres. To the north, the country is bounded by the Mediterranean Sea; to the east by Egypt and Sudan; to the south by Niger, Chad and Sudan; and to the west by Algeria and Tunisia. In terms of size (1,775,500 square kilometres), Libya is the fourth largest country in Africa, and seven times the size of the United Kingdom. However, over 90 per cent of the land is either desert or semi-desert, and the country's climate is affected by the Mediterranean Sea to the north and the Sahara to the south

1.5 Methodology of this Study

Due to the complexity and the extent of the problem, several methodologies had to be developed at several stages in order to obtain the necessary information for subsequent analysis and recommendations.

Initially, a method had to be developed to identify the organizations involved in road safety in Libya and Great Britain. Although this was anticipated to be an easy process, it turned out to be rather difficult. There is no one organization in Libya that holds all Libyan accident and injuries data.

The World Bank was first approached for information relevant to this aspect of the study. Unfortunately, they did not have any data directly related to Libya, but were able to supply some information which was useful in the initial literature review.

After lengthy discussions and research, it was found that the Secretariat of the Interior was the main source of information concerning accidents in Libya. Data such as number of accidents and number of casualties are available from the Secretariat but details of data such as pedestrian accidents and casualties, vehicle types involved in accidents, and injuries sustained by vehicle occupants were not available. The Secretariat of the Interior advised us to contact the police station at the region where an accident occurred to gain more details about the crash circumstances and injuries sustained for each victim. Population denominator data were obtained from the Libyan Annual Statistics (2000). Comparative data were obtained from the Great Britain Road Accidents Casualties Report (2000).

It has been noted that Libyan accident databases are still managed manually. As a result of this, many accident details are unreported, such as vehicle type, seat belt usage, and injuries sustained by occupants.

Vehicle licence numbers were obtained from Libyan Human Resources Report (1999) and the Ministry of Transport, Libya. The numbers of licenced vehicles were not available in the Libyan database for the years 1997 to 2000. The mean pre-impact speed for each accident was calculated from information given by the vehicle driver, passengers, and the officer who reported the accident, and the mathematical mean of these estimates was taken as the pre-impact speed for each accident.

Details of injury data were obtained from three hospitals in different districts in Libya. Al-Zintan General Hospital is located in Al-Zintan city which is located on the top of Al-Gabal Al-Garbe (Western Mountain) with the biggest population in the region (50,000 people). The second hospital was Aboslime Accident Hospital in Tripoli, the capital city of Libya (population 1,127,118), and the third was the Accident Hospital in Benghazi city (population 615,463), which is the second largest city in Libya. These three regions were chosen as a representative sample of Libyan accidents because of their high vehicle population and number of inhabitants. The three also have different topographic characteristics.

1.6 Injury Data

Details of the injuries received were obtained from four sources. For nonfatal accidents injury data were obtained from the police accident records, the hospital where the victim was treated, and from the occupants themselves wherever possible. For fatal accidents detailed information was available from the post mortem reports.

The majority of the hospitals contacted agreed to cooperate in this study. Questionnaires were also sent to injured vehicle occupants (see appendix D1.1) requesting information on their injuries.

1.6.1 Accuracy of Data

As stated earlier, information about non-fatal injuries was obtained from four sources:

- The hospital that treated the injured person.
- The injured person.
- The accident report obtained from the police station that kept it in its own database.

- To increase the accuracy of data a postal questionnaire was sent to the victim's families for more details about their injuries and accident circumstances.

A comparison has been made of the information received from these four sources. After analysing the available data, from 1569 cases, 357 cases were excluded from this study. The main reason for this was that many of the occupant details were not recorded in sufficient detail in the accident database.

1.6.2 Accident Cost Data

An attempt was made to estimate the cost of fatal traffic accidents in Libya, and the findings were used for comparison with Great Britain traffic fatality costs.
Data on fatal accident costs, police costs and family and community losses were obtained from different sources in Libya. Number of deaths and property damage costs were obtained from Traffic Accidents in Libya M.O.I. (1996). Lost quality of life (human cost) was obtained from the Libyan Insurance Company. The costs of hospitalization and nursing, physician services, physical therapy, emergency services and transport of casualties were obtained from questionnaires sent to the staff of the central hospital at Tripoli.

1.7 Accident and Injuries Analysis

Details of vehicle impact directions were collected from the scale drawings in the accident reports, and then analysed according to the Collision Deformation Classification (CDC) system (SAE, 1985).
Impact direction in this study is described by the Collision Deformation Classification

CDC system. The CDC is a seven character code, used universally, for describing and communicating the essential factors of collision deformation (SAE 1985). The code is of great benefit in the section studying accidents meeting similar criteria. More details concerning CDC are located in Appendix A.1.

Impact directions are defined as: frontal impacts, where the principal direction of force is between 11 and 01 o'clock inclusive; side impacts have a principal direction of force between 01 and 05 o'clock or 07 and 11 o'clock inclusive.

In the absence of any routine injury coding system in Libya, the study used trauma and orthopaedic specialists to help in estimating injury severity from patient records, using the Abbreviated Injury Severity Scale (AIS) (AAAM, 1990) and Maximum AIS. This was done through converting injury diagnosis and text descriptions of injuries into AIS90 codes (AAAM, 1990). The Abbreviated Injury Scale (AIS) (AAAM, 1990) is commonly used in international accident surveys. It is the most commonly used injury classification system in accident studies. AIS classifies injuries into 7 degrees of severity (from 0 uninjured, 1 = minor, 2 = moderate, 3 = serious, 4 = severe, 5 = critical, 6 = immediately fatal) in seven body regions (see figure 1.1): external, head, neck, thorax, abdomen, spine, extremities. More details about AIS are given in Appendix A.2.

The border between severe, almost fatal and fatal injuries is at AIS4. Thus the sample was separated into groups; occupants who have received minor injuries (AIS 1); and occupants experiencing injuries ranging from AIS 2 level to AIS 6 level are classified as having received moderate to fatal injuries.

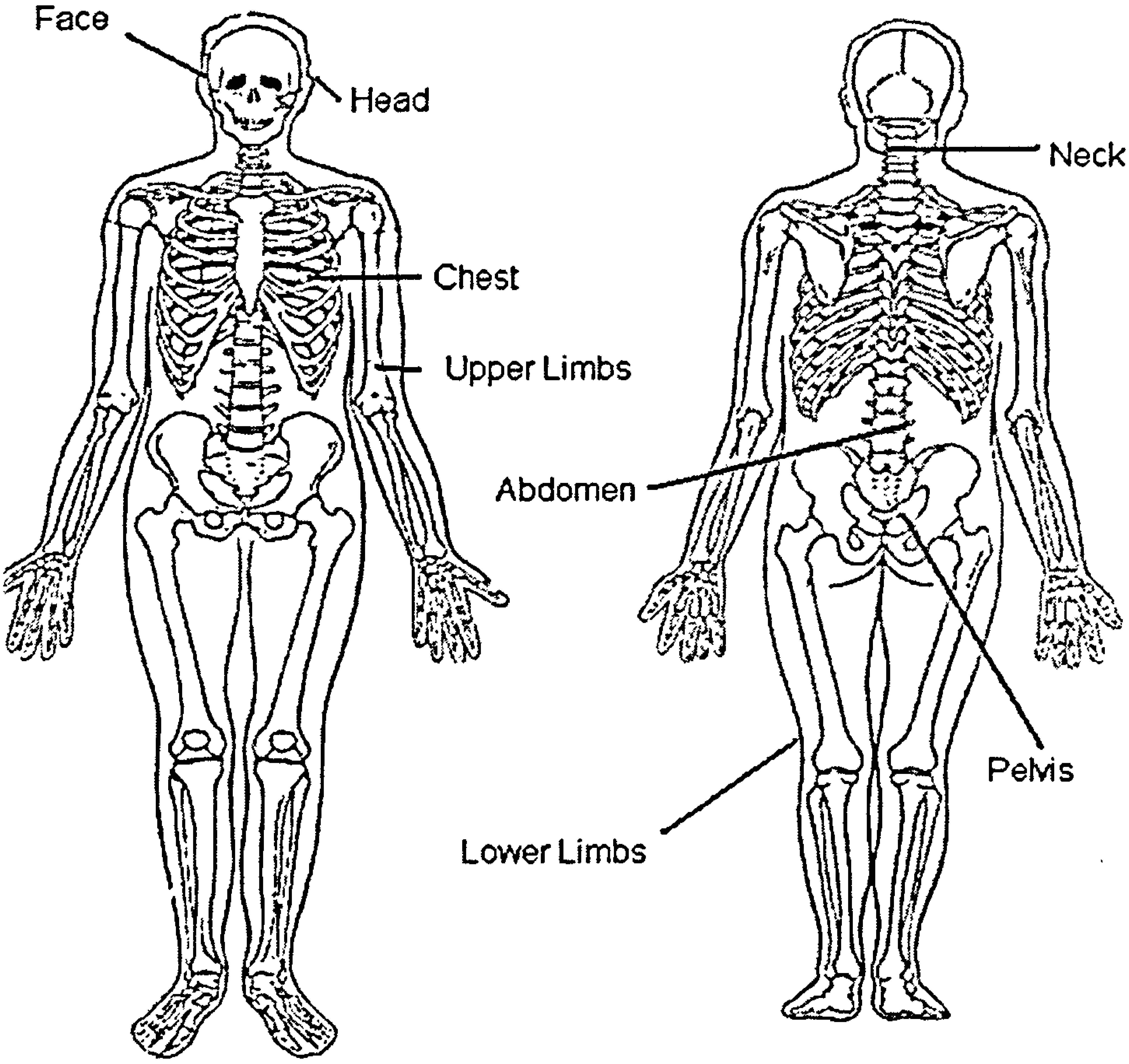


Figure 1.1 Body Regions

1.8 Data Analysis Procedure

The data acquisition resulted in the collation of data relating to over 20 variables, each having several values, for each of the 765 accidents (332 vehicle and 433 pedestrian accidents) and 1203 casualties. It was apparent that manual methods of data manipulation and analysis would prove to be impractical. Therefore the option of using computers for handling such a large volume of data was pursued.

A PC computer at the University of Newcastle was used for computerised data storage and processing. A compatible commercial statistical software package MINITAB 14 (Statistical Package for Social Sciences) was used to perform all of the statistical analysis.

1.9 Statistical Model

A statistical model was designed to achieve the main aims of the study. As illustrated in figure 1.2, the data were coded for input to the computer and stored in three separate files

1. Accident file.
2. Occupant file.
3. Injury file.

The accident data file contained information relating to the accident and vehicle as extracted from the police database, which included urban and motorway accidents, pre-impact speed at all locations, and impact direction. The occupant data file contained information relating to the occupant's seating position and seatbelt use as extracted from the police database. The injury data file included information on impact directions, occupant seating positions, and injury sustained. For each occupant, the body was divided into seven regions, and injury severity was recorded according to the Abbreviated Injury Scale coding system AIS (AAAM, 1985).

The creation of three separate files did not limit the range of analysis that could be carried out. The software package (MINITAB 14) provided procedures which allow cross-file analyses to be performed. Cross-file matching allows variables from separate files to be analysed together, which is performed frequently in this study.

1.10 Statistical Analysis

Crude and specific rates of road traffic accidents and injuries and deaths were calculated using the following formulae:

RTA fatality rate per 100,000 population =

$$\frac{\text{number of deaths in Libya from RTA during the year} \times 100,000}{\text{total Libyan Population}}$$

RTA injury rate per 100,000 population =

$$\frac{\text{number of injuries in Libya from RTA during the year} \times 100,000}{\text{total Libyan Population}}$$

Rate of RTAs per 100,000 population =

$$\frac{\text{number of RTAs during the year in Libya} \times 100,000}{\text{total Libyan Population}}$$

Rate of RTAs per 10,000 registered vehicles=

$$\frac{\text{Number of RTA during the year in the Libya} \times 10,000}{\text{total number of registered vehicles during the year}}$$

1.10.1 Univariate Analysis

The statistical techniques employed in the analysis of data are only briefly described here, since most of the techniques are well documented (Afifi 1990, Hosmer 1989 , Edwards 1979, Tabachinck 1983, Zar (984 and Freeman 1987). The techniques employed are dictated by the type of data being analysed, which were categorical. Multivariate analysis was performed, and the statistical significance level model for the rejection of the null hypothesis was set at the probability level of $\leq 5\%$.

The type of statistical techniques applied for performing univariate analysis is dependent upon the type of response and predictor variables under study (Afifi and Clark, 1990). Non parametric statistical methods are employed when both the response and predictor variables are categorical with two or more levels. Parametric statistical methods are employed when the response variable under study is of the ratio or interval type.

The non parametric statistical model of the chi-square test is used when it is desired to identify whether a significant relationship exists between two categorical variables (Neave 1988). The chi-square test is basically a goodness of fit test which involves comparing a set observed frequencies with a set of expected frequencies calculated under the null hypothesis of no association between the two quantities. The data are arranged in the form of a contingency table with R number of rows and C number of columns. This method is employed in chapters four and five.

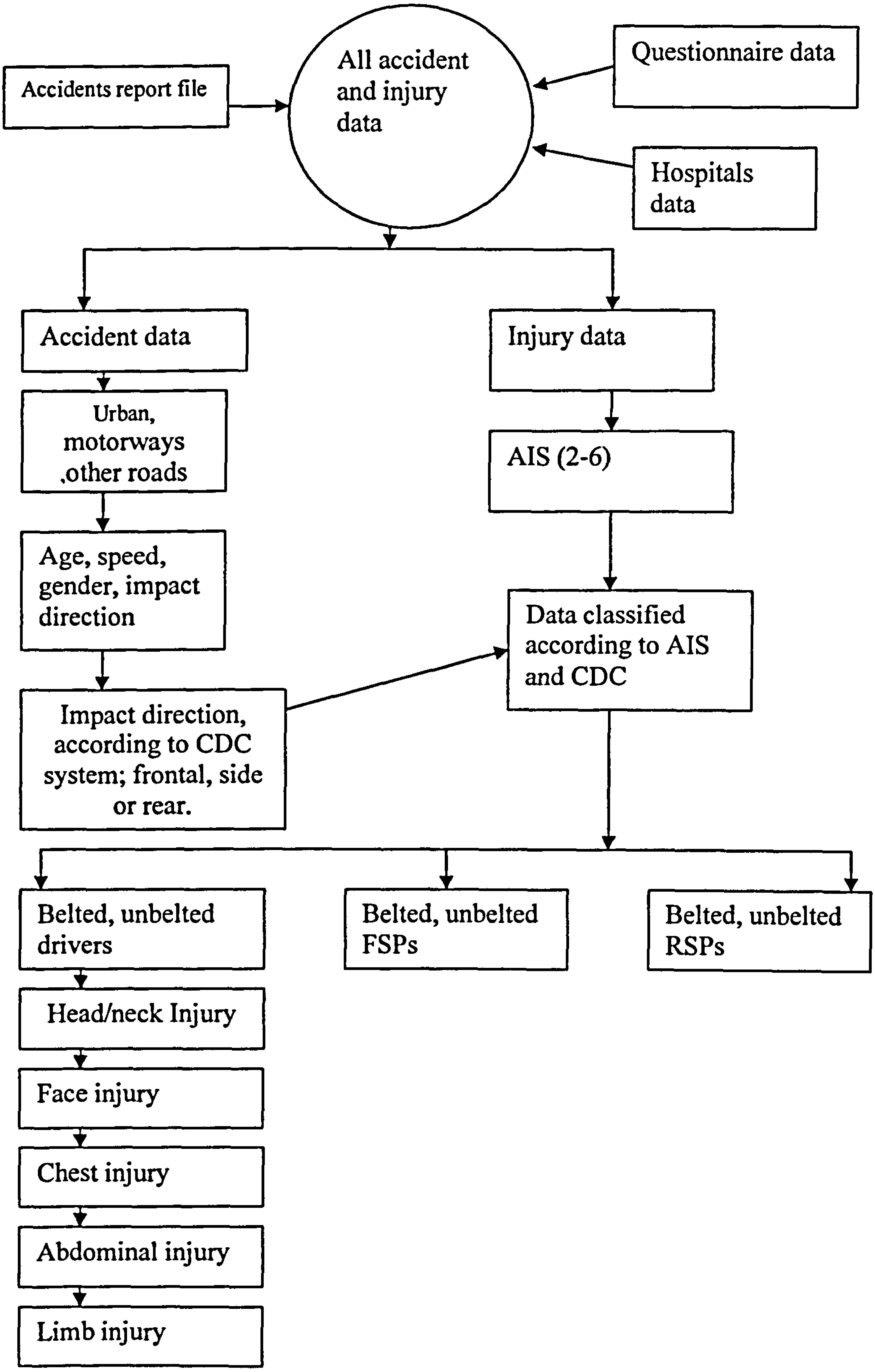


Figure 1.2 Data Analysis Model

1.10.2 Multiple Regression Model

Multiple regression techniques have been employed in this study to determine the significant independent variables which contribute to the outcome variables. The most common regression method is conventional regression analysis. This is used in chapter three.

1.10.3 P-value

Representing how significant rejecting or accepting the null hypothesis understudy. Generally speaking, if this value is less than the alpha value ($\alpha = 0.05$ or 0.01 and is called the level of significance), it is mean that the test is significance and null hypothesis is rejected. If this value is greater than alpha, then null hypothesis is accepted.

These methods have been used by various authors (Richter 2001, Hill 1994, Xuejun Liu 2003, Koushki 2002, Chliaoutakis 2000 and Hussa 1994) in analysing traffic accidents and injuries data. Statistical analysis was only performed when a sufficiently large sample size was available. Only descriptive analysis of observed values is offered when an insufficient sample size is available for valid statistical analysis to be performed.

1.10.4 Significance Tests

In practice, expected frequencies are computed on the basis of a hypothesis H_O (the null hypothesis). If under this hypothesis the computed value of x^2 is greater than some critical value (such as $x^2_{0.95}$ or $x^2_{0.99}$, which are the critical values of the 0.5 and 0.1 significance levels, respectively), it would conclude that the observed frequencies differ significantly from the expected frequencies and would reject H_O at corresponding level of significance; otherwise, it would accept it. This procedure is called the chi-square test of hypothesis or significance.

1.11 Objectives of this Study

The main objectives of this study were to analyse Libyan road accidents and injuries data to identify the main causes of accidents and injury and possible underlying factors for the high casualties, and to try to find any preventive clues which can be employed for future planning. The specific objectives of the study were to:

1. Perform analysis of the available data, relating to the type and nature of collisions, occupant characteristics and the causation of their injuries.

2. Assess the influence of seatbelts on injury severity outcomes with different seating conditions as measured on the Abbreviated Injury Scale. The significant characteristics that influence injury severity are to be identified by performing chi-test analysis.

3. Analyze pedestrian data relating to age of casualty, speed of the vehicle, location of the crash, and injury outcomes of the crashes.

4. Learn lessons from accident experiences and remedies in developed countries (with particular reference to Great Britain).

5. Use available data to estimate the fatality costs of traffic accidents.

6. Analyse the pattern of road accidents and casualties in Libya for the period 1966-2000, and to identify the factors which contributed to the problem of road traffic accidents in Libya, and the most useful directions for future research and road traffic safety to take in Libya.

These objectives are addressed in the subsequent chapters of this report as follows Chapter three gives an overview of road accidents in Libya from 1966 to 2000. Chapter four analyses 770 vehicle occupants and their injury patterns according to the direction of impact and seating position. Chapter five analyses 442 pedestrian accidents according to their age and sex, vehicle speed, location of accidents, and injury outcomes. A comparison between Libya and Great Britain is carried out in chapter six in terms of different aspects such as number of accidents, accident reporting system, and other factors.

CHAPTER TWO

LITERATURAL REVIW

2.1. Introduction

This chapter reviews the literature related to traffic accident and injury patterns. Unfortunately very few studies have been conducted in Libya; only two studies were carried out in the middle-1980s about traffic accidents in Libya, and after that, no studies at all have been carried out.

The scope of this review ranges from vehicle accidents and injuries to pedestrian accident and injuries, seat belt effectiveness, and traffic accident costs. This chapter is not intended to be comprehensive review of all work conducted in this field, but it explains the current state of the art in traffic accident and injuries work and provides the basis and context for the remainder of this study.

2.2 Road Traffic Accidents in Developing Countries

Over the past decades motor vehicles have become the primary mode of transportation in developing countries. At the same time, improvements in automotive engineering and manufacturing - as well as the phenomena of urbanisation have resulted in more vehicles spending more time on the road at higher speeds. Inevitably, the larger number of vehicles on the road and an increase in the speed at which they travel leads to vehicle accidents. Most low income countries are facing hard time due to rapid urbanization and motorization in combination with poverty; (Graitcer 1987; Frerichs 1991). Many studies have addressed the traffic accidents in developing countries from different perspectives, Smeed (1949) studied the relationships between road accident fatality rate (per licensed vehicle) and vehicle ownership (per head of population) in 20 developing countries, using data for the year 1938.

An equation was derived as follows:-

$$\left(\frac{F}{V}\right) = 0.0003\left(V/_P\right)^{-0.67}$$

Where F = fatalities from road accidents

V = number of vehicles in use

P = population.

Further research by Smeed (1968) showed that the above relationship, derived using data for the year 1938, was still a remarkably good fit for data from many countries as late as 1968. Smeed (1968) used this relationship to show that the future number of road deaths in a country can be predicted from knowledge of the future number of people and vehicles in that country. Thus: -

$$F = 0.0003\left(VP^2\right)^{0.33}$$

The predicted number of death from the formula differed from the actual number by a margin of 15% in the half of the twenty countries. For figures like this, tese differences are reasonable, and the formula may be accepted as giving a rough guide to the expected number of deaths annually in a country.

Smeed (1968) studied the changes in fatalities and casualty rates (per licensed vehicle and per person), and vehicle ownership rates (per head of population) over a 9 year period in 15 mainly developed countries. He also found that in all but one of the countries, the fatality rate per licensed vehicle fell whilst in all the countries vehicle ownership rose.

Jacobs (1977) presented an analysis of personal injury accident rates for roads in selected urban area in developing countries and Great Britain. The study illustrates, for a number of cities, the distribution of accidents by type of road, class of road-user and vehicle involved. This report showed that accident and casualty rates (per licensed vehicle) were about 60 per cent greater in cities of the Third Word than in Great Britain and fatality rates were found to be up to 800 per cent greater. He also found that in these cities there were a greater proportion of pedestrian casualties than in Great Britain. Furthermore, a comparison of accident rates per kilometre of road per annum and average vehicle flow per hour indicated that cities in developing countries have higher accident rates in their central areas than shopping streets in four towns in Great Britain, for similar levels of vehicle flow. It was also found that the relative risk was much higher in the cities of developing countries than in shopping centres of Great Britain for similar levels of vehicle flow. It was noted that factors such as overloading of buses, or the use of potentially unsafe vehicles, obviously contribute to the high accident rate in the cities of the Third World. His final conclusion was that the main causes of high accident rates in developing countries were the poor skid resistance of the road surface, badly maintained vehicles and poor user driving behaviour. Another attempt has been made, by, (Jacobs 1984) to compare road safety between two developing countries (Jordan and Ethiopia). According to this study, it was found that in Ethiopia the fatality rate of over 200 deaths per 10,000 licensed vehicles was particularly high; the rate in Jordan being about one quarter of this value. The fatality index for Ethiopia at 27 per cent might be considered high in comparison with most other countries. In Jordan the fatality index of 7 per cent was one of the lowest in the developing world and could be associated with good medical facilities. Furthermore, in both countries the pedestrian causality rate was high (40 per cent in Ethiopia and 45 per cent in Jordan) in comparison with both European and other Their Word countries. Jacobs has noted that, in both countries, the road network showed similar deficiencies, with function, design, road markings, warning and direction signs and canalisation and pedestrian facilities all needing improvement. In both countries, better use could be made of roadside spot checks by the police, with particular attention paid to the condition of tyres and brakes. Finally, it was suggested that improved medical facilities, especially ambulance services, could do much to reduce the high road accident fatality rate in Ethiopia.

A comparison between developing and developed countries was also carried out (El-Sadig 2002) using data from United Arab Emirates UAE addressing the morbidity and mortality from road accidents. Identifying trends during the period 1977-1998, the results were compared with those of developed countries; in order evaluate the information available on possible causes with a view to identifying the most useful direction for future research. During the period of this study the rates of road traffic accidents and road traffic casualties declined, whereas the severity rate was still high compared with developing countries. He thought that the main causes of increases in severity rate were speed, careless driving, and the standard of immediate care available for victims. It was suggested that a key area would be to investigate the effectiveness of traffic safety measures. Immediate steps to control the problem would be: to increase police surveillance on roads and to conduct effective education campaigns on safe driving, roadway risk factors and safety precautions, more appropriate management of casualties at the roadside and during transportation to hospital, and the training of traffic policemen and ambulance personnel in casualty handling.

Using data from Nigerian Police Headquarters, the role of improvements of the economy on road accident trends in Nigeria between the period 1960 and 1989 was studied by, (Adeolu 1993) who found that death rates from road accidents have increased since 1960. In the 1960s the absolute number of accidents was relatively low compared to later decades. It was pointed out that Nigeria had just become an independent country with a less buoyant economy and a relatively small number of vehicles on the roads. The alarming increase in the accident rate in the seventies until the early eighties may be attributed to improvements in the economy in the 1970s due to the oil boom. It was suggested that the decrease in number of road accidents between 1982 to 1989 was probably due to the economic recession during that period. Another reason why many accident victims die is the fact that drivers and passengers do not consider it necessary to wear their safety belts, which are considered as mere decoration.

Over the period 1966-2002, very little work was carried out on the subject of road accidents in Libya, especially when compared with the amount of research carried out in other developing countries. At the end of the 1970s (Shembesh 1978) conducted a study of road accidents in Libya. The main focus of this study was the effect of increasing population and vehicle numbers on road accidents in Libya. It was noted that over the period 1966 to 1976 the total number of accidents reported did not increase anything like in step with the growth of vehicle numbers from 40,000 private cars in 1965 to 233,000 in 1976. However, between 1966 and 1976 the number of fatalities and injuries increased by 330 and 240 per cent respectively, while the number of accidents was some way short of doubling. In addition, of the total accidents 30 per cent occurred in darkness, and while an average of 45 per cent of accidents took place in major urban areas, they accounted for only 25 per cent of fatalities. He concluded that the main causes of accidents in Libya were related to human failures, mechanical failures, and road conditions. The severity of the consequences of road accidents and injuries could be reduced through the provision and efficiency of emergency services. He suggested that improvements should be made in the methods adopted in the recording and collection of road accident data, and suggested improvements in the reporting of information at the scene of an accident. Further research by Makky (1984) addressed patterns of road accidents of Libya compared with industrialised countries and some Arabic countries. The study showed that, in 1977, road accidents were the cause of 10% of all deaths and 62% of male deaths in the age group 15-25 years. The pedestrian fatality and casualty rates were high (20,134 per 100,000 population) especially among elderly males (89,384 per 100,000 population), the drivers fatalities rate was 1,256 per 100,000 drivers. Also, road deaths per person and per vehicle in Libya were much higher than in Industrial countries. The death rate per vehicle in Libya was excessively high even among developing countries. In 1979 road accidents in Libya cost the country about $160 million. Makky suggested that the factors which affect accident rates and severity are divided into behavioural and structural factors.

In Latin American countries traffic accident was the main cause of death, Martha (1999) tried to address the traffic accident problem in Latin American and the Caribbean countries, looking at the issues that are specific for these particular countries, and what can be done to understand and evolve new safety policies. He showed that the number of deaths occurring in this region due to traffic injuries was 109,000 in 1990. The number of deaths peaks in the late teenage years and early twenties. It was suggested that new methods of speed control needed to be applied, road design, along with policing methods which would be effective in traffic scenarios that will take into account the differences among road users. Great care must be taken to make the traffic environment consistent with traffic rules, which should be homogeneous and easy to understand for all road users. Media campaigns need to be planned with these considerations in mind, and shared international experience can be of great benefit in evolving successful strategies for the future, along with investment in research dedicated to these issues.

However, many expertises from industrial countries have been working to reduce road traffic accidents in developing countries. The U.K. Overseas Unit of the Transport and Road Research Laboratory (TRRL 1981) conducted a project about road-user behaviour at traffic signals, uncontrolled pedestrian crossing and priority junctions in a number of cities in developing countries. The study was carried out in urban areas over the period 1975-1979. It was noted that the proportion of drivers passing the red signal in the cities in developing countries was about 50 per cent of all drivers. However, there were slight reductions in the proportion of drivers passing red signals when a police officer was present. This study also included a survey to determine the readiness of drivers, given a free choice, to stop for pedestrians using crossings. It was noted that few drivers chose to stop for pedestrians in the cities in developing countries.

Most Arabic countries suffering from traffic accidents problem. Many studies have been carried out to understand the main causes of road accidents and what remedies are possible. (Bener 1999) studied road traffic accident admissions in the United Arab Emirates, over the twelve months of 1995, considering those traffic accident victims who did not survive the accidents, and those who did survive the initial management in the emergency department. The study showed that 80% of the victims were less than 40 years old. About 13% were children. This was due to the fact that many young children are unrestrained front seat passengers, leading to the conclusion that children were more susceptible to injuries inside the moving vehicle than getting hit by one on the road. It was suggested that there would be no more effective measure than legislation to increase awareness of the necessity of wearing seat belts, and that simple measures such as the strict imposition of speed limits would pay rapid and rich dividends in terms of life, disability and the use of national resources. High rates of road traffic crashes, in conjunction with the absence of order on the road, has long been considered a critical social problem in developing countries.

A study by (Bong-min 2002) described what has happened in the area of road traffic crashes, injuries and fatalities in Korea from 1970-2000. It was noted that the number of traffic crashes increased from 37,000 crashes in 1970 to 290,481 in 2000. During the same time period, the number of fatalities increased 3.3 times from 3,069 deaths in 1970 to 10,236 deaths in 2000. He thought that primary cause of traffic crashes was reckless driving, including drunk driving. According to this study, it was found that after eight months of campaigning and legal enforcement through financial penalties, the rate of the use of safety belts increased from 23% to 98%; more than 1100 deaths were prevented as a result of monitoring cameras; and the number of fatalities fell by 60% in areas where the crash risk was high. Furthermore, the Korean government introduced a reward system for citizens reporting traffic violations. Finally police agencies initiated several education programmes for improved road traffic safety, for children in school, the elderly in nursing homes and a new education programme was to be enforced for people who apply to take a driving test.

School age children were the age group most suffering from road traffic crash in African countries; this was noted by (Franceline 2001) who studied road accidents in Mozambique. It was noted that the heaviest toll in traffic related trauma occurred when crash involved buses and other passenger ferrying vehicles like trucks. Crashes involving a pedestrian were the most frequent form of crash (47%), followed by collisions between vehicles (30.6%). Franceline concluded that the mean age of the victims was most commonly 25-38 years, followed by 16-24 years, and then 5-15 years. Deaths among children were mainly a result of being run over, either playing or on their way to or from school. The general condition of roads was also poor and the police were generally ill-equipped and unable to prevent most of the reported violations of the traffic code.

2.3 Traffic Road Accidents in Developed Countries

Over the past 30 years, developing countries have seen a remarkable decrease in the total number of fatalities associated with traffic accidents. This has occurred despite the large growth in the total number of kilometres travelled by private vehicles and increases in population. Many pre-active polices are often held responsible, such as safer vehicle design, better engineering of road infrastructure, tougher enforcement of speed limits, and increased seat belt use. All of these factors have been addressed in developed countries.

(Newby 1961) studied the effect of traffic-light improvements on the overall reduction in accidents. Twelve four-way junctions were selected in the Metropolitan Police District, London, U.K as being those at which all-red period of one or two seconds had been added in recent years to existing signal cycles without any other alterations in phasing or control. The total numbers of casualties during the periods in the local authority areas in which the junctions were situated were used as the best available controls. In addition, the number of injury accidents at each site in comparable periods of 24 months before and after the addition of all red periods was calculated. It was found that, at the twelve sites combined, injury accidents in the after-periods were 41 per cent fewer than the number to be expected if the sample junction had experienced the same trends as occurred in the control areas. The improvement was confined almost entirely to accidents involving two moving vehicles on different roads, which were 83 per cent fewer than expected. They concluded that the all-red period was effective in preventing crossroad collisions at those traffic signals where it was considered appropriate to add such a period.

Reckless overtaking is also after classified as the main contribution to road accidents. A report commissioned by the headquarters of Nottinghamshire police studying overtaking accidents (Clarke 1998). Ten classes of overtaking were distinguished, each with a different age-profile of drivers. The comment overall overtaking was involving collision with a right-turner further ahead. This study derived two measures: (a) comparing drivers involving in one type of overtaking accident with other types; and (b) comparing characteristics of the driver at fault, with those of the driver not (or less) at fault. Pointed out that misjudgement of the distance and time needed to get past vehicles they wished to overtake were the main causes of accidents. Furthermore, looking ahead for junction's signs and avoiding overtaking when approaching bends were also important. Clarke conduced that some drivers do not take these factors into account and do not consider the behaviour of traffic that was not in view at the time of the "go" decision, adding that drivers seem to operate in the overtaking situation under two major areas of what might irrationality be term. Firstly, they do not consider anything that cannot yet be seen as a danger. Secondly, drivers seem to discount the possibility of any dangerous interaction with the vehicles which they are overtaking. Many studies have addressed reckless driving and speed limits. Corbett (1989) has described an initial survey of driver attitudes and behaviour conducted following the experimental introduction of speed cameras in the United Kingdom. The survey was designed to determine by means of driver's self-reports: (a) to what extent a driver's choice of speed had changed due to the presence of speed cameras; (b) whether this change would be generalised to areas where cameras were absent; and (c) patterns of individual differences in response of cameras. It was found that there were encouraging signs that a more widespread use of unmanned speed cameras was likely to curb the speeds of most drivers who came into contact with them. 29% of drivers had slowed down since the introduction of the cameras, although a further 27% had slowed down in some places but either drove no differently or faster in other places. It was also found that some generalisation had occurred among all driver types on other main roads where no camera signs were posted.

2.4 Speed, Speed Limits and Accidents

Road traffic accidents are a result of many factors, although excessive speed is often thought to be a major cause. Speed limit signs are introduced as a safety measure; and the relationships between the speed characteristics of traffic, speed limits, and accidents have been debated each time limits have been changed;. (Nicholson 1964; Munden 1967; Brenac 1990; Finch 1994). However, over the years many studies have been reported from a number of countries relating to the introduction of, or changes to, speed limits and subsequent changes in the numbers of road accidents.

In the winter of 1973-1974, oil supply problems led to the introduction of legislation in the UK which was intended to conserve fuel using a variety of measures. Scot (1976) studied the effect of the imposition of a compulsory 50 mph on all roads not subject to a lower limit. The effect on accident rates was analysed by comparing actual numbers of accidents with predictions made from historic trends on road accident data. There were statistically significant reductions in accident rates on motorways of 40.1 per cent and on all-purpose roads of 21.5 per cent normally subject to speed limits of 50 mph and higher. Johansson (1980) studied monthly UK fatality data for the period 1970 to 1979 taking into account a wide variety of possible confounding factors. They estimated that 7,532 lives were saved in 1974, declining to 6,454 in 1979. These estimated savings would have represented about a 14 per cent reduction in all motor vehicle fatalities on all roads. They concluded that the 50 mph speed limit was one of the most effective countermeasures ever to have been used in reducing fatalities. Marburger (1986) carried out a study on the number of accidents occurring on stretches of motorway where temporary maximum speed limits of 100 km/h (62mph) were imposed in West Germany during 1985. Historical comparisons were made for the same road sections, together with comparisons of control sections of unrestricted motorway during imposition of the limits of less than six months and longer-term limits (six months or more) reduced all accidents by 17 per cent and 25 per cent respectively, whilst the long-term limits reduced accident injuries by 30 per cent.

In 1974 the United States adopted a 55 mph national maximum speed limit as a temporary measure to save fuel. Immediately after the imposition of this limit both speeds and fatalities dropped dramatically. Wagenaar (1989) used a multiple time series experimental design to compare Michigan road sections where the limit had been raised, to those where it had not. They demonstrated that a significant increase of 19.2 per cent in fatalities had occurred. The U.S.A raised the speed limit from 55 mph to 65 mph on rural interstate roads and limited-access highways. Rock (1995) examined roads where the speed limit was raised and those where it remained at 55 mph, considering the impact of higher limits on mean speeds, and speed variance, traffic diversion, traffic generation, speed spill over. The data was collected from the Illinois Department of Transportation. Rural accidents were aggregated into one of five location categories for which numbers of accidents and counts of fatalities and injuries were summarized. The rural locations were categorised as "controlled access roads", and "toll categories roads" were designated as 65 mph highways, while other locations were designated as 55 mph highways. He found that 15 more deaths, and 150 more injuries occurred monthly on rural Illinois highways due to the 65 mph speed limit. Increases in casualties on 55 mph road sections were also discovered, which many have been due to a 'spill over' effect.

The relationship between various measures of traffic speed under free flow conditions and accident rates were investigated by (Aljanahi 1999) for two group of sites. The sites were selected from the county of Tyne and Wear in England and the other in Bahrain over a five-year period (1987-1990). It was thought that the two areas were sufficiently diverse to allow generalisation of any common Trends. The aims of this study were to investigate any relationship between traffic speed characteristics and personal injury from accidents. The second objective was to establish a relationship between speed limits and the distribution of traffic speeds. In both areas, it was found that the effect of speed limits is to reduce the mean speed of traffic by at least one quarter. Furthermore, in both areas, there is an apparent decrease in accident rates if the percentage of heavy vehicles increases, with the speed distribution held constant.

Many studies have proved that vehicle speed is the leading cause of death and injuries world wide. Francis (2002) explored vehicle speed as a factor in the causation of road traffic crashes, using the example of Ghana, examining the effectiveness of various speed control measures based on police reported traffic crashes in Ghana and published works on speed control measures. According to this study, the speed factor accounted for more than 50% of all Ghanaian road traffic collisions. While the enforcement of speed limits by traffic police might not be affordable for most developing countries. Francis suggested that rumble strips and speed humps were found to be effective in reducing the speed in developing countries. It was concluded that reducing vehicle speeds is one of the most effective interventions to stem traffic crashes, adding that passenger safety could be enhanced by speed regulation through the use of speed governors.

In the early 1990's, speed camera technology had been developed and was in use in the USA and Australia. A New Zealand trial involving speed enforcement and publicity focused on road sections with high proportions of speed-related crashes showed promising results in terms of speed reductions. (Hunt 1992) Study by (Keall 2002) has updated analysis of the first year of New Zealand trial of hidden speed cameras. The purpose of the trial was to evaluate the potential impact of changing the existing speed camera operation in 1000 km/h speed limit zones. In the course of first two years of the hidden speed camera trial. They have noted that on open roads, mean speeds fell by 1.3 km/h and 85th percentile speeds fell by 4.3 km/h. over the period of the study, the open road crash rate fell by 11% and open road causalities fell by 19% associated with the hidden speed camera programme. However, the hidden camera programme was significantly more effective at deterring excessive speed than the existing visible camera programme.

Based on data collected from 12 U.S.A intersections, Retting (1998) found a red light violation rate of 13 violations per 10,000 vehicles. Strading (1998) conducted a survey on a large sample of drivers in four different countries: the

United Kingdom, Australia, Sweden, and China. Based on a six-point scale from 0 never violated to 5 violated nearly all the time, violation grades ranged from 0.14 in Sweden to 1.08 in China. Strading also found that violations were reported with higher frequency by male, younger, and high-mileage drivers. Retting (1999) have studied the characteristics of red light runners who were involved in crashes in the United States. It was found that such drivers were more likely to be younger than age 30, male, have prior moving violations and convictions for driving while intoxicated, have invalid driver's licenses, and have consumed alcohol prior to the crash. Regarding the safety effects of running red lights, Retting found that red light runners cause about 750 deaths and more than 260,000 injuries in the United States every year. Running red light violations were responsible for 623 out of 54,791 traffic accidents (1.14%) occurring in Jordan during 1999 alone. (Jordan Traffic Institute 2000; Al-Omari 2003) studied red light violations at selected rural and suburban signalized intersections in Jordan, determining the effects of driver age, vehicle type, intersection type, traffic volume, and approach speed. He showed that the percentages of red light runners who were young adults, adults and elders were 16.4%, 11%, and 6.3%, respectively. The highest percentage of red light runners was that for trucks 18.2%, followed by small vehicles 12.9% and then buses 6.9%. The use of traffic signals with low traffic volumes increased the percentage of red light runners; while installing traffic signals on highways with high speed limits increased the percentage of red light runners.

2.4.1 Driver's Characteristic Speed and Accident History

Interest in relating a driver's speed on some occasion to his or her accident history has been evident from at least the 1930s (Tilden 1936). Early studies indicated that fast drivers, defined variously, had greater experience of (recorded) crash involvement than relatively slow drivers (DeSilva 1940; Lefeve 1956; Cleveland 1959). However, this dichotomous classification of speed behaviour meant that the relationship between speed and crash risk was not depicted over a range of speeds.

From the early 1960s, the notion that an individual's manner of driving on one occasion would be linked to their past accident involvement was pursued in a series of studies using a device known as a drivometer. This mechanical device could be fitted to a car to record information such as the trip time, steering actions that changed the direction of the vehicle, accelerator and brake applications, and vehicle speed. At least two studies that searched for differences in drivometer variables between accident-free and accident-involved drivers found no difference in the case of speed (Greenshields 1963; Johns 1974). This vein of research was taken up again by (Wilson 1983). These authors used the drivometer to record various aspects of driving behaviour of 100 volunteers. Males and females differed in their manner of driving, taking into account the number of miles driven per year (exposure). With regard to accident history, the overall suggestion from the data was that accident-involved drivers had higher speeds and moved more continually in traffic during the drivometer tests than other drivers. In particular, among males and females with moderate exposure to driving, mean preferred speed on a clear stretch of road was lower among those with no history of accidents than those who had been involved in accidents in the past. Among males with high exposure to driving, mean clear speed did not distinguish between those with and without prior accident-involvement, but the accident-free males appeared to adjust their speeds to changing conditions more than the accident-involved males. However, as this summary of results shows, there was no attempt to describe the full functional form of the relationship between speed and crash involvement.

Another study which related drivers' typical speeds and accident rates is that of (Wasielewski 1984). The aim was to examine factors which predicted risky driving, where speed was taken as an indicator of risky driving. Speeds were recorded for vehicles using a two-lane road in Michigan. Vehicles were photographed and some 2,600 registration numbers were matched with state files. Repeated measurements of speed were obtained for about half of the sample; the correlations between pairs of speeds for the same vehicle were relatively weak. However, a positive correlation was found between the number of crashes a vehicle had been involved in during the preceding seven years and the mean speed of vehicles in each crash-frequency group.

A study was conducted in Australia by (Fildes 1991) with the aim of examining relationships between speed behaviour and a large number of possible contributory factors, including driver, vehicle and trip characteristics, and driver attitudes. In addition, the relationship between speed behaviour and five year accident history of the driver was assessed. Unobtrusive measurements of vehicle speeds were made on two urban arterial roads and on two rural undivided highways in Victoria during 1989 and 1990. It is noteworthy that an urban sample was obtained, since little work of this kind has been undertaken in an urban setting. More than 7,00 drivers were stopped and interviewed after their speeds were recorded; these drivers were asked whether they had been involved in a crash in the past five years and, if so, to give details of when and how severe the crash was. As noted earlier, a problem with this research design is that only drivers who have survived past crashes are able to be studied, and since high-speed crashes are least likely to be survivable, it is possible that involvement rates for high speeds may be systematically under-estimated.

Speed behaviour was found to be associated with many of the variables on which information was collected when considered separately. Multivariate analyses for the urban data suggested that the following factors were the most important indicators of a speeding driver: being aged less than 34 years and having a high accident history; reporting a safe travelling speed that was high; having a vehicle less than five years old; travelling on business and doing a large amount of such travel each week. However, only a third of the variance in speed behaviour was able to be explained.

For the urban sample a linear relationship between characteristic speed and crash involvement was found. Drivers with speeds above the 85th percentile were more likely to have been involved in a crash, than were drivers with speeds in the middle range, while drivers with speeds below the 15th percentile were less likely. In addition, fast drivers were more likely to have experienced multiple and more severe crashes than relatively slow drivers. Results for the rural sample were consistent with those of the urban sample.

Fildes, Rumbold and Leening (1991) contrasted their results with those of Solomon (1964), drawing attention to the fact that they found no evidence of elevated crash involvement for drivers who travelled slowly, rather the reverse, but noting that their sample size was relatively small and that few extreme speeds were recorded. It was also acknowledged that self-reports of crash involvement were probably subject to error, however, it was pointed out that another study had demonstrated self-reports to be more reliable than official records.

The results of Fildes, Rumbold and Leening (1991) are consistent with those of a study carried out in England at about the same time. West (1993) recruited 48 drivers, ostensibly to test an automated in-car route guidance system. Assessors recorded aspects of the subject's driving, including maximum and preferred speed, over a 50 mile test drive. A high preferred speed was found to be positively associated with self-reported involvement in at least one accident during the past three years. The models developed indicated that for each 1 km/h increase in preferred speed on the motorway, the odds of having had a crash in the past 3 years increased by a factor of between 1.27 and 1.55.

The survivor bias inherent in most of these studies has already been mentioned, as well as the need to assume that the characteristic speed applied at the time of involvement in a crash. Also it is conceivable that a driver's speeding behaviour may change after involvement in a crash. A further difficulty with this approach is the required sample size. Crashes are relatively rare events, so a large sample is needed in order to capture sufficient individuals with recent crash involvement for a full analysis. It is not clear how far back the accident history remains relevant, so while increasing this time span effectively increases the available data, it also renders the method more dubious. These weaknesses in the method mean that it is more useful for other purposes, such as characterising crash-involved drivers, than for quantifying the relationship between speed and crash risk.

2.5 Seat Belt Use

Crashes have always been a by product of the use of the automobile. The second collision that while takes place between the vehicle occupant and the interior of the crashed car has produced millions of fatalities and injuries. Safety belts provide a means of substantially reducing the deaths and injuries resulting from crashes by reducing the frequency and severity of the second collision. The following Table 2.1 shows belt use changes and casualty reduction performance resulting from belt use laws in nine different jurisdictions. It was clear from this table that belt use laws become increasingly effective as belt use levels increase. Much work has been done in industrialised countries to show the effectiveness of seat belts in reducing the severity of injury to the occupants of motor vehicles.Many attempts have made world wide to evaluate the efficiency of restraining systems in reducing crash injury severity. Crinion (1975) measured the effect on casualties of a compulsory seat belt wearing law in South Australia during 12 months periods before and 12 months after the date that the wearing of seat belts became compulsory. It was pointed out that the ratio of causalities among car occupants in accidents involved cars significantly lower in 1967 and late models (which had compulsorily fitted belts) than in 1966 and earlier models, in both the twelve months after the introduction of the law. It was observed that a substantial shift in severity of casualty, as defined from more severe to less severe, differential shift in severity, more pronounced in 1967 and later models compared with 1966 and earlier; a fall, of 7.5 per cent overall in occurring entirely in the 1967 and late models, which showed a fall of 21 percent.

Monthly surveys by (Scott 1985) about seat belt wearing of occupants of cars and vans were started in February 1982. This survey used over 50 sites, on all types of roads throughout Great Britain, observing drivers and front seat passengers. Wearing rates of almost 40% were found during 1982; rates for selected months are listed in table 2.2. Rates rose to over 50% on January 1983, the month before seat belt wearing became compulsory, and reached 95% soon after. It was noted that rates have been lower on built- up roads, and lower on C and unclassified roads than on motorways and A class roads.

Country	Usage Pre-law (%)	Usage Post law (%)	Fatality reduction Performance (%)	Injury reduction Performance (%)
Canada	24	50	37	20
New York	16	61	41	-
Denmark	19	67	13	27
Switzerland	37	76	35	35
Sweden	35	84	23	36
UK	40	94	41	38

Table 2.1 Belt use Changes and Casualty Reduction Performance, (OECD 1986)

Scott further studied the effect of the law on wearing seat belts on casualty frequencies during its first year of operation. This study showed very clear reductions in casualty frequencies among car and van occupants. There were 20 per cent reductions in fatal and serious casualties for van and car drivers, and 10 a per cent redaction in slight casualties. It was concluded that the reductions represented 7,000 fatal or serious casualties and 13,000 slight casualties in the year. The Department of Transport report (1988) measured the extent to which car occupants used seat belts and other restraint in the UK, and also whether or not child passengers used appropriate types of restraint, whether restraints were worn and if so of what type.

Month	Driver (%)	Passenger (%)
Feb 1982	37	39
May 1982	37	39
Dec. 1982	40	43
May 1983	94	95
Apr 1984	95	94
Apr 1985	93	94
Apr 1988	94	94

Table 2.2 Seat Belt Wearing Rate in Great Britain

In this research all car occupants were observed, and the year letter from the vehicle registration was recorded to compare restraints used in older and newer cars. The months of April and October were selected for the survey in the expectation that they would be unaffected, by summer holiday traffic or adverse winter weather. It was noted that wearing rates were lower for male than for female drivers; the rate for 17-57 year old males was about 2% below average, while for female drivers it was over 2% above average. Moreover, the wearing rate for adult front seat passengers was about 4% lower among males than among females. It was added that among rear seat passengers, the wearing rate fell with increasing age. However, only one tenth of adult rear seat passengers were wearing seat belts at that time.

The effects of setting on the risk of dying in crashes has been investigated by (Braver 1998) using 1985-95 data from the United State Fatality Analysis Reporting system on passengers aged 12 and younger who were involved in fatal crashes for different categories of restraint use and in vehicles with and without passenger airbags. Deaths were studied among 26,233 children younger than age 13 who were passengers in all motor vehicles involved in fatal crashes during 1988-1995. All child passengers of motor vehicles were selected for inclusion in the study if they were riding in either the front, second, third, or fourth row of seats, whether or not their exact position on the seat was known. Child passengers were classified as restrained if including shoulder belts only, lap belts only, forward or rear facing child safety seats, or booster seats. It was concluded that restrained children in rear seats had the lowest risk of dying in fatal crashes. Risk of death was reduced 35% in vehicles without airbags, 31% in vehicles equipped only with driver airbags, and 46% in vehicles with passenger airbags. Both restrained and unrestrained children aged 0-12 were at a lower risk of dying in rear seats, and children aged 5-12 restrained only with lap belts were offered additional protection compared with lap/shoulder belted children. Children restrained have been studied in many different respects in the USA. (Ferguson 2000) investigated where children sit in vehicles and whether the likelihood of being restrained varies with seating position, and also if the presence of passenger airbags affects either seating position or restraint use. It was found out that the majority of children age 0-2 years were restrained. However, children ages 3-6 seated in the front were least likely to be restrained and most likely to be improperly restrained. It was noted that restraint use was higher when the driver was belted, but about 30% of 3-6 year olds were unrestrained even with a belted driver. Ferguson suggested that parents should be educated about the importance of correct restraint use and rear seating for children.

A sample consisting of 200 young Greek drivers was studied by (Chliaoutakis 2000) to clarify the relationship between the intentions of young drivers (motivation to use/not use seatbelts) and their behaviour. Additionally, seatbelt wearing rates among young drivers in relation to the type of trip was evaluated. The main draw from this study was that young Greek drivers tend to buckle up in a lower than "often" level.

2.6 The Effect of Seat Belt on Reducing Occupant Injuries

The effectiveness of current automotive occupant restraint systems in reducing injuries and fatalities in road traffic accidents is widely documented and recognised. In the UK, for example, since 1983 when seat belt use became mandatory for front seat car occupants, it is estimated that the numbers of fatalities have been reduced by approximately 25% (Rutherford 1985). Similarly, the numbers of patients taken to hospital following a road accident have been reduced by 15% and this is believed to be accompanied by a 25% reduction in the number of patients requiring admission to wards.

Langwied (1976) studied the achievement of restraint systems in reducing injury severities, and it was found that wearing seat belts led to a distinct reduction in both the probability and the severity of injury. Injuries to the upper and lower extremities were reduced by about a third with a lesser reduction to the driver than to the front seat passenger due to the proximity of the steering wheel. It was also included that restrained passengers were more likely to sustain multiple rib fractures and internal organ ruptures in severe impacts than was the case for restrained drivers. Langwied explained that the driver sustains impact with the steering wheel structure, which has energy absorbing properties, whereas the passenger is restrained throughout the collision phase by the belt bearing on the thorax and abdomen. Harms (1991) examined the effectiveness of seat belt in reducing second crash injuries, by comparing restrained and unrestrained casualties. It was found that there were 4,491 occupants in the sample who were known to have sustained injuries of some severity. Most analyses in this study were carried out on those occupants whose injuries were AIS 2-6 and excluded surface injuries.

Restraint use/seating position	MAIS 2-6 (%)	MAIS 3-6 (%)	Number of Injury
Restrained drivers	43	18	2,117
Unrestrained drivers	61	28	194
Restrained FSPs	36	15	1,048
Unrestrained FSPs	66	34	70
Restrained RSPs	14	3	306
Unrestrained RSPs	33	12	756

Table 2.3 Injury Comparisons all Impact Directions (Harms, 1991)

These were compared on a restraint–use basis for different seating positions using MAIS values as an indicator. Table 2.3 shows that the effectiveness of restraint use on overall injury severity can be seen in all groups, particularly amongst the higher injury levels MAIS 3-6 and also with rear seat passengers.

The effectiveness of rear seat belts in limiting injuries during car collisions has been addressed by (Guerde 1997). In this study, 620 rear seat passengers (RSPs) of cars were extracted from the UK (CCIS) database who were 15 years or older, and had been involved in collisions between 1992-1995. The study began by discriminating the injury outcomes for restrained and unrestrained rear seat occupants and compared them to those in front seats. Guede estimated that the effectiveness of rear lap and diagonal seat belts at limiting injuries during car collisions was 40%. Some of the serious chest and abdominal injuries were related to rear belt geometry and the specific way in which the seat belt was being worn. 15.6% of belted RSPs sustained minor neck strains (AIS 1) without head or neck impacts. The interaction between front and rear occupants could increase the risk of injury to all car occupants. Several authors including; (Huelke 1974;Griffiths 1976; and Rattenbury 1979) have pointed out that there is an increased risk of front occupant injury when loaded by an unrestrained RSP.

Seatbelt use was introduced in Kuwait very late compared to developed countries such as the UK. Parviza (2002) have reported the results of a research project examining the effect of belt use on the type and frequency of road accident injuries in Kuwait. It has been noticed that the enactment of the seat belt law in Kuwait in 1994 resulted in a dramatic increase in belt use from 2.8% to nearly 100% during the first week of the law's implementation. Also, the fatality rate for the non-users of belts (36%) was six times greater than that of belt users (6%). The slightly larger value of the mean injury rate for the users of belts was also in accordance with expectations. It was also noted that the injury rate for users of the belt may have prevented some injuries from occurring in minor traffic accidents.

2.6.1 The Cost Benefit of Using Seat Belt

The benefits of using seatbelts throughout a vehicle's lifetime are estimated to be 1,575 pound for a drivers. The corresponding benefit for front seat passengers is calculated to be 663 pound, and for rear seat passengers, the benefit is calculated at circa 166 pound (Bjornskau 1993).

Based on Norwegian statistics (Rune 2004), the benefit of using seat belts has been calculated at circa 2,387 pound for all seats in the vehicle. It can be estimated that the use of child restraints in cars prevents, on average, 40 injuries per 100,000 children per year. The average cost 1,18547 pound per injured child in injury accidents reported to the police. This assumes a lifetime of 4 years for children restraints.

2.7 Injury Classification and Severity

The type of classification adopted is normally decided by the purpose that the injury information is to be used for. Analysis of mass accident statistics is normally carried out using a simple classification, while research work needs a more detailed classification system. The simplest classification is a division into injured and non-injured; the most complicated is one in which each injury is minutely described.

In the UK the classifications used by the police in the reporting of road accidents are as follows (Road Accident in Britain, 2000):- no injury; slight injury; serious injury; fatal injury.

A modified form of these classifications was initially used by the Road Research Laboratory in their accident investigations (Hobbs 1968). Another simple classification of injuries was that used by (McNicol-Smith 1961) in a study of hospital admissions. The classes used were:

Uninjured

Injured and survived

Killed instantly

These simple classification systems are of little use for research purposes because of the broad nature of the classes. Various classification systems have been developed by research workers which take account of the severity of the injuries or, in hospital based studies, the location of the injuries.

The first research injury classification system or injury scale was developed by (Haven 1952) in a study of light aircraft accidents. He divided the body into six areas and assessed the severity of the injury to each area on a ten point scale. The overall injury severity was taken as that of the most severely injured body area. This scale was used by Cornell in the Automotive Crash Injury Research programme (Hasbrook 1956). It has formed the basis of injury scales used by other accident investigation teams. (Robertson 1966) in Australia and the Road Accident Research Unit at the University of Birmingham (de Fonseka 1969) have both used six point scales, though for some purposes the very severe and fatal classes were combined to form a five point scale at Birmingham. The Vehicle Trauma Research Group at the University of California have also used a five point injury scale.

2.8 Standardization of Injury Severity Classification

As more teams investigated accidents it soon became necessary for comparisons between the various investigations to be made. Discussions between those investigating accidents in the UK, namely the Road Accident Research Unit at Birmingham Accident Hospital and the Road Research Laboratory (RRL), resulted in a classification system which split the (serious) category, previously used by the Road Research Laboratory, into moderate, non-life threatening injuries and severe life threatening injuries (RRL 1967). In America, an informal meeting of accident investigators at the Eleventh Stapp Car Crash Conference led to the formation of the International Ad Hoc Committee of Collision and Injury Indices. A sub-committee was set up under States (1969) to prepare a descriptive type of injury scale and work towards a quantitative injury scale. This brief resulted in the presentation at the Thirteenth Stapp Car Crash Conference (States 1969) of the Abbreviated Injury Scale (AIS), which is a descriptive scale, and the Comprehensive Research Injury Scale (CRIS) which is a quantitative scale.

The AIS was based on the various injury scales that have been used in accident research, and in particular that used by Cornell. Consequently it is similar to de Haven's injury scale but has been up dated in the light of present medical knowledge. It is intended for use by both non-medical and medical personnel. The AIS has been accepted as the standard injury classification system for use in accident investigations.

2.9 Classification by Injury Location

The injury classification systems define the overall severity of the injuries sustained but give no indication of the number of injuries or their location. Classification systems which consider injury location have been used in hospital based accident studies. Jamieson (1966)divided the body into eleven regions. Gissane (1970) analyzed injuries by cause, location and type of injury. They divided injuries into four main classes:

1. Fractures
2. Major internal injuries
3. Major soft tissue injuries
4. Minor soft tissue injuries

The first three classes were then subdivided to give the location of the injury. Burns and concussion were noted separately

Gogdon (1962) has analyzed the injuries sustained in road accidents in Germany according to the body area injured. de Fonseka (1969) reported on body areas injuries in a representative sample of accidents occurring in Birmingham and Worcestershire.

2.10 Injury Patterns Related to Occupants Body Regions

A TRRL study by (Sabey 1977) compared patterns of injury between restrained and unrestrained car occupants involved in accidents, and showed an improvement in injury outcomes for most body regions between belted and unbelted front seat occupants of cars (see table 2.4). The most significant improvement due to seat belt wearing shown in this particular study was to head injuries, followed by those to the chest. However, there was an apparent increase in neck and also feet/ankle injuries. Sabey also observed that seat belts offer important protection from ejection in accidents.

A prospective study of 500 road traffic accident casualties at Al-gala Hospital, Benghazi, Libya was carried out by (Kazeem 1979). It was found that male predominance was present in all age groups of the injured. The results of this study are summarised in table 2.5. The highest mortality rates for vehicle occupants were attributed to spinal injuries in 26%, followed by chest injuries in 25%, followed by abdominal and head injuries at 14% and 11% respectively. Skeletal and multiple limb injuries were highly significant and more common among unprotected road users compared to the protected group.

Body region	Injuries per 1,000 Occupants (ASI 2-6)	
	N=1163 person	N=490 person
	Unbelted	Belted
Head	237	106
Arms	37	20
Chest	52	39
Abdomen	20	12

Table 2.4 Comparison of Belted and Unbelted Front Seat Occupants, (Sabey 1977)

Type of Injury degree	Fatal	%	Serious	%	Slight	%
Head	27	11	101	41	120	48
Facial	13	9	59	42	70	49
Chest	17	25	31	46	20	29
Abdominal	4	14	21	72	4	14

Table 2.5 The Seriousness of Injury in Different Parts of the Body, (Kazeem 1979)

In the UK analyses carried out by (Ashton 1985) highlighted the pattern of injuries for each of the five AIS body regions for restrained front seat occupants. CCIS data was used in this study. It can seen from table 2.6 that overall, the legs were the most frequently injured. However, if only non-minor injuries of AIS 2-6 are considered, the head and chest were the body areas most frequently injured. For injuries in the AIS 4-6 category, which were mainly fatal injuries were sustained to the head, chest and abdomen in roughly equal proportions.

AIS	Head		Chest		Abdomen		Arms		Legs	
	Number	%	Number	%	Number	%	Number	%	Number	%
0	1013	74	730	53	974	71	926	67	732	53
1	107	8	419	30	324	24	370	27	513	37
2	184	13	133	10	7	1	65	5	81	6
3	18	1	30	3	16	1	14	1	50	4
4	7	1	28	2	12	1	0	-	0	-
5	18	1	22	2	43	3	0	-	0	-
6	28	2	5	1	0	-	0	-	0	-
Total	1375	100	1367	100	1376	100	1372	100	1376	100
AIS 1-6	362	26	631	46	402	29	449	33	644	47

Table 2.6 Patterns of Injury for Restrained Front Seat Occupants, (Ashton 1985)

A CCIS Paper by (Bradford 1986) agreed with Ashton's finding. It was confirmed that the head was the most frequently injured amongst all body regions. Table 2.7 shows the injury distribution for 1,603 restrained casualties, the maximum AIS score being the highest of any surface, skeletal or internal injuries for each body region. The head and face were injured in 42% of cases and were the most frequent sites of injury above AIS 3, accounting for 40% of all the MAIS 4-6 injuries. Of the 1,603 occupants in the sample, 89 (6%) died, of which, 58 (65%)

sustained a skull and/or brain injury. It was concluded that in the total sample embracing all seating positions, 61 % of head injuries above AIS 2 were caused by contact with objects external to, but mainly intruding into, the car and most non-surface head injuries of AIS 2 and below occurred either due to steering wheel contact or with no direct skull contact at all.

Body region	Maximum AIS						No of Casualties/% of injuries
	1	2	3	4	5	6	
Head / Face	379	199	33	25	24	15	675/42
Neck	210	4	16	0	2	8	240/15
Chest	337	65	34	18	17	15	486/30
Abdomen.	91	7	20	22	28	0	168/10
Extremities	587	154	91	0	0	0	832/ 52

Table 2.7 Severity of Injuries to Body Regions, (Bradford 1986)

Takatsu (2000) analysed injury severity and the effect of seat belt use with findings from forensic autopsies of 50 persons who had died in motor vehicle accidents. The Abbreviated Injury Scale (AIS) and Injury Severity Score (ISS) were calculated and analysed epidemiologically, and cases were classified on the basis of seating position and whether or not a seat belt had been worn. It was found that the chest was the region with the highest AIS, followed by the abdomen, head and neck, and external. Takatsu thought that, thoracic and abdominal injuries were associated with contacts with steering wheel columns in drivers, contacts with the dashboard or as a result of intrusion into the vehicle by a collision in front passengers, and contact with the back of the front seat in rear passengers. It was suggested that, if seat bets were not worn, the driver would usually sustain more severe chest and abdominal injuries than other occupants.

2.11 Injury Distribution by Vehicle Impact Direction

It has been widely reported that front seat passenger generally receive more injuries than does the driver in fontal impacts. Kihilberg (1965) studied the American car in frontal impact, reporting that front seat passengers received more injuries than drivers. He noted that whilst drivers received more injuries from the steering assembly than from any other component, the presence of the steering assembly reduced the number of injuries from other components. The front seat passenger received injuries from more components than the driver and suffered more head and lower limb injuries than the driver. In a study of accidents involving Volvo cars in frontal impacts (Bohlin 1967) reported that unbelted front seat passengers sustained injuries more often than belted drivers, as much as 50% more at 30 mph and 22% more at 60 mph.

Variation in injury patterns between different impact directions has been addressed in many studies, (Mackay 1969) tried to identify the main cause of injuries inside the vehicle at different impact directions. It was noted that in front corner impacts the occupants were projected diagonally inside the car so that they struck the door pillars on the central part of the facia. The door, side structure, and roof were all major sources of injury. However, passengers were ejected and seriously injured more frequently than drivers, who were protected to some extent by the steering wheel. Injuries from instrument panels and windscreens were less frequent in drivers than in passengers.

Tampen (1968) suggested that in side impacts only minor injuries are sustained when the permanent intrusion is less than 10 inches (25.4 cm) and that normally there will be fatal injuries when the permanent intrusion is greater than 17 inches (43.2 cm). In general terms the injuries sustained depend on the relative impact velocity of the occupant and the structure which is impacted.

Lister (1969) noted that there were a higher proportion of fatally injured occupants in side impacts than occur in all impacts grouped together. Nearly 20% of occupants seriously injured were killed. This suggests that side impacts were more severe than other types of accidents.

Another CCIS paper by (Ashton 1985) considered the MAIS 2-6 injury distribution of all restrained occupants in relation to body region and impact direction. Predominance of head impacts in frontal collisions and trunk injuries in side impacts was found. His findings are summarised in Table 2.8.

These results show that the wearing of restraints reduces the likelihood of injury in both frontal and side impacts. However, there was a higher probability of sustaining serious injury in the latter compared to the former. (Danner 1987) studied injury patterns related to frontal impact accidents, and also addressed the problem of life threatening to injuries body regions amongst front seat occupants. This study showed that the driver's head was the most frequently injured in the life threatening, vulnerable body regions and the chest for the front passenger. A high proportion of the driver's head injuries were caused by steering wheel contact whilst the majority of the front passenger chest injuries were due to the restraining effects of seat belt webbing. The main findings of this study are summarised in table 2.9

Frontal Impacts Body region		Side Impacts (Occupant Location). On struck side. Body region		Side Impact. Non-struck side Body region	
Head	33%	Head	31%	Head	50%
Chest	29%	Chest	34%	Chest	-
Legs	24%	Legs	-	Legs	22%
Arms	10%	Arms	-	Arms	6%
Abdomen	5%	Abdomen	34%	Abdomen	22%

Table 2.8 Most Severely Injured Body Regions

by Impact Direction MAIS 2-6

Differences in injury patterns in frontal and side impacts were explored by (Harms 1991) in relation to all known seating positions, restraint use and impact direction, using data samples from the CCIS database. Table 2.10 shows that there was a proportional increase in the number of injured, restrained frontal setting occupants (FSOs) on the struck-side compared to frontal impacts; this was shown by comparing percentages between the two groups; 1.3:1 (53/42) for drivers and 1.2:1 (42/35) for passengers. There was also a comparative increase of 1.7:1 between frontal and nearside impacts in the case of unrestrained rear seat occupants (RSPs). Furthermore, the data confirmed the efficacy of seat belts by comparing the unrestrained with restrained front seat occupants in frontal impacts.

This gives 1.2:1 (51/42) for drivers in frontal impacts and 1.7:1 (16/35) for front passengers.

Seating position/ Body location	AIS				
	1	**2**	**3**	**4/5**	**6**
	N/%	N/%	N/%	N/%	N/%
Driver					
Head	161/76	32/15	5/2	8/4	7/3
Chest	123/87	16/11	5/3	1/1	1/1
Abdomen	22/63	4/11	5/14	1/3	3/9
FSPs					
Head	57/75	17/22	1/1	1/1	-
Chest	72/84	10/12	4/ 5	-	-
Abdomen	16/11	1/1	-	-	1/1

Table 2.9 AIS Distribution, Drivers and Restrained Front seat Occupants in Frontal collisions, (Danner 1987)

The lower extremities of restrained front seat occupants of cars were the second most common site of the AIS 2-6 injuries of seriously injured car crash survivors. Morgan (1991) analysed NASS data and found that in the US the limb was the second most common site of the AIS 2-6 injuries of belted occupants. A similar result was found by Word (1994) analysis of UK data, Seriously injured survivors of crashes were shown by Thomas (1994) to have sustained an average of 1.2 AIS3+ injuries to any body region, 47% of these survivors sustained AIS3+ lower limb injuries.

In depth accident data collected to identify the types and causes of AIS 2+ lower extremity injuries in frontal car impacts were analysed by, Thomas (1995) who found that the driver risk of AIS2+ lower limb injury was 52% greater than the passenger risk. Intrusions increase the risk of pelvis to knee and leg injury with constant crash severity. The magnitude of the intrusion effect on pelvis to knee injuries was similar to that of crash severity.

The causes of lower limb injury have been examined by, Gloyns (1979) who found that fractures of the knee; thigh, hip and leg are associated with intruding structures. Harms (1991) addressed the limb injuries of unrestrained rear seat passengers, and found that the majority of limb injuries were to the arms, and the tights and lower legs also featured. The probable causes of injury in a frontal impact, which the majority of limb injuries were caused by contact with the rear of the front seats

Impact direction	Restrained		Unrestrained		
	Drivers	FSPs	Drivers	FSPs	RSPs
Frontal	526/42%	206/35%	68/51%	27/61%	120/27%
Nearside	84/43	57/42	9	5	42/47%
Offside	114/53	25/26	17	-	23/31

Table 2.10 Injuries Relative to Seating Position/ Impact Direction, (Harms 1991)

Injury of vehicle occupants inside impacts have been investigated by (Yngve Håland 1992) who focused on injuries in later collisions with the aim to evaluate and compare life threatening and disabling injuries to different body regions in car to car side impacts, in order to form the basis for the future development of protective systems. The study focused on side impacts with belted occupants in the front seat. The car accident data file of the Swedish insurance company Folksong was used in the study. The frequencies of struck side and non struck side impacts were compared with other impact directions. The results showed that side impact injuries were more severe than those in frontal impacts. The AIS 3-6 injuries in near side impacts for the driver amount to 8.9% of all injuries. Serious to fatal injuries to drivers were 2.3 times side than to the passengers side. However, serious to fatal injuries (AIS 3-6) for front seat occupants in rear side car-to-car impacts amount to 10% of all injuries, and the most vulnerable body regions are the chest 37%, abdomen/pelvis 25% and the head 15%. It was suggested that the neck and legs need to be better protected in rear side impacts, due to the high risk of permanent disabilities, and the head, chest, and abdomen/pelvis need to be protected from life threatening injuries.

According to the National Highway Traffic Safety Administration (NHTSA 1995) approximately 34% of passenger cars and 32% of light trucks in police reported crashes in the US were initially impacted on the side. Most side impact crashes occur at roadway intersections and involve the front of one vehicle impacting the side of another (IIHS 1995). Injuries tend to be more severe in side impacts compared with cars in front and rear impacts, largely because of the limited side crush space. Dischinger (1993) reported that drivers involved in near side impacts had mortality rates twice as high as drivers involved in frontal crashes. They also found that drivers in near side impacts were more likely to incur multiple abdominal or chest injuries than drivers in frontal crashes. Serious injuries (AIS$\geq$3) in side impacted cars most frequently occur to the chest, head and abdomen. A study of vehicle crashes by Fildes (1994) revealed that the chest and abdomen were typically contacted by the door panel, whereas the head tends to contact exterior objects, the side window, and the B-pillar. In a study of car to car side collisions in Sweden, Haland (1993) found that males in near side receive twice a many chest injuries as females. They hypothesized that this is due to the higher average weight of males, which leads to greater compression of the chest by the impacting door.

Side impacts involving the occupant compartment are more likely to produce serious injuries than impacts confined to the side areas ahead of the rear of the occupant compartment. In a study of side impact crashes in Germany, Otte (1984) reported that less than 14% of seat belt wearing occupants were injured when the impact area was away from the passenger compartment, and none of these injuries were serious. Miltner (1995) addressed the interrelationship between accident severity and injury severity for restrained front seat occupants in car to car side impacts. It was found that at speeds of 40 km/h all near side occupants and about half of the far side occupants sustained severe injuries. Within the range of 30-60 km/h the probability of severe injuries increased dramatically from approximately 20% to more than 90%. The most frequently severely injured body locations were the trunk and head. The main cause of death for both sides was head injuries. Farmer (1997) studied the relationship between vehicle and crash characteristics and the severity of injuries received in two vehicle side impact crashes in US. He found that 2.9% of car occupants and 1.9% of light track occupants in side impacted vehicles were seriously injured. Only 1% or less occupants of vehicles impacted away from the occupant compartment were seriously injured. Among both near side and far side occupants the most often severe injury was to the chest. However, seriously injured far side occupants were more likely than near side occupants to have received the most severe injury to the head (32%) or neck (17%). Near side occupants receive more severe chest injuries, and most serious injuries on the near side are due to contact with the adjacent side structure.

The patterns of injury to vehicle occupants in side impact crashes are different from those sustained in other crashes. Mclellan (1996) compared 141 patients hospitalized after lateral crashes to 207 after non-lateral crashes in a trauma centre in Toronto, Canada. Head injuries were common in both groups. Internal soft tissue injuries and pelvic fractures were significantly more common in lateral crash victims, and injuries to the face and fractures of the arms and legs were significantly less common in this group. The overall severity was slightly, but significantly, higher in the lateral crash group (ISS = 25) than in the non-lateral crash group (ISS = 20). The proportions wearing three-point seat belts were the same in both groups at 67–68%. Factors that affect the risk of injury if a crash occurs are usually quite different from those affecting the risk of a side impact crash in the first place. Age, however, was important for both outcomes. Not only were older drivers more likely to be involved in side impact crashes, they-and older passengers-were also more likely to be severely injured or killed in these crashes.

A study of side-impact crashes from Fatal Analysis Reporting System (FARS) data in the United States found that vehicle occupants aged 65 or more were three times more likely to be seriously injured than occupants aged under 65 in similar crashes. (Farmer 1997; Zhang 2000) examined the differences in risk of fatal, hospitalized, and less severe injuries in all types of traffic crashes from the Ontario section of Road Safety and Motor Vehicle Regulations Directorate (TRAID) of police-reported crashes. All drivers in this study were over 65, but increasing age still increased the chances of fatality, as did being male, failing to yield right-of-way, disobeying traffic signs, and not using seat belts. Failure to yield and disobeying traffic signs are both violations associated with side impact crashes. Similar, but weaker, associations were found when the outcome was hospitalization or a less severe injury. Other factors, notably the use of occupant restraints, will affect the risk of death or injury, whether occupants are in the striking or the struck vehicle. Seat belt use, while clearly protective in frontal impacts, for example; (Rivare 2000; Waller 2002), can also be shown to reduce injuries in side-impact crashes. Reiff (2001) used data from North American Spine Society (NASS) in the United States for 1996–1998 to illustrate this. Although these authors were concerned with splenic injury in drivers in side impact crashes, they also calculated the odds of overall mortality (OR = 0.40) for belted versus non-belted occupants. Unrestrained drivers were more likely to be male, to drive a larger (>3000 lb) or smaller (<2500 lb) vehicle, to drive an older vehicle and one that sustained more crush and had a higher ∂V. Thus, there were many confounding factors that may explain parts of the reduced odds of mortality. These confounding factors alone, however, are unlikely to explain all of such a strong association (Kleinbaum 1982).

The problem of later impact injuries has been addressed by several researchers. Lister (1969) noted that in an unbelted population of car users, lateral impacts accounted for 13% of all accidents involving cars which resulted in serious or fatal injuries. They also noted that head injuries were particularly few in car to car impacts but were more apparent in car to fixed object collisions, where only half of the occupants escaped moderate, severe or fatal head injuries. Serious injury was equally likely to occur to those on either the near or the far side from the point of impact, though other injuries were more likely for occupants on the side of the impact. Fildes (1990) reviewed case studies of drivers involved in lateral impact, and found that the most frequent body regions injured were the abdomen 90%, the chest 70%, the head 63% and the upper extremity 63%, for severe injuries (>AIS 2), the most frequent body regions injured were the chest (47%), the abdomen (30%) and the head (17%). It was also noted that drivers had a slightly higher risk of head injury than front seat passengers. Contact sources in lateral impacts have also been examined. Mackay (1993) examining sources of injury to fatally injured occupants (AIS>3) found that the most frequent contact source was an exterior object such as another vehicle, or a pole or tree (42%), the side header (19%) and via ejection 6%. It was also noted that sources of injury to seriously injured struck side occupants were the side header (20%), side glass (16%), A-pillar (12%) and via ejection 10%. Morris (1995) noted that (48%) of head injuries in lateral impact collisions were moderate in severity (AIS 2), (48%) of contact sources for all injury types originated from outside the vehicle, and such exterior sources were more likely to result in high severity of injuries, where (30%) of injuries resulted from head contact with other vehicles. The most frequent vehicle interior contact source was the side window glass. Mackay (1993) describes some of the characteristics of these collisions as they related to the front seat occupant sitting on the side opposite to the impact. It was found that 39% of the non struck side occupants received an AIS≤2 head injury, mainly from contact with the opposite header, the roof, side window glass, opposite door, or the other occupant. Chest injuries occurred in 42% - mainly multiple rib fractures which are caused primarily by seat belts. Abdominal injuries occurred in 23% of cases, the great majority (71%) of which were caused by the seat belt.

According to numerous authors, head-on collisions are the most frequent type of car accident, constituting between 58% and 79% of the total number of accidents; (Walz 1980; Ropohl 1988). The factors influencing occupant injury severity in head-on car collisions has been observed by (Miltner 1995). According this study, above the energy equivalent speed (EES) of 50 km/h, severe or fatal injuries could be expected for all vehicle types and occupant age groups. Below an EES of 50 km/h the risk of fatal injury was less than 10%, even for elderly car occupants. On the other hand, there was hardly any chance of remaining uninjured at an EES≥50 km/h. Furthermore, occupant position affected only the severity of head injury, where drivers were injured more severely than passengers. The accident factors that were most significant for injury severity were velocity (EES or delta v) and deformation depth.

Neck injuries are the most frequent disabling injuries among car occupants in road traffic accidents. Injuries to the neck are often regarded as a problem in rear end impacts. However, 27% of the AIS1 neck injuries occurred in frontal impacts (Galasko 1993). For AIS1 neck injury mechanisms, different hypotheses exist concerning rear end impacts, covering flexion, (Koch 1995) extension (McConnell 1995) and hyper extension (States, 1979). In frontal collisions, Larder (1995) found that no head contact with the interior of the vehicle compartment had been noticed and the forward flexion of the neck was assumed to be the motion causing injury. Walz (1995) described the motion of the head relative the neck in a frontal collision with no head contact. For a restrained occupant in the initial phase of a collision a purely translational motion occurs forming an S shape of the cervical spine. After that the cervical spine is forced into flexion. Walz suggested that neck injury may occur due to such acceleration mechanisms. Anders (2000) analysed the influence of different characteristics derived from the acceleration time history on the risk of short and long term disability to the neck in frontal impacts. The results showed that shape of the crash pulse influences the risk of long term disability to the neck. It was also shown how change of velocity and mean and peak accelerations influence the risk of neck injury.

An overview on differences of injury outcomes between male and female occupants of modern European passenger cars was provided by (Lenard and Welsh 2001). The over all number of occupants in the Co-operative Crash Injury Study (CCIS) database for the year 1992 to 2000 was around 14,000 occupants of whom 8,346 (60%) were male and 5,644 (40%) were female. The study focused on restrained occupants. It was found that soft tissue neck injury was more frequent among across front side and rear impacts, female front occupants appear to be more vulnerable to injury in frontal impacts, especially with regard to the skeletal chest and possible leg injuries. Males and females appear generally equally vulnerable to injury in struck- side impacts, also in rear impacts, female drivers more frequently have an unfavourable injury outcome compared to accompanying front seat passengers than do male drivers. It was suggested that female characteristics should not be neglected in the design of driver safety features. Variations of injury outcomes between male and female occupants were addressed by (James 2002) who examined crash data from two UK resources (CCIS, and State 19) to study the differences between male and female passenger car drivers in collision circumstances and injury outcomes. The data showed that around 60% of both male and female drivers involved in collisions on UK roads were under the age of 35, and female drivers had a higher proportion of primary impacts to the rear and right side of the vehicle. However, comparing the uninjured rates, women were considerably more at risk of receiving an injury than men. This difference was accounted for exclusively at the slight injury level (49% women, 31% men). The data presented in this paper showed women to have high propensity toward skeletal chest injury. Furthermore, men more frequently receive serious and fatal injuries, the respective male and female rates being 4.1% compared to 4.5% for serious injury and 0.4% compared to 0.2% for fatal injury. The greatest difference in injury rates was seen for frontal impacts. For this impact type a higher proportion of women than men appear at all injury levels. In the driver side, there were a higher proportion of women in all but the most severe injury category, MAIS 3+. For the remaining types of impact woman were seen to be more susceptible at the higher levels.

2.12 Occupant Injury Causation

A number of accident investigations have identified those features of vehicle design responsible for injury causation and have determined the relative frequencies with which those features cause injury. An early study by Schwimmer (1962) reported that in a study of American accidents the instrument panel was found to be the leading cause of injury when all injuries were given the same importance. Ejection was the second most frequent cause of injury, the windscreen the third and the steering wheel was the fourth. Nahum (1966) reported that a study of non-fatal injury producing accidents in California indicated that the steering assembly was the most frequent cause of injury. Ryan

(1967) reported that in a study of accidents in Adelaide, Australia, the instrument panel was again the leading cause of injury but that the door structure was the next most frequent cause. Table 2.11 gives the leading causes of injury found in this study. These two studies of accidents agree on the leading cause of injury but differ on the relative importance of other causes of injury. The reason for this difference is that in both these studies the injury causation factors have been given for all occupants and all accident types, but the injury causation varies with seating position and impact direction, since the occupants are exposed to different items of the vehicle interior with seating position and impact type. For instance in a frontal impact the driver will contact the steering assembly but the passengers will not. The door structure is more likely to be contacted in a side impact than a front impact. It is therefore more realistic to consider injury causation by seating position than for all occupants together. Nahum (1967) analysed the injuries to rear seat occupants seen in a study of accidents in California. He found that children tended to become airborne and to suffer severe injuries from the windscreen, mirror, dashboard and header. Adults, however, tended to receive head and face injuries from the top of the front seats and to sustain leg fractures from trapping their feet under the seats. Ryan (1967) reported that, from a study of accidents in Adelaide, occupants in rear seats are less likely to be injured than front seat occupants and that when they are injured they normally receive less severe injuries than front seat occupants. These differences, however, tend to decrease with increased vehicle damage.

De Fonseka (1969) described the leading causes of injury for drivers and front seat passengers involved in urban and rural areas. He found that as well as there being a difference in injury causation between the driver and nearside front passenger, there was also a difference in injury for both drivers and passengers in urban accidents. However, in rural accidents the steering assembly was the leading cause of injury for drivers and the instrument panel was the leading cause for passengers.

Cause	Number/ %
Instrument Panel	170/19.03
Door	160/17.09
Windscreen	66/7.39
Header and Mirror	56/6.27
Steering Wheel	47/4.59
Ejection	41/4.59
Front Seat	36/4.04
Other	31/3.47
Corner Posts	14/1.57
Not Known	272/30.46

2.11. Table Injury Causation Factors, (Ryan 1967)

As well as there being a difference in injury causation factors between the different seating positions and accident types, there was also a difference in injury location. Mackay (1969) gave details of injury location for the major injuries only by location of injury for the same series of accidents as de Fonseka (1962). This data was reproduced in Table 2.12.

Location	Injured Drivers (%)		Injured Near side FSPs (%)	
	Urban	Rural	Urban	Rural
Head	67	55	72	81
Face	19	28	28	23
Neck	2	0	0	1
Upper Limbs	19	9	9	12
Abdomen	2	1	1	12
Pelvis	14	3	3	8
Lower Limbs	35	16	16	23

Table 2.12 Frequency of Major Injuries, Drivers and Near Side Front Seat Passengers, Urban and Rural Accidents, (Mackay 1969)

It can be seen that more nearside front passengers received head injuries than drivers, but that more drivers received chest injuries and lower limb injuries than nearside front passengers. More occupants received major injuries in rural accidents than in urban accidents. The greater incidence of all major injuries in the rural environment was attributable to the higher impact speeds associated with rural accidents- 23.2% of rural accidents occurring at an impact speed greater than 40 mph as opposed to only 3.8% of urban accidents (Mackay, 1969).

A study by Harms (1987) discussed side impact collisions and implications for serious and fatal injuries. Out of 410 struck side, restrained occupants analysed in this paper, it was noted that the adjacent door was identified as the most common contact zone-giving rise to serious injuries to the trunk in side impacts. Table 2.13 shows that the passenger compartment suffers the majority of impacts. Intruding external objects will have caused a large proportion of the head injuries and, since the injuries were not mutually exclusive between body regions, it is possible that part of those same objects could have also loaded the door-giving rise to the trunk and limb injuries.

Probable Contact. Injuries level.	Head/Face AIS 3+	Chest/Upper back AIS 3+	Abdomen/Lower back. AIS 3+	Arms AIS 2+	Legs AIS 2+	Total
Intruding ext. object	28	-	17	-	-	45
Adjacent door/door	-	25	33	48	28	124
Intruding foot well	19	11	7	20	6	63
Total	64	36	57	68	39	264

Table 2.13 Restrained Front Seat Occupants in Struck-side Impacts, (Harms 1987)

2.13 Pedestrian Accidents

Although the frequency of pedestrian accidents has reduced significantly in recent years, there are still about 1000 pedestrians killed annually in Great Britain, and about 7,000 in the European Union, with about ten times as many being seriously injured (Harly 2000). Pedestrians form a significant proportion of those killed on the road. In GB about a quarter are pedestrians; while within the European Union it is about a sixth. The pedestrian crossing has been the subject of observations on pedestrian and driver behaviour since 1948 (Oder 1961). A team from the Road Research Laboratory has accounted for the number of pedestrians on or within 20 yards of pedestrian crossings at Crouch End Broadway, Hornsey, UK. Also, the vehicle flow was counted. From these observations, two measures of road user behaviour; "a behaviour index for pedestrians and a courtesy index for drivers" were calculated. It was noted that pedestrian use of the crossing shows a fairly steady improvement between 1948 and 1954, with a marked rise in 1952 following the general introduction of Zebra markings for pedestrian crossings. Since 1954, when over 80 per cent of pedestrians in the vicinity used the crossing, a slight decrease in the use of the crossing was noted by both men and women. Mackay (1969) has described some of the findings from a study of road accidents undertaken in and around Birmingham from1965 to1969. The technique used was to examine a representative sample of road accidents selected from specified environments. It was found that pedestrians were injured both by the primary impacts with the vehicle and secondary impacts with the road surface; the road surface produced most of the injuries, the primary vehicle impacts most of the severe and fatal ones. European and British studies add to the range of findings. Mass (1984) reported ratios of 0.78 and 0.82 for numbers of police-reported versus hospital-reported pedestrian and bicyclist injuries, respectively, in Netherlands during the early 1970s. In a subsequent article, Harris (1990) reported that these ratios had declined to less than 70 per cent by the late 1980s. Using information gathered from a national telephone survey that was restricted to "reportable" accidents, but which included all levels of injury severity and not just hospital cases, Harris documented ratios of 0.11 for bicyclists and 0.25 for pedestrians. The figure for bicyclists was the lowest of any of the examined road-user groups. In other research, a German study reported ratios of 0.30 for hospitalized bicyclists and 0.20 for bicyclists receiving outpatient treatment only (Hautzinger 1993) while an early British study reported a ratio 0.24 for bicyclists receiving either inpatient or outpatient treatment (Bull 1973). Pedestrian crossing behaviour was addressed by (Keall 1995) to estimate the pedestrian risk of road crossing behaviour. Pedestrian risk of accident disaggregated by sex and age were examined by combining road accident data with survey data using the exposures "time spent walking and number of roads crossed". The amount and type of pedestrian activity derived from a national house survey in New Zealand between1989-1990. It was found that pedestrians under 10 years-old and over 70 years old were more likely to be injured in a reported accident, both per road crossed and per hours of walking than other age groups. Both the elderly and young spent a greater proportion of their travelling time as pedestrians than did other age groups and females spent considerably more time walking than did males. Pedestrians in their twenties crossed roads more frequently per hour of walking than any other age group. Moreover, pedestrians had a significantly lower risk of injury when crossing on Zebra crossings than when crossing at other places. A study of pedestrian casualties and fatalities in road traffic crashes in Durban, South African for 1999 was undertaken by, (Olukoga 2003) which found that cars were involved in 52% of the vehicle pedestrian crashes but had fewer crashes than minibuses and buses, and fewer casualties and fatalities than minibuses, which recorded the most crashes at 1,037 per 100 million km, the highest casualty rate of 268 per 100 million km, and the highest fatality rate of 17 per 100 million km.

2.14 Pedestrian Accidents in Developing Countries

Studies in developing countries have shown that pedestrians are a high-risk group of road-users representing a significant proportion of all reported road accident casualties. For example, in African countries, more than 40 per cent of road accident fatalities were pedestrians, and in Middle Eastern countries more than 50 per cent of road accidents. By comparison, in Europe and the United States of America, pedestrians represented about 20 per cent of road accident fatalities (Eke 2000). The higher involvement of pedestrian accidents in developing countries may simply be due to more people making walking trips; (Jacobs 1983). However, there was some evidence (Jacobs, 1984) showing that, when pedestrian and vehicle flows were taken into account, pedestrians were more at risk in Third Wold cities than they were in UK cities. Downing (1991) also showed that approximately 20 per cent of fatal road accidents in third world countries involved young people under the age of 15 years. In Libya, Kazeem (1979) found that 30% of pedestrians injured were children, who formed the highest group susceptible to injury. Females injured as pedestrians were significantly more common than males. In Europe countries and the USA it was 10 per cent. On average, children in Africa represented more than a quarter of pedestrian road accident deaths. However, the proportion of the population here aged less than 16 was approximately double that of developed countries.

Many studies have shown the benefit of crossing facilities in saving pedestrians life. Jacobs (1967) showed that in the UK, pedestrian usage of zebra crossings was on average 89 per cent of all pedestrians crossing. Similar surveys were conducted in Nairobi, Colombo, and Bangkok, and the average percentages of pedestrians using the crossings were 49 per cent in Nairobi, 43 per cent in Colombo, and 48 per cent in Bangkok. The pedestrian accidents in Botswana, Pakistan, and Zimbabwe have been investigated by (Sayer 1996). The study included replies from questionnaires distributed to Ministries of Education throughout the world and to schools in the above cities. It was concluded that in

Papua New Guinea and Zimbabwe about 70 per cent of a sample of pedestrians were injured when walking along roads with their back to the traffic. Seventy-two per cent of injured pedestrians in Karachi were injured when crossing a road. It was suggested that crossings and using roads safety should form fundamental parts of any road safety campaign.

Field research was carried out by (Hkhan 1998) about the risky behaviour of pedestrians in Karachi, Pakistan. Ten of Karachi's highest risk locations for pedestrian road traffic accidents were selected. He noted that pedestrians crossing the street performed the majority of the most dangerous behaviour. Crossing barely two seconds before an oncoming vehicle, running while crossing, and crossing one lane at a time made it necessary for drivers to swerve their vehicles to avoid pedestrians. People crossing in groups were a significant cause for traffic to swerve as well. This was not only due to their slow movement in crossing streets but also because nearly half of the observed pedestrians were talking to each other. It was noted that fourth of pedestrians that had a zebra crossing available to them did not use it. Moreover, even when they crossed at zebra-crossings the cars usually did not stop or slow down. As a consequence, a large number of pedestrians were exposed to the hazards of accidents, further reflecting the poor enforcement of road safety regulations. It was suggested that since the majority of RTA fatalities in Karachi were pedestrians, piloting efforts to modify pedestrian behaviour and the environment they negotiate were important next steps to decrease the burden of pedestrian RTA mortality.

The patterns of injuries to Africa pedestrian children have been studied by (Adesunkanmi 2000). The main purpose of this study was to assess patterns of severity and outcome of childhood injuries from RTAs. They found that children who were pedestrians and who were aged over 5 years were most affected by RTAs. They thought that economic factors might have contributed significantly to the high incidence of RTAs in children in Nigeria, since a good number of these children were engaged in buying and selling along the roads.

Eke (2000) presented for the first time an accurate picture of RTA deaths in Nigeria. It was found that female pedestrians below 15 years of age were more susceptible to death in RTAs. This can readily be explained by the fact that they were more involved in the hawking of wares along streets along with the poor conditions of roads with hardly any zebra crossings, and many rickety vehicles. The same reason can be given for the 20 –39 years group, which constituted 44% of all accident victims. Furthermore, Eke thought that the preponderance of males was due to the paternalistic nature of Nigerian Society. There males, as breadwinners, are more involved in outdoor activities such as driving and travelling.

2.15 Pedestrians Injury Patterns

A pedestrian struck by the front of a vehicle experiences a series of impacts, first from the vehicle and then from the ground. With an adult, the bumper strikes the lower legs and the leading edge of the bonnet strikes the upper legs or pelvis. The exact location of the contacts depends on the relative heights of the pedestrian and the vehicle bumper and bonnet front edges. The pedestrian then wrap over the leading edge of the bonnet until the head or upper torso contacts the vehicle, this contact being with the bonnet, windscreen glass or windscreen frames (Xuejun Liu. 2003). Each of these contacts may, and often does, cause injury.

As might be expected from consideration of the impact dynamics, the struck pedestrian frequently sustains multiple injuries. The pattern of injury depends on the overall severity of the injuries sustained and on the severity of the injuries counted.

Table 2.14 gives details of various studies that have described pedestrian injury patterns in terms of all injuries sustained. There seems to be general agreement that the legs and the head are the body areas most frequently injured. The arms are generally found to be the third most frequently injured area, followed by the pelvis, chest and abdomen. Injuries to the neck and spine are, in overall terms, relatively infrequent.

Head injuries are the most important pedestrian injuries, being not only the most frequently sustained but also those most likely to result in death. They can be divided into three types: surface injuries, skeletal injuries and brain injuries.

(Nelson. 1974), in a study covering all casualties, found that of those with head injuries 97% sustained surface injuries, 52% lost consciousness-although only 9% were still unconscious on arrival at hospital - and 17% sustained skull fracture., Gogler (1962) however, in a study of hospital inpatients, found that of those with head injuries only 34% sustained surface injuries, 75% were concussed and 31% sustained skull fracture. However, in-depth studies have suggested that contact with the vehicle is an important cause of serious head injury. Contact with the vehicle has been reported to be responsible for 35% of all head and neck injuries and 50% of all fatal head and neck injuries by; (Robertson 1966) for 66% for all life-threatening or fatal head injuries by; (Tharp 1976) and for 65% of all head injuries and 88% of all life-threatening or fatal head injuries by. (Thomas 1976) Whilst there are differences in these various figures due to differences in the severity of injuries counted and in the samples used, there is general agreement that contact with the vehicle is responsible for a high proportion of the more serious head injuries.

Injuries to the upper limbs are the third most frequent type of injury sustained by pedestrians. Surface injuries predominate, followed by fractures and then joint dislocations. Backstrom (1963) noted 21% with surface injuries and 15% with fractures, whilst Nelson (1974), noted 21% with surface injuries, 6% with fractures and 1% with joint dislocations. Both of studies showed that fractures to the humour are the most frequent upper limb fractures, followed by clavicle fractures, then forearm fractures. Dislocations of the shoulder joint are more frequent than elbow or wrist dislocations.

Contact with the vehicle was reported to be the cause of 72% of all upper limb injuries by Robertson (1966), and 48% of all injuries by Thomas (1976). The T.R.R.L. (1974) attributed 67% of all non-minor upper limb injuries to vehicle contact. Injuries to the lower limbs are reported to be either the most frequent or the second most frequent type of injury sustained by pedestrians, and are only equalled by head injuries in relative overall importance. A high proportion of the lower limb injuries are minor. Nelson (1974) found that 71% of pedestrians sustaining leg injuries received only minor injuries, whilst Grattan (1976) noted that 80% of the leg injuries were minor. Nelson noted that surface injuries were sustained by 84% of the pedestrians with leg injuries, fractures by 34% and joint dislocations by 1%.

However, there is general agreement that when all casualties are considered, the order of importance of different fracture locations is first lower leg, then thigh, pelvis, knee, ankle, and foot. Goler (1962), however, who only considered hospital inpatients, reported a higher incidence of ankle injuries and a lower incidence of pelvic injuries

Study	Study type	Head	Thorax	Abdomen	Pelvis	Arms	Legs
Aston (1954)	Hospital study Sample=51 case	54	17	-	-	35	65
Backstom (1963)	Hospital study Sample=220 case	66	10	4	7	21	47
Robertson (1966)	Accident Study Sample =51 case	76	22	16	18	51	87
Jamieson (1971)	Accident study Sample=34 case	65	14	27	25	106	144
Nelson (a) (1974)	Hospital study Sample=413 4 case	59	16	13	8	33	56
Hall (1972)	Police data Sample=4134 case	48	3	2	2	24	86
Grattan (1976)	Hospital study Sample=299	54	9	8	5	10	28

Table 2.14 Percentage of Pedestrian Injuries by Body Area all Severities of Injury

2.16 Multiple Injuries in Pedestrians

All studies of pedestrian trauma have noted that the injured pedestrian is likely to sustain more than one injury. Table 2.15 summarizes the results of the various studies. Although direct comparison between studies is not possible due to differences in the types of casualties considered, severity of the injuries counted and the number of body areas used, it is apparent that the more severe the overall severity of injury the greater the number of body areas injured. Table 2.16 summarizes the studies reporting on the injuries sustained by those fatally injured. Although minor injuries were not included in the reporting of the injuries in all the studies, it was probable that the actual selection criteria for inclusion of injuries varies with the different studies and this could explain part of the variation in incidence between the different studies.

Head injuries were still the most frequent type of injury and lower limb injuries the second most frequent injury. The incidence of neck and abdominal injuries was greater for fatalities than for all casualties. If only injuries responsible for death were considered, it was generally agreed that head injuries were the most frequent and chest injuries the next most frequent injuries sustained. However, the fatally injured often sustain more than one fatal injury, and a small proportion die as a result of complications rather than as a direct result of the injuries (Huelke and Davis, 1969). The elderly have been noted as being particularly susceptible to complications (Robertson, 1968; Sevitt 1968)

Study	Casualties considered	Injuries counted	Number of Body area considered	Average number of Injuries
deFonseka (1969)	All	All	9	2.7
	All	Non-minor	6	2.2
Huelke (1969)	Fatalities	Non-minor	7	2.8
	Fatalities	Fatal	–	1.6
Jamieson (1966)	All	Major	8	2.1
	Survivors	Major	8	1.6
	Fatalities	Major	8	3.6
McCoarroll (1962)	Fatalities	Non-minor	7	2.7
Robertson (1966)	All	All	6	2.7
	All	Non-minor	6	1.9
Sevitt (1968)	Fatalities	Non-minor	6	2.3
	Fatalities	Fatal	-	1.3

Table 2.15 Average Numbers of Injuries Sustained by Casualty Class, Severity of Injuries Counted and Number of Body Areas Considered

Study	Notes	Head	Neck	Abdomen	Arms	Legs	Pelvis
Huelke & Davis (1969)	Sample =355	80	20	49	25	99	33
Hall (1972)	Sample = 287	75	5	10	9	91	15
Tonge (1972)	Sample = 187	55	42	20			4
Nelson (1974)	Sample = 373	81		14	1	8	7
Tharp (1976)	Sample = 39	80	44	39			

Table 2.16 Percentage Incidence of Pedestrian Injuries by Body Area Fatal Injuries

An early TRRL study carried out by Grattan (1976) identified the injury patterns of pedestrian casualties together with some basic accident details. Out of 523 pedestrian casualties, of whom 27% sustained fatal injuries, 50% were classified as serious and the remaining 234 (45%) were slightly injured. It was noted that

17% were hit by cars/LGVs with most of the impacts to the vehicle front. However, the injury distribution by body region and the overall injury severity according to the AIS scale is shown in table 2.17. It is clear that most of the injuries are to the lower limbs but to the head most frequently in life threatening injuries, with a proportion of serious injuries also occurring to the chest. 45% of the casualties in this sample were children.

AIS	Shoulder/Arms	Head/Neck	Face	Chest	Spine	Abdomen	Pelvis	Legs/Feet
1	94	112	159	23	4	28	2	443
2	46	128	38	8	-	8	5	29
3-4	16	25	3	14	3	3	18	88
5	-	16	-	2	1	-	-	-
6	-	10	-	2	2	3	-	-
Total	156	291	200	49	8	42	25	560

Table2.17 Injury Distribution and Overall Severity Pedestrian Casualties, (Grattan 1976)

To investigate the effects of vehicle impact velocity and front-end structure on the dynamic responses of child pedestrians, an extensive parametric study was carried out by (Xuejun Liu 2003) using two mathematical models for children aged 6 and 15 years old. The effect of the vehicle impact velocity was studied at 30,40, and

50 km/h in terms of the head linear velocity, impact angle, and head angular velocity as well as various injury parameters concerning the head, chest, pelvis, and lower extremities. The variation of vehicle front-end shape was determined according to the shape corridors of modern vehicles, while the stiffness characteristics of the bumper, bonnet edge, and bonnet were varied within stiffness corridors obtained from dynamic component tests. The simulation results showed that the vehicle impact speed was of great importance on the kinematics and resulting injury severity of child pedestrians. A significant reduction in all injury parameters can be achieved as the vehicle impact speed decreases to 30 km/h. The head and lower extremities of children were at higher injury risks than other body regions. Older children are exposed to higher injury risks to the head and lower leg, whereas younger ones sustain more severe impact loads to the pelvis and upper leg. The results from factorial analysis indicate that the bonnet edge height has a significant effect on the kinematics and head impact responses of children. A higher bonnet edge could reduce the severity of head impact for younger children, but aggravate the risks of head injury for older children. A significant interaction exists between the bumper height and the bonnet edge height on the head impact responses of younger children. Nevertheless, improving the energy absorption performance of the bonnet seems effective for mitigating the severity of head injuries to children.

The evaluation of pedestrian head protection mainly concentrates on the bonnet in the European Enhanced Vehicle-Safety Committee Working Group 17 test procedure (EEVC 1998). However, recent pedestrian accident research Jarrett (1998) showed that the area around the windshield (windshield glazing/trim and A-pillar) had a larger effect on head injuries, and that one reason for this phenomenon is the change in the front shape of recent vehicle models. In the EEVC report the head contact area was determined with the wraparound distance along the vehicle front shape, so this line was parallel to the bumper shape. But the construction of the vehicle outer sides was different from that of the vehicle middle portion. The bumper beam does not spread to the end of the outer side, and the front bulkhead shape not straight for headlight layout. So the head contact points and contact conditions were also thought to be influenced by the construction. Yutaka (2003) has studied vehicle pedestrian impact in a study whose purpose was to consider the reason for the change in injury sources for recent vehicle models. The head contact points and contact conditions, speed and angle, were thought to be influenced not only by the vehicle's geometry, but also its construction (rigidity). In this study, vehicle-pedestrian impact simulations were calculated with a finite element model for several hitting positions, including the outer side areas. These results showed that, for impacts at the outer sides of the vehicle, the head contact points were more rearward than at the vehicle centre. In addition, the speed and angle of the head contact were found to be influenced by pedestrian height

2.17 Road Traffic and Injury

Traffic injuries are a worldwide public health problem which it has been addressed from different perspectives according to the purpose of the study. Moor et al. (1960) reported on injury patterns to child occupants of vehicles involved in rural accidents in the U.S.A. 9 per cent of the occupants were children and 16 per cent were youngsters (age 12-14). It was found that children had a greater frequency of head injury (77 per cent), compared to 69 per cent of the adolescents and 70 per cent of adults, but that although children sustained more head injuries the injuries were generally of a less severe nature. It was further noted that younger children were more likely to receive serious injuries than older children when injured. Robertson (1966) reported on the results of an at-the-scene study of accidents in Adelaide, Australia. A report by Ryan (1968) had considered in more detail injuries sustained by children. A child was defined as aged less than 15 years. The findings of the study were similar to the American findings. Ryan noted that a greater proportion of children under 5 years occupy the front seat than the rear seat. It was found that for front seat occupants children were injured less frequently than rear seat occupants. Head injuries were the most frequent injuries sustained by children, with lower limb injuries the next most frequent. A report from Cornell (1967) considered the incidence of head injury in rural accidents. They reported that children were less likely to be injured than adults in the same seating position. The younger child was found to be less likely to be injured than the older child, but, when injured, to be more likely to receive head injury. Rear seat occupants were less likely to be injured than front seat occupants. Although young children sustained head injuries more frequently than older children their injuries tended to be less severe. For front seat occupants the leading case of injury for young children was the instrument panel, and for older children the windscreen, whilst for rear seat occupants the back of the front seat was found to be the leading cause of injury for both age groups. Young children were likely to receive cranial fractures and less likely to receive facial fractures than older children.

A field study by Mackay (1973) studied road accidents involving 105 vehicles; examining severe and fatal injuries of the whole injury spectrum were examined. Each collision was examined to assess the benefit of an airbag and a lap/diagonal seat belt. His findings are summarised in table 2.18. He suggested that if the belt wear rate exceeded 63% for drivers and 85% for front passengers, then belts would provide greater benefits than airbags. He thought that the importance of intrusion into the passenger compartment, especially in fatal collisions is emphasized as a restriction on restraint effectiveness in European car designs.

	Front Impacts			Single Impacts Front Corner			Single Impacts Side			Single Impacts Rear		
	Driver	Pass.	Both	Driver	Pass.	Both	Driver	Pass	Both	Driver	Pass.	Both
Number	24	16	40	27	16	34	20	14	34	4	1	5
Airbag	11	11	22	12	8	20	2	1	3	0	0	0
Effective (%)	45.8	68.7	55.0	44.4	50.0	46.5	10	7.1	8.8	-	-	-
Belt	11	10	21	15	8	23	3	2	5	1	0	1
Effective (%)	45.8	62.5	52.5	55.6	50.0	53.5	15	14.3	14.7	25.0	0	20.0

Table 2.18 Airbag and Seat Belt Effectiveness by Occupant Injury for Single Impacts, (Mackay 1973)

Tunbridge (1988) investigated injuries for all major groups of road users. According to the finding, young adults were particularly susceptible to being injured in road accidents, and the incidence of mortality was strongly age dependent. Head injuries (mostly minor) were most marked among vehicle occupants, but life threatening injuries were most likely to involve combinations of injuries to the head, chest and abdomen, with combinations of brain injury with fractures of the lower limbs more commonly resulting in long term disability. It was also noted that MAIS was found to strongly correlate with mortality, the rate being low for serious (MAIS-3) injuries (1 per cent), higher for severe (MAIS-4) injuries 29 per cent, and truly "critical" for MAIS-5 injuries (69 per cent).

Soft tissue neck injuries are still a major concern but it is a common misconception that they occur more or less exclusively in rear impacts. Soft tissue neck injuries in U.K car occupants was studied by (Morris 1996) who showed that over 50% of these injuries occurred in frontal impacts, with 25% occurring in side impacts. The overall soft tissue neck injury rate was 16%. Soft tissue neck injuries can occur at comparatively low speeds and are associated with seat belt use. They also occur more to females (21%) compared to males (13%). Rutherford (1985) detected a relative increase of 18% in neck 'sprains' co-incident with the U.K seat-belt use increasing from 26% to 93% after the introduction of the U.K seat belt law. This data was supported in a study by, (Galasko 1993) who found a corresponding increase in the incidence of soft tissue neck injuries of occupants in car crashes between the years 1982 and 1991. It was found that in 1982, 12 months before the introduction of the compulsory seat belt legislation, the incidence of soft tissue neck injury rose to 12% and thereafter it raised steadily each year until 1991, by which time the incidence had risen to approximately 46%. Larder (1995) found that in frontal impacts 17% of occupants sustained a neck injury whilst for rear impacts, the rate was 31%. Females appear to have a higher risk of these injuries than males, and Lovsund (1988) found that more Than 10% of car occupants involved in a rear-end collision sustained a neck injury.

Motor vehicle traffic crashes are the leading cause of injury to the spinal cord. A study by O'Connor (2002) concentrated on injuries to the spinal cord in motor vehicle traffic crashes. One of the aims of the study was to describe the neurological outcomes of motor vehicle traffic crashes occurring in South Australia over the period (1988-1995) in which a vehicle driver or passenger received a spinal cord injury and was admitted to hospital over this period. There were 43 cases of spinal cord injury (SCI), 75% of whom were car occupants and 19% were motorcyclists. It was found that there was a higher likelihood of spinal cord injury in single vehicle car crashes; this was five times higher for occupants of non-sedan type cars compared with sedans. The likelihood of spinal cord injury was especially high in non-sedan type cars involved in rollover crashes-ten times higher than for sedans. O'Connor suggested that attention should focus on eliminating single vehicle crashes involving the rollover of non-sedan type cars.

An attempt to study road accidents and injury severities in Riyadh, the capital of Saudi Arabia, was carried by (Al-Ghamdi 1999). The study described the association between the severity of a traffic accident injury and accident characteristics. According to this study, the most frequently injured body regions were the arms, head, face, and pelvis. Head and face injuries, considered the most dangerous injuries, accounted for high percentages (35.5 and 30.5 per cent respectively). Furthermore, the severity of injury among those scaled with AIS ≥ 3 according to the type of accident was; 42.31 per cent for pedestrian accidents; for crashes between two or more vehicles 33.64 per cent; and fixed-object accidents. 33.46 per cents with 13.46 percent, more than half the injured people studied had serious injuries (AIS ≥ 3). It was suggested that the traffic accident problem in Riyadh was threatening many lives; and that countermeasures were urgently needed.

Several studies have reported that motor vehicle occupants are at a lower risk of death or non-fatal injury when riding in the rear seats of passenger vehicles, as compared with riding in the front seat. Reported risk reduction estimates for death range from 26 to 41%; (Evans 1988 and Glass 2000; Smith 2003) studied passenger seat position and the risk of death and serious injury for passengers in traffic crashes using 1993-2000 data from the U.S. National Highway Traffic Safety Administration's Crashworthiness Data system. The risk ratio for death and serious injury was estimated for rear seat passenger compared with front seat passengers in motor vehicles crashes. According to this study, the rear seat passenger position may reduce the risk of death in a motor vehicle crash by about 38%, and may reduce the risk of death or serious injury in a crash by 33%, compared with front seat passengers.

2.18 Ambulance Rescue Time

The purpose of emergency medical care is to stabilize patients who have a life-threatening or limb-threatening injury. Mackay (1969) reported that of riders and vehicle occupants who died, some 43% might have had a greater chance of survival if medical treatment had been available at the scene of the accident within 10 minutes. In contrast to preventive medicine or primary care, emergency medical care focuses on the provision of immediate or urgent medical interventions. It includes two major components: medical decision-making, and the actions necessary to prevent needless death or disability because of time-critical health problems, irrespective of the patient's age, gender, location or condition.

Ambulance rescue time was evaluated in Riyadh city, Saudi Arabia by (Al-Ghamdi 2002) with the aim of comparing the response time there with corresponding times in other countries. A sample of 874 emergency calls was collected during 1999. Ambulance rescue time consists of three components: response time, time at the scene and travel time to hospital. It was found that mean response time in urban area was 10.23 min, which was below acceptable standards in developed nations such as the UK and the US. The analysis showed that the mean speed of an ambulance during the journey back to the station from the hospital was 17 km/h less than the speed from the station to the scene and from the scene to the hospital. It was suggested that the city response time could be significantly improved by considering the station as the centre of a circle. The study also suggested a statistical method for performing a simple hypothesis test for percentile of response time.

The role of medical technology has been examined using US data (Noland 2002a) and international data for industrialized countries, where improvements in medical technology are statistically significant and associated with reduced fatalities. Noland (2003) studied the impact of improvements in medical care and technology and other factors associated with reducing fatalities in road accidents.

Cross section time-series data for the U.K was used in this study, and was obtained from several sources, including the Department of Environment, British Road Federation, and the Office of National Statistics. There were 6,423,709 casualties over a period of 20 years (1979 to 1998). The results suggested that medical technology improvements (such as radiographs, ECEs, and changes in procedures, and management systems of treating accident victims) seem to be more important than the changes in medical care. Surprisingly, other results were included that increased average vehicle age seems to reduce fatalities. Increased motorway length per area reduced fatalities, and injuries, while increases in the percent age of population over age 65 increased fatalities. These results were supported by a team of researchers who analyzed similar effects in the US (Noland, 2002a).

2.19. Airbags and Injury

Through the installation of the three-point seatbelt and legislation for its use in most countries, the severity of injuries in road-traffic accidents (RTAs) has undeniably been reduced. In spite of this, severe injuries to the head and thorax of accident victims have continued. This led to the development of the airbag as an additional passive safety device. Under test conditions the airbag has proven its effectiveness in the reduction of severe injuries to the head and thorax.

Extensive studies of airbag effectiveness in the U.S have shown effectiveness in reducing fatality by 31% in frontal crashes (NHTSA, 1996). Studies have also examined effectiveness related specifically to airbag and belt combinations, belt only and airbag only. It has been shown that drivers have a high probability of receiving an AIS2+ brain injury or a facial injury if they were restrained by only an airbag compared with only a seat belt (Kuner 1995). Concerning overall injury reduction, for serious injury, the combined airbag plus lap shoulder belt provides a 60% reduction in injury risk, automatic belts alone 37% effectiveness and the airbag alone a 7% effectiveness (NHTSA 1996). A German survey by Kuner (1995) examined the efficiency of the airbag in real road traffic accidents. It was shown that the risks from a frontal collision at legal speeds on city streets can be greatly reduced if the vehicle occupants were additionally protected with an airbag. Correspondingly low was the number of patients from accidents occurring at speeds below 50-km/h. Furthermore it was clear from the results that the airbag protected victims who had predominately only superficial injuries (AIS 1), amounting 74.6 per cent of head and neck injuries, 67.2 per cent thoracic, and 77.9 per cent abdominal. Injuries of the limbs amounted to 57.3 per cent. The positive influence of the airbag could also be clearly recognized with more severe injuries (AIS 3+). Only 3.3 per cent of patients had severe injuries of the head and neck. Severe injuries of the limbs amounted to 16.4 per cent. The results of the study also showed that the combination of the three-point seatbelt and airbag clearly create better protection for passengers. Cameron (2001) measured the mortality reduction associated with airbag deployment and seat belt use for drivers involved in head-on collisions in the United States. He examined all head-on collisions involving two passenger cars reported to the Fatality Analysis Reporting System (FARS) during 1992-1997 for differences in safety restraint use and mortality. A substantial reduction was found in mortality which was attributable to the use of either air bags or seat belts. Driver airbag independently reduced head-on passenger car crash mortality by one fourth; wearing a seat belt also reduced mortality by one quarter. Furthermore, in head-on collisions, both having an airbag deploy and wearing a seat belt were found to reduce the driver's risk of dying by over 80 per cent.

Roberta (1999) has provided base line information on America children who were at the highest risk sitting in passenger cars and vans from 1985 to early 1996. The study focused on children in different age groups. It was found that one-third (32.5%) of children under the age of 13 years in cars and minivans were seated in front seats, and over the 12-year period the percentage of children in front seats declined steadily among infants and toddlers but not among young children and sub teens. According to this study, young children riding in the front seat without proper restraint was more likely; many of these children could be injured or even killed by airbags in crashes. Shimamura (2001) evaluated the effectiveness of the (SRS) restraint system airbag. The focus of this in-depth study was to examine the injuries of drivers in detail, based on the vehicle damage level in each accident. The research mainly focused on belted drivers in conjunction with the SRS Airbag System. It was found that the rate of the total number of fatally and seriously injured drivers compared to the total number of drivers who were involved in frontal accidents, was found lower for cars with than for cars without airbag systems. It was also noted that the percentage of injuries in the head/face body region was lower for cars with system than without airbag systems. Tanno's (2000) experimental work studied the influence of the steering wheel in cases of air bag deployment, using two forensic autopsies which represented two cases of unbelted occupants associated with airbag deployment in motor vehicle collision. He found that serious injuries associated with airbag deployment are likely to occur to unbelted occupants. On the other hand, serious injuries occurred even in front seat occupants close to the steering wheel at the initial impact. It was concluded that the airbag is more effective if the occupant was wearing a seat belt and was in an appropriate seating position.

2.20 Economic Costs of Traffic Accidents

Official estimates of road accident costs have been prepared in most of the highly motorized countries of the world for a number of years. Theses economic valuations have mainly been intended for use in cost benefit analyses of safety measures. The first estimates were made in the 1950s in the United States and Great Britain. At the outset, the economic valuation of a traffic accident fatality was based on the so-called human capital approach. According to this approach, the cost to society of a fatality consists of the net present value of the production that is lost because of the fatality. In the first estimates that were made, the present value of the consumption of the accident victim was subtracted from the present value of his or her production. During the 1960s this approach was abandoned in favour of the gross value of lost production, where consumption was no longer subtracted. Around 1970 the human capital approach was criticised for several inconsistencies (Schelling 1968; Mishan 1971) with the theoretical principles of cost benefit analysis. Schelling, Mishan, and others have argued that the economic valuation of road accidents ought to be based on the willingness to pay criterion-that is, that costs should reflect the amounts that road users are willing to pay for a reduced risk of accidents. This point of view is now accepted by most economists working in this area. Recently, authorities in a number of motorized countries, including Great Britain, the U.S.A, New Zealand, Sweden, and Switzerland, have changed the basis of their official economic valuation of traffic accidents from the human capital to the willingness to pay approach.

In the early 1990s, a review was requested by the Commission of the European Communities (Krupp 1993) to estimate the socio-economic costs of accidents in road transport in 14 European countries. This report provided an overview of the methods that were used for valuing road accidents, as well as the costs per road fatality, per seriously injured and per slightly injured person in each country. The COST 313 (Socio-Economic Costs of Accidents) study showed a great difference between countries regarding cost levels, with costs ranging from 0.1 to 2.2 million ECU in1990. There were also differences in the sizes of the cost elements; especially medical costs, and which other costs were included. Further more, the methods used to estimate costs varied between the cost of restitution method, the human capital approach and the willingness-to-pay (WTP) approach. A further international comparison of the costs of fatal casualties in road accidents was carried out by (Trawen 2002) who assembled information on costs per fatal casualty in traffic accidents adopted by authorities in different countries, and analysed and compared these figures as well as the methods used for estimating these values. A questionnaire was mailed to individuals involved in COS313 and to other contact persons. The questionnaire asked about the purpose for estimating the costs per fatal casualty and what cost elements were included. It also asked for detailed information about the methods used for estimating the different cost elements. The study revealed that the total cost per fatality adopted by official authorities increased in most countries between 1990 and 1999 due to both changes in methodology and valuation. The mean total cost increased by about 6% annually from $0.9 million in 1990 to $1.56 million in 1999. This implies a higher annual increase in cost per fatality in these countries than the mean annual growth in GDP of about 3%. Official economic valuations of traffic accident fatalities in 20 motorized countries were described by (Elvik 1995) for all 20 countries, where an attempt was made to specify three components of the total economic valuation of a traffic accident fatality: the value of lost output; direct costs; and lost quality of life. The method used was based on taxonomy of valuation methods developed by (Krupp 1993). Data on the number of fatalities, personal risk, traffic risk, and motorization rates were taken from the IRTAD database. Data on the use of quantified road safety targets were taken from a draft OECD report (Organisation for Economic Co-operation and development) , and data on gross national product and domestic price level were taken from the OECD National Accounts(OECD 1992). The results of this study are shown in table 2.19. It was concluded that the official economic valuation of a traffic accident fatality in 20 motorized countries varied from $0.121 million to $2.5 million, with a median value of $ 0.8 million. In countries where lost quality of life has been evaluated, the economic valuation of a traffic accident fatality is more than twice as high as in countries where lost quality of life is not included.

Road accidents and associated costs in developing countries were studied by (Fourancre 1976). The purpose of this report was to collate in comparative form such information as exists, to briefly discuss the methodologies employed and to indicate some of the problems, particularly as regards data sources and definitions, which have been identified. Information from seven studies in developing countries was collected. Data for Great Britain were included to give a comparative order of magnitude and also because the methodology employed in the British studies provides a good basis for discussing the other studies. The eight countries surveyed, as shown in table 2.20, were Kenya, the Ivory Coast, Thailand, South Rhodesia, South Africa, Ghana and Turkey. It was shown that accident costs are significant in developing countries, where total accident costs were of the order of 1 per cent of GDP. This figure was similar to that for Britain. No definitive methodology was found for measuring accident costs. It was apparent that the soundest arguments favour the use of a gross valuation for measuring output.

The economic cost of traffic accidents in Jordan during the year of 1996 was studied by Al-Masaeid Hashem (1999). The specific objectives of this study were to estimate the economic costs of traffic accidents during the year of 1996, and to derive unit accident costs for different accident severity levels. The data were acquired from sources, including private hospitals and medical centres, and in this study a framework for applying unit casualty class costs, unit property damage costs, and police activities and insurance administration costs of different severity levels was suggested. The unit cost of a death included the loss of output, valuation of lost quality of life, hospitalization and medical treatment, and community and family losses. The analyses carried out in this paper estimated that1996 traffic accidents in Jordan cost the country about $146.3 million. The unit cost of fatal, injury, and property damage accidents were $90,668, $ 5,900, and $1,988, respectively. These values were considered to be huge for a country with a population of only about 4.5 million.

Country	lost productive capacity (million)	Direct Costs (million)	Lost quality of life (million)	Total costs
Australia	2.79	0.05	-	2.84
Canada	-	-		1.98
Denmark	1.68	0.04	344	5.16
France	1.78	0.02	0.13	1.93
Germany	5.5	0.01		5.51
G.B	0.55	0.01	7.28	7.84
Japan	3.97	0.27	-	4.24
Netherlands	0.87	-	-	0.87
New Zealand	-	0.05	6.28	6.33
Norway	2.68	0.07	-	2.75
Spain	0.93	0	0.48	1.41
Sweden	1	0.05	10.55	11.6
Switzerland	6.82	0.04	11.05	17.8
United States	3.82	0.94	12.8	17.56

Table 2.19 Official Economic Valuation of Traffic Fatalities in 20 Motorized Countries in 1991

	Thailand 1963 1964	S.Africa 1963	Ghana 1970	Turkey 1971	G.B 1970
Estimated total cost of accidents G.D.P.	6.3	40	2.8	29.8	300
Total accident cost as	170	3800	810	2780	45000
% of G.D.P	0.4	1.0	0.3	1.1	0.7

Table 2.20 Total Estimated Accident Costs as a Percentage of GDP, G.B Pound

2.21 Public Education and Information

This section deals with the effects of four measures in the field of road safety education and information. The four measures are:

1-Education of pre-school children (0-6 years)

2- Education in school (6-18 years old)

3- Road user information and campaigns.

A comprehensive literature survey (OECD 1983) concludes that the majority of studies of effects of the road safety education for pre-school children are inadequate. Only a few studies have attempted to measure the effect of education on the number of accidents.

2.21.1 Education of Pre-school Children (0-6 years)

A study of the effects of pre-school education carried out in Norway (Schioldborg 1974) found that children who were members of Barnas Trafikklubb had, on average, a 30% lower risk of traffic accidents (per 10,000 children per year) than children who were not members. In the cities of Los Angeles (California), Columbus (Ohio) and Milwaukee (Wiscosin) in the United States, an information film about the correct way to cross a road was shown on children's television at the same time as information material was distributed to pre-schools children and in school (Blomberg, Preusser, Hale and Leaf 1983). A before and after study found that these measures reduced dart-out accidents among schoolchildren aged between 5 and 9 by around 10% (-15%, -7%).

21.2.2 Education in School (6-18 years old)

A number of studies have evaluated the effects of road safety education for children on the number of accidents involving children as active road users. Broadly speaking, a distinction can be made between training in the right way to cross a road, and cycling proficiency training. Training children in the right way to cross a road appears to lead to fewer accidents when crossing roads, particularly amongst children aged between 9 and 12. Various studies evaluated the effects on accidents of these measures (Sergeant and Sheppard 1974; Dowing and Spendlove 1981; Forenberry and Brown 1982).

21.2.3 Road User Information and Campaigns

It is not clear how important lack of information is as a risk factor. Some types of behaviour strongly increase the risk of accident and injury. These include exceeding the speed limit (Munden 1967, Wasielewski 1984), the use of alcohol (Gad 1985), ignoring red lights (Sakshaug and Sten1979) and non-use of seat belts (Evans 1987). Police enforcement and sanctions cannot always prevent such behaviour. It is therefore necessary to supplement enforcement and sanctions with information given to road users.

Road user information and campaigns are intended to reduce accidents by promoting safer behaviour in traffic, by giving road users improved knowledge and more favourable attitudes towards such behaviour. Another objective is increased understanding of restrictive measures which are introduced to increase safety, such as speed limits. The campaign for increased use of safety belts in rear seats in Victoria, Australia (Lane, Milne and Wood 1983) led to wearing rates increasing from 39.5% to 73.5%. The number of injured rear seat passengers then went down by around 20%. A campaign against drink-driving targeted at young drivers in Northern Jutland in Denmark (Studsholt 1990) produced interesting results. The number of accidents involving drunk drivers in the target age group went down by 50%. A campaign in Darmstadt, Germany (Christie 1990) to maintain the 30 km per hour speed limit found that mean speed was reduced from 39.1 to 34.8 km per hour, and the proportion who drove at speed of 30km per hour or less increased from 13% to 32%.

2.22 Conclusions

The literature review highlights that most developing countries suffering from road accidents and their injuries. The main causes of this increase were speeding, careless driving, luck of public education, and shortage of government spending on the road safety scoters and also, standard of immediate care available for victims at the scene of an accident.

Road accidents in developing countries have seen a remarkable redaction in the total number of fatalities associated with traffic accidents. This achievement were take place on many safety aspect improvements, such as safer vehicle design, better engineering of road infrastructure, tough enforcement of speed limits and seatbelt legalisations, and finally, better road used education.

However, since seatbelt legalisation introduced in developed countries, it provide a means of substantially reducing the deaths and injuries resulting from crashes be reducing the injuries resulting from crashes by reducing the frequency and severity of the second collision.

Various studies have shown that the majority of collisions are frontal with a tendency towards the offside front of the vehicle. Although less in number side impacts also represent a threat with the added problem that the door often remains supported by the striking object during the impact phase. Such impacts produce a high proportion of trunk, and pelvic injuries to front seat occupants. There are also a high proportion of head injuries.

Proof of seat belt efficacy in injury reduction is overwhelming. Conversely, unbelted occupants show markedly more severe and fatal injury patterns, including those due to ejection from the car following serious impact. Whoever, despite the use of restrains, car occupants are still being killed and seriously injured in impacts.

Restrained drivers in frontal impacts sustained mainly head/face and limb injuries. The steering wheel assembly is responsible for a number of head, face and number of trunk injuries. Drivers and front seat passengers sustain limb injuries in frontal impacts, particularly to the legs. The majority of chest injuries are relatively minor and tend to be seatbelt-relate. The unbelted rear seat passenger sustained head and leg injuries, usually from striking the front seat structure. Unrestrained rear occupants are also likely to load the occupants of the front subject to an increased load.

Gnarly speaking, most pedestrian impacts are with the front structures of the cars, with the legs being struck first. Depending upon the stiffness of the bumper area, the height of the pedestrian with respect to the bonnet distance from the ground. Nonetheless, all studies have shown that children have a high involvement rate as pedestrian casualties. Although the elderly have a lower rate than children, more elderly pedestrians are killed. All studies show that the lower legs and heads are the most common body regions to be injured and those to the head will be life threatening in a number of cases.

In view of the above discussion, it has been noted that very little work has been carried out on traffic accidents in Libya. Since the late 1970s and mild 1980s; (Makky 1984; Shembesh 1978) no work has been done. According the literature review, 55% of accident deaths in Libya were pedestrian, the severity and causes of pedestrian injuries require extensive study to identify the main causes. However, the literature review has summarized a broad range of studies carried out in developing countries and industrialised countries. Although varying methodologies, data sources, reporting requirements, and traffic environments apply, and the culture difference this review provides some understanding of the problem of traffic accidents in developing countries such as Libya. According to the most recent studies the developing countries, with special reference to Libya; require extensive study in order to identify the patterns and major causes of traffic injuries and how to prevent them, the economic costs of traffic accidents, seatbelt effectiveness. The next chapters will address these issues in details, starting with overview on the road accidents in Libya in general, than is followed chapter four which depth study about the injury patterns and direction of crashes.

CHAPTER THREE

OVERVIEW OF LIBYAN ROAD ACCIDENTS

3.1 Introduction

In accident analysis, two types of population are of prime importance, namely, the vehicle and human populations. Many countries in the world have experienced the explosive growth of one or both of these populations (Zahavi 1976). The first type has occurred in most Western industrialised countries. The second type has occurred in most of the (industrially) developing countries for decades, hindering their growth. Both explosions, however, are happening simultaneously in the oil-rich developing countries as such Libya, Kuwait, Qatar and Bahrain. Accordingly, travel and traffic characteristics as well as accident experiences in these countries might be radically different from other developing countries

In this chapter, overviews of patterns of road accidents and casualties in Libya, the growth of vehicle ownership, and rates of accidents per population and per vehicle were studied from 1966 to 2000. A linear regression model was used to find any correlation between numbers of licensed vehicles and number of accidents and fatalities, and relationships between the population and numbers of accidents and fatalities.

3.2 Official Definitions of Types of Accidents

Injury accidents: accidents in which one or more persons are injured, but no injury resulted in death within one month of the accident, Road Accidents and Casualties in Libya (2000).

Minor injury accidents: an injury of a minor character such as a sprain or bruise.

Serious injury accidents: an injury for which the person is detained in hospital as an in –patient; or any of the following injuries whether or not the patient is detained in hospital: fractures, concussion, internal injuries, severe cuts, severe general shock requiring medical treatment.

Fatal accidents: accidents in which one or more persons are killed within one month of the accident. This includes those who die as a result of injuries sustained in the accident within 30 days of the accident.

3.3 Vehicles and Population

In order to gain some understanding of the background of road safety problems in Libya, it is useful to examine the growth of vehicle ownership in Libya and its population in recent years. The statistics available are presented in figure 3.1 which shows the growth of motor vehicles and the population. The oldest available records for motorised road vehicles date back to 1966, and the total number of vehicles registered in that year amounted to 78,204 vehicles 46 vehicles per 1, 000 inhabitants. By 1976 Libya had already attained a comparatively high level of car and other vehicle ownership. The number of vehicles increased at a dramatic rate of 14% per year. This means that the number of vehicles was doubling every 5 years. This is more than the rate in Great Britain in the early fifties (Tanner 1979) when the motorisation level (per household) was similar to that in Libya in 1966.

The massive increase in the vehicle population (12-fold) over the period 1966 to 1981 gave rise to an increase in the number of vehicles per 1,000 households from 46 in 1966 to 219 in 1980, and 272 in 1993. However, since 1980 reliable data on the vehicle population has not been available, as the compilation of vehicle population statistics was stopped. Data on the total vehicle population at the statistics office are available only until 1980 and for the year 1993. For 1981 onwards, only the number of vehicles that were registered on the new registration system for each year was available. However, the numbers of vehicles in 1980 and 1993 were used as indicators to estimate the vehicle population in Libya between 1980 to 1993.

During the 1970s and 1980s the Libya population has increased massively. The high rate of population growth was due to a high natural rate of increase and the large inflow of immigrants, as well as greatly improved medical care. The population of Libya increased at an annual average growth rate of 3.4% per year until 2000 (Libyan National Database 2000).

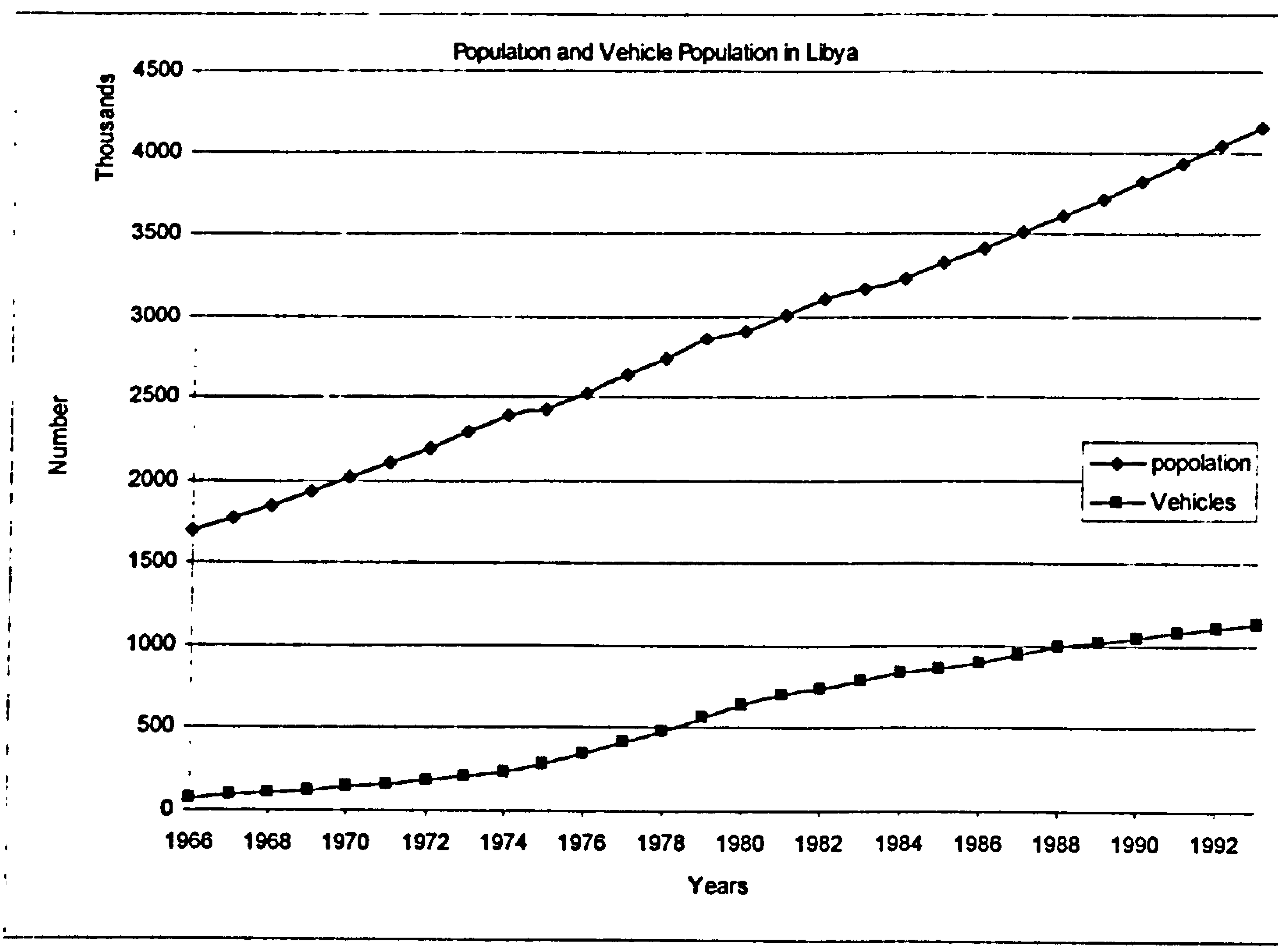


Figure 3.1 The Growth of the Population and Vehicle Numbers in Libya

3.4 Road Accidents

The discovery of oil in the early 1960s and its subsequent rapid exploitation have clearly had a dramatic impact on the Libyan national economy. This impact was perhaps expressed most convincingly in terms of per capita annual income, which increased more than fifteen times in 1977 (Libyan Human Development Report, 2000). This increase in the national wealth is reflected in the increase in the number of registered motor vehicles in this period. This rising trend was accompanied by increasing trends in the numbers of road traffic accidents and casualties (figure 3.2). In 1966, 8,400 accidents were reported and 306 persons were killed. Since then, the number of accidents has increased, to reach the highest figure in 1978 of 17,863 reported accidents - an increase of 9,463 accidents during 12 years, or an average increase of 789 accidents per annum. The number of fatalities in traffic accidents during these 12 years (1966-1978) also sharply increased. A total of 1,210 persons were killed in 1987, an average increase of about 75.3 per annum.

The pattern of traffic injuries during the same period was unsteady, but with an upward trend. In 1966, the number of injuries was 4,071, compared to 13,871 in 1978 - an increase of 9,800 injuries during the 12 years; approximately a 71% increase, or about 817 more injuries per annum.

The statistics show that the number of fatal accidents between 1966 and 1978 sharply increased, reaching 1,453 at the end of 1982 compared to the lowest record of 370 fatal accidents in 1966 an average increase within 12 years of 1,083 fatal accidents, at an average of 90.3 per annum.

The overall casualty rates expressed as casualties per 100,000 population rose by 53 per cent during the 12 years 1966 to 1978. Since then, the number of road accidents and fatalities has dropped sharply to reach the lowest level in 1987 of 6,698 accidents and 963 victims killed. In 1987 the lowest ever number of accidents and casualties since 1966 were reported in Libya and the statistics show that during the ten years

1978-1987 the total number of fatal injuries dropped to 247 persons, an average of 25 persons per annum. The number of injuries in traffic accidents decreased in the same period to 7,956 injuries an average of 795.6 per annum.

Between 1987 and 1993 the number of accidents gradually increased to reach 9,009 accidents (80 accidents per 10,000 vehicles) in 1993, of which 1,207 were fatal (10.7 fatal accidents per 10,000 vehicles). The number of reported fatalities increased to 1925 victims in 1989 (52 deaths per 100,000 inhabitants) which was the highest ever recorded rate of deaths in road traffic accidents in Libya since 1966 an average increase of 477 during ten years or an average increase of 47.7% per annum. Since 1993 the number of accidents and injuries fluctuated, and in 2000 10,667 accidents, 9,619 injuries, and 1,504 fatalities were recorded.

Table (3.1) shows that almost three per cent of all casualties in built up areas were fatal injuries, whilst the equivalent value in rural areas and on motorways was over 10 per cent. This greater level of accident severity in rural areas has been found in many countries, including Great Britain, and is probably due to the fact that accidents occur at higher speeds in rural areas, where medical treatment is less readily available.

Casualty	Built up areas		Non built up areas		Motorways	
	Number	Rate (%)	Number	Rate (%)	Number	Rate (%)
Killed	486	2.8	1282	7.4	589	3.4
Serious Injured	2271	13.2	3142	18.2	1180	6.8
Slight Injured	2896	16.8	3913	22.7	1505	8.7
All Casualty	5653	32.8	8337	48.3	3274	18.9

Table 3.1 Injuries by Severity in Urban and Rural Areas, Libya (1995-1996)

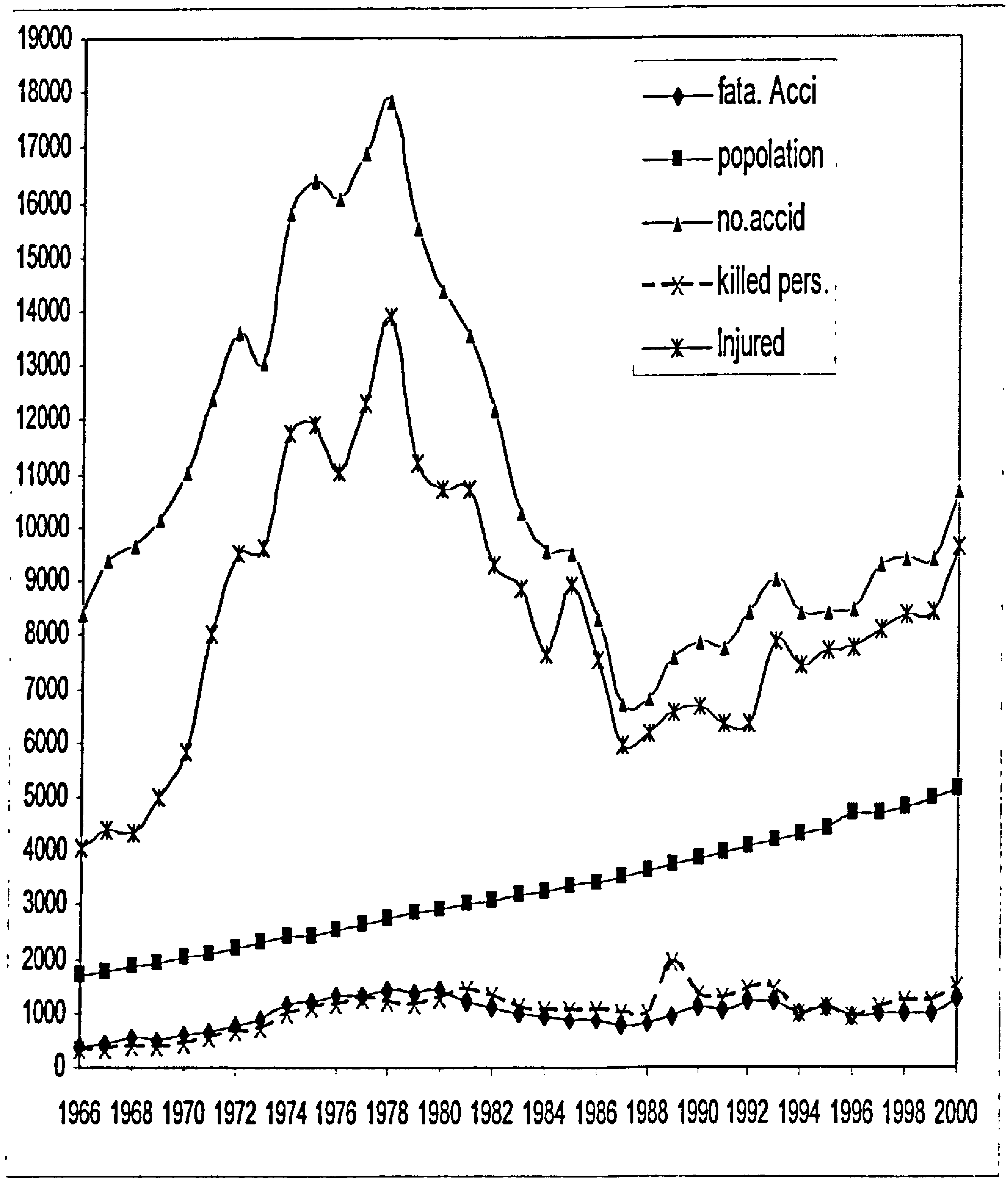


Figure 3.2 Trends in Population, Road Accidents and Casualties in Libya (1966-2000)

3.5 Discussion

In Libya, 90% of the population lives in 10% of the geographical area (a100 km in wide adjacent to the Mediterranean Sea). Half of the population lives around the two poles of Tripoli (20.3 % of the Libyan population), and Benghazi (11% of the Libyan population) which are about 1,000 km apart. The two centres are to some extent economically independent of each other, which has resulted in a relatively small number of trips between them; there is good evidence to believe that the number of vehicle journeys made on urban roads in Libya is much higher than on other roads, (Makky 1984).

The problem of road traffic accidents is becoming an internationally recognised concern. Road traffic accidents are becoming increasingly common in Libya. They are a major cause of morbidity and mortality at a rate of 3.4 victims per day according to the Road Accidents in Libya report (2000), and road deaths account for 11 per cent of all Libyan deaths. Jacobs (1973) indicated that accident rates (per licensed vehicle) in developing countries are higher in comparison with those of Western Europe and North America.

Between 1966 and 1978 the number of licenced vehicles increased at an average rate of 8.3% per year. This rising trend was accompanied by increasing trends in the numbers of RTA deaths and injuries. Linear regression revealed the following respective trend components: ($P<0.001$; $R^2=0.89$) for RTA fatalities, and ($P<0.001$; $R^2=0.82$) for RTA injuries. According to statistical analysis, the increase in road accidents was mostly from a progressive increase in the number of registered vehicles in Libya. This is in agreement with the work of Smeed (1964), who found that with the increase of motorization, accidents involving a collision between vehicles tend to increase faster than accidents involving pedestrians. Another contributing factor to the increase in road accidents in Libya is an increased number of expatriates from different countries with different habits and cultures who are unfamiliar with local driving conditions and requirements. The trend analysis on the basis of resident population and number of fatalities ($p<0.001$; $R^2=0.942$) for fatalities ($p<0.001$; $R^2=0.95$), the regression model showed that the relationship between number of population and number of fatalities was a linear relation shape. El-Sadig (2002) found that non-UAE citizens accounted for an average of 65.4% of total RTA deaths in that country. Other factors, however, have boosted the demand for private transport, for example the relatively inefficient public transport system, the high rates of increase in school enrolment, and improvements in the economy.

In the period 1978-1987, accident rates witnessed a rapid decline, to reach 11 accidents per 1000 vehicles, and 27 deaths per 100,000 population. This reflected the effect of safety improvements in road design in Libya, where the length of paved roads, for instance, increased between 1970 and 1980 from 3,200 to 10,700 km (Makky 1984). Livneh (1972) noted that highway improvements may reduce the rate of road traffic accidents. Another factor that might have contributed to the decrease in the number of accidents in Libya was the efforts of the Libyan government to displace illegal immigrants.

At the end of the 1980s, there existed in Libya due to the sluggish economy a large second hand market for all types of vehicles, and this in turn led to a large number of older vehicles on the roads. For such vehicles correct maintenance is of the utmost importance. The state of the economy enables only a certain proportion of the population to afford such facilities, and consequently many owners of vehicles tend to make use of more economical service alternatives, or in order to maintain their vehicles they often fit less expensive mechanical parts of poorer quality. As a result of this, road fatalities in 1989 reached the greatest ever number since 1966 - 1,925 victims, representing 52.3 deaths per 100,000 populations, and almost 26 times the GB rate in the same year. This agrees with Schoor's (2001) finding that a large percentage of accidents investigated resulted from mechanical failure

Libyan government efforts to improve traffic safety have been hampered because long-term public campaigns have not been adopted when introducing new traffic regulations. The authorities have not adopted quantitative targets for the reduction of road fatalities and injuries within a defined future period.

The Libyan Mission to the UN in September 1996 reported that, owing to the aerial embargo and the consequent increase in overland traffic, there had been a rise in the number of road accidents since Libyans had to take to the roads linking the major cities in the country.

3.6 Conclusion

The above findings strongly suggest that motor vehicle accidents are probably the commonest single cause of death in Libya. Whereas in other highly motorised countries the problem has been adequately controlled to show a declining trend of death tolls, in Libya the situation has still not met with sufficient concern.

There is ample scope for improvement in traffic safety in Libya. Investing a very small percentage of G.D.P. could result in significant traffic safety improvements if spent according to an efficient and comprehensive traffic safety programme. Such a programme should put the emphasis on improving road user behaviour by education and propaganda campaigns, as well as enforcement - especially using electronic means.

It is necessary to improve, standardise and modernise accident data collection and storage, and there is an urgent need for analysis to relate accident data to identified risk factors that cause RTA injuries. The Libyan government should improve general public transportation, and encourage the general public to use it. However, a restriction on the importation of motor vehicles is an issue worthy of consideration to reduce the volume of traffic and the car population ratio in Libya. With regard to the number of older vehicles on Libyan roads, it might be prudent to require periodic motor vehicle inspections.

CHAPTER FOUR

VEHICLE OCCUPANT INJURIES

4.1 Introduction

This chapter examines some of the injury patterns which occur among Libyan road users in vehicles currently in use, in order to demonstrate the types, incidence and severities of injuries for the different seating positions and vehicle impact directions, and also to indicate some of the leading causes of the more severe injuries sustained, and the relationship between seat belts and injury. The final section estimates the costs of fatal road accidents on Libyan roads.

The chi-square test is a measure of divergence of observed and expected frequencies. It is used in goodness-of-fit tests to determine if a sample of data are from a population with a specified distribution. Tests of independence determine the association between the rows and columns of a two-way table. This test is used in this chapter to test the association between each two sets of data and to predict how many subjects in each group fall into different categories (see appendix B.1).

4.2 Occupancy Rate

There were 770 occupants involved in a total of 332 crashes in the sample. Of these, 498 occupants were involved in frontal collisions, 106 occupants in strike side collisions, 85 occupants in offside collisions and 81 in rear collisions. The sample comprises 440 drivers whose seating position is designated as front left, and the front right seating position was mostly occupied by a front seat passenger. The characteristics of injuries received by the occupants involved in these accidents are also presented and analysed in this chapter.

4.3 Impact Characteristics

Of the 332 accidents investigated 196 (59%) were in urban areas, 107 (32%) were motorway accidents, and 9% occurred on other roads (agriculture roads, unclassified roads) Table 4.1 shows the relative frequency with which various parts of cars were struck. Frontal impacts accounted for approximately three quarters of all impacts, side impacts accounted for just 25.4 per cent and rear impacts 10.3 per cent.

Location of impact (CDC)	Urban /%	Motorway/%	Other/%	Total	Percentage %
Frontal (11, 12, and 1 o'clock)	122/57	72/34	20/9	214	64.5
Right side (2, 3, and 4 o'clock)	30/71	7/2	5/1	42	12.7
Lift side (8, 9, and 10 o'clock)	26/62	13/31	3/7	42	12.7
Rear (5, 6, and 7 o'clock)	18/53	15/44	1/1	34	10.3
Total	196	107	24	332	100
%	59	32	9	100	

Table 4.1 Accident Distribution According to Impact and Location

4.4 Vehicle Speed

It is well known that vehicle speed has a significant effect on accident rates and the severity of injuries received in the UK (Munden 1967; Brenac 1990). This is also true of Libya (M.O.I 2000; Shembesh 1978). The data shown in table 4.2 relates the estimated mean pre-impact speed to the location of the accident on a motorway or in an urban setting. The mean pre-impact speed was calculated from information given by the vehicle driver, passengers, and the officer who reported the accident, and the mathematical mean of these estimates was taken as the pre-impact speed for each accident.

Estimated Mean Pre-impact Speed, Km/hr	Urban Location Number in range/% of sample	Motorway Number in range/%
30-50	65/20	8/2
51-60	47/15	16/5
61-70	19/6	10/3
71-80	22/7	10/3
81-90	10/3	10/3
91-100	20/6	40/12
101-110	32/10	66/20
111-120	12/4	42/12
121-130	22/7	35/10
>130	20/8	45/13
Not Known	56/15	57/17
Total	325/100	339/100

Table 4.2 Mean Pre-impact Speed

The posted speed limit on motorways in Libya is 110 km/hr with 50 km/hr being the limit on urban roads. It can be seen in table 4.2 that over 73% of urban collisions occurred at a mean vehicle speed that exceeded the posted speed limit. Speeding in excess of the 110 km/hr limit was a factor in 54% of the accidents examined that occurred on the motorways and in urban areas. The chi-square test shows that there is a significant association between the vehicle accident speed in motorways and urban areas (*x^2 =139.693; df=10; p<0.05).*

4.5 Age as Factor in Car Occupant Casualties

Road accidents statistics from Libya (1996) show that certain age groups appear to be over-represented. These include the 9-15 year group, whose accident vulnerability is well documented, and where accident prevention becomes a major concern.
Infants and children cannot be considered as small adults as they differ anatomically from the latter in a number of ways. Some differences are obvious, such as size, shape, weight and mobility. Others, such as segment proportions, centre of gravity, limb strength, skeletal elasticity and vulnerability, all change during the child's natural development, and are not so obvious except to a paediatrician.

4.5.1 Age and Sex of Occupants

Table 4.3 displays data that categorizes the 440 drivers featuring in the sample in terms of age and sex. The ratio of male to female drivers was found to be 11: 1. Nearly 91% of drivers were male *(x^2=12.047; df =4, p< 0.05).* This figure gave indicates that females in Libya have less accident involvement that males. Also, this result is much higher than that found in similar European studies; for example, James (2002) found that only 67% of drivers were male. The drivers in the age range 15-30 years accounted for 46.7% of the sample. The proportion of male drivers was slightly lower in this age group.

The ratio of male to female passengers was found to be 1.9:1. Table 4.5 shows that 65% of passengers were male and 35% were female *(x^2= 10.484; df = 4; p<0.05).* Again these figures are higher than would be found in a European based study, as shown by James (2002) who reported that 60% of passengers were male and 40%

were female. The proportion of female passengers was higher in the age range 15-45 years. It can be seen that the majority of vehicle occupants featuring in this study were young males below the age of 30 years, who accounted for 66% of the sample.

Age range Years	Male Number/%	Female No/%	Total/%
0-14	5/1	3/8.3	8/1.8
15-30	185/45.9	21/55.6	206/46.7
31-45	130/32.3	7/19.4	137/31.2
46-59	56/13.9	6/16.7	62/14.1
≥60	27/6.7	-	27/6.2
Total	403/100	37/100	440 /100

Table 4.3 Age and Sex of Drivers in this Study

Age range (years)	Male Number/%	Female No/%	Total No/%
0-14	33/15.6	12/10.4	45/13.9
15-30	119/55.3	53/46.1	172/52.1
31-45	51/23.5	42/36.5	93/28
46-59	5/2.2	8/7	13/3.9
>60	7/3.2	-	7/2.1
Total	215/100	115/100	330/100

Table 4.4 Age and Sex of Passengers

4.5.2 Relationship between Age and Injury

An analysis of the distribution of MAIS 2-6 (Maximum Abbreviated Injury Scale) injuries according to age for the whole sample and for severe injury cases is shown in table 4.5. The greatest number of injuries occurred in the 15-30 age group, with a very similar result applying to the 31-46 years age group. However there were significant differences in injury severity between children in the age group 0-14 and adults in the 15-59 age group *(x^2=10.123; df = 4, p<0.05)* of MAIS 2-6 and no effect of age on injury severity between children and older adults, *(x^2 = 4.143; df= 4, p>0.05)*, as well as no relationship between age and injuries sustained for adults and older adults *(x^2 =4.346; df = 4, p>0.005)*.

	Age group				
MAIS	0-14/%	15-30/%	31-45/%	46-59/%	>60/%
2	13/25	165/45	102/44	33/44	13/38
3	12/23	115/30	42/18	10/13	8/24
4	7/13	26/7	21/9	14/19	1/3
5	9/17	35/9	23/10	6/8	4/12
6	12/23	37/10	43/18	12/16	8/24
Total	53	378	230	75	34

Table 4.5 MAIS (2-6) for all Ages

4.5.3 Children's Injuries

The data collected contained details of head, face, and limb injuries sustained by 53 children in the age range 0-14 years. The location of injuries received by these children was analysed, and the results displayed in Table 4.6. It can be seen that head injuries were the most frequent kind of injuries at the AIS 2-6 injury level. 36% of the sample received head injuries and these proved to be the main cause of fatalities ($p<0.005$). This mirrors the findings of Anderson (1978), who showed head injuries to be the main cause of death in children in car accidents. The data recorded indicated that none of the children injured were using seat belts, and therefore the high incidence of head and face injuries is not surprising. These findings agree with those of Melvin (1978) and Sturtz (1977) who demonstrated the high vulnerability of unrestrained children to head and face injuries.

Body Region	N= 53 children AIS (2-6)	Percentage %
Head	19	36
Face	10	19
Limbs	16	30

Table 4.6 Children's Head, Face and limb Injuries, AIS 2-6

4.6 Seat Belt Usage

Drivers and front seat passengers in Libya are required to use seat belts when travelling in cars and vans on high speed roads only (Traffic Accident Libya, 1996). However, seat belts are an active safety system whose injury reducing capabilities have been well documented in numerous publications (Scot 1985; Sabey 1977). Passenger cars in Libya are fitted with the three point lap and shoulder type of seat belts. The vehicles in this study were all fitted with this type of seat belt.

The seat belt usage of the occupants in this study is shown in table 4.7. The category 'use' relates to occupants who claimed that they had used the seat belt. However this claim could not be supported due to the absence of other evidence such as seat belt markings.

Seat Belt Use status	Drivers No/%	FSPs No/%	RSPs No/%
Used	36 /8.2	15/7	0
Not used	404/91.8	199/93	116/100
Total	440/100	214/100	116
Usage rate (%)	8.2	7	0

Table 4.7 Seat Belt Use

Seat belts were found to have been used by only 8.2% of drivers and 7% of front seat passengers. These figures are very small compared to the 95% usage rate in the U.K. as reported in Road Accidents in Great Britain (HMSO 1995). The effectiveness of seat belts in different impact directions has been extensively studied for instance; (Ashton 1985; Campbell 1986; Evans 1987;1988; Roudsari 2004), and all results show that the effectiveness of any restraint system is a function of collision type. The greatest benefits are in frontal impacts and rollovers, and the least protection is offered in rear collisions and side impacts.

4.7 Time and Method of Transport of Patient to the Hospital

The basic philosophy of any type of emergency transportation is to get victims to the nearest hospital as quickly as possible without worsening the patient's condition. Past research has shown some evidence to suggest a link between ambulance response time, and subsequent likelihood of survival for victims involved in accidents such as road traffic accidents. Brown (1979) found a positive association between ambulance delay time and the ratio of serious to fatal injuries, suggesting that road traffic accident victims who had to wait the longest for ambulances to reach them were the most likely to die.

Method	Number	Percentage (%)
Ambulance	57	7
Private car	630	82
Police car	35	5
Not Known	48	6
Total	770	100%

Table 4.8 Method of Transfer to Hospital

There were 57 (7%) cases who were transferred to hospital by ambulance as demonstrated in table 4.8, and 630 (82%) of the victims were taken to hospital in passing private cars by unskilled personnel. Some highway cases (48; 6%) were transferred to the nearest health centre by police vehicles, and then by ambulance to the nearby hospital. None of the transferred casualties received any resuscitation treatment during the journey.

Ambulance services in Libya are managed separately by each hospital. Ambulances are used for transferring patients from remote medical centres to the central hospital in Tripoli or Benghazi city, and some lucky victims of road accidents are transferred from accident scenes to hospital by ambulance.

4.7.1 Time Spent in Transport

Table 4.9 shows the transport time of victims to the hospital by ambulance and private car. The average time of transport from an urban area to the nearest hospital by ambulance was 43 minutes, and the average journey taken from motorway to hospital was 30 minutes. In general, 23% of road traffic victims spent between 10 to 30 minutes making their journey to the hospital.

	Ambulance		Private Car			
Transport time	Motorway Number of victims	Urban Road Number of victims	Motorway Number of victims	Urban Road Number of victims	Total	%
10 min.	3	3	0	8	14	2
10-30	5	5	58	85	153	21
30-60	3	4	70	76	153	21
1-1.5 hrs	6	4	58	38	106	15
1.5-2	4	5	51	30	90	12.5
2-2.5	5	4	53	38	100	13.8
>2.5 hrs	1	4	56	45	106	14.7
Total	27	29	346	320	722	100
Not known					48	

Table 4.9 Transport Time to Hospital

4.8 General Injury Distribution

The distributions of serious injuries AIS (2-6) related to seating position, restraint use and impact direction are given in table 4.10. The data shows that head, face and limb injuries predominated. This will be explored in subsequent sections.

4.9 Injury Distribution

One of the main aims of introducing traffic safety measures is to reduce the injury severity of accidents. Therefore consideration of crash site, vehicle crashworthiness and occupant characteristics in terms of injury severity completes the understanding of vehicle accidents. Furthermore, such considerations provide a perspective for measuring and prioritising features which need to be targeted for remedial action.
The analysis of injury accidents is considered in terms of injury severity by AIS (Abbreviated Injury Scale).

4.10 Frontal Impact

Frontal impacts in automobile accidents can be placed into several categories.

1. Head-on collisions - vehicles going in opposite directions
2. Frontal impact into barriers - e.g. poles, trees, concrete dividers, etc. (These are not considered in this study).
3. Frontal impact into vehicles stopped or moving in the same direction - rear-ending the vehicle in front of you.
4. Front end collisions where a vehicle may be crossing your path and you strike the side of their vehicle.

Each of the above collisions acts with its own impact forces and velocities upon the occupants. In head-on collisions, the speed and weight of the vehicle play a role in the injuries of the occupants. Also, the distance that can be measured in the crash zone of the vehicle plays a role in injuries.

Body Region/Seat Position	Head/Neck	Face	Chest/Upper Back	Abdomen/ Lower Back	Pelvis /Limbs	Casualties per group
Frontal	Number of casualties					
Restrained DVRS	18	10	9	11	28	36
Unrestrained DVRS	137	57	67	14	149	258
Restrained FSPS	12	13	7	5	13	15
Unrestrained FSPS	67	44	21	12	60	120
Unrestrained RSPS	25	11	7	3	47	69
Nearside						
Restrained Drivers						
Unrestrained Drivers	16	5	10	2	16	53
Restrained FSPS						
Unrest. FSPS	14	8	2	6	20	41
Unrestrained RSPS						12
Offside						
Restrained. Drivers						
Unrestrained Drivers	21	12	8	7	35	49
Restrained FSPS						
Unrestrained FSPS	4	7	3	3	11	20
Unrestrained RSPS	4	2	2	2	8	16
Rear						
Unrestrained DR	11	5	8	1	16	44
Unbelted. FSPs	6	8	4	-	11	18
Unbelted. RSPs	4	7	1	-	11	19

Table 4.10 Distribution of AIS 2-6 Injuries to Casualties by Body Region

In barrier accidents, the result is often more severe than in head-on collisions. Impacts with objects like barriers, poles and trees can lead to higher rates of fatalities. This is because those objects do not give on impact, as does the front end of another car as described above. In frontal impact collisions with vehicles going in the same direction, the speed and size of the vehicle again determine the injuries that can occur. In the case of rear-end collisions the striking vehicle not only undergoes a collapse, but transfers momentum to the struck car by pushing it forward. In frontal collision with the side of another vehicle, the exact position in which that vehicle is struck will determine the injuries to the occupants and their severity

4.10.1 Frontal Impacts, Driver Injuries

From table 4.10 there were 36 restrained and 258 unrestrained drivers involved in frontal impacts who received injuries at AIS 2-6.

4.10.1.1 Head, Face and Neck Injuries

Head injury is the most common cause of death in motor vehicle crashes, and is the most frequently injured body region, even among occupants using three point restraint systems (Tonge 1972; Hassack 1972; Dalmotas 1980). However, many of the injuries sustained in this group are not mutually exclusive. Of the restrained drivers, 18 casualties (50%) sustained a skeleted or internal injury to the head and neck. 10 casualties (28%) received facial injuries, whereas, 137 (53%) of unbelted drivers received injuries to the head and neck. Conversely, 57 (22%) unbelted casualties sustained face injuries. The injury severity distribution is shown in table 4.11.

	Belted N=36		Unbelted N=258	
AIS	Head/Neck/%	Face/%	Head/Neck/%	Face/%
2	6/16.7	7/19.4	35/13.6	38/14.7
3	5/14	3/8.3	19/7.4	7/2.7
4	3/8.3		14/5.4	12/4.7
5	2/5.6		19/7.4	-
6	2/5.6		50/19.4	-
Total	18/50	10/28	137/53	57/22

Table 4.11 AIS 2-6 Head, Face and Neck Injury Severity Distribution

Many of the face and neck injuries were concomitant with head injury, as shown in table 4.12.

Restraint Use	Face + Head	Face + Neck	Head + Neck	Head, Face and Neck
Belted	6	2	3	3
Unbelted	20	8	8	9

Table 4.12 AIS (2-6), Head, Face and Neck Injuries

There were a number of head injuries caused by facial contact, which only resulted in AIS 1 or 2 surface injuries to the face. The former usually involved brief periods of unconsciousness and possibly other head injury involvement.

4.11 Front Seat passenger (FSPs), Frontal Impact; Head, Face and Neck Injuries

As with the drivers in frontal collisions, many of the injuries in this group were not mutually exclusive per casualties. From table 4.13, of the restrained FSPs, 14 (80%) sustained head and neck injuries of AIS (2-6) severity. The corresponding figure for the head/neck in the case of the unrestrained FSPs was 67 (55%). The number of belted FSPs casualties sustaining facial injuries was 13 (87%) whilst 44 (37%) of unbelted FSPs receive facial injuries. The analysis of (x^2) revealed that a using seat belt made significant difference between belted FSPs face injury and unbelted FSPs face injury *($x^2 = 7.750$; $df = 2$; $P < 0.05$).*

	Unbelted, N=120			Belted , N=15		
AIS	Head	Face	Neck	Head	Face	Neck
2	21/17.5	29/24	4/3.3	1/6.7	4/27	2/13.3
3	13/10.8	11/9.2	2/1.7	1/6.7	4/27	3/20
4	3/2.5	4/3.3	-	2/13.3	5/33.3	2/13.3
5	9/7.5	-	-	1/6.7	-	-
6	15/12.5	-	-	2/13.3	-	-
	61/51	44/36.7	6/5	7/46.7	13/87	7/47

Table 4.13 FSPs, AIS 2-6 Number of Head, Face and Neck Injury Distribution

As with drivers, a number of the facial and neck injuries were concomitant with head injuries, as shown in table 4.14. However the numbers of belted FSPs in the sample were very small to analysis. Nonetheless the table gives overview of the injury pattern for FSPs.

Body Region	Head only	Face only	Neck only	Face and Head	Head and Neck	Head, Face and Neck
Belted FSPs	1	8	2	-	2	2
Unbelted FSPs	30	25	2	36	2	1

Table 4.14 AIS 2-6 Head, Face and Neck Injuries

4.12 Head/Neck and Face Injuries, Rear Seat Passengers (RSPs)

All rear seat occupants (RSPs) in this study were unrestrained. However, the lack of restraint not only increases the rear seat passenger's own injury probability in an accident, including ejection, but was also likely to load any front seat occupant in the more-common frontal impact (Cuerden 1997).

In this study, in the unrestrained sub-set 25 (36%) RSPs received head/neck injuries, and only 11 victims sustained face injuries of AIS 2-6. Table 4.15 gives the AIS distribution of the 36 separate injuries.

Ns=69 injured	AIS (2-6)					Total
	2	3	4	5	6	
Head	3	6	1	1	9	20 (29%)
Face	5	4	2	-	-	11 (16%)
Neck	2	3	-	-	-	5 (7%)
Total	8	13	3	1	9	36

Table 4.15 AIS 2-6 Distribution of Head/Neck and Face Injuries

The table shows a high proportion in the AIS 3 category. There was also a significant number of severe head injuries as indicated by the higher scores. As with other occupant casualties, a head injury was sometimes concomitant with a face and/or neck injury - see table 4.16.

Body region	Head only	Face only	Neck only	Face and Head	Head and Neck	Head, Face and Neck
Number	11	6	2	3	2	1

Table 4.16 AIS 2-6 Head, Face and Neck Injuries

4.13 Chest/Upper back injuries; Drivers

Of the restrained drivers, 9 (25%) sustained chest or upper back injuries. 67 (26%) of the unrestrained drivers sustained chest/upper back injuries. The AIS 2-6 distribution is given in table 4.17

AIS	2	3	4	5	6	Total
Restrained N=36	5	2	1	1	-	9 (25%)
Unrestrained N=258	27	17	13	4	6	67 (26%)

Table 4.17 AIS 2-6 Distribution of Chest/Upper Back injuries

4.13.1 FSPs, Chest or Upper Back Injuries

According to this study 47% of belted FSPs received chest or upper back injuries, two of whom received upper back injuries. Conversely, 21(18%) of unbelted FSPs sustained chest or upper back injuries. The AIS distribution for this group is shown in table 4.18.

AIS/ Restraint use	2	3	4	5	6	Total
Restrained N= 15	1	2	2	1	1	7 (47%)
Unrestrained N= 120	9	3	2	1	6	21 (18%)

Table 4.18 Injury Distribution, Chest/Upper Back Injuries

4.13.2 Chest/Upper Back Injuries to RSPs

There were 7(10%) unrestrained RSPs who sustained chest or upper back injuries. This number is too small for statistical analysis.

4.14 Abdomen/Lower Back Injuries to Drivers

There were 11(31%) belted drivers who received abdomen or lower back injuries, whereas 14(5%) unbelted drivers sustained abdomen/lower back injuries. The injury severity distribution is given in Table 4.19.

AIS	2	3	4	5	6	Total
Restrained	3	3	5	-	-	11 (31%)
Unrestrained	6	1	1	5	1	14 (5%)

Table 4.19 AIS (2-6) Distribution, Abdomen and Lower Back injuries

4.14.1 Abdomen /Lower back Injuries, FSPs

Twelve unrestrained FSPs (5%) sustained abdomen or lower back injuries. Only five of 15 restrained FSPs sustained lower back abdomen injuries. The injury distribution is shown in table 4.20.

AIS/	2	3	4	5	6	Total
Restrained	2	1	2	-	-	5 (33%)
Unrestrained	3	2	-	1	6	12 (1%)

Table 4.20 AIS (2-6) Distribution, Abdomen and Lower Back injuries for FSPS

The numbers of unrestrained RSPs who sustained abdomen/upper back injuries in frontal impacts were too small for analysis.

4.15 Limb and Pelvic Injuries

Motor vehicle crashes are a major cause of limb injuries. These injuries are costly, frequently resulting in lifetime impairments, and are preventable. The number of those recorded disabled from road accidents in Libya in 1996 was 255 victims (Road

Accident Statistics in Libya, 1996). Although current information in the biomechanics of these injuries is still insufficient, it is known that they occur most often in frontal and offset frontal collisions.

4.15.1 Limb and Pelvic Injuries, in Drivers

There were 28 restrained drivers in frontal impacts who sustained limb and pelvic injuries (78%) of AIS (2-6). For unrestrained drivers, there were 149 casualties (58%) with limb/pelvic injuries, whilst 149 (58%) unrestrained drivers sustained limb/pelvis injuries. However in practice these injuries were often to different limb regions throughout the sub-set, sometimes in more than one individual limb. They were frequently concomitant with serious injuries to other regions in the same casualty, and the distribution is given in table 4.21.

Restrain use	Pelvis	Arm	Leg
Restrained			
Left side	5 (14%)	3 (8%)	7 (19%)
Right side		8 (22%)	5 (14%)
Unrestrained			
Left side	20 (8%)	16 (6%)	32 (12%)
Right side		37 (14%)	44 (17%)

Table 4.21 Restrained Drivers in Frontal Impacts, Number of Individual Limb Injuries

This shows that right limb injuries predominate by a considerable amount. If the lower limb regions are combined, the data shows them to have received the highest number of injuries. This finding is in agreement with findings from other studies (Harms, 1991; Thomas, 1995).

4.15.2 Pelvis/Limbs FSPs

Of restrained FSPs, 13 (87%) received limb or pelvis injuries of AIS (2-6). Of the unrestrained FSP casualties, 60 (50%) had limb injuries.

There were 19 individual pelvis injuries. The injury distribution for both groups is given in Table 4.22 and further distribution by limb injuries in Table 4.23.

Restraint Used	AIS 2	AIS3	Total
Unbelted	37	23	60 (50%)
Belted	3	10	13 (87%)

Table 4.22 Limb and Pelvic AIS 2-3 Injury Distribution FSPs

Body Region	Left Arms	Right Arms	Left Legs	Right Legs	Pelvic
Unbelted	12	18	10	12	8
Belted	2	1	2	4	4

Table 4.23 Distribution of AIS 2-3 Limb Injuries, FSPs

There was a difference in the injury distribution between the left and right sides of the body, with more injuries to right side limbs. Due to the small numbers amongst belted FSPs, only those results for the unbelted subset will be presented.

4.15.3 Limb included Pelvic Injuries for RSPs

47 (68%) of unrestrained RSPs sustained limb injuries. Of these 11 casualties received pelvic injuries of AIS 2-3. The injury distribution of AIS 2-3 is shown in table 4.24, and injuries by limb region detailed in table 4.25. It can be seen that rear seat occupants were injured much less frequently than front seat occupants, and that this reduction in injury also occurred in the fatal and severe categories. The most common type of severe injury sustained was to the limbs. These results confirm early research by Grattan (1974) that rear seats are safer than front seats.

Restraint Used	AIS 2	AIS 3	Total
Unbelted	21	26	47 (68%)
Belted	-	-	-

Table 4.24 Distribution of AIS 2-3 Limb Injuries, RSPs

Body Region	Left Arms	Right Arms	Left Legs	Right Legs	Pelvic	Total
Unbelted	7	13	7	9	11	47

($P<0.05$)

Table 4.25 Distribution of AIS 2-6 Limb Injuries RSPs

4.16 Side Impacts

Although the highest proportion of accident impacts are to the vehicle front (OHE 1982, 1990; Rouhana 1987; Danner 1987; Ropohl 1988), there is concern amongst accident researchers regarding the vulnerability of occupants in side impacts. This is due to the close proximity of the vehicle side compared to the relative protection offered by the vehicle front structure in frontal impacts. The passenger compartment is involved in most side impacts and injuries are explored by considering the vehicle side struck relative to seating position (Harms 1991; Lenard and Welsh 2001). For the purposes of definition, a driver in an offside impact and a front seat passenger in a nearside impact are considered as having been on the struck side with the converse for the non-struck side. Using this principle, data on drivers and FSPs will be combined as front seat occupants (FSOs) in struck-side impacts. This method was also applied by Harms (1991) and Lenard (2001).

4.16.1 Front Seat Occupants (FSPs) in Struck-side Impacts

As explained above, restrained front seat occupants involved in struck-side impacts have been combined, including drivers involved in an offside impact and front passengers involved in nearside impacts. There were 90 casualties who were unrestrained struck side FSPs (41 FSOs, 49 drivers).

4.16.2 Head, Face and Neck Injuries

Most of the injuries in this sub-set were to the head itself but some were concomitant with other cranium injuries, principally to the face.

There were 23 (26%) injuries to the head, and 20 (22%) received face injuries. The AIS 2-6 of head and face injuries are shown in table 4.26. It is clear that the head sustained a high incidence of injuries of AIS (5-6) severity in struck-side impacts.

	AIS (2-6) N= 90					
Body Region	2	3	4	5	6	Total/%
Head	5	5	3	3	7	23/26
Face	13	3	4	-	-	20/22

Table 4.26 Unrestrained FSPs in Struck-side Impacts with AIS 2-6, Head, Face Injuries

4.16.3 Abdomen/Lower Back

In this subset, there were 13 unbelted FSPs in struck-side impacts who sustained abdomen or lower back injuries. The severity distribution is detailed in table 4. 27.

AIS	2	3	4	5	6	Total/ %
Number	4	1	4	3	1	13/14

Table 4.27 Unrestrained FSPs in Struck-side Impacts with AIS 2-6 Abdomen or Lower Back Injuries

4.16.4 Pelvis/ Limb Injuries

55 (61%) in the unrestrained subset sustained limb injuries, of whom five received pelvis injuries. This finding agrees with Grattan's (1974) findings, where the risk of sustaining a fracture of the pelvis was higher in side impacts. The individual limb region distribution for this subset is given in table 4.28. It is necessary to differentiate between the left and right limbs in relation to the impact. Not surprisingly, there were more injuries to the limbs adjacent to the impact side than the remote side.

Limb	Arms	Legs	Total/%
Remote Adjacent	6 11	14 19	20/22 30/33
Total	17/19	33/37	

Table 4.28 Unrestrained FSPs in Struck-side Impacts, Distribution of AIS 2-6 Limb Injuries

4.17 Unrestrained Front Seat Passengers (FSPs) in Non-Struck Side Impacts

As with the struck side analysis, data on unrestrained FSPs have been combined. Therefore drivers involved in nearside and front seat passengers in offside impacts have been considered, of which there were a total of 73 casualties (53 drivers and 20 FSPs).

4.17.1 Head, Face and Neck Injuries

There were 20 injuries to the head/neck, and 12 casualties sustained injuries to the face. Table 4.29 shows the injury severity distribution.

	AIS (2-6) N = 73					
Body Region	2	3	4	5	6	Total
Head	11	5	-	1	-	17
Face	6	2	4	-	-	12
Neck	2	1	-	-	-	3

Table 4.29 Unrestrained FSPs in Non-struck Side Impacts, Distribution of AIS 2-6 Head, Face and Neck Injuries

4.17.2 Chest /Upper Back Injuries

13 casualties received chest or upper back injuries. Table 4.30 again shows the AIS 2-6 distribution of these.

AIS	2	3	4	5	6	Total
Number	11	2	-	-	-	13

Table 4.30 AIS 2-6 Injury Severity Distribution, Chest and Upper Back

4.17.3 Limb Injuries (including Pelvis)

There were 27 of the subset (16 drivers, 11 FSPs) who sustained limb or pelvis injuries of AIS 2-6 (4 sustained pelvis injuries). The distribution is given in table 4.31, and using the previous convention, a driver's right leg in a near side impact is classified as adjacent whilst the left leg in the same impact would be classified as remote for a front seat passenger in an offside impact. The converse would apply for the left and right limbs.

Limb side	Leg	Arm	Total
Adjacent	6	8	14 (19%)
Remote	3	6	9 (12%).

Table 4.31 Distribution of AIS 2-6 Limb Injuries on Non-struck Side

4.18 Fatal Injuries

The fatality rate indicated in this study was very high at 113 (15%) victims. This is shown in table 4.32. The majority of fatalities occurred in accidents featuring front impacts, but 12 unrestrained occupants received their fatal injuries during a side impact, most of these injuries being to the victim's head. Of the fatalities that were involved in frontal impacts, 11 (11%) were restrained but the remaining 90 occupants (80%) were unrestrained. 54 unbelted victims received fatal head injuries and 20 received fatal chest injuries.

Body region	Frontal Impact N=101 victim		Side Impact N=12 victim		Total/%
	Belted/%	Unbelted/%	Belted	Unbelted/%	
Head	8/72	54/60	-	8/67	70/62
Neck	1/9.1	5/5.6	-	2 /16.7	8/ 7
Chest	1/9.1	20/22.2	-	-	21/19
Abdomen	1/9.1	11/12.2	-	2/16.7	14/12
Total	11/100	90/100		12/100	113/100

Table 4.32 Fatal Injuries to Occupant's

4.19 Probable Causes of Injury

The probable causes of injuries in this study were taken from the questionnaire answered by the injured person or by his or her relative. Only 103 unbelted and 17 belted drivers in frontal impacts specified the main cause of their injuries, which are shown in tables 4.33 and 4.34.

Several points must be borne in mind when describing contact zones giving rise to injuries. Injuries and mechanisms are not mutually exclusive, there could be more than one injury from a single source, and also several sources could be responsible. Some injuries arise from direct blows, while others could be induced from contact with another body region. Non-contact deceleration-type injuries were also a possibility. Rebound injuries also occur, particularly with restrained occupants. There is sometimes a degree of uncertainty in assigning injury causes.

The steering wheel was the main causation of injury for all body regions, followed by the windscreen. The causation of most neck injuries was unknown. This sort of injury is very common in vehicle accidents which result from violent movements of the neck forwards and backwards. In this study 29% of belted drivers and 15% of unbelted drivers sustained neck injury. This finding is in agreement with research (Rutherford 1985; Galasko 1993) showing that neck injury is relatively more common among belted compared to unbelted occupants.

Belted drivers in frontal impacts are vulnerable to injuries from doors, dashboards, and seatbelt webbing. Belted drivers receive a high incidence of injuries to legs, included the pelvis. Harms (1991) stated that lower limbs are sometimes subjected to indirect loads which give rise to injury. It was noted in this study that more head and face injuries were sustained by drivers in high speed accidents. Unbelted drivers sustained a high incidence of head/face, and chest injuries, which are very common among unbelted drivers.

Most occupants in this sample sustained face injuries from the windscreen and side window glass. Because of the absence of Libyan vehicle standards, it may be that the high incidence of face injuries is related to the standard type of glass (BS AU 178a) which has been replaced in developed countries by the 1990 version produced to align standards with the ECE (United Nations Economic Commission).

Injury Source	Sample number = 103 unbelted drivers Body regions					
	Head, Face/%	Chest/%	Abdominal /%	Leg, Pelvic/%	Arm/ Should/%	Neck/ %
Steering wheel	44/14	30/29	7/7	17/17	14/14	1/1
Windscreen	54/52					
Adjacent doors	2/2			8/8	9/9	2/2
Roof	5/5				1/1	
Pedals/ brackets				15/15		
Seats				1/1	2/2	1/1
Not Known						15/15

Table 4.33 Unbelted Drivers, Probable Causes of AIS 2-6 Injuries

Sample number = 17 belted driver Body regions						
Injury source	Head, Face/%	Chest/ %	Abdominal / %	Leg, Pelvic/ %	Arm, Shoulder/ %	Neck/%
Steering wheel	9/52	5/29		2/12	5/29	
Windscreen	5/29					
Adjacent door				2/12	2/29	
Roof	5/29			15/88		
Pedals/brackets				3/18		
Front Seat				1/6	2/29	1/6
Seatbelt			4/23	2/12	1/6	5/29

Table 4.34 Belted Drivers, Probable Causes of AIS 2-6 Injuries

According to the questionnaire answered by the victims, fifty six of 120 (47%) unbelted front seat passengers in frontal impacts specified the probable injury causes, as shown in Table 4.35. The number of injuries caused to unbelted front seat passengers in frontal, offside, and nearside impacts was too small for statistical analysis. The adjacent door, dashboard, and roof were the main causes of injuries for front seat passengers. Heads/faces followed by arms/shoulders were the most injured body parts. Some unexpected FSP injury causations were noted, such as the steering wheel which mostly occurred as result of more than one passenger sitting in the one seat. This is very common among Libyan vehicle occupants.

	Sample number = 56 Body regions					
Probable injury source	Head/Face N/%	Chest N/%	Abdomen N/%	Leg/ Pelvic N/%	Arm/ Shoulder N/%	Neck N/%
Steering wheel	2/4				2/4	
Wind-screen	42/75					
Adjacent door	1/2	8/14		4/7	4/7	1/2
Roof	6/11				1/2	2/4
Dashboard	5/9	2/4	3/5		1/2	
Frontal Seats		4/7		1/2	6/4	4/2
N.K						5/9

Table 4.35 Unbelted FSPs in Frontal Impact, Probable Causes of AIS 2-6 Injuries

4.20 Cost of Traffic Accident Fatalities in Libya

In this chapter an attempt is made to estimate the fatality costs of traffic accident in Libya, and the findings were used for comparison with Britain traffic fatality costs.

Data on fatal accident costs, police costs, family and community losses were obtained from different sources in Libya, such as Traffic Accidents in Libya (2000), and property damage costs were obtained from the Traffic Department in Tripoli. Data on lost quality of life (human costs) were obtained from the Libyan Insurance Company (there is only one insurance company in Libya). Costs of hospitalization and nursing, physician services, physical therapy, emergency services and the transport of casualties were obtained from the questionnaire which was sent to the staff of the Central Hospital in Tripoli.

The costs documented in this chapter include the economic (or human capital) cost components for motor vehicle fatal crashes in Libya. The costs per fatal injury are usually defined as direct costs, rehabilitation costs, insurance administrative expenses, legal costs, and employer costs. Indirect costs are productivity costs in the workplace due to death. Following Krupp's (1993) findings, three approaches were used for estimating the death loss of output, the gross loss of output the net less of output, and the value of time. Each approach has its own drawbacks; but the first approach is the most simple and widely accepted in traffic accident costing (Jadaan 1986; Morden 1989; Elvik 1995; Miller 1997). The value of lost quality of life represents the economic valuation of pain, grief, and suffering. Three distinct approaches are used to evaluate lost quality of life (Mishan 1971; Miler 1990, 1991; Viscusi 1993) based on court awards, public decisions, and the willing to pay. The total costs of fatal accidents were estimated according to the mathematical model recommended by the European Commissions report COST313 (Alfaro 1994).

The total cost of a fatal accident = direct costs + indirect costs.

Indirect cost = losses in output + lost quality of life

Using the distribution of fatalities by age, the loss of output from death is estimated by discounting to the present the deceased's expected future earnings. The Ministry of Labour in Libya indicates that productive age begins at 18 and ends at 65 years of age. Furthermore, the unemployment rate in Libya during the 2000 was 18%. The average gross earnings, including fringe benefits, were 9 L.D (£4) per day for 2000, (L.H.D 1997) a figure used to estimate the loss of output.

Libyan discount rate = interest rate - growth rate

$$5.5\% - 2.5\% = 3\%$$

Losses to present value = number of loss years (47 years) × mean annual income (Al-Masaeid 1999).

Discount rate = 0.03 × losses to present value

$$= 0.03 \times 50{,}132 = £151\ (355\ \text{LD})$$

The gross loss of output = losses to present value – discount rate

$$= 50{,}132 - 151 = £49{,}980\ (117{,}500\ \text{LD})$$

The compensation paid by the Libyan Insurance Company was used for the lost quality of life in this study, which was £33,300. The same method was applied by Al-Masaeid (1999) for the value of lost quality of life in Jordan.

Indirect cost = 49,890 + 33,300 = £83,200 (196,000 LD).

Direct cost = repairing or replacing damaged vehicle + medical costs + administrative costs.

Repair or replacement of the damaged vehicle = £566, according to a Libyan source (M.O.I.. 2000).

Medical and ambulance costs = £533

Administrative costs = £90.

Direct costs = 556 + 533 + 100 = £1189

The total cost of a fatal accident in Libya ≈£84,400 (198,000 LD).

4.21 Discussion

The data indicate that women have less accident than men. The involvement of women in driving is very low compared to Western countries where typically 36% of all females in the age group of 17-20 years are drivers (Lenard and Welsh 2001). The Tripoli Home Interview Survey (Mekky 1982) found that only 3% of new driving license holders in Benghazi were female, this figure is quite different from the present situation where more families are driving cars compared to the 1980s and 1990s, Unfortunately, there are no official records of families holding driving licences in Libya. However, the passengers were mainly males. Mekky (1984) stated that 80% of road accident occupants in Libya were males. In this study male passengers accounted for 65% of the sample. The apparent bias was a result of the low participation of females in outdoor activities, as highlighted in the Tripoli Home Interview Survey. 1.8 % of the drivers were under driving age, most from remote areas such as Al-Gabal Al-Garge where lack of policing and bad driving behaviour are widespread.

The age distribution of victims in this study shows that the highest casualty rates were in the age group 15 to 46 years. This implies that the loss of life and the accompanying economic loss to the country are actually much greater than the statistical average might suggest.

The incidence of frontal impacts in this study was large compared with Great Britain. Studies attribute this mainly to bad road layout and poor maintenance (M.O.I. 1996, 1997, 1998). Improvements in traffic management and road design in developed countries have been instrumental in reducing this type of accident. Berhanu (2004) indicated that improvements in roadway width and access management are effective in reducing road traffic accidents. A major contribution to frontal impacts is overtaking at high speed on a single carriageway, which accounted for 7.9% of fatal road accidents in Nottinghamshire during 1971 to 1975, and 8.1% of all accidents in Libya in 1995 (Road Accident Statistics in Libya), as well as bad road lay out. Aljamahiria newspaper (2004) reported that many roads in Libya are without shoulder lines and medial lines between the carriageways. Bad driving behaviour has a big impact on frontal impacts on Libyan roads, where drivers misjudge the distance and time needed to pass a vehicle. 70% of the Libyan road network is single carriageway (Libyan Human Resource Report) (L.H.D 2000) and it is possible that the construction of dual carriageways will have a significant impact on reducing the incidence of frontal impacts, as indicated by Ivan (1997), Hadi (1993), Miaou (1992), and Mantly (1995). All these studies indicate that road geometry plays a significant part in vehicle accidents. Wong (1992) observed that modifications to roadway geometry are important because of the strong association between adverse geometric elements and high accident locations. This association has been confirmed in various studies for example (Boughton, 1975); and the Federal Highway Administration FHA (1982).

The proportion of side impact accidents at 33.5% in this study was large compared to other data. Several investigations (such as Hobbs 1980; Jones 1982; Harms 1987; and

Appel 1997) have shown that in UK, side impacts normally represent only 20% of all impacts. Some studies (Hartoman 1976; Griffiths 1983; and Rouhana 1987) have examined this type of impact and concluded that the main cause or the most likely contributing factor was the lack of traffic controls at road junctions. Jacobs (1973) indicated that the number of junctions per kilometer was the most significant factor relating to road traffic accidents. This is supported by data obtained in Libya that showed that 10.6 per cent of Libyan accidents in 1997 (M.O.I 1997) were due to drivers ignoring red traffic signals. This may be due to poor driving skills, as 28.7% of Libyan road accidents in 1996 were attributed to human failure (M.O.I. 1996), whereas in the U.K this accounts for only 2.7% of all accidents. The poor mechanical condition of vehicles could also be a contributing factor as reported by Schoor (2001) who noted that tyres and brakes are the two most dominant components that contribute to mechanical defects causing accidents.

The Libyan government has set speed limits on all Libyan roads, but excessive speed is still the main cause of death and injuries in Libya, as reported in Road Accident statistics in Libya (M.O.I 1975). A report by the Transport Research Laboratory (TRL 2002) shows that excessive or inappropriate speed helped to kill 1,200 people annually in the UK, and to injure over 100,000 more. Statistical aggregate studies have demonstrated that there is a causal link between speed and accidents (O'Neill 1990; Baum 1991; Finch 1993), suggesting that up to a third of all fatal road traffic accidents are speed related. It is clear from this study that speed constitutes one of the main social dilemmas on Libyan roads.

In this study 93% of vehicle occupants were transported to the hospital by passing private cars without receiving first aid at the scene of the accident. This led to the worsening of their injuries or loss of life. This finding should urge the Libyan government to take steps to improve ambulance and emergency services, by introducing new ambulance vehicles with all the necessary requirements for paramedic equipment, and well-trained crews. Many studies stress the advantages of ambulance services in saving the lives of injured persons. Brown (1979) found a positive association between ambulance delay times and the ratio of serious to fatal injuries, suggesting that RTA victims who had to wait the longest for ambulances to reach them were the most likely to die, Redmond (1994) showed that pre-hospital deaths from injury are not inevitable and that at least some can be prevented by simple first aid measures. For example, Hussain (1994) showed that at least 39% and up to 85% of preventable pre-hospital deaths may be due to airway obstruction.

4.21.1 Effectiveness of Seatbelts in Reducing Occupant Injuries

Many studies in Britain and other countries have addressed seatbelt usage rates. In Britain 95% of vehicle occupants are restrained (HMSO 1999). The effectiveness of restraint for drivers and passengers has been documented in previous sections. It is clear that belted drivers experience a high reduction in AIS 4-6 injury severity compared to unbelted drivers in frontal impacts. Harms (1991) found that only 11% of restrained drivers sustained head\neck injuries, and 7% sustained facial injuries of AIS 4-6. He also confirmed a high reduction of head/neck and face injuries of AIS 4-6 for belted FSPs in frontal impacts. Whereas in this study high incidences of head/neck (22.5%), and Chest (41%) injuries of AIS 4-6 for unbelted FSPs in frontal impacts have been found, the probable causes of which were instrument panels and windscreens. Most studies agree with this study's findings (e.g. Koushki 2002) that the non-use of belts leads to higher frequencies of head, face, abdominal and limb injuries. Harms (1991) found that the effectiveness of restraint use on overall injury severity can be seen in all groups, particularly amongst the higher injury levels of AIS 3-6. Cameron (1981) concluded that the wearing of seatbelts by frontal occupants of cars is associated with a reduced likelihood of severe or fatal injuries to the head, face and thorax. Evans (1996) mentioned that a safety belt reduces the driver fatality risk by around (40 ± 4) %. Grattan (1974) showed that un restrained drivers suffer more head injuries in frontal impacts than restrained passengers. Analysis of the CCIS data by Harms (1987) showed that one third of front seat occupants were uninjured and approximately half had injuries of only MAIS1. Danner (1987) addressed the problem of injuries to life threatening body regions amongst FSPs, showing that the driver's head was the most vulnerable part of a front seat passenger, a finding in agreement with those of the present study.

Seatbelt abdomen injuries accounted for 23% of drivers in frontal impacts. This was most likely due to wearing Libyan traditional costume, which leads to the improper position of the seat belt. As a result of this, the abdomen is subjected to belt loading or submarining. Figure 4.1 shows Libyan traditional costume. Hills (1994) suggested that intra-abdominal injuries associated with seat belts are the result of improper application of the belt. Other probable causes of abdomen injuries were sharp adjacent on doors particularly on locally-made and uncovered vehicle doors, as shown in figure 4.2, and by sharp front of the other vehicle, as demonstrated in figure 4.3. These findings are in agreement with those of Harms (1987) suggesting that the adjacent door is the most common contact zone giving rise to serious injuries to the trunk in side impacts.

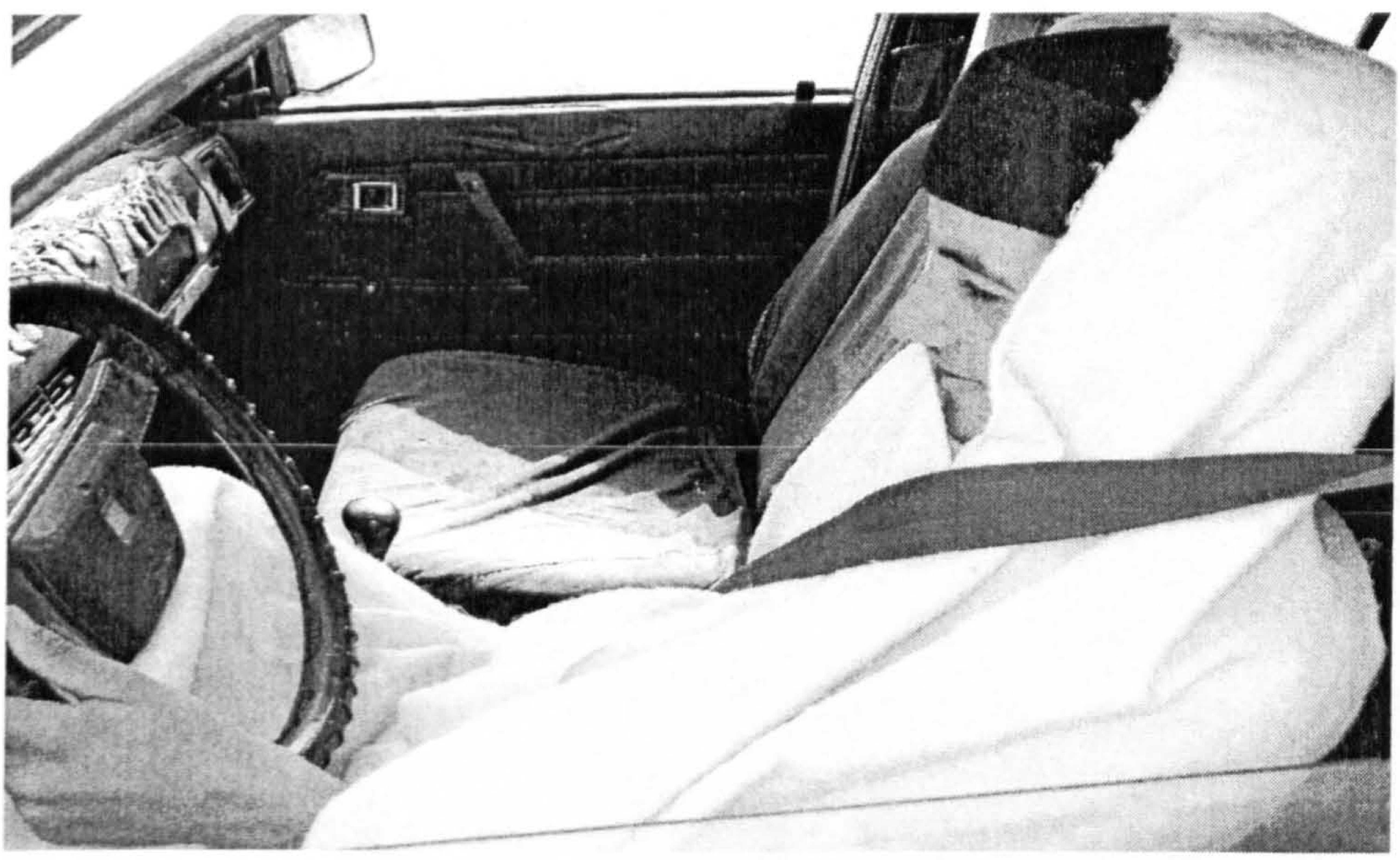


Figure 4.1 Libyan Traditional Costume

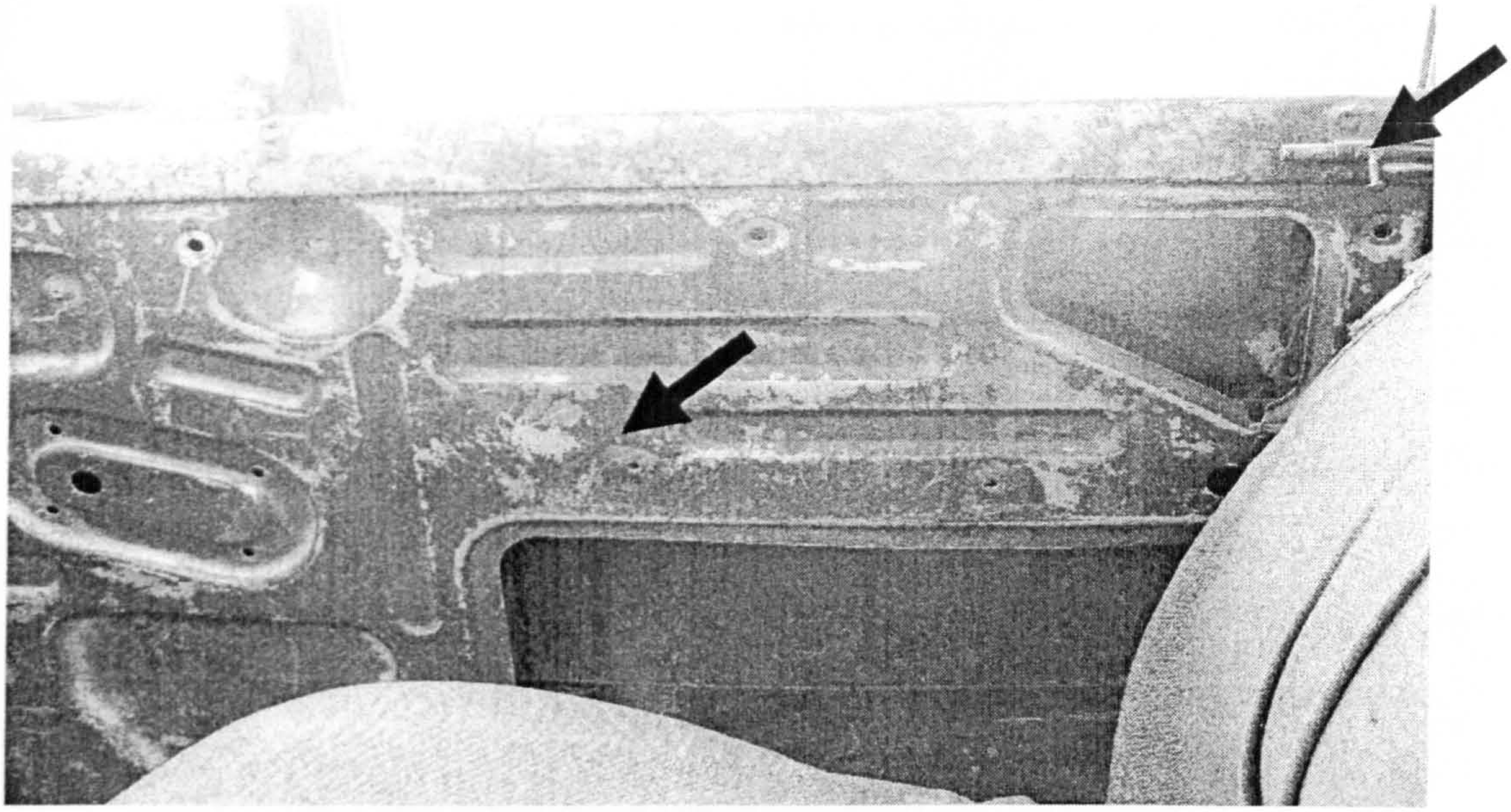


Figure 4.2a Vehicle with a Locally-made Door handle with Sharp Edges

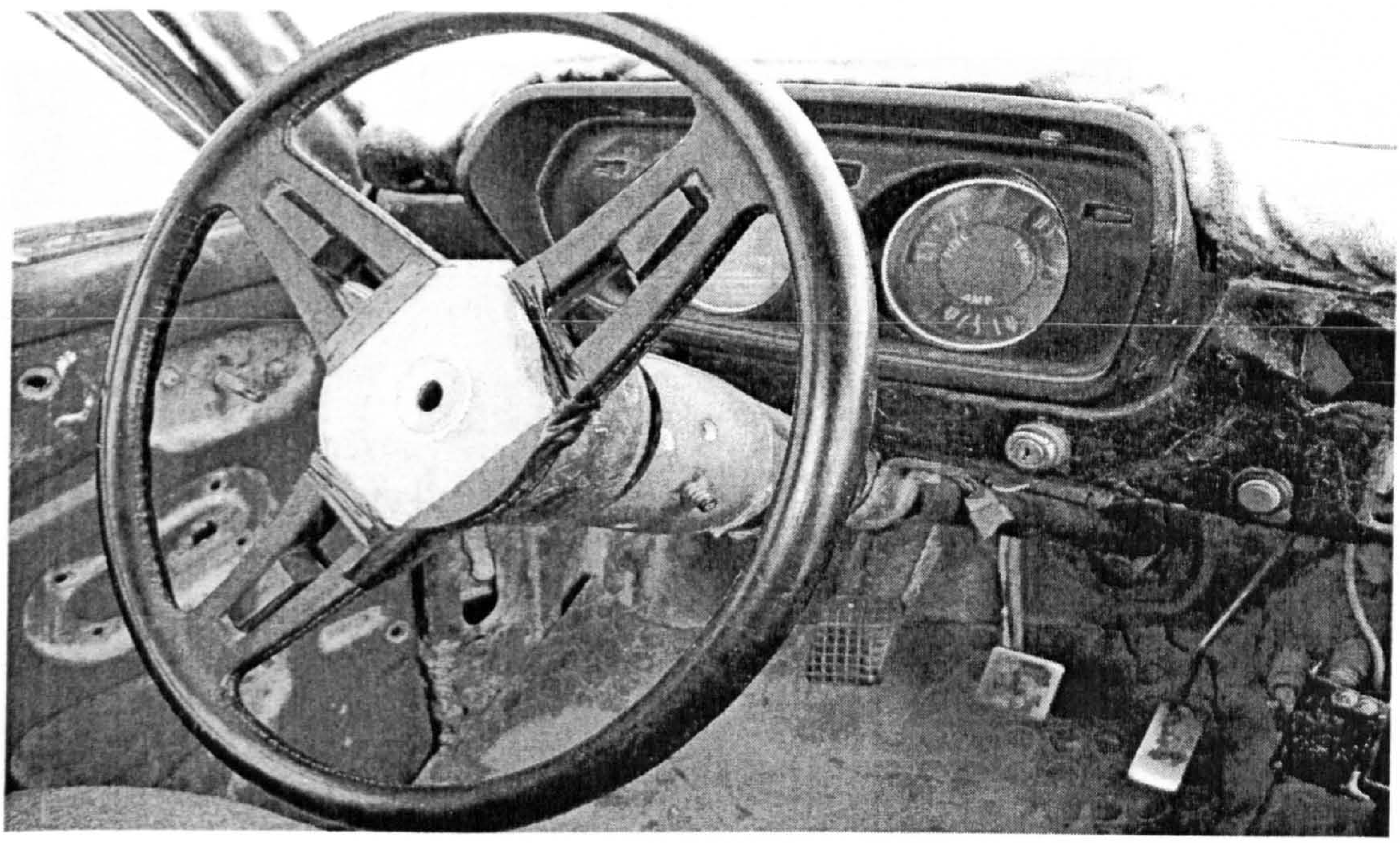


Figure 4.2b An Aggressive Steering wheel

Figure 4.3 Pick-up vehicle in Libya.

Various studies have addressed the benefits of seat belt wearing in side impacts. For example, Ashton (1985) showed the predominance of trunk injuries in side impacts. The effectiveness of seatbelts in side impacts has been studied by Thomas (1987), who found that there was only a small protection offered by the seatbelt for a near side occupant, but that there was a noticeable improvement for passengers seated on the opposite side to the impact. The number of injuries was higher (40%-60%) for occupants on the struck side than for occupants on the opposite side to the impact. Several studies (Jones 1982; Otte 1984; Harms et al 1987; and Rouhana 1987) consider the chest as the most vulnerable body region, followed by the abdomen and then the head. Jones (1982) ranked the abdomen as slightly more vulnerable than the chest, with the head less vulnerable than the chest.

Several authors (including Huelke 1974; Rattenburynd 1979; Griffiths 1976) have found an increased risk of front occupant injury when loaded by unrestrained RSPs. Therefore, an increased risk of front occupant injury from interaction with RSPs could exist when all the car's occupants are unbelted. This might help to explain some of the injuries to drivers and FSPs in this study.

According to Libyan law, seatbelt use and child safety seats are not compulsory requirements for child rear seat passengers. This has led to a high incidence of head and limb injuries for this group, in agreement with the findings of Melvin (1978) and Ruta (1993) who commented on the increased risk of injury for children traveling unrestrained in a car. Wagenar (1987) showed the effectiveness of mandatory child restraint laws in reducing fatalities.

4.21.2 Fatal Injuries

The main fatal injuries noted in this study were to the head (62%) and the chest (21%). These injuries could be prevented if the occupants were restrained. Generally, the effectiveness of current automotive occupant restraint systems in reducing injuries and fatalities in road traffic accidents has been widely recognised. In the U.K. it has been estimated that the number of fatalities has been reduced by approximately 25% (Rutherford 1985). Similarly, the number of patients taken to hospital following a road accident is reduced by 15%, and this is believed to be accompanied by a 25% reduction in the number of patients requiring admission to wards. Also, Nelson (1974) confirmed the effectiveness of seat belts in both injury reduction and also in decreased length of stay in hospital. Sabey (1977) highlighted a general reduction in injuries due to the effects of restraints. All of these studies strongly support the premise that the use of seatbelts must be a legal requirement for drivers and front and rear seat passengers in all vehicles in Libya. Before this becomes law, however, the government must increase public awareness by sponsoring public campaigns aimed at convincing all vehicle occupants of the advantages of using seatbelts in reducing the number of unnecessary and avoidable deaths and injuries that occur in vehicle accidents.

According to the findings in this study, each fatal road accident cost Libya around £84,400 (198,000 LD), (0.7 from Libyan GNP, 2000) which is a big loss of national income for a country with a small population such as Libya. Jacobs (2000) estimated that road accident costs in the UK were 2.1% of gross national product (GNP). Al-Masaeid (1999) found that the total annual fatality cost of road accidents in Jordan was £91 million (0.6 of GNP).

Only 7% of casualties in this study were transported to hospital by ambulance, a figure which should urge the Libyan government to establish new ambulance systems able to respond immediately in the event of traffic accidents, and equipped with sophisticated equipment and well-trained crews.

4.22 Cost benefit of Seatbelt Enforcement

When the results of both studies (Wells, P and Willams 1992; Williams, Reinfur and Wells 1996) are combined, seat belt enforcement results in an increase in usage rate of 20%. Seat belt usage in urban areas increases by 20%, while the increase in use is somewhat lower in rural areas (16%). The costs of police enforcement of the use of seat belts in Norway have been estimated at £3.1 million (Hagen 1994). The best estimate of the reduction of accident costs is £22.38 million per year. This is considerably more than the costs of increasing the degree of enforcement. The number of injured persons that can be prevented in Norway is estimated at 102 injuries, and reduced costs £22,383 million.

The British government has estimated that since seat belt wearing was made compulsory in 1983, casualties have been reduced by at least 370 deaths and 7000 serious injuries per year for front seat belts and 70 deaths and 1000 serious injuries for rear seat belts (DETR 1997). Preventing this number of deaths and serious injuries will have resulted in cost savings of almost £1,599 million a year, based on the DfT's (2001) valuations for road accident casualties.

4.23 Cost benefit of Speed Camera

Exceeding the speed limit is probably the most common traffic law violation among drivers. Speed cameras (automatic enforcement) are intended to provide an enhanced capacity for enforcement by applying a technical solution. A 1996 study by the Police Research Group in the UK (Hooke et al. 1996) gave the capital and annual operating costs of a speed camera installation to be 15,247 pound. If the cameras have a life of five years, then the annualised capital cost of one such installation is about 3,685 pound. And the value of consequent crash reduction is £1063 million. A Norwegian study by Brekke (1993) estimated accident savings to be £6.6 million. The total cost of setting up and operating the system was around £0.25 million. This gives a benefit cost ratio of 26.7.

The effect of speed cameras on accident redaction is clear in developing countries such as the UK, but in countries such as Libya they will not be effective at the present time for two reasons. Firstly the lack of an available accident database to locate the speed camera in the high speed accident sites, and secondly the accident reporting in Libya is still not computerised which, would lead to increases in the operating costs of speed cameras.

4.24 Cost benefit of Traffic Signal Control at Intersection

Traffic signal control at intersections separates different streams of traffic from each other, and can improve the flow of traffic at intersections. A compilation of cost figures from a number of sources (Elvic 1996) shows that the average cost of traffic signal control at intersections on a highway can be estimated to be 79,000 pound at 1995 prices. Annual maintenance costs can be estimated at 4000 pound per intersection. For a four leg junction, the reduction in accident costs is 1.3 million; the thus benefit is greater than the cost.

The above findings should convince the Libyan government that any amount of mony spent on any of the above measures will yield returns in the form of significant accident reductions and casualties needing treatments.

4.25 Conclusion

The combined studies of many workers into road traffic accident causes and the contribution of restraints in reducing the severity of injury appears to have had little impact on the situation in Libya. Using seatbelts for all occupants of vehicles and children's seats on all Libyan roads could be a very simple and effective way of reducing the number of people killed and injured on Libyan roads. Reducing vehicle speed may be one of the most effective interventions to stem traffic crashes in Libya. However, setting lower speed limits is not an effective intervention without the enforcement of traffic law and allocation of resources to ensure that limits are followed. All this must be done in such a way that it becomes acceptable to most drivers. Regular inspection of vehicles and elimination of sharp edges could also help to prevent injuries to occupants in the event of accidents. A substantial road building plan to improve standards and reduce the possibility of collisions would be beneficial. Introducing emergency services, especially equipped with first aid equipment and staffed with medically trained personnel, would save many lives and decrease the effects of injuries. The high incidence of accidents involving frontal impacts and the high frequency of side impacts indicate a lack of traffic controls at road junctions, poor road layout and low driving standards. In the long term, appropriate speed limits and legal sanctions can be introduced and the Libyan Government must set up a long-term strategy of investment and education to eliminate the type of road safety problems highlighted in this study.

Apart from the humanitarian aspect of reducing road deaths and injuries in Libya, a strong case can be made for reducing road accident deaths on economic grounds alone, as they consume massive financial resources that the countries can ill afford to lose.

CHAPTER FIVE

PEDESTRIAN ACCIDENTS AND INJURIES

5.1. Introduction

Motor vehicle crashes resulted in approximately 2,169 pedestrians injured and 496 killed on Libyan roads in 1996; a ratio of 11 pedestrian deaths per 100,000 persons (Road Accident Statistics LB, 1996). 46 per cent of Libya RTA deaths were pedestrians. During 1996 there were 341 fatalities due to road crashes in Tripoli, the capital city of Libya, and of these 178 (52%) were pedestrians. In Great Britain, for instance 1.7 pedestrian deaths per 100,000 people is a representative ratio Road Accident Statistics, G.B (1996) which is less than the Libyan rate by around seven times.

Pedestrian-vehicle collisions are a serious concern because of the severe nature of the injuries to those who are struck by vehicles. Past research has established that pedestrians suffer very serious injuries when struck by vehicles. The traditional view of pedestrian traffic safety tends to place the burden of responsibility on the behaviour of pedestrians and emphasizes education as the means to prevent accidents (Harruff 1998). This view has been modified by data from developed countries showing that education efforts are less effective than efforts aimed at modifying the physical and social environment of the transportation system (Roberts 1994).

In this chapter, the general characteristics of a sample of 442 pedestrians struck by vehicles on Libyan roads are described in terms of the vehicles involved, age and sex of the casualties, the location of impact, the mean impact speed of the vehicle, and the overall severity of injuries sustained. The influence of impact speed on the overall severity of injuries is considered. The general location of the injuries received by severity is noted, and the injury patterns compared according to MAIS (Maximum Abbreviated Injury Scale) for each of the main body areas (head, neck, face, chest, abdomen, pelvis, arms and legs). The relationship between impact speed and overall injury severity is considered. Statistical analysis using the chi-squared test is used to identify whether a significant relationship exists between two each pair of categorical variables (see appendix B.2).

5.2 The Sample

Four hundred and thirty three accidents involving 442 pedestrians were investigated during the study. Table 5.1 gives details of the accidents investigated in terms of the number of pedestrians and vehicles involved.

Number of pedestrians in an accident.	Number of vehicles in an accident		Number of casualties/%
	1	2	
1	426	-	426/96.4
2	5	-	10/2.3
3	2	-	6/1.3
Total	433	-	442

Table 5.1 Numbers of Accidents and Pedestrians Involved

Ninety six per cent of accidents involved only one pedestrian, and five involved vehicles striking two pedestrians each. Two accidents each involved three pedestrians.

5.3 Vehicles Involved

In this study passenger cars and taxis accounted for 70% of the vehicles that struck pedestrians (67% of the Libyan fleet; L.H.D 2000). Light goods vehicles, such as pick-up and trucks, accounted for a further 21%. These categories accounted for 30 per cent of the entire Libyan vehicle population (L.H.D 2000). Table 5.2 gives details of the vehicles striking the 442 pedestrians. Other vehicles included in the category other were ambulances, tractors, military vehicles, and two wheeled vehicles.

Vehicle	Number/%
Car and Taxi	303/69.8
Good vehicle	97/21.8
Other*	9/2.1
Not Known	24/5.7
Total	433/100

* Ambulances, tractors, military vehicles, and two wheeled vehicles

Table 5.2 Vehicles Striking Pedestrians

5.4 Age and Sex of Pedestrians

Table 5.3 gives details of the age and sex of the pedestrians involved. Children persons aged less than 15 years accounted for 53.5% of these pedestrians, adults aged 16-60 years accounted for 36.4%, and elderly adults aged more than 60 years accounted for 10%. Overall, male casualties were almost twice the females. The proportion of males, however, varied with age, representing 62.5% of children, 45% of the adults and 93.2% of the elderly.

Age of Pedestrian	Sex of pedestrian		
	Male	Female	All
	Number/%	Number/%	Number/%
1-4	52/17.8	32/21.3	84/19
5-9	51/17.5	34/22.7	85/19.2
10-15	45/15.4	23/15.3	68/15.3
16-30	70/24	47/31.3	117/26.5
31-45	24/8.2	7/4.7	31/ 7
46-60	9/31	4/2.7	13/2.9
>61	41/60	3/2	44/10
All ages	292/66	150/ 34	442/100

$X'^2 = 20.345; Df = 6; p < 0.05.$

Table 5.3 Age and Sex of Pedestrians

5.5 Pedestrian Behaviour

Nearly 70.6% of the pedestrians were crossing the road when struck. A large proportion were crossing roads (64.2% schoolchildren), 8.8 % crossing highways, and a small number (11.3%) were on pavements when struck. Table 5.4 gives details of the actions of the pedestrian by pedestrian age. There were small significant differences between different age groups for crossing roads. According to the chi-square test results, age was a contributing factor at pedestrian crossings, and there was a significant difference between children and adults $X^2 = 99.177; Df = 5; p < 0.05$, children and elderly adult $X^2 = 51.767; Df = 6; p < 0.05$ at crossing places,

Action of Pedestrians	Age by years			
	0-14	15-59	>60	All
	No/%	No/%	No/%	No/%
Crossing road not at pedestrians crossing	152/64.2	33/ 75	33/75	273/61.8
On pavement	14/5.9	5/11.4	28/6.3	50/11.3
In road not crossing	31/13.1	-	-	31/7
Highway crossing	4/1.7	35/21.7	-	39/8.8
Waking near the road (road without pavement)	14/5.9	11/6.8	2/ 4.5	27/6.1
Not known	22 /9.3	18/11.2	4/9.1	44/10
All	237/62	161/36.4	44/10	442

Table 5.4 Behaviour of Pedestrians by Age

5.6 Mean Speed of Vehicle at Impact

The mean vehicle speed distributions for the different age groups of children, adults and elderly adults are shown in table 5.5. Examination of the speed distributions shows that there were statistically significant differences between age and mean impact speed for children and adults *($x^2 = 21.219$, $df = 10$, $p<0.05$)*. where df is degree of freedom, p is p-value (p=0.5). A larger proportion of the children and adult were involved in lower speed accidents than the elderly adults. 11% of children, 11.2% adult, and 4.6% of elderly adults were struck at mean impact speeds less than 20 km/h, whilst 60% of the children, 55% of adults and 13.7 % of elderly adults were struck at speeds greater than 50 km/h.

Mean Impact speed km/h	Age			
	0-14	15-59	>60	All
	No/%	No/ %	No/ %	No/ %
5-10	4/1.7	4/2.5	-	8/1.8
11-20	22/ 9.3	14/8.7	2/4.8	38 /8.6
21-30	19/8	8/5	10/22.7	42/ 9.5
31-40	32/13.5	21/13	9/ 20.5	62/14
41-50	32/13.5	8/5	3/6.8	43/ 9.7
51-60	37/15.6	15/9.3	8/18.2	54/12.2
61-70	17/7.2	11/6.8	-	28/6.3
71-80	20/8.4	18/11.2	4/9.1	42/9.5
81-90	4/1.7	3/1.9	-	7/1.6
91-100	15/6.3	21/13	-	36/8.1
101-110	-	--	-	-
>110	16/6.8	21/13	-	37/8.4
N.K	19/8	17/10.6	8/20.5	45/10.2
Total	237/54	161/36.4	44/10	442/100

Table 5.5 Mean Speed of Vehicles at Impact

5.7 Overall Severity of Injury

Table 5.6 details the overall severity of the injuries sustained by pedestrians of different ages, classifying the injuries using the Maximum Abbreviated Injury Scale (MAIS). 28% of the children, 33.5% of adults and 9.1% of elderly adults sustained no injury or minor injuries. Life threatening or fatal injuries (MAIS 4-6) were sustained by 34.1% of the children, 17.5% of adults and 38.7% of the elderly adults. The statistical analysis using the chi-squared test revealed that there was strong evidence that age and injury severities are related (old adult sustained more injuries than child): (x^2= 47.367, df= 6, $p<0.05$) for children and adults; (x^2= 14.758, df= 6, $p<0.05$) and for children and elderly adults.

MAIS	Age (years)			
	0-14	15-59	>60	All
	No/%	No/%	No/%	No/%
No injury	22/ 9.3	-	1/2.3	23/5.2
1	44/18.6	54/33.5	3/ 6.8	101/22.9
2	57/24.1	64/39.8	16/39.8	137/31
3	30/12.3	15/ 9.3	7/16	52/11.8
4	24/10.1	8/ 5	-	32/7.2
5	29/12.2	4/2.5	9/20.5	42/ 9.5
6	31/13.1	16/10	8/18.2	55/ 12.4
Total	237	161	44	442

Table 5.6 Pedestrian Overall Injury Severity, MAIS 1-6

5.8 Injury Severity and Impact Speed

It was necessary to consider the relationship between injury severity and mean impact speed in more detail than in the last section, to consider if there were any differences in the overall injury severity sustained by different aged pedestrians in similar situations. Table 5.7 gives details of the overall severity of injury by mean impact speed for children, adults and elderly adults. It can be seen from the table that the overall severity of injury sustained tends to increase with increasing impact speed, and that children tend to sustain more serious injuries than either adults or elderly adults. 22.4% of children sustained minor injuries in the mean impact speed range 5-40 km/h, at the 41-80 km/h range only 3%, and in the 81-110 km/h range 0% sustained minor injury. For adults the corresponding figures were 49%, 23.5% and 13.6% and for elderly adults 14.5 %, 6.7 % and 0%. At mean impact speeds between 41-80 km/h, 12.3% children sustained severe injuries of MAIS 4-6.

61% of children and 73% of elderly adults were injured at speeds less than 60 km/h. This figure indicates that most children and elderly pedestrians were struck in urban areas. 57% of adults were struck at speeds higher than 60 km/h, most of them on main roads or motorways. Injury severities of all pedestrian age groups increased with vehicle speed.

Age 1-14 years, N= 237 persons.

Velocity km/hr	0 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80	81 - 90	91 - 100	1001 - 110	>110	Not Known	All
No injury	1	5	7	4	-	8	-	4	-	-	-	-	2	31
Minor	1	7	-	9	-	-	3	-	-	-	-	-	2	22
Moderate	1	5	9	12	-	11	1	4	1	1	-	2	4	51
Serious	-	-	2	1	-	4	1	4	-	5	-	2	4	23
Severe	-	-	-	5	13	4	2	5	3	6	-	6	-	44
Critical	-	4	-	-	12	5	-	4	-	3	-	3	1	32
Fatal	1	1	1	-	8	4	10	-	-	-	-	3	6	34
N.K	-	-	-	-	-	-	-	-	-	-	-	-	-	
Total	4	22	19	31	33	36	17	21	4	15		16	19	237

Age 15-59, N= 161 persons

Speed Range km/hr	0 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80	81 - 90	91 -100	1001 - 110	>110	Not Known	All
No injury	2	-	-	4	1	-	2	-	-	3		-	-	12
Minor	1	9	1	12	5	3	1	3	-	-		2	1	38
Moderate	1	3	7	5	-	9	3	8	-	6		2	6	50
Serious	-	2	-	-	2	3	-	3	2	8		-	3	23
Severe	-	-	-	-	-	-	-	-	1	1		2	2	6
Critical	-	-	-	-	-	-	-	-	-	-		5	2	7
Fatal	-	-	-	-	-	-	3	5	-	1		10	5	22
N.k	-	-	-	-	-	-	-	-	-	-		-	3	3
Total	4	14	8	21	8	15	9	19	3	19	-	21	20	161

Age 60+, N= 44 persons

Velocity Range km/hr	0 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80	81 - 90	91 -100	101 - 110	>110	Not Known	All
No injury	-	-	-	-	-	-	-	-		-			-	-
Minor	-	-	3	-	-	1	-	-		-			1	4
Moderate		2	4	3	2	2	1	-		-			-	15
Serious		-	1	-	-	-	-	-		-			2	3
Severe	-	-	-	-	-	1	-	-		-			1	2
Critical	-	-	1	3	-	-	-	1		-			2	7
Fatal	-	-	1	3	1	4	1	1		1			2	15
N.K			-	-	-			-					-	-
Total	-	2	10	9	3	8	-	4	-	-			8	44

Table 5.7 The Overall Severity of Injury by Mean Impact Speed for Children, Adults and Elderly Adults, Maximum AIS (MAIS)

5.9 Pattern of Injuries

A general description of the injuries sustained is dependent not only on the injuries received but also on the methods used for describing them. In describing the overall pattern of injuries, the body has been divided into eight regions and the most severe injury sustained by each region noted. The regions used were head, neck, face, chest, abdomen, pelvis, arms and legs.

5.9.1 Overall Severity of Injuries

Tables 5.8a, b, c, and figures 5.1a, b, and c show the general locations and severity of the injuries sustained by the three age groups: children, adults, and elderly adults. The tables show that the body regions most frequently involved were the head, the chest and the legs.

Head and lower limb injuries dominated all age groups. 57% of the children sustained head injuries, leg injuries were sustained by 41% and face injuries were sustained by 25%. Leg injuries were received by 52.8% of adults, head injuries by 77.6%, and arm injuries in 62.7% of the cases. There were head injuries in 82%, arm injuries in 79.2%, and leg injuries in 82% of the elderly adults.

Location of Injuries	Age 0-14 AIS 1-6 Ns= 237						
	1	2	3	4	5	6	Total/%
Head	32	25	21	13	20	24	135/57
Face	22	19	18	-	-	-	59 /25
Neck	-	2	-	2	-	1	5/2
Chest	4	9	7	2	3	3	28/12
Abdomen	3	4	3	2	5	3	20/ 9
Pelvic	2	2	1	-	-	-	5 /2
Arms	15	4	10	-	-	-	29/12
Legs	47	32	19	-	-	-	98/41

Table 5.8a Injury severities AIS (1-6) in children

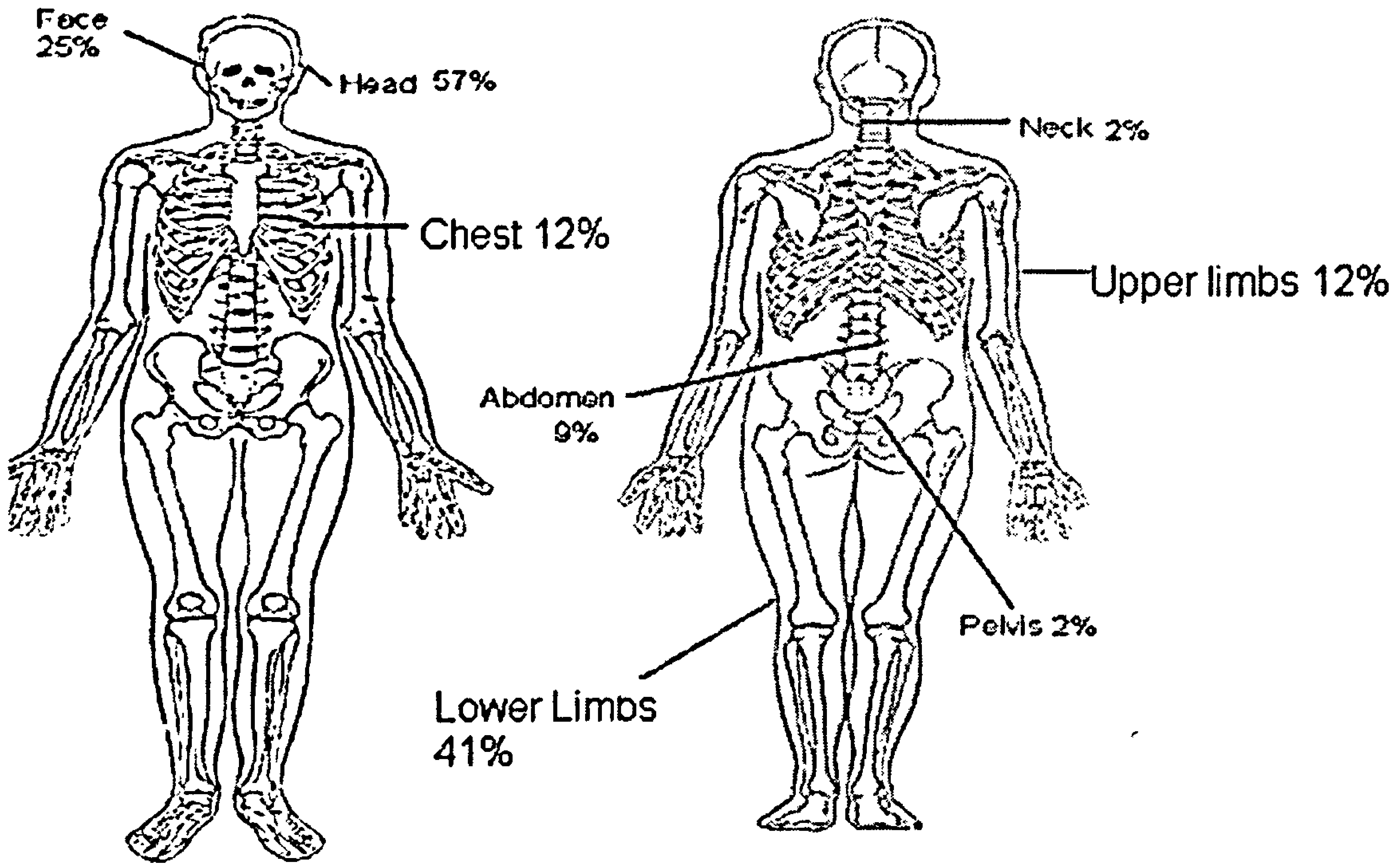


Figure 5.1a Injury Severities AIS (1-6) in children

Location of Injuries	Age 15-59 AIS 1-6 Ns=161						
	1	2	3	4	5	6	Total/%
Head	27	32	32	13	-	21	125/77.6
Face	23	3	5	5		-	36 /22.4
Neck	5	1	-	1	-	-	7 /4.3
Chest	10	5	5	7	1	-	18/11.2
Abdomen	-	2	2	1	-	2	7/4.3
Pelvis	-	9	9	-	-	-	18/11.2
Arms	67	17	17	-	-	-	101/ 62.7
Legs	45	20	20	-	-	-	85/52.8

Table 5.8b Adult Injury Severities AIS (1-6)

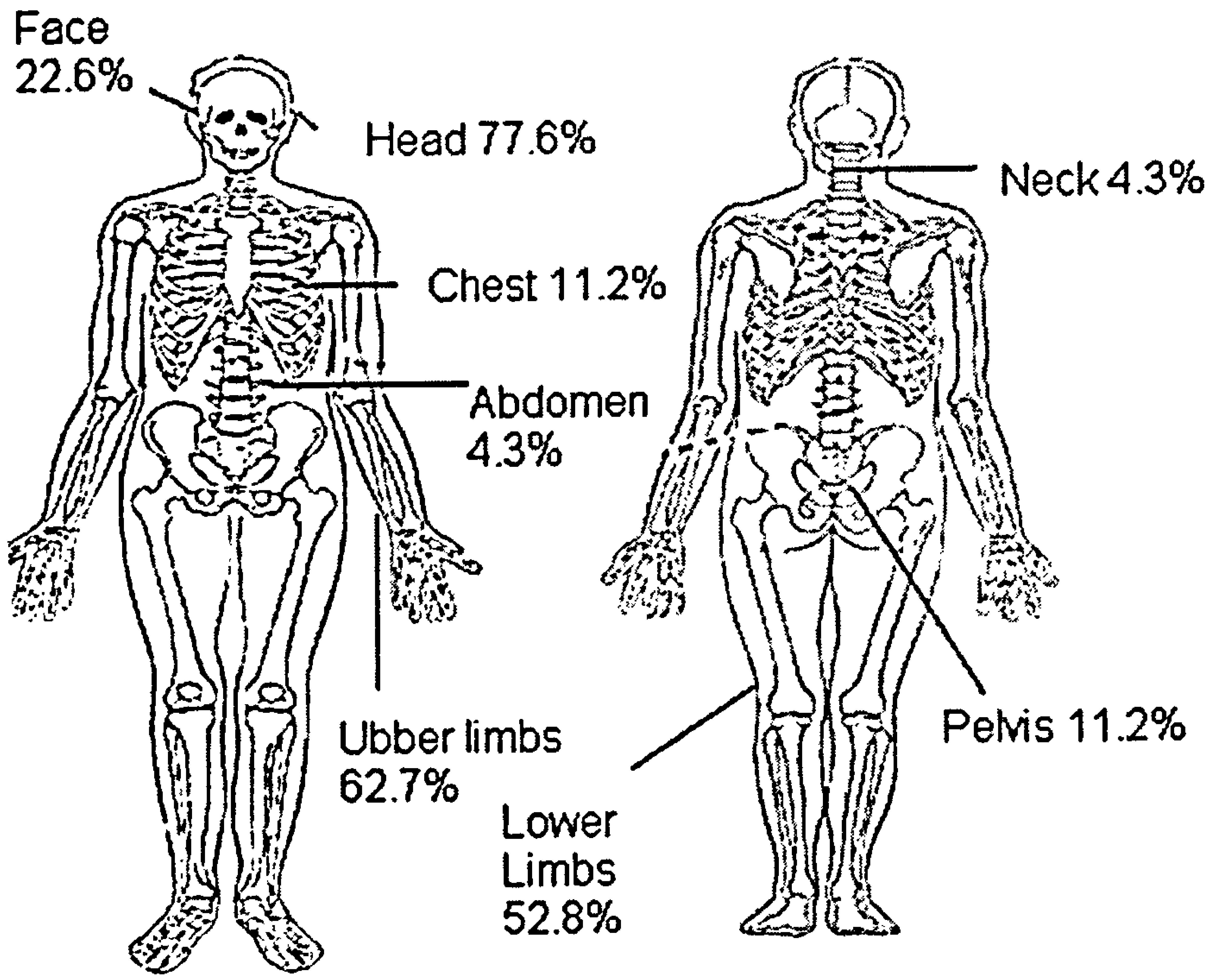


Figure 5.1b Adult Injury Severities AIS (1-6)

Location of Injuries	Age 60+ AIS 1-6 Ns=44						
	1	2	3	4	5	6	Total/ %
Head	13	8	3	3	4	8	36/82
Face	12	7	-	-	-	-	19/ 43.2
Neck	1	-	-	-	-	-	1/2.3
Chest	7	4	2	1	-	-	14/8.7
Abdomen	4	-	1	-			5/ 3.1
Pelvis	-	1	-	-	-	-	1/ 2.3
Arms	18	12	5	-	-	-	35/79.6
Legs	19	12	5	-	-	-	36/82

Table 5.8.c Elderly Adult Injury Severities AIS (1-6)

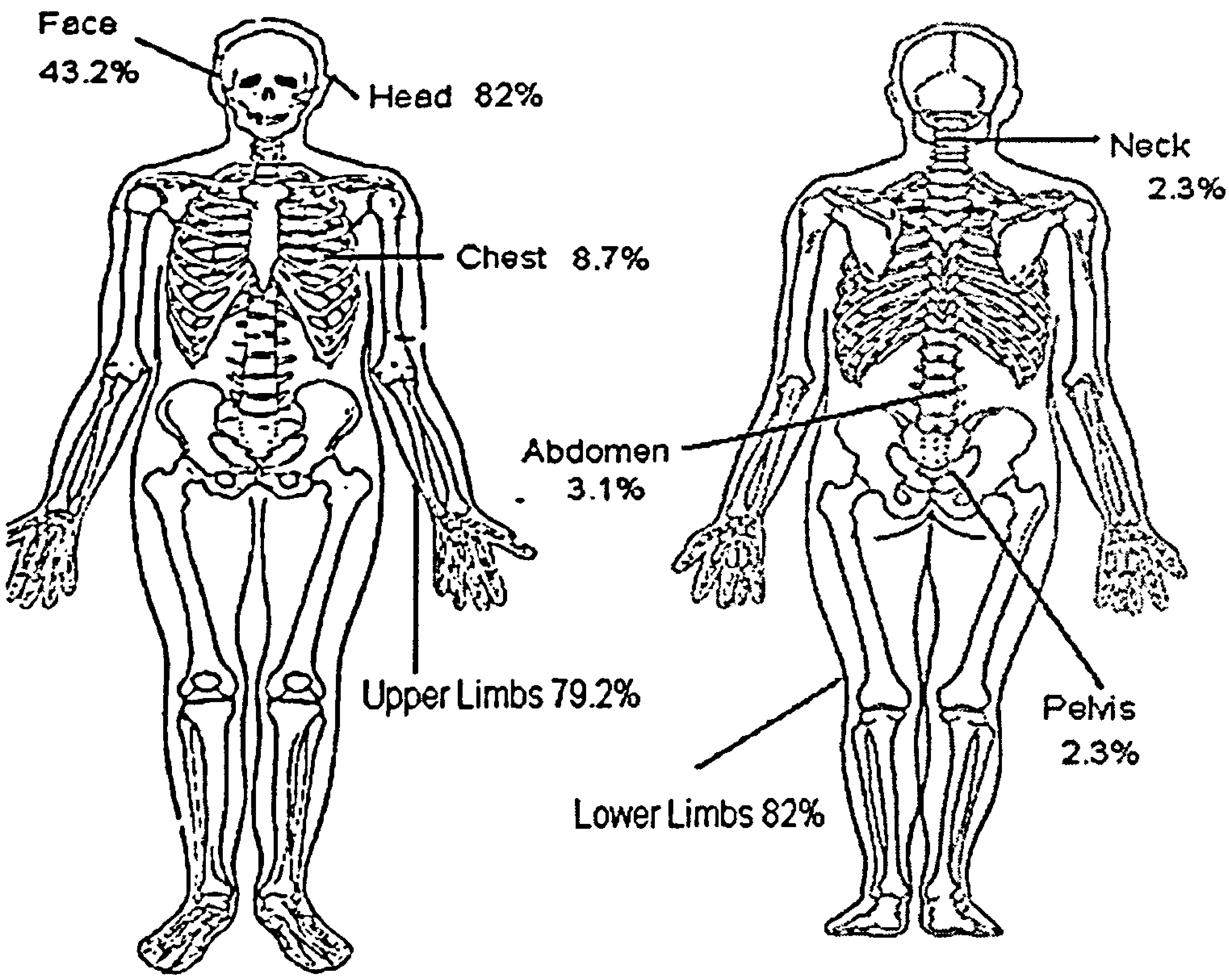


Figure 5.1c Elderly Adult Injury Severities AIS (1-6)

5.10 Fatal Injuries

Tables 5.9a,b, and c give details of the injuries sustained by those pedestrians who were killed. Twenty nine children struck by cars were killed; head injuries were sustained by 86.2% followed by face and neck injuries to 58.6% and 55.2% respectively. (These are unusual results, most likely due to improper handling of victims at accident scenes), Franceline (2001). It was noted that children sustained high incidences of chest (38%) and abdomen (31%) injuries. Seventeen adults were killed; head injuries were sustained by 70.6%, 23.5% received chest injuries, and 82.4% leg injuries. Thirteen elderly adults were killed; head injuries were sustained by 69.2%, 46.2% chest injuries, and leg injuries by 23.1%.

If only life threatening or fatal injuries are considered then head injuries were sustained by 71%, and neck and abdomen injuries were of the same frequency.

Location of Injuries	Age 0-14 AIS 1-6					Ns = 29	
	1	2	3	4	5	6	Total/%
Head	-	2	3	1	5	14	25/ 86.2
Face	5	7	4				17/ 58.6
Neck	-	4	2	2	5	3	16/55.2
Chest	1	-	2	2	1	5	11/38
Abdomen	-	1	1	1	3	3	9 /31
Pelvis	-	1	1	1	-	-	3/10
Arms	3	4	5	-	-	-	12/ 41.4
Legs	9	5	7	-	-	-	21/72.4

Table 5.9a Injuries Sustained by Children Pedestrians Killed

Location of Injuries	Age 15-59 AIS 1-6					Ns =17	
	1	2	3	4	5	6	Total/%
Head	-	-	-	1	2	9	12/70.6
Face	-	1	2	-	-	-	3/17.7
Neck	-	-	-	2	1	-	3/17.7
Chest	-	-	1	-	2	1	4/23.5
Abdomen	-	-	1	1	-	1	3 /17.7
Pelvis	-	-	1	-	-	-	1/ 5.9
Arms	2	4	3	-	-	-	9/52.9
Legs	5	3	6	-	-	-	14/82.4

Table 5.9b Injuries Sustained by Adults Pedestrians Killed

Location of Injuries	Age 60+ AIS 1-6 Ns =13						
	1	2	3	4	5	6	Total/%
Head	-	-	2	-	3	4	9/69.2
Face	1	1	2	-	-	-	4/30.8
Neck	1	1	-	-	2	-	4/30.8
Chest	-	1	3	-	-	2	6/46.2
Abdomen	-	-	1	-	-	-	1/8
Pelvis	-	1	1	-	-	-	2 /15.4
Arms	-	2	2				4/30.8
Legs	-	2	1				3/23.1

Table 5.9c Injuries Sustained by Elderly Adults Pedestrians Killed

5.11 Discussion

In this chapter female pedestrians represented 34% of all pedestrian victims. This finding is in agreement with those of the published Road Accident Statistics in Libya (M.O.I. 1995) where female pedestrian victims represented 31% of the total. In this study the number of males was nearly twice that of females, and these findings agree with Fontaine's (1997) finding that the male gender was associated with a particularly high risk of death among pedestrians. It should be noted that the small population of female pedestrian injuries in Libya would be influenced by the traditional Arabic custom that a women's main duty is to look after her family and educate the children, while the man is the breadwinner. Another reason is that most females walk less, and in the event of visiting relatives, a car is used for transport. The Home Interview survey in Tripoli by Mekky (1982) showed that the average rate of daily trips by females was half that of males.

53.5% of pedestrian victims were less than 15 years of age. According to Libyan Road Accidents Statistics (1995), 24% of pedestrian victims were under the age of 15 years, whereas in Great Britain 40% of all pedestrian casualties were children (HMSO 1999). The high incidence of school age victims relates to the fact that most Libyan schools are normally built very close to main roads, and it is easy for children to wander from the school onto the road. LaScala (2003) stated that annual numbers of pedestrian injuries during school months were greater in areas containing schools. Another factor that might contribute to the number of school age pedestrian injuries is that, in Libya, parents of younger children allow them the freedom to walk and/or cycle to school without the accompaniment of an adult. Moreover, increased numbers of pedestrian children casualties on Libyan roads are likely to result from a lack of proper crossing facilities, poor road design and lighting, and an absence of children's play areas. The lack of crossing facilities has been cited in the Libyan Road Accident Statistics (1996) as the main cause of pedestrian collisions during the night time in Libya in general. The corresponding figures for the U.K, as reported in the British Road Accident Statistics (HMSO 1998) indicate that 56% of pedestrian collisions occur 50m or more from a pedestrian crossing. Research studies have revealed that engineering shortcomings contribute to the number of pedestrian collisions, such as a lack of proper crossing facilities (Ribbens 2000). It is surprising that children age 1-4 years of age accounted for 19% of pedestrian accidents, compared to Britain in 1998 where only 11% of all pedestrian casualties were of this age group. This percentage may be the result of many factors. Firstly parents may be unaware of road hazards, and secondly, most houses are located on main roads (some houses being only 2 or 3 metres from the road) so that infants can wander on to main roads. The absence of children's playgrounds may also be significant.

In this study 61.8% of pedestrian victims were struck when crossing roads with no crossing facilities. Many studies agree with this finding. Al-Ghamdi(a) (2002) studied pedestrian accidents in Saudi Ariba, and revealed that 77.1% of pedestrians were probably struck while crossing a roadway. Baker (1974) indicated that 60% of pedestrians and 46% of drivers were negligent in such cases. Another study by Stutts (1996) showed that the most common contributing factor was pedestrians running into the roads. The problem of pedestrian accidents has been a major concern in many developing countries. A South African study by Ribbens (1999) noted that approximately 65% of pedestrian casualties in South Africa occurred while crossing the road, and 20% were walking, standing or playing near the road. The absence of pedestrian education programmes for pupils and parents using crossing facilities in some main roads has greatly contributed to the rising numbers of pedestrian victims in Libya, and, as noted by Farez (1999) pedestrians in Karachi, Pakistan, who had Zebra crossings available to them often did not use them.

A high incidence of elderly adult pedestrians struck while crossing highways (21.7%) has been found. Motorways in Libya pass through the coastline cities without any guard fences or crossing bridges. Furthermore, many shops are located very close to main roads.

In fact, much blame can be placed on the transport department for failing to protect pedestrians on high speed roads, for not providing proper crossing facilities and not educating the general public about road hazards. However, at speeds higher than 40 km/h, 31% of children sustained high injury severities of MAIS 4-6. This finding is in agreement with many studies showing that vehicle mean impact speed is one of the most important factors influencing the severity of pedestrian injuries; (Al-Ghamdi (a) 2002); Road Accident Statistics Libya, M.O.I. 2000; Rokytova 2002; Xuejun Liu 2003). Evidence of the effects of high speeds on pedestrian injuries shows that at speeds less than the speed limit, there is a high probability that the pedestrian will survive the crash or will suffer only light injury, and this finding agrees with the present findings. Konosu (2002) analysed the effect of reducing impact speed on pedestrian safety, and the results suggested that if 20% of cars reduced their impact speeds by 5 or 10 km/h, approximately 100 to 200 pedestrian lives would be saved.

For all injury groups (children, adults, and elderly adults), head and leg injuries predominated. 57% of children, 77.6% of adults, and 82% of elderly adults sustained head injuries; whilst 41% of children, 52.8% of adults, and 82% of elderly adults received leg injuries. Most pedestrian injury studies are in agreement with these findings. Aston (1954) found that 54% of hospital pedestrian inpatients received head injuries, and 35% leg injuries. Many pedestrian studies have noted high incidences of pedestrian head and limb injuries (Robertson 1966; Jamieson 1971;Nelson(a) 1976; Ramet 1976). Similar findings were reported by Langwieder (1980), who confirmed that children have a high incidence of head injury, and elderly pedestrians were found to have serious/fatal head injuries and also frequent lower limb injuries. Xuejun Liu (2003) found that the head and lower extremities of children were at risk of higher injury than other body regions.

According to Road Accident Statistics Libya (1995-1996), children represented 50% of pedestrian deaths in Libya. In this study, children accounted for only 12.2% of pedestrian deaths (29 children), and head/neck and chest injuries were the most frequent causes of death. Other studies (Levy 1976; Kinny 1990; Crawford 1991; Mullins 1994) have reported similar findings. Many studies have reported head injuries as the commonest variety of injuries in children following a road traffic accident (for instance, Grattan, Hobbs and Keigan 1976). Whereas most adult pedestrian injures were to the lower limbs and head, Danner and Langwieder (1980) showed that children, due to their lower height, have a higher incidence of head injury. This was also confirmed by Tunbridg and his co-workers (1988) and Yutaka (2003). According to many studies, collision with the top surface of wings and bonnets was the main cause of the head injuries to children and also to some of the elderly victims. The conclusion drawn by the European Experimental Vehicle Committee (EEVC 1998) was that this high incidence of children's head injuries was due to their comparative height relative to the vehicle's front structure (Langwieder, 1970). In this study, pedestrians who were struck at speeds higher than 60 km/h sustained high incidences of injury. Worldwide studies (including Makky 1984; Tharp 1976; Langwieder 1980; Xuejun Liu 2003) confirmed that injury multiplicity was a function of speed.

It was noted that 31% of children pedestrian victims sustained abdominal injuries; it was most likely that most of these cases were from Al-Zintan city, in which 40% of its vehicle population are light pickups with very poor mechanical conditions (Hamza 2004). When pedestrians struck by such vehicles fall to the ground without wrap contact, the casualty could sustain severe abdominal and chest injuries by being run over.

17 adults were killed, and 70.6% of them sustained fatal head injuries. 56.5% of these crashes accrued at speeds greater than 60 km/h, and 54.7% were on main roads with

no crossing facilities. This finding supports the conclusion that a lack of pedestrian crossings and vehicle speed control are the main contributory factors in pedestrian accidents on Libyan roads. Jacobs (1967) expressed the same opinion that the risk of pedestrian accidents is lowest on a zebra crossing.

There was a high incidence of elderly adults killed in this study, representing 22% of all pedestrians, and head injuries were the leading cause of death in this group. Ryan (1967) and Shkrum (1994) reported similar findings. Most elderly pedestrians in this study also sustained leg injuries. It is likely that with lower tolerance to injury and with more brittle bones, they are more likely to sustain multiple injuries in an accident than any other group (Harms 1994). Gotzen (1976) found that the increased severity of injury in the elderly was attributed to increased fragmentation of the skeletal system as, in old age, the bones become more brittle.

5.12 Cost benefit of Pedestrian Improvement Facilities

The measures included in this section are: (1) constructing normal pedestrian crossings, (2) creating refuges on pedestrian crossings; (3) constructing raised pedestrian crossings; (4) setting up pedestrian guard rails at crossing points; and (5) signalised mid-block pedestrian crossings.

Hun and Griffiths (1989) and Summersgill and Layfield (1996) evaluated the effects of signalised mid-block pedestrian crossings in Norway. The studies show that signalised crossings reduce the number of injury accidents by around 5 to 10%, and the number of pedestrian accidents was reduced most clearly on the pedestrian crossing itself; a 27% decrease. A compilation of cost figures from different sources (Ewik 1997) shows that a signal–regulated pedestrian crossing costs on average around 22,400 pound (1995 prices). Annual operating and maintenance costs can be estimated at around 2100 pound. Savings in accident costs are 75,000 pound.

The cost of pedestrian control measures in Norway is shown in Table (5.10).

Costs (1995 prices)		
Measures	Cost (£)	Saving in accident costs (£)
Constructing refuge on pedestrian Crossing	829	41,450
Constructing raised pedestrian crossings	22,383	178,000
Erecting traffic guard rails	7000	49,0000

Table 5.10 Cost of Pedestrian Control Measures in Norway

The above results clearly exceed the costs of implementing the measures. If the above measures were applied in Libya's urban areas, a great reduction of pedestrian casualties and accident costs would be expected. The Libyan government needs to be aware of culture differences between Libya and Norway, such as the willingness of the public to respect traffic laws and the level of road safety education in the two countries.

5.13 Conclusions

The study has illustrated that children had a high involvement rate as pedestrian casualties. Although the elderly have a lower rate than children, more elderly pedestrians were severely injured. Head injuries were the commonest form of injury, closely followed by limb fractures. The most common locations for this type of accident were roadways.

The absence of crossing facilities and excessive speed on urban roads were the most common causes of accidents involving pedestrians. Often drivers do not respect the right-of-way of pedestrians. It is considered that improvements in crossing facilities will have a beneficial impact on the accident statistics, as will supervision at school arrival and departure times. In the long term it is evident that much more drastic measures will be required in order to reduce the incidence of pedestrian injury.

Central and local government in Libya have vital roles to play in the prevention of pedestrian injuries through the control and regulation of traffic, speed and driver behaviour and the design of safer environments. Making the car less injurious in the impact situation by eliminating stiff structures. Road safety education can also play a part in reducing pedestrian casualties. Drivers need to learn that lower speeds in residential areas and around schools and playgrounds will increase their chance of stopping in time and will reduce the likelihood of serious injury to and death of pedestrians.

In the event of applying any pedestrian safety measures in Libya. Libyan government needs to focus on the long term cost benefit instead of actual cost of the measures.

CHAPTER SIX

ROAD ACCIDENTS IN LIBYA

AND GREAT BRITAIN

6.1 Introduction

It was thought useful to view traffic accidents in an international context in order to address Libya as such. International comparability is subject to variations in population, road structure, and traffic composition. Three measures of exposure are often used: the resident population, number of registered vehicles, and vehicle kilometres travelled. The former two are employed, but rates adjusted for kilometres driven are not used due to the unavailability of estimates of vehicle kilometres travelled in Libya.

The number of accidents and casualties in Great Britain were collected from Road Accidents in Great Britain (2003), the Casualty Reports, and The Department of Transport.

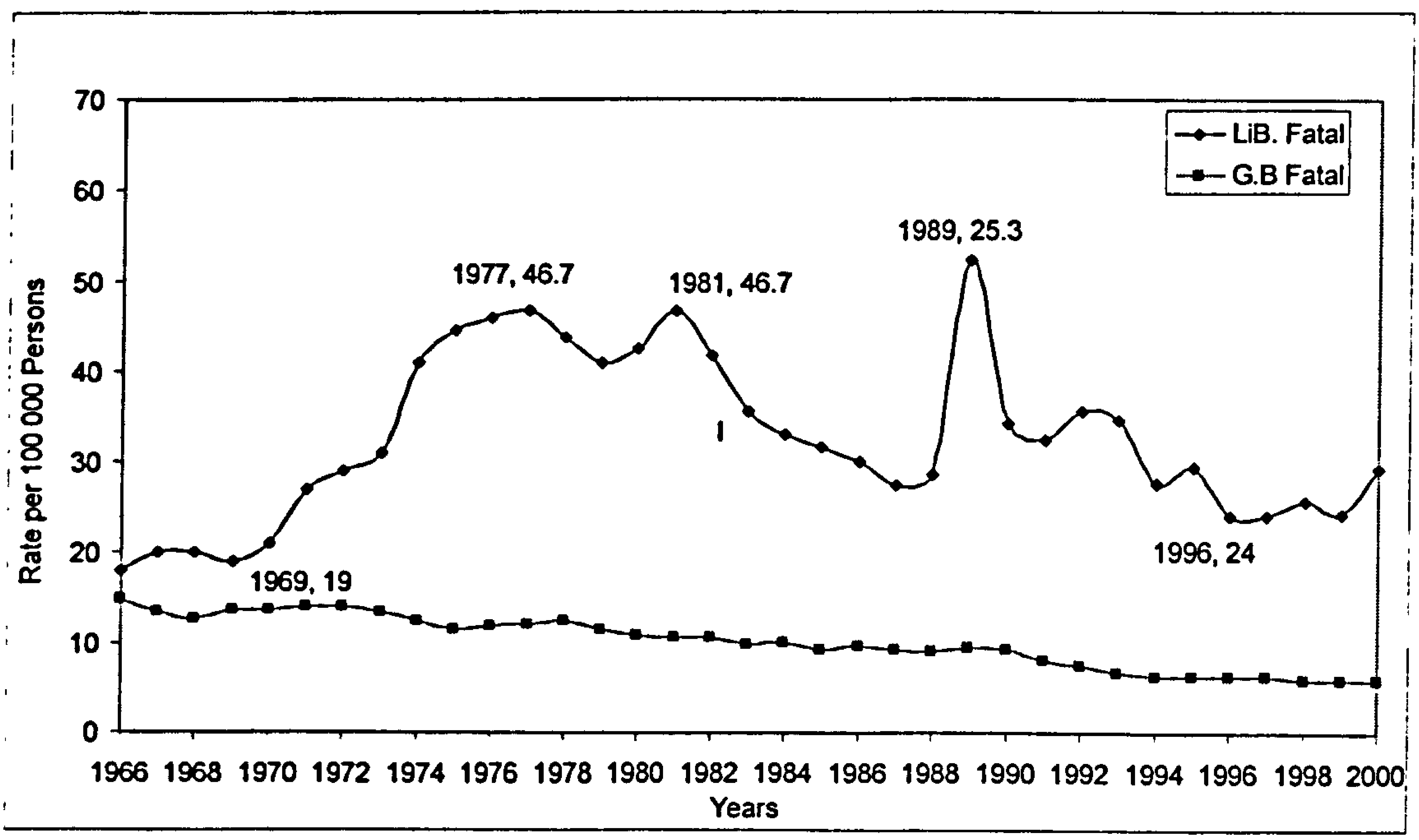


Figure 6.1 Fatality rates per 100,000 persons, in Libya and Britain

There is potential value in investigating past trends, in terms of understanding what has been achieved by specific road safety actions in the past, and how this been achieved. The approaches adopted here will be two fold. The first looks at the pattern of changes in fatality rates per vehicle population over the period 1966-200. Appendix C gives more details about the lessons to be learnt from accident experiences and remedies in developed countries.

6.2 Trends in Fatality Rates per Head of Population and Vehicle Numbers

These indicators are most commonly used for international comparison of trends in fatalities per head of the populations. They show different patterns for the two countries, but close examination indicates the interactive effect of changes in traffic growth and in safety programmes. As population distribution, road networks, and traffic distribution differ between countries, these indicators will not necessarily mean that the same safety programmes have been followed.

Figure 6.1 shows that, in 1966 the road death rate per population in Libya was some 20% higher than that in Great Britain. While the rate Great Britain in began to slowly decease in the mid 1970s despite the growth of the road network in Libya road accidents rates per inhabitant rose much more quickly to reach their highest ever peak of 46.7 in 1977, almost 4 times the Great Britain rate in the same period. By 1983 wearing seat belts had become compulsory for front seat passengers and drivers in Great Britain. As a result, the fatality rate per head of the population in Britain dropped to 9.4 in 1985. Since then, it has kept dropping, to 5.9 in 1998, whereas the fatality rate in Libya has increased by 1989 to 25.3 people per 100,000 population. Suddenly, Libya road death rates dropped sharply by nearly 49% in 1997 and have fluctuated since then.

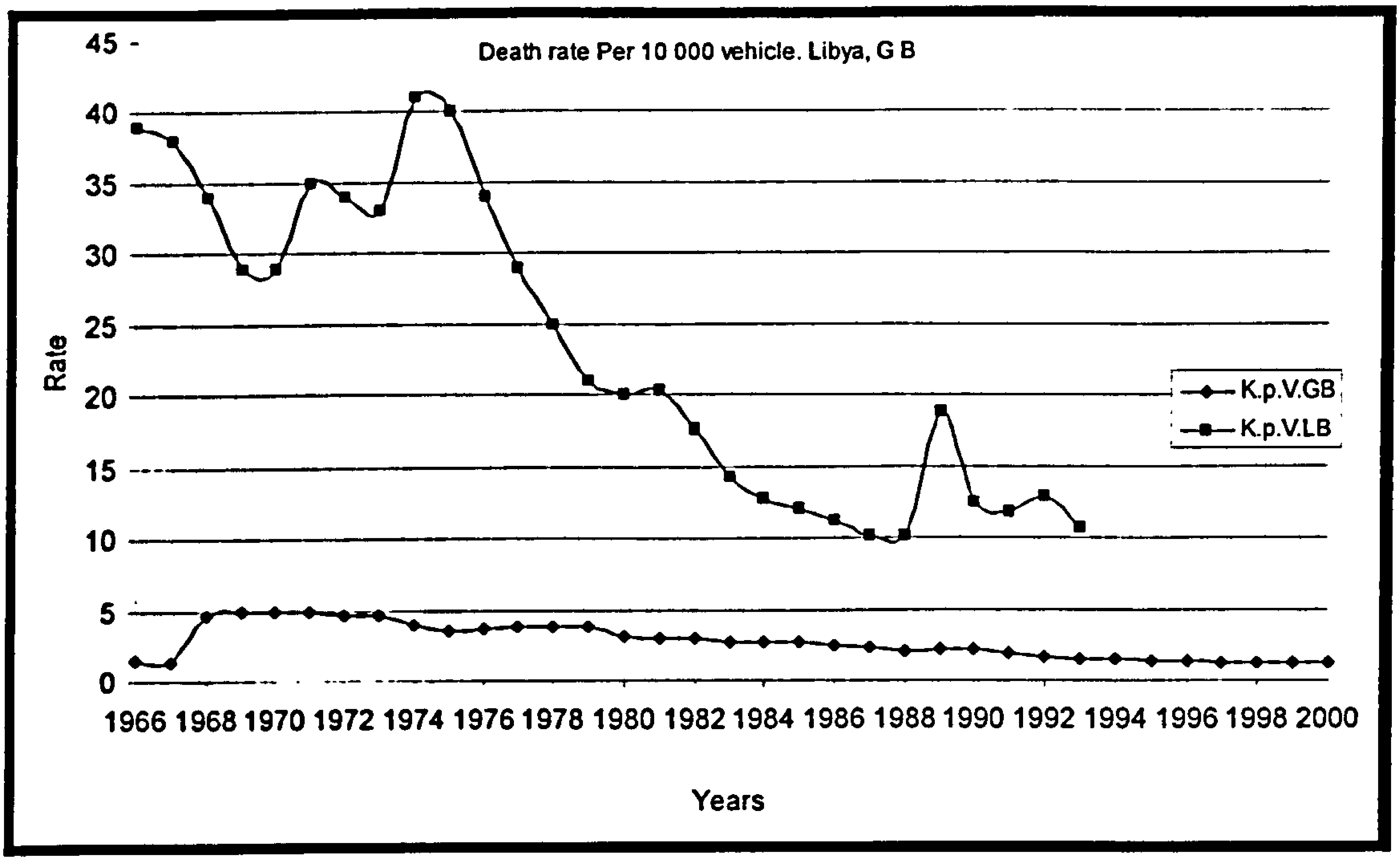


Figure 6.2 Fatality rate per 10,000 vehicles in Great Britain and Libya

In the 1990s, United Nations sanctions and the political situation in LB had an unfortunate influence on road accident rates.

In 1991 the seat belt laws in Great Britain were extended to make it compulsory for rear seated adults to wear belts. As a result of this law, the fatality rate dropped to 6.4 deaths per 100,000 of the population in 1995. In 1998 the drinking and driving law also had a significant effect on reducing the number of casualties in Great Britain. Road deaths decreased to reach 5.9 deaths per 100,000 of the population.

Figure 6.2 shows fatality rates per ten thousand vehicles for both countries. This shows that since 1966 the Libyan rate dropped yearly by an average of 10% until 1970. Since then, it increased to its highest ever peak in 1974-41 at-deaths per 10,000 vehicle, approximately 10 times higher than Great Britain in the same year. Between the mid-1970s and 1980s the Libyan fatality rate per vehicle fell to the lowest ever recorded figure of 10.1 people killed per 10,000 vehicles in 1988. The explanation for this drop in the death toll is most likely that new roads were constructed, and the Ministry of Transport spent most of its budget on road maintenance and safety.

6.3 Accident Reporting in Britain

It has already been emphasised that extending the range and improving the quality of information collected at the scene of road accidents is of fundamental importance to increasing the effectiveness of road safety research in developing countries such as Libya, as noted by Jacobs (1975). Improved accident statistics are likely to be of value not only to the police and those engaged directly in road safety research, but also to such organisations as government departments responsible for roads, local highway authorities and national records departments.

Accident reporting systems in Great Britain start from the police officer attending the scene of an accident. Any accidents which come to the attention of the police will form part of national accident statistics. What usually happens following the completion of the accident report is that the relevant section of the report is passed to an administrative Accident Records office where the necessary statistical information is extracted. All police forces work to a common standard which is encompassed in a guidance publication known as Stats 20 (HMSO 1985). This gives definitions of what is required in order to produce the final statistical information known as Stats 19 (see appendix B.2). Batched information is sent from the police accident office via their headquarters to local authority county offices, whose staff not only use the information related to their own geographical areas, but are also part of the information processing chain. At this stage the basic data is entered into a computer, records from which are sent to the Department of Transport (DfT) on a regular basis. Finally the information collected is published in several formats, the principal one being Road Accidents in Great Britain.

6.4 Accident Reporting in Libya

In Libya traffic police employ a standardised report form in the event of an accident which results in injury or fatality. In the event of an accident resulting only in damage to property or a vehicle, this form is completed only if the parties involved fail to agree as to who was responsible for the accident. In cases of only minor vehicle damage, the completion of an even briefer note rather than a report is deemed necessary in order to meet the legal requirements that a vehicle owner must have written permission from the police before approaching a vehicle repairer to make good such damage.

The standard report form runs to four pages, but only provides for the recording of the barest details of the circumstances in which the accident took place. As a result of lack of government funding, in many cases police officers use blank sheets to write down accident reports instead of the standard accident form (shown in appendix D.3). However, the standard report form is principally designed to meet the requirements of legal proceedings which may arise from the accident, rather than the recording of information likely to be of value in accident research. Provision is thus made for the recording of the statements of those involved and witnesses together with a sketch plan and an assessment by the officer as to who or what, in his view, was responsible for causing the accident. No provision is made for the recording of the causes of injuries sustained by particular individuals involved, vehicle descriptions, or road and weather conditions.

In Libya there is no equivalent to the Great Britain Stats 19 form (Chapman 1973) onto which a summary of accident report information can be transferred for coding and later computer-based analysis. Key report information is currently abstracted monthly from individual report forms at local police stations and transferred to the Central Traffic Department of the Secretariat of the Interior in Tripoli. Here these statistics a remanually complied into a national summary. In this way much information is lost, which would be valuable if preserved intact in relation to individual accidents.

6.5 Principal Direction of Impacts

It is worth recalling that no previous study exists of Libyan vehicle accidents and injuries which might be used for comparison, so that the findings of this study are used for comparison between the two countries.

The Collision Deformity Classification (CDC) system allocates directions of impact using the twelve clock points. The system is used widely in accident analysis and investigation (Galer 1985; Harms 1991; Ashton 1985). This simplified system is used to categorise impacts in this study and to compare vehicle impact directions on Libyan and Great Britain roads. The CDC system is illustrated in appendix A.1.

A vehicle could have more than one impact in an accident. Only the direction of the most severe impact is considered in this study. Frontal impacts were the most common kind in accidents in this study (64.3% of all accidents), and in 52.3% of all accidents in Great Britain (Road Statistics G.B, 2000).

Offside impacts accounted for 12.7% of road accidents on Libyan roads, nearside impacts 12.7%, and rear impact 10.3%. Conversely, offside impacts were 13%, nearside 11% and rear side impacts 18.9% of all road accidents in G.B in 2000.

In this study 59% of accidents occurred in urban areas and 32% on motorways, and figure 6.3 shows that 78.4% of Libyan accidents were on built up road. On motorways, which are supposed to be safer roads, the proportion of car accidents was 15.9%, and non-built up roads 5.9% (M.O.I. 1996). In G.B 4% of all accidents occurred on motorways, 73% on built-up roads, and 23% on non-built-up roads (HMSO 2000). The high standard of design and safety on Great Britain highways are probably the main reasons for low accident and fatality rates on motorways.

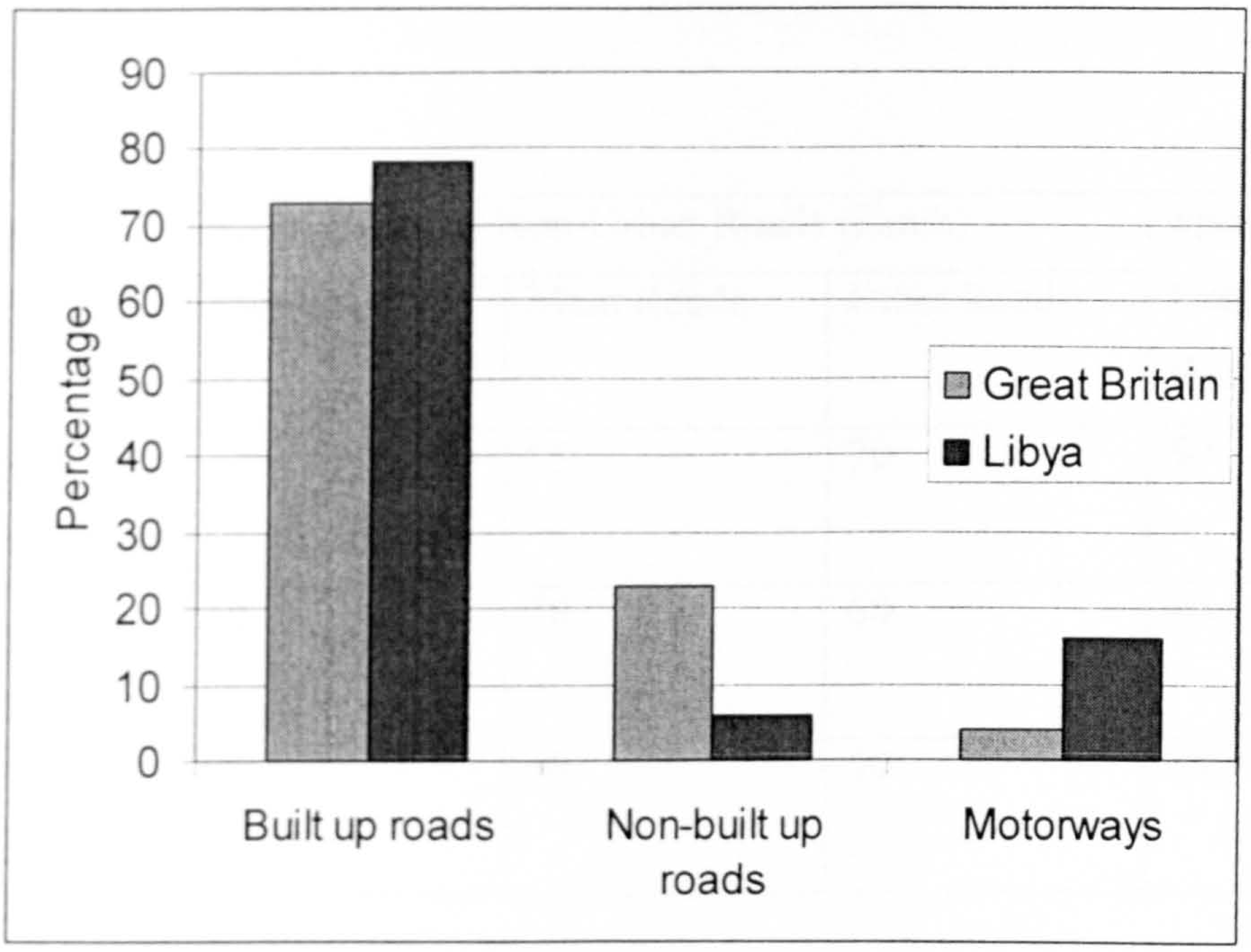


Figure 6.3 Road Accident Distribution According to Road type

6.6 Speed Limits

The Libyan authorities have set speed limits on all roads and motorways, as shown in table 6.1. Exceeding the posted speed limit is still the main cause of deaths and injuries on Libyan roads, where speeding accidents accounted for 20.6% of road accidents in Libyan (M.O.I. 1975). In this study, 71% of vehicles exceeded the speed limits on urban roads. On motorway 48% of cars exceeded the posted speed. Conversely, 66% of vehicles exceed the speed limits on G.B urban roads and 55% of cars do so on motorways (Nelson. 1979).

Vehicle	Speed Limit on Non-Urban Roads (Km/h)			Speed Limit in Urban areas (Km/h)
	Motorway	Main Roads	Other Roads	
Cars, Motorcycles	110	85	70	50
Taxis, Buses	80	70	60	40
HGVs, Tractors	65	60	50	30

Table 6.1 Speed Limits on Libyan Roads, Ministry of the Interior, Libya (2000)

6.7 Seatbelt Use

Wearing seatbelts has been the law for drivers and front seat passengers on Libyan motorways since 1986. Nonetheless, the seatbelt wearing rate is still very low. Table 6.2 displays wearing rate from Harms (1991) findings and from the present study. It is clear that seatbelt use in this study is very low (7%) compared to Great Britain's 95% (HMSO 2000). Harms (1991) found a rate of 75%, and Cuerden (1997) found 88.5% for drivers, 88.4% for FSPs and 38.3% for RSPs. Broughton (2004) noted that seatbelt usage rates appear to be lower in built up areas compared to non-built up areas.

Seating Position	Seatbelt use in this study	Seatbelt use (Harms findings)
Drivers	8.2%	75%
Front seat passengers	7%	78%
Rear seat passengers	0%	5%

Table 6.2 Percentage of Seatbelt Use: Comparison with Harms (1991) findings.

6.8 Cost of Traffic Accident Fatalities

In Great Britain the costs of traffic accidents are published yearly in detail, including the total cost of all casualties and property damage. However, few details are known about traffic accident and injuries costs in Libya. In most Libyan traffic accident studies the cost of property damage in accidents was estimated without sufficiently detailed information about fatality and injuries costs, or were estimated based on the unit accident costs derived from other developed countries. It is believed that differences in accident evaluation approaches and the different economic conditions of countries lead to different estimates.

The results of this investigation for both countries are shown in table 6.3. The derived unit costs cannot be compared directly with values derived for other countries due to the following reasons: a) differences in estimating the value of lost quality of life; b) differences in computing the loss of output; c) differences in the economic wealth of countries, d) differences in safety policies and cultural attitudes. However, for Great Britain human cost and lost output were almost 4 and 7 times respectively the Libyan costs. According to our findings, each road traffic fatality cost the Libyan government about £84,400 in 2000.

Cost elements	LB costs (£)	GB costs (£)
Lost output	49,980	329,860
Medical and ambulance	533	4070
Lost quality of life	33,300	642,060
Administration costs	90	180
Damage to property	556	6440
Total	84,400	£ 983,710

Table 6.3 Road Traffic Accident and Fatality Costs, Libya and Great Britain 2000

6.9 Health Sector Spending in Britain

The NHS was set to spend £54.2 billion in 2000-01 (6.8 of GNP), a large proportion going on hospital and community health services. The largest part of this spending goes on acute hospital treatment, and this proportion has increased from 45.1 per cent in 1988-87 to 53.5 per cent in 1997-98. Ambulance service expenditure alone was £617 million in 1997-98, which increased to reach £808 million in 2000. Most of this spending is for the training of ambulance crews in all aspects of pre-hospital emergency care, emergency care equipment such as heart defibrillators, oxygen, intravenous drips, spinal and traction splints and a variety of drugs for medical and traumatic emergencies, and on Accident and Emergency services which deal with emergencies and urgent cases. The NHS Ambulance Service is provided by 38 local ambulance services distributed throughout the regions.

6.10 Health Sector Spending in Libya

A shortage of studies about the Libyan health system and the lack of transparency of health authority spending has led to a lack of information about government spending plans for the health sector. Only one international source, the WHO (World Health Organisation), includes statistical data about the health system in Libya. From 1995 to 1998, the Libyan government spent £75,696 m (LD177, 886 m) on the health sector which is about 1 per cent of Libyan G.D.P. It is not clear how or where this money was spent. According to the WHO, the Libyan government spent 2.9 per cent of Libyan G.D.P on health services in 2001, which is considerably below the global average of 5.5 per cent (Schieber 2003). £28.2 million (LD 66 million) was spent on building new hospitals, medical centres, and new ambulances. (However, it is not clear how much the government spent on ambulance services.)

6.11 Road Death and Medical Care

Higher fatality rates in developing countries are usually attributed to lack of medical facilities (Franceline 2001). If medical attention can be given to crash victims promptly then the chance of survival is increased. Unfortunately, with very limited emergency services and a general lack of qualified medical personnel, the chance of a road crash victim receiving prompt medical attention in Libya is low. The link between the chances of being killed in a crash and level of medical services was first identified by Ghee (1997), who noted a statistically significant relationship between the fatality index and the number of doctors per head of the population.

The fatality index (FI) is usually defined as the percentage of all persons injured who actually die.

$$FI = \frac{fatalities}{totalCasualties} \times 100\ \%.$$

Fatality indices are used to evaluate health care in many countries. In countries where medical facilities are poor, the fatality index is high. Figure 6.4 shows the FI to be consistently greater in Libya in the range of 7.2 to 16.4, whilst the values for Great Britain range from 1 to 2.1.

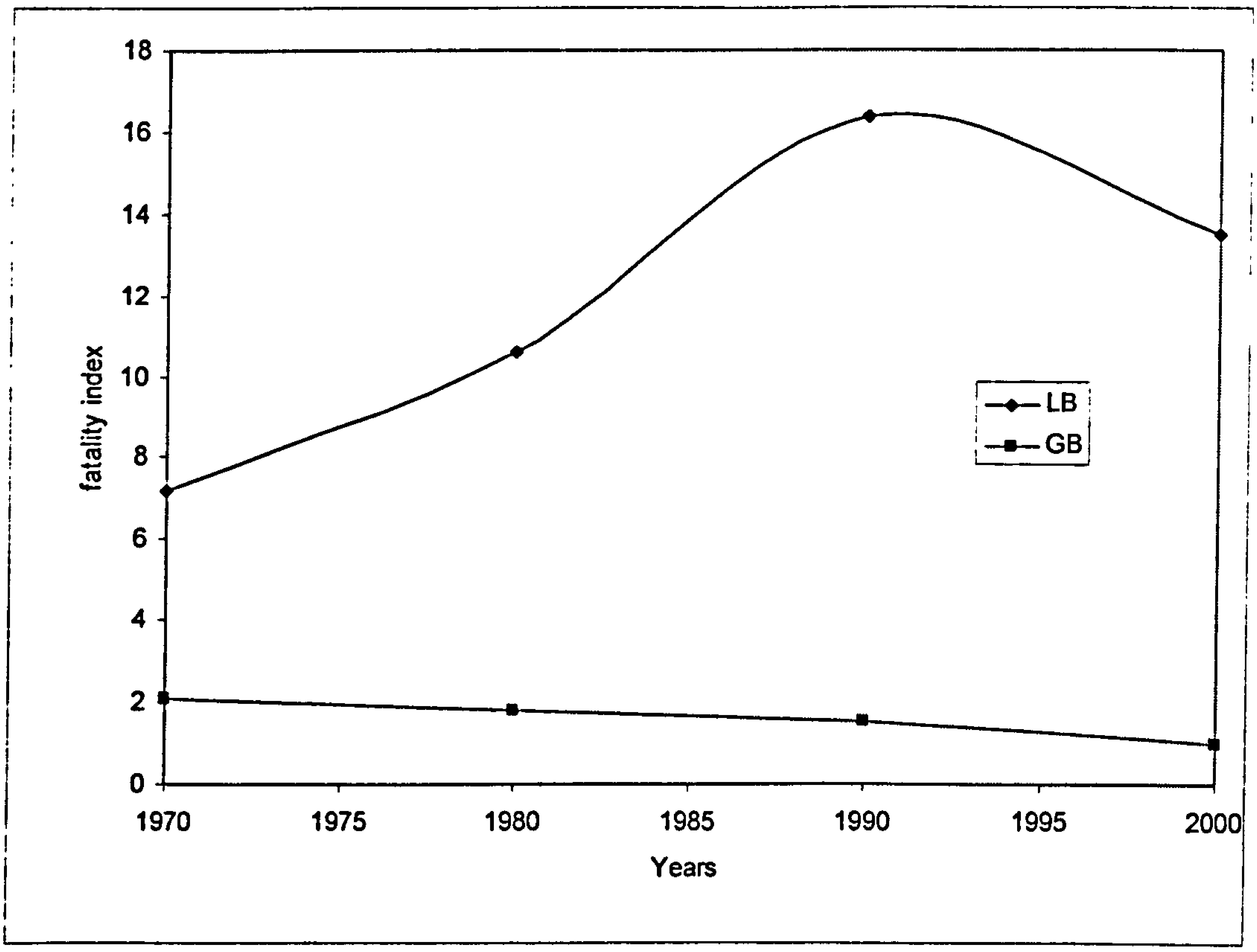


Figure 6.4 Fatality Index: Libya and Great Britain

6.12 Ambulance Services in Libya

Actually, no ambulance services operate in Libyan cities. Instead unequipped vehicles are used to transport patients from one hospital to another one or from the residence of a patient to a hospital without any pre-hospital care. This is managed separately by each hospital. Ambulance services are clearly less effective in Libya and a more flexible approach is required due to the lack of equipment, communications networks, and paramedic crews. One particular problem in Libyan cities is the congested nature of streets, which prevents those ambulances which do exist from reaching the scene of a crash quickly, and also inhibits the speedy transfer to hospital, given the unwillingness of the public to give ambulances priority.

Due to the absence of ambulance services in Libya, passers-by take injured people to hospital. Whilst praiseworthy in a moral sense, this often means that treatment is not given at the scene of the crash and no resuscitation measures are used. Indeed, the movement of victims, through well-intentioned, can worsen some injuries.

6.13 Ambulance Services in Britain

Optimal pre-hospital care by the Great Britain statutory ambulance services aims to maintain life and alleviate patient morbidity, until definitive care can be delivered in a hospital facility. Ambulance crews are highly trained in all aspects of pre-hospital emergency care, ranging from crush injuries to cardiac arrest, whilst ambulances are equipped with a wide range of emergency care equipment. The patient transport services use especially designed vehicles (usually with tail lifts) to provide high levels of comfort for patients.

NHS authorities are set a response time wherein 75% of life threatening emergencies should have an ambulance on the scene within eight minutes of the call, and 95% within 14 minutes. For rural services rates of 50% within 8 minutes and 95% within 19 minutes are expected (John 2003).

Air ambulance services were introduced in 1987, with the aim to deliver paramedic help and to provide, fast transport of patients to hospital. The average annual costs of operating an air ambulance range from £720,000 to £1.2 million, all of which has to be paid through charitable donations, as the helicopters receive no form of official funding.

6.14 Impact of Cultural Differences on Road Accidents in Libya and Britain

There is currently a lot of international agreement amongst those researching the area of road safety that the sorts of methods that have been tried in the past are limited in their effectiveness. Attempts to improve road safety can be considered to have fallen into two broad categories-the environment and behaviour.

The major area of concern remains the driver, and this is also seen as the most difficult aspect of road safety to deal with. The behaviour all approach has tended overwhelmingly to focus on driving skill. Researchers have noted, however, that driver behaviour does not change substantially through skill-based training. Such training often focuses on dealing with sudden and dangerous situations, which drivers find rarely occur in their experience.

The influence of social traditions has shaped driver behaviour in Libya. Strong relationships in extended families in some cases force drivers to travel for four and five hours to see their family members. During, religious festivals such as Al-Eiad, thousands of vehicles travel from cities to remote villages for celebrations with relatives (Shembesh 1978). As result of this, the number of the vehicles on the road may exceed the road capacity, leading to increasing numbers of accidents especially on highways and main roads. In Britain sending a greeting card for such events would traditionally be enough.

Tribe relationship between families is very strong in Libya, and in some cases the influence of the tribe may be used to excuse a traffic offender from traffic law punishment. In the event of death in accidents, drivers and the community believe that the accident was an act of god and that no one could prevent it. Same finding by Schoor's (2001). (As a consequence of this belief drivers who kill innocent victims, may be freed within a couple of months without any charges. The situation in Great

Britain is completely different, where in the event of an accident there is no influence of social tradition on the law. So no one could escape from the force of the law.

The annual income for a householder in Libya is very low compared to that in Great Britain (L.H.D 2000). Many householders in Libya were unable to buy new vehicles, as a consequence of the economic situation. Therefore many vehicles in poor mechanical condition are still running on Libyan roads. According to Schoor's (2001) finding this lead to increasing numbers of injuries and accidents on Libyan roads,

The warm climate which prevails in almost all Libyan cities might prove to have significant effects on road accidents through influencing the way people drive and walk on the streets. Intuition suggests that in warm countries people spend more time outside their houses. And since exposure to risk is the thing which matters most in accident occurrence and analysis, it is expected that the number of "person minutes" people spent on the streets in a warm country is higher than that in a cold country (Makky 1984). The concept of "person minutes" or "person meters" might explain some of the variation- especially in pedestrians' casualties-between Libya and Britain.

6.14.1 The Future

The consequences of not taking these aspects of driving in Libya seriously are of some concern. The rise in traffic infringements and the continuing high rates of crashes and fatalities on the roads indicate that the directions taken by research, the police and media campaigns are not sufficient to deal with the problem. The high incidence of crashes involving young people in Libya is alarming. Many initiatives are underway but very few have focused on the cognitive and related behavioural aspects of driving.

There is a need for some social awareness of attitudes, expectations, beliefs and assumptions and the role these play in the driving experience. This can be achieved by putting drivers through a facilitation process which enhances important aspects of thinking and brings into focus and questions some of the prevailing attitudes and beliefs. Carefully controlled media campaigns, informed by an understanding of the more social and cultural aspects of driving behaviour can also aid a greater focus on thinking and bringing into focus appropriate attitudes and beliefs.

There is a need for an overall cultural change and reflection on a bout the attitudes, expectations and beliefs of Libyan road user. Technology has brought about major changes in vehicles but drivers themselves, their expectation and attitudes and the culture of driving, have received no attention from Libyan authorities.

6.15 Discussion

The main reason for this comparison between a developing country such as Libya and the developed country Great Britain is to understand the factors which might contribute to road safety in both countries and how Great Britain's road safety measures could be adapted on Libyan roads.

In this part of the discussion, the effectiveness of road safety measures in Great Britain is assessed, and the explanation of reductions in casualty rates in Great Britain also takes account of changes in road use activity occurring in the same period. There has been a decline in the number of road casualties in Britain as a consequence of a range of safety measures introduced by a combination of governments, local authorities and private investors, and including both enforcement and management measures.

Unfortunately, in Libya there have been no clear long term strategies for road safety. Efforts to improve traffic safety usually operate for short periods of weeks or months. The overall target is to make roads safer for vehicle occupants and pedestrians, but the underlying target is to make money by issuing fines for traffic violations. It is worth mentioning that the traffic police in Libya earn their wages from fines on drivers. As a result of this, most policemen try to issue as many tickets to drivers as possible so as to receive their wages at the end of each month without any delay.

Before introducing any new traffic law, Great Britain's authorities plan long term publicity campaigns, in order to inform vehicle users and the general public. For example, the use of safety belts by car occupants developed gradually in Britain. The fitting of seat belts was made compulsory in the front seats of new cars in 1965, and successive publicity campaigns were mounted in subsequent years to educate the motoring public as to the advantages of seat belt wearing. Front seatbelt wearing was then made compulsory in 1983. Once high wearing rates had been achieved among those travelling in the front seats of vehicles, attention turned to those in the rear. Mounting points for seat belts in rear of the cars was made compulsory in 1981. In 1991 seat belt wearing by rear seat adult passengers became law. As a result of this strategy, it has been estimated that about 500 fatalities were saved in 1983 alone. The rate of seatbelt wearing by drivers and front seat passengers increased from 40% to 95% by 2000 (HMSO 2000). It is estimated that the lives saved by wearing rear seat belts in Britain in 2000 was higher than 50 fatalities (Koornstra 2002).

In Libya, seat belt wearing is compulsory on motorways and main roads. According to this study, wearing rates are very low at 7% of all vehicle occupants. El-Shtewi (1997) studied the cause of eye injuries in Libya, and found that the rate of seat belt wearing was 7% in his sample. A few studies in some low income countries have reported some successes and failures with seat belt use. Trikhopoulos et al (1998) reported that seat belt regulations did not seem to impact on traffic fatalities. In Greece, however, a comprehensive intervention campaign to increase seat belt use, even in the absence of increased law enforcement, resulted in moderate gains (Petridou 1998). Since seat belt law was implemented in Libya, no improvements have been seen in the number of casualties. This is probably due to the implementation of seat belt regulations without long term publicity campaigns introducing to the general public the benefits of using seat belts. Another factor which might have affected the seat belt rate wearing is that most Libyan vehicle occupants believe that accidents are acts of God: "if it is your time to die, you will die, so it does not matter whether you wear your seat belt" was an attitude reported by Chaudhary (2004) in the US.

The Great Britain government spent £30-50 million per year on local road safety schemes in the 1990s. This funding only represented a very small part of the total spent on roads, but the primary purpose of the remaining funds was to improve mobility and accessibility, and to maintain the structure, strength and road surface quality of the network. As a result of major funding, British governments have managed to reduce the number of individuals killed or seriously injured on the roads by 35% between 1989-1998 (Road Accident in Great Britain 1998).

Vehicle safety improvements have had significant effects on the numbers killed and injured in traffic accidents in Great Britain. Over the last two decades such improvements have produced a 15-20% reduction in occupant fatalities. About 650 fatalities have been saved in Britain, according to Koornstra's (2002) study; which argued that, between 1980 and 2000, the total fatalities saved due to long term individual safety policies were:

- Vehicle safety, seat belts: 1,200 persons.
- Local road engineering: 300 people.
- Measure related to other vulnerable road users 1,190 people.
- Estimated total fatalities saved: 3,124 persons.

Libya's population trends showed large increases in road deaths in the 1970s and early 1980s due to the increased vehicle population on the roads (114 vehicle per 1000 persons in 1975) (Makky 1984). Vasconcellos (1995) found that the increase in the number and gravity of traffic accidents was directly related to increases in the use of motorized transport, especially of private cars. Although paved road lengths in Libya were increased between 1960 and 2000 from 3,303 to 47,590 km - a change of 95% (S.C.M.T 2000) nonetheless, the numbers of road deaths and casualties still rose. Adeolu (1993) stated that because of increased numbers of vehicles on the roads, the number of road deaths increased.

Libyan government efforts to improve traffic safety have been hampered for two reasons. Firstly, long-term publicity campaigns have not been adopted when introducing new traffic laws. Secondly, transport authorities have not adopted quantitative targets for reductions of road traffic fatalities and injuries within defined future periods of time.

In the 1980s and 1990s many external and internal factors affected Libyan road traffic trends. The internal factors included the new political system introduced in Libya (Popular Congresses). As a result, many local authorities were abolished, leading to road accident data being lost, incomplete and inaccurate traffic accident data reported, and thousands of traffic officers being employed as army officers. Within this period of time the Libyan government tightened spending on all government sectors. This led to shortages of car spare parts, and an increased number of vehicles of poor mechanical condition on the roads, and as well as a collapse of public transport. The external factors included the United Nations sanctions on Libya which caused increased numbers of land journeys between Libyan cities, as well as the numbers of traffic accidents to increasing. According to a Libyan Mission report to the UN in 1996 (UN 1996), owing to the aerial embargo and the consequent increase in overland traffic, there was a rise in the number of road accidents as Libyans took to the roads linking the major cities in the country.

Urban area programmes in Britain have generally been seen as individual measures forming part of local road safety strategy in areas of high risk. In the early 1970s, several urban residential redevelopment programmes modified road networks to enhance the environmental quality of the areas, through the use of restricted access and/or rumble areas at the entrances to access roads. Traffic calming programmes, drawing heavily on the Dutch experience, were implemented by many authorities in 1992. Legislation was also established allowing the creation of 20 mph zones in residential areas, providing that roads were modified to ensure that lower speeds would be achieved. The total number of accidents recorded on roads with 20 mph speed limits was 289 in 1993 (Road Accidents in G.B, 1993). A 60% reduction was claimed; this implies that the total number of accidents that were on these roads before treatment was about 720 (Road Accidents in GB, 1999). Since 1982, an increasing number of programmes using low cost remedial measures have been implemented. The results of this programme are shown in table 6.4.

Year	Urban Roads		Rural Roads	
	Spending £ million	Accidents saved per year	Spending £ million	Accidents saved per year
1982/1983	4	600	3	600
1986/1987	4	650	3	500
1992/1993	34	1150	11	850
1996/1999	66	2700	10	800

Table 6.4 Accidents Saved though Remedial Programmes in Britain, (Downing 2000)

It is estimated that a total saving of about 285 fatalities has resulted over the period 1980-2000, and more injuries will have been saved in urban areas under this programme. About a third of these savings in fatalities are from the treatment of junction sites, a further 40% from the general improvement of road links, and 10-15% each from improvements in signing and marking at bends.

As a result of oil revenues invested in various national development schemes, the road network in Libya has grown rapidly. This was clear during the development plans of 1973-1975 and 1976-80 whereas, nonetheless, the numbers of accidents in built up areas and on motorways were still high compared to Britain. Motorway deaths in 1996 were still 25% of all road deaths (M.O.I. 1997), whereas in the same year road deaths on Britain motorways represented only 9% (HMSO 1996). This high rate of deaths on Libya motorways is due to the fact that these roads are heavily congested and precarious to navigate, especially at night and during the winter rainy season. The presence of sand deposits and domestic and wild animals frequently crossing these highways, as on rural roads, makes them even more hazardous.

Libyan national road strategy has focused on simply building more and more new roads as the answer to traffic growth, without any strategy for the future maintenance of these roads. Many accidents recorded on countryside roads are as result of the absence of traffic signs warning of potholes on main roads. The Libyan Transport Authority needs to establish routine programmes for investigating sites associated with accident problems, and to develop remedial measures.

Transportation and traffic agencies in Libya have road departments but do not have traffic safety departments. The technical expertise in designing and building roads is highly advanced, but expertise in analyzing and addressing traffic accident causes is poorly developed. As non-motorized social groups often do not have access to the decision making process, pressure comes from the well-organized, motorized groups, and the road construction sector. The built environment of roads is thought of as being of good quality, and the blame for accidents is routinely placed mainly on humans or vehicles (Whitelegg 1981).

There are a number of ways in which the form of reporting accidents in Libya can be improved to achieve standardised and modernised accident data collection. A key step towards the achievement of this important objective would be the adoption of a version of the simplified analysis form suggested by Jacobs (1973) for use in developing countries in the analysis of accidents involving personal injury. Priority should at the same time be given to the provision of facilities which would enable the data supplied in this way to be transferred to computer systems.

64.3% of all vehicle impacts were frontal. The incidence of frontal impact collisions on Libyan roads is high compared to most developed countries such as Britain. The main causes of frontal impacts on Libyan roads have been discussed in chapter four.

25.3 per cent of impacts in this study were side impacts, compared to Britain's 23.4% in 2000 (HMSO 2000). The main causes of side impacts on Libyan roads were the absence of traffic control lights at road junctions, reckless driving and poor driving skills. 28.7% of Libyan road accidents in 1996 were due to human failings and errors of judgement (M.O.I 1996). Generally speaking, numerous contributory factors increase road accident levels in Libya, such as shortages of spending on road safety, and traffic police being powerless to enforce regulations. However, the police in the capital city, Tripoli, are able to enforce the regulations which prevent vehicles without indicators or lights, or with faulty head-lamps, brakes, or poor bodywork from using public roads. Outside the main cities the police are unable to enforce such regulations.

Although the Libyan government has set speed limits on all Libyan roads, excessive speed is still the main cause of death and injuries on Libyan roads. Speeding accidents accounted for 20.7% of all accidents (Road Statistics in Libya, 1975). One report has shown that excessive or inappropriate speed helps to kill around 1,200 people annually in the UK and to injure over 100,000 more (Finch 1993). Statistical aggregate studies have demonstrated that there is a causal link between speed and accidents, which has prompted the need for lower speeds (Finch 1993; Baum 1991; O'Neill 1990). Research suggests that up to a third of all fatal road traffic accidents are speed related, and such a finding is in agreement with this study's findings.

Nonetheless a number of local authorities in Libya have applied speed measures to reduce excessive speed in urban areas, such as humps near schools, and posting speed limit signs at the sides of roads. Unfortunately, the numbers of speeding accidents are still rising. The Libyan authorities have been urged to establish a long term road safety study to specify those speed-reduction method which might be successfully applied to Libyan roads.

Speed constitutes one of the main social dilemmas on Libyan and British roads. On the one hand high speed on roads is valued and attractive; on the other hand it can kill or injure and it adds to environmental pollution. Because of these tensions, lowering speeds to acceptable levels may not be simple. The Department of Transport in Britain has managed to achieve some success by maintaining speed limits on all roads. New safety methods have been introduced, such as long term advertising campaigns. Independent research into public reactions to such an advertising campaign (eight weeks during 2001-2002) showed that the spontaneous awareness of drivers about reducing their speed increased from 57% in June to 69% in early July (TRL 2002).

Many countries have found that speed cameras have been a useful method for reducing speeding accidents. In Australia, introducing mobile cameras rotated between 2,500 sites across the country reduced vehicle speeding by three quarters and accidents by 45% (Bourne 1993). Introducing enforcement cameras obviously has a substantial effect on speeding. One report shows that, on average, the percentage of drivers exceeding the speed limit at pilot camera sites was reduced from 55% to 16%; average speed at the camera sites was reduced on average by 10 km/h (Corbett 1989). The risk of collisions at these high risk sites was expected to be reduced by 30%; and on average there were 47% fewer people killed and seriously injured at the camera sites. From this it was estimated that £27 million had been saved by the reduction of casualties and collisions at safety camera sites. There has been a decline in the number of road accidents in Great Britain, as a consequence of a range of safety measures introduced by a combination of government, local authorities and private investors, and including both enforcement and management measures. The total spending on road safety in Great Britain in 1999 was £1,232 million. The Department for Transport in Great Britain had overcome many of these problems using long term government strategy and substantial spending on road safety (over £2 million every year), as well as by identifying where the majority of these accidents took place in order to specify the proper remedy. The total estimated benefit from this spending is shown in table 6.5.

Methods	Cost (Pounds)	Reduction in accidents
Speed Cameras	8,600 per site/annum	28% (1.25 per site)
Red Light Cameras	5,600 per site/annum	18% (0.48 per site)
Traffic Calming	100,000 to 200,000 per scheme	60% in annual accident frequency

Table 6.5 Total Benefit from Spending on Road Safety in Britain (Koornstra, 2002)

Earlier, the unit cost of a fatal traffic accident had been estimated to be £84,400 (185,000 LD), which is very low compared with fatality costs derived for Great Britain (£983,710 in 1996). The difference in mean annual income between the two countries clearly has implications for the amount of lost output. Table 6.5 shows that the lost quality of life can be valued at 73% of productive capacity, and direct costs, as pointed out for Great Britain, have evaluated lost quality of life as more than twice the lost productive capacity and direct costs associated with a traffic accident fatality.

6.16 Conclusions

The starting point for improving road safety in Libya is to improve the reporting form of accidents in Libya to achieve standardised and modernised methods of accident data collection. Extending the range and improving the quality of information collected at the scene of road accidents is of fundamental importance to increasing the effectiveness of road safety research in Libya.

Establishing traffic safety departments in transportation and traffic agencies and encouraging non-government organisations to become involved in the road safety debate in Libya are also necessary. Libya's authorities must carefully evaluate which strategies might work in considering options for technology transfer, since what has been found to be effective in a high-income setting may not necessarily be effective in Libya. Before introducing any new traffic policy, cost benefit must be calculated, long term publicity campaigns must be conducted, in order to inform vehicle users and the general public.

Traffic injury intervention is crucial too. With careful analysis and synthesis of country-specific problems, as well as proper planning, Libya could import traffic injury intervention strategies developed in high-income settings such as Great Britain.

Building new roads without giving sufficient attention to road safety aspects such as, pedestrian crossings and the ambulance system will never allow good traffic accident targets to be met.

The most cause of accidents in Libya was speeding. Introducing enforcement cameras in Libya roads obviously will have a substantial effect on speeding and huge reduction of road accident costs. In Britain, it was estimated that £27 million had been saved by the reduction of casualties and collisions at safety camera sites which greater than the camera operation costs. There is a need for an overall culture change and reflection on Libya drivers' attitude, expectations and beliefs of road use. Technology has brought about major changes in vehicles but drivers themselves, their expectation and attitudes, and the culture of driving, have received no attention from Libyan authorities.

CHAPTER SEVEN

CONCLUSION AND FUTURE STUDIES

7.1 Introduction

This study's findings strongly suggest that motor vehicle accidents are probably the commonest single cause of death in Libya. Whereas in other highly motorised countries the problem has been adequately controlled resulting in a declining death toll, the situation in Libya has still not met with sufficient concern. There is ample scope for improvement in traffic safety in Libya. The observations made in this study are summarised in this section. The results relating to culture issues, vehicle occupants and their injury patterns, the causation of injuries, and pedestrian accidents and their injury severity are summarised.

7.2 Results

1. The Libyan government should improve general public transportation, and encourage the general public to use it. However, a restriction on the importation of motor vehicles is an issue worthy of consideration in reducing the volume of traffic and the car population ratio in Libya. With regards to the number of older vehicles on our roads, it might be prudent to require periodic motor vehicle inspections.

2. The high incidence of accidents involving frontal impacts and the high frequency of side impacts indicate a lack of traffic controls at road junctions, poor road layout and low driving standards. In the long term, appropriate speed limits and legal sanctions can be introduced and the Libyan Government must set up a long-term strategy of investment and education to eliminate the type of road safety problems highlighted in this study.

7.2.1 Pedestrian Accidents

1. There were small but significant differences between accidents involving different age groups crossing roads. According to the results of chi-square tests, age is a contributory factor in accidents occurring when pedestrians cross roads. There were significant differences between the numbers of children and adults, and children and elderly adults at crossing places.

2. Children aged less than 15 years accounted for 62% of pedestrians struck, adults aged 16-60 years accounted for 36.4% and elderly adults aged more than 60 years accounted for 10%. Overall, numbers of male casualties were almost double the females. Nearly 70.6% of the pedestrians were crossing roads when struck. A large proportion (61.8%) were crossing roads, and 8.8% crossing highways. A small number (5.9%) were on the pavement when struck.

3. Motorways in Libya passing through coastal cities lack protection fences or crossing bridges. Furthermore, many shops are located very close to roads. These explain the high incidence of adult pedestrians struck while crossing highways (21.7%).

4. Head and lower limb injuries dominated all pedestrian age groups. 57% of the children sustained head injuries, (41%) Legs injuries and 12% arm injuries. Leg injuries were received by 52.8% of the adults, head injuries 77.6%, and arm 62.7%. For elderly adults head injuries were received by 82%, arm injuries by 79.6%, and leg injuries by 82%.

5. 31% of children pedestrian victims sustained abdominal injuries, Most of these came from Al-Zintan city in which 40% of the vehicle population are light pickups, with very poor mechanical conditions. When pedestrians are struck by such vehicles and fall to the ground without wrap contact, the

casualties could sustain severe abdominal and chest injuries by being run over.

6. The study illustrated that children have a high involvement rate as pedestrian casualties. Although the elderly have a lower rate than children, more elderly pedestrians were severely injured. Head injuries were the commonest form of injury, closely followed by limb fractures. The most common locations for this type of accident were urban roads. The absence pedestrian's school educations, lack of crossing facilities and excessive speed on urban roads were the most common causes of accidents involving pedestrians. It is considered that improvements in crossing facilities will have a beneficial impact on accident statistics, as will supervision at school arrival and departure times. In the long term it is evident that much more drastic measures such as pre-school and in school education will be required in order to reduce the incidence of pedestrian accidents.

7. Reduced speeds in the vicinity of schools are known to be effective in reducing both the frequency and the number of accidents.

8. Central and local government in Libya have vital roles to play in the prevention of pedestrian injuries through the control and regulation of traffic, speed and driver behaviour and the design of safer environments. The following measures have all been shown to have an effect in reducing pedestrian accidents and injuries:

   - Calming, including speed bumps and 30 km/h speed zones.
   - Traffic management that encourages drivers to avoid residential streets.
   - Pedestrian crossings, parking restrictions and the provision of playgrounds all help to make the environment safer for children.
   - Reducing pedestrian and vehicle conflicts by keeping the two parties separate where possible.

- Making the car less injurious in the impact situation by eliminating stiff structures.
- Road safety education (Television, School, and Mosque) can also play a part in reducing pedestrian casualties. Drivers need to learn that reducing speed in residential areas and around schools and playgrounds will increase their chance of stopping in time and will reduce the likelihood of serious injury to and death of pedestrians.

7.2.2 Road Safety

1. The starting point for improving road safety in Libya is to improve the form of reporting of accidents in order to meet standardised and modernised accident data collection. Extending the range and improving the quality of information collected at the scene of road accidents is of fundamental importance in increasing the effectiveness of road safety research in Libya.
2. Speed constitutes one of the main social dilemmas on Libyan roads. The Libyan Government can maintain speed limits on all roads by introducing new speed measures such as speed cameras. Many countries have found that the speed camera is a good method in reducing speeding accidents, and roads can be modified to ensure that speed reductions are substantial.
3. Traffic safety departments in transportation and traffic agencies should be established, and non-government organisations encouraged to be involved in the road safety debate in Libya. Libya's authorities must carefully evaluate what might work in considering options for technology transfer, cost benefit, since what has been found to be effective in a high-income setting may not necessarily be effective in Libya. Before introducing any new traffic policy, long term publicity campaigns must be conducted, in order to inform vehicle users and the general public.
4. The Libyan government most follow low cost remedial measures in urban areas, such as the treatment of junction sites, road links, and improvements in signage and marking at bends. These have been proven to achieve great reductions in the numbers of traffic accidents and great cost benefit in Great Britain.

5. Traffic injury intervention is also crucial. With careful analysis and synthesis of country-specific problems, as well as proper planning, Libya could import traffic injury interventions and strategies developed in largely high-income settings such as Great Britain.
6. A substantial road building plan to improve standards and reduce the possibility of collisions would be beneficial.
7. Building new roads without giving attention to other road safety aspects such as pedestrian crossings and the ambulance system will mean that traffic accident targets will never be achieved.
8. Reducing vehicle speed may be one of the most effective interventions to stem traffic crashes in Libya. However, setting lower speed limits is not an effective intervention without the enforcement of traffic laws and the allocation of resources to ensure that limits are respected. According to Norwegian studies the costs of increased enforcement were estimated 6.5 times as high as the costs of police speed enforcement.
9. Regular inspection of vehicles and elimination of sharp edges could also help to prevent injuries to occupants in the event of accidents.

7.2.3 Vehicle Occupant Injury Patterns

1. The age distribution of victims in this study shows that the highest casualty rates were in the age group 15 to 46 years. This implies that the loss of life and the accompanying economic loss to the country are actually much greater than the statistical averages might suggest.

2. 57 (7%) cases were transferred to hospital by ambulance, and 630 (82%) of the victims were taken to hospital in passing private cars by unskilled personnel. In 77% of cases more than 30 minutes was spent making the journey to the hospital.

3. Seat belts were found to have been used by only 8.2% of drivers and 7% of front seat passengers. These figures are very small compared to the 95% usage rate in the U.K.

4. The data recorded indicated that none of the children who were injured were wearing seat belts. A high incidence of head and face injuries at high AIS level was noted. Most of these injuries can be prevented simply by using seatbelts.

5. Children's head injuries were the most frequent kind of injuries at the AIS 2-6 injury level. 42% of unbelted children received head injuries and these proved to be the main cause of fatalities. Most of these injuries could be prevented if children were belted.

6. The combined conclusions of many researchers investigating road traffic accident causes and the contribution of restraints in reducing the severity of injury, appear to have had little impact on the situation in Libya. Using seatbelts and children's seats for all occupants of vehicles on all Libyan roads could be a very simple and effective way of reducing the number of people killed and injured on Libyan roads.

7. Great care will need to be paid to the establishment of an effective ambulance service, staffed with trained personnel and supplied with resuscitation equipment to deal with the patient at the scene of the accident, and to continue care during transportation. In parallel with the provision of an efficient ambulance service, the methods to alert ambulance services need proper planning. As well as the use of radio callout systems from a central station to the ambulance. The provision of enough telephones accessible on roads for use by accident attendants should also be stressed. For the time being, the Libyan government should educate all drivers how to give first aid to injured persons in the event of road accidents, until new ambulance services can be established.

8. The fatality rate indicated in this study was high at 113 (15%) victims. The majority of fatalities occurred in accidents featuring front impacts, but 12 unrestrained occupants received their fatal injuries during a side impact, most of these injuries being to the victim's head. Of the fatalities involved in frontal impacts, 11 (10%) were restrained but the remaining 90 occupants (80%) were unrestrained. 54 unbelted victims received fatal head injuries and 20 received fatal chest injuries.

9. The doors, dashboard, and roof were the main causes of injuries for front seat passengers. Head/face followed by arms/shoulders were the most frequently injured body parts. Some unexpected FSPs injury causations were noted, such as the steering wheel, which mostly occurred as a result of more than one passenger sitting in one seat. This is very common among Libyan vehicle occupants.

10. Seatbelt abdominal injuries accounted for 23% of belted drivers in frontal impacts. This was most likely due to wearing Libyan traditional costume, which leads to the improper position of the seat belt. Other probable causes of abdominal injuries were sharp edges on locally-made adjacent doors.

11. According to the findings in this study, each fatal road accident in 2000 cost Libya around ≈£84,400 (0.7 of Libyan G.D.P).

12. Investing a very small percentage of G.D.P. could result in significant traffic safety improvements if spent according to an efficient and comprehensive traffic safety programme. Such a programme should put some emphasis on improving road user behaviour by education and propaganda campaigns, as well as enforcement - especially using electronic means.

However, the key factors of reduce number of accidents and injuries in Libya are introducing new speed reducing advices such as mobile speed camera, Humps, and Speed zones, Long road safety education campaign in schools and mosques.

7.3 Future studies

The characteristics identified in this study are all amenable to further research study. In fact an in-depth study to establish and consolidate the observations would be beneficial. However there are some areas of road accidents and injuries in Libya which have much to gain from an in-depth study.

1. Vehicle front and side impacts and these main causes.
2. The social and economic consequences of road accidents for Libyan society.
3. Pedestrians are the road use group who suffer most from road accidents. It would be worth studying pedestrian accidents in Libya in more detail to specify the causes and possible remedies.
4. Cost benefit analysis of road safety measures in Libya.
5. Which measures give the greatest benefits for traffic safety seen in relation to the cost of the measures?

APPENDICES

Appendix A

A.1 Vehicle Damage Configuration

The vehicle damage configuration is described by the collision Deformation Classification (CDC). The CDC is a seven-character code, used universally, for describing and communicating the essential factors of collision deformation (SAE 1985). The code is of great benefit in the selection of accidents for study meeting similar criteria.

The CDC code contains six pieces of information related to vehicle damage sustained during impact. The constituents of the code are as follows;

1 2 A B C D 3

The first two characters of the CDC code indicate the Principle Direction of Force (PDF) of the impact as experienced by the vehicle and occupants. The PDF is split into twelve 30 degree sectors as on a clock face, from 1 o'clock to 12 o'clock figure a1. The PDF of the impact is identified by super imposing the clock face on the vehicle. The clock face is aligned with the long axis of the vehicle and centre of the clock face being coincident with point of the impact to the vehicle. The PDF is not applicable to accidents such as rollover. A PDF of 00 is assigned in such accidents.

The third character of the CDC code describes the side of the vehicle most damaged by the direct force of the impact. The sides are generally described as front, back, right, left, top or bottom figure A2 . the character "X" is used to denote the situation where the damage to that vehicle is such that a particular side cannot be identified as having received a direct impact as in the case of a rollover.

The fourth character of the CDC code describes the horizontal location of the direct contact damage. The damage to the side of the car is coded with respect to the longitudinal axis while damage to the front or back of the car is coded with respect to the lateral axis figure 1c. The vehicle is split in width into 3 bands. Each band is represented by specific code (B, P, F, C, or R). where more than one of these areas has direct contact damage than addition codes (D, Y or Z) are used.

The fifth character of the CDC code describes the vertical location of damage Figure A3 . the vehicle height is split into 3 bands. Each band is represented by a specific code (G, M, L). The code M is assigned where there is damage to the vehicle which dose not involve loads directly applied to the vehicle chassis or the main structure members such as in an under-run type of collision. Where more than one area shows direct contact damage, than additional codes are used (A, E or H).

The sixth character describes the nature of the impact type figure A4. The code W is used for direct impact damage wider than 41 cm and N is used for direct impact for less than 41 cm. The code S is used when there is extensive but shallow damage along the side of the car. The code E is a special case of the narrow code where the direct damage to the corner of the vehicle is more than 10 cm and less than 41 cm.

The seventh character describes the extent of the direct contact damage in relation to the side of the vehicle, which is indicated by the relation to the side of the vehicle that is indicated by the third digit. The extent of damage is specified with respect to zones along the longitudinal, lateral, or vertical axis of the vehicle depending on the deformation figure A5 There are 9 extent zones.

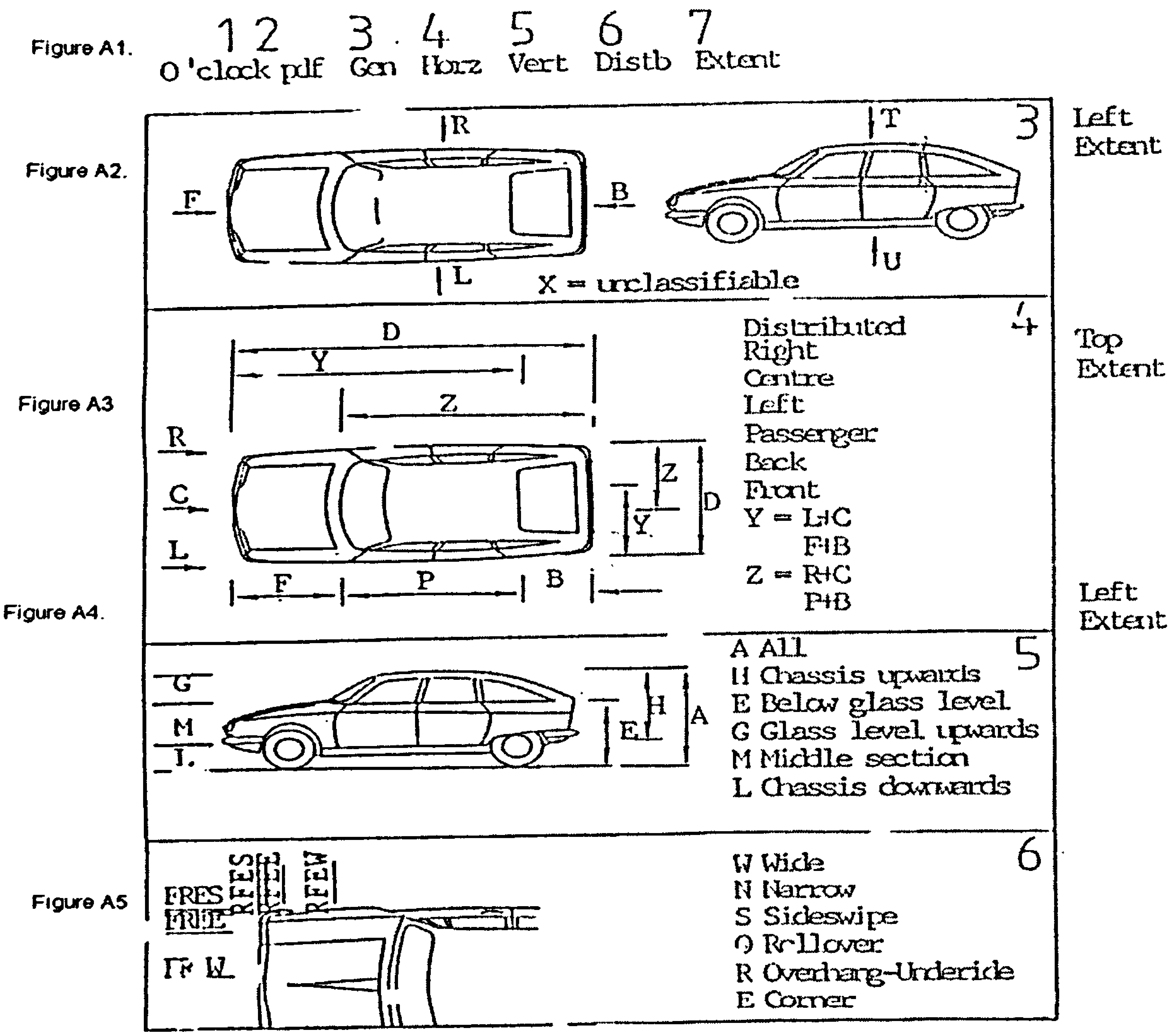


Figure A.1 Collision Deformation classification (SAE 1985).

A.2 The Abbreviated Injury Scale (AIS)

A more useful method used for classifying injury severity is the widely adopted Abbreviated Injury Scale (AIS).

The Abbreviated Injury Scale (AIS) is an anatomical scoring system first introduced in 1969. Since this time it has been revised and updated against survival so that it now provides a reasonably accurate was of ranking the severity of injury. The latest incarnation of the AIS score is the 1990 revision. The AIS is monitored by a scaling committee of the Association for the Advancement of Automotive Medicine.

Injuries are ranked on a scale of 1 to 6, with 1 being minor, 5 severe and 6 an unsurvivable injury. This represents the 'threat to life' associated with an injury and is not meant to represent a comprehensive measure of severity. The AIS is not an injury scale, in that the difference between AIS1 and AIS2 is not the same as that between AIS4 and AIS5. There are many similarities between the AIS scale and the Organ Injury Scale of the American Association for the Surgery of Trauma.

Appendix B

B.1 Chapter Three Statistical Analysis

B.1.1 Regression Analysis: Vehicles_1 versus killed_1

1966-1978

```
The regression equation is
Vehicles_1 = - 18376 + 331 killed_1

Predictor        Coef     SE Coef         T        P
Constant       -18376       27698     -0.66    0.521
killed_1       331.15       34.40      9.63    0.000

S = 43228       R-Sq = 89.4%     R-Sq(adj) = 88.4%

Analysis of Variance

Source            DF          SS          MS         F        P
Regression         1 1.73183E+11 1.73183E+11     92.68    0.000
Residual Error    11 20555286842  1868662440
Total             12 1.93738E+11

Unusual Observations
Obs   killed_1   Vehicles        Fit      SE Fit    Residual    St Resid
 13       1210     478901     382320       20521       96581       2.54R

R denotes an observation with a large standardized residual
```

B.1.2 Chi-Square Test: Vehicles_1, killed_1

```
Expected counts are printed below observed counts

     Vehicles killed_1    Total
  1     78204      306    78510
     78254.13   255.87

  2     92790      353    93143
     92839.44   303.56

  3    112557      377   112934
     1.13E+05   368.06

  4    124172      361   124533
     1.24E+05   405.86

  5    145531      423   145954
     1.45E+05   475.67

  6    166327      575   166902
     1.66E+05   543.94

  7    190000      645   190645
     1.90E+05   621.32

  8    214000      713   214713
     2.14E+05   699.76

  9    239436      985   240421
```

```
        2.40E+05   783.55

    10   278046      1081   279127
        2.78E+05   909.69

    11   340976      1159   342135
        3.41E+05  1115.04

    12   424938      1248   426186
        4.25E+05  1388.97

    13   478901      1210   480111
        4.79E+05  1564.71

 Total  2885878      9436  2895314

 Chi-Sq =   0.032 +   9.822 +
            0.026 +   8.053 +
            0.001 +   0.217 +
            0.016 +   4.958 +
            0.019 +   5.833 +
            0.006 +   1.773 +
            0.003 +   0.902 +
            0.001 +   0.250 +
            0.169 +  51.795 +
            0.105 +  32.260 +
            0.006 +   1.733 +
            0.047 +  14.307 +
            0.263 +  80.411 = 213.008
DF = 12, P-Value = 0.000
```

B.1.3 Regression Analysis: Number of Vehicles Versus Injured Persons

```
The regression equation is
Vehicles_1 = - 60640 + 32.9 Injured_1

Predictor          Coef      SE Coef          T        P
Constant         -60640        42119      -1.44    0.178
Injured_         32.910        4.566       7.21    0.000

S = 55472         R-Sq = 82.5%      R-Sq(adj) = 80.9%

Analysis of Variance

Source            DF           SS           MS         F        P
Regression         1  1.59889E+11  1.59889E+11     51.96    0.000
Residual Error    11  33848978160   3077179833
Total             12  1.93738E+11
```

B.1.4 Chapter Three Regression Analysis: Population Versus killed_1

1966-1978

```
The regression equation is
Popul. = 1549 + 0.897 killed_1

Predictor          Coef      SE Coef          T        P
Constant        1548.81        54.02      28.67    0.000
killed_1        0.89736      0.06709      13.37    0.000
```

```
S = 84.31        R-Sq = 94.2%     R-Sq(adj) = 93.7%

Analysis of Variance

Source            DF        SS         MS        F       P
Regression         1   1271670    1271670   178.89   0.000
Residual Error    11     78196       7109
Total             12   1349866
```

B.1.5 Chapter Three Regression Analysis: Population Versus Number of Injured Persons.

1966-1978

```
The regression equation is
Popul. = 1400 + 0.0932 Injured_1

Predictor        Coef     SE Coef          T        P
Constant      1399.75       59.49      23.53    0.000
Injured_     0.093202    0.006449      14.45    0.000

S = 78.35        R-Sq = 95.0%     R-Sq(adj) = 94.5%

Analysis of Variance

Source            DF        SS         MS        F       P
Regression         1   1282332    1282332   208.87   0.000
Residual Error    11     67533       6139
Total             12   1349866
```

B.1.6 Chi-Square Test: Population (thousands), killed

1966-1978

```
Expected counts are printed below observed counts

    Populati    killed    Total
 1      1703       306     2009
     1521.66    487.34

 2      1776       353     2129
     1612.55    516.45

 3      1853       377     2230
     1689.04    540.96

 4      1934       361     2295
     1738.28    556.72

 5      2017       423     2440
     1848.10    591.90

 6      2105       575     2680
     2029.88    650.12

 7      2196       645     2841
     2151.83    689.17

 8      2291       713     3004
     2275.29    728.71
```

9	2390	985	3375
	2556.29	818.71	
10	2430	1081	3511
	2659.30	851.70	
11	2530	1159	3689
	2794.12	894.88	
12	2634	1248	3882
	2940.30	941.70	
13	2743	1210	3953
	2994.08	958.92	
14	2856	1171	4027
	3050.13	976.87	
15	2910	1266	4176
	3162.98	1013.02	
16	3004	1418	4422
	3349.31	1072.69	
17	3102	1296	4398
	3331.13	1066.87	
18	3167	1125	4292
	3250.84	1041.16	
19	3231	1070	4301
	3257.66	1043.34	
20	3323	1050	4373
	3312.19	1060.81	
21	3416	1020	4436
	3359.91	1076.09	
22	3513	963	4476
	3390.21	1085.79	
23	3613	1007	4620
	3499.28	1120.72	
24	3715	1925	5640
	4271.84	1368.16	
25	3821	1312	5133
	3887.83	1245.17	
26	3929	1279	5208
	3944.64	1263.36	
27	4041	1435	5476
	4147.63	1328.37	
28	4155	1440	5595
	4237.76	1357.24	
29	4273	998	5271
	3992.36	1278.64	
30	4394	1071	5465
	4139.30	1325.70	
31	4648	927	5575
	4222.61	1352.39	

```
   32     4648      1119      5767
       4368.04   1398.96

   33     4772      1224      5996
       4541.49   1454.51

   34     4958      1204      6162
       4667.22   1494.78

   35     5125      1504      6629
       5020.93   1608.07

Total   113216     36260    149476

Chi-Sq = 21.612 + 67.480 +
         16.568 + 51.732 +
         15.915 + 49.692 +
         22.038 + 68.809 +
         15.435 + 48.195 +
          2.780 +  8.679 +
          0.907 +  2.831 +
          0.109 +  0.339 +
         10.817 + 33.776 +
         19.771 + 61.733 +
         24.966 + 77.954 +
         31.909 + 99.629 +
         21.055 + 65.741 +
         12.355 + 38.578 +
         20.234 + 63.178 +
         35.601 +111.157 +
         15.761 + 49.210 +
          2.162 +  6.752 +
          0.218 +  0.681 +
          0.035 +  0.110 +
          0.936 +  2.923 +
          4.447 + 13.886 +
          3.696 + 11.540 +
         72.586 +226.638 +
          1.149 +  3.587 +
          0.062 +  0.194 +
          2.741 +  8.559 +
          1.616 +  5.047 +
         19.728 + 61.597 +
         15.673 + 48.936 +
         42.854 +133.804 +
         17.944 + 56.027 +
         11.700 + 36.532 +
         18.117 + 56.566 +
          2.157 +  6.735 = 2084.480
DF = 34, P-Value = 0.000
```

B.2 Statistical Analysis, Chapter Four

Chi-Square Test, Speed at Urban and Motor

```
Expected counts are printed below observed counts

        Urban     Motor     Total
   1       65         8        73
        39.22     33.78

   2       47        16        63
```

	33.85	29.15	
3	19	10	29
	15.58	13.42	
4	22	10	32
	17.19	14.81	
5	10	10	20
	10.74	9.26	
6	20	40	60
	32.23	27.77	
7	12	3	15
	8.06	6.94	
8	1	42	43
	23.10	19.90	
9	2	6	8
	4.30	3.70	
10	20	50	70
	37.61	32.39	
11	20	10	30
	16.12	13.88	
Total	238	205	443

```
Chi-Sq = 16.947 + 19.676 +
          5.112 +  5.935 +
          0.751 +  0.872 +
          1.345 +  1.561 +
          0.052 +  0.060 +
          4.644 +  5.391 +
          1.928 +  2.238 +
         21.145 + 24.549 +
          1.229 +  1.426 +
          8.243 +  9.570 +
          0.935 +  1.086 = 134.693
DF = 10, P-Value = 0.000
2 cells with expected counts less than 5.0
```

B2.1 Chapter four relation between injury severity and age

Chi-Square Test: Age 0-14, Age 15-59

Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

	Age 0-14	Age 15-59	Total
1	13	300	313
	22.15	290.85	
	3.779	0.288	
2	12	167	179
	12.67	166.33	
	0.035	0.003	
3	7	61	68
	4.81	63.19	
	0.995	0.076	

```
    4          9          64      73
            5.17       67.83
           2.846       0.217

    5         12         104     116
            8.21      107.79
           1.752       0.133

Total         53         696     749

Chi-Sq = 10.123, DF = 4, P-Value = 0.038
1 cells with expected counts less than 5.
```

Chi-Square Test: Age 0-14, >60

```
Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

       Age 0-14     >60  Total
    1        13      13     26
          15.66   10.34
          0.452   0.684

    2        12       8     20
          12.05    7.95
          0.000   0.000

    3         7       1      8
           4.82    3.18
          0.988   1.496

    4         9       4     13
           7.83    5.17
          0.175   0.265

    5        12       9     21
          12.65    8.35
          0.033   0.050

Total        53      35     88

Chi-Sq = 4.143, DF = 4, P-Value = 0.387
2 cells with expected counts less than 5.
```

Chi-Square Test: Age 15-59, >60

```
Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

       Age 15-59    >60  Total
    1        300     13    313
          298.01  14.99
           0.013  0.263

    2        167      8    175
          166.62   8.38
           0.001  0.017

    3         61      1     62
           59.03   2.97
           0.066  1.305

    4         64      4     68
           64.74   3.26
```

```
          0.009   0.170

    5       104       9     113
          107.59    5.41
           0.120   2.382

Total       696      35     731

Chi-Sq = 4.346, DF = 4, P-Value = 0.361
2 cells with expected counts less than 5.
```

```
Welcome to Minitab, press F1 for help.
Retrieving project from file: H:\ch4 MINITAB.MPJ
```

B.2.2 Chi-Square Test: Head Belted Dr, Head Unbelted Dr

```
Expected counts are printed below observed counts

      Head Bel Head UnB.    Total
    1        6       35       41
          4.76    36.24

    2        5       19       24
          2.79    21.21

    3        3       14       17
          1.97    15.03

    4        2       19       21
          2.44    18.56

    5        2       50       52
          6.04    45.96

Total       18      137      155

Chi-Sq =  0.322 +  0.042 +
          1.757 +  0.231 +
          0.533 +  0.070 +
          0.079 +  0.010 +
          2.701 +  0.355 = 6.101
DF = 4, P-Value = 0.192
4 cells with expected counts less than 5.0
```

B.2.3 Chi-Square Test: Belted and Unbelted FSPs, Facial Injuries .

```
Expected counts are printed below observed counts

      Face fsp face Fsp    Total
    1       29        4       33
         25.47     7.53

    2       11        4       15
         11.58     3.42

    3        4        5        9
```

```
         6.95     2.05

Total       44       13       57

Chi-Sq =  0.488 +  1.652 +
          0.029 +  0.098 +
          1.250 +  4.232 = 7.750
DF = 2, P-Value = 0.021
2 cells with expected counts less than 5.0
```

B.2.4 Chi-Square Test: Belted driver, Chest Injuries (Frontal impacts), Unbelted Driver Chest Injuries (Frontal impacts)

```
Expected counts are printed below observed counts

      Driver(F Driver (    Total
    1        5       27       32
          4.95    27.05

    2        5       16       21
          3.25    17.75

    3        1       13       14
          2.17    11.83

    4        1        6        7
          1.08     5.92

    5        1        9       10
          1.55     8.45

Total       13       71       84

Chi-Sq =  0.000 +  0.000 +
          0.942 +  0.173 +
          0.628 +  0.115 +
          0.006 +  0.001 +
          0.194 +  0.035 = 2.095
DF = 4, P-Value = 0.718
5 cells with expected counts less than 5.0
```

B.2.5 Chi-Square Test: Vehicle Occupants Male, Female

```
Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

      Pas M  Pas. F  Total
    1    34      12     46
      29.80   16.20
      0.593   1.090

    2   120      53    173
     112.06   60.94
      0.562   1.034

    3    51      40     91
      58.95   32.05
```

	1.071	1.970	
4	5	8	13
	8.42	4.58	
	1.390	2.556	
5	7	5	12
	7.77	4.23	
	0.077	0.141	
Total	217	118	335

Chi-Sq = 10.484, DF = 4, P-Value = 0.033
2 cells with expected counts less than 5.

Appendix C

C.1 Lessons to be learnt from Accident Experiences and Remedies in Developed Countries (with Particular References to the U.K.)

C.1. Introduction

The main concerns of this chapter are firstly to provide an understanding of the nature and causes of road accidents in developed countries like the U.K, and secondly to see what lessons can be learnt to help reduce accidents in developing countries, especially Libya.

For a long time, road accidents were a major problem in developed countries and substantial sums of money have been spent on trying to contain this problem. Now, a similar situation is arising in the developing countries. Due to the recent increase in motorization in many of them, road accidents have become a serious problem. This has led to an increase in the number of countries turning to developed countries for advice in combating their road safety problems.
However, there are difficulties in transferring road safety experience gained in developed counties straight to developing countries. Although experience from developed countries can provide guidance, it is clear from different studied, that caution is needed in applying them in developing countries. Therefore, any counter - measure evaluation should be carefully considered by developing countries in relation to their own accident experience, and to do this does require a good, practical accident recording and analysis system.

C.2 Safety

Of all the influence which the motor vehicles has on the environment, one that should be put first and foremost. To be safe, to feel safe at all times, to have no serious anxiety that husbands, wives or children will be involved in a traffic accident, was surely a fundamental right that every body should enjoy. However, the conditions in towns, resulting from the use of motor vehicles, obviously leave a great deal to be desired. There are virtually no urban streets that are completely safe. In the past, even in the developed countries residential streets contained few car owners and the only traffic was the occasional delivery lorry or van, but now domestic deliveries are made by motor vehicles and many residents are car owners. Theses changes have resulted in continuous movement of vehicles up and down residential streets. In many areas the majority of residents do not have private garages; hence cars stand in the streets and create additional hazards. As main roads have become congested with traffic, drivers have sought alternative routes, including many streets quite unsuitable for the purpose. Some of these infiltrations were taken by drivers on their own initiative, in other cases it has been the result of official policies for speeding up the movement of traffic with consequential damage to road safety. The main safety hazards in Libya however, occur for rather different reasons.

C.3 Road Safety Administration in the U.K.

In the UK road safety is administered through the allocation of various responsibilities to different governmental bodies. The central Government is responsible for passing legislation and regulations setting engineering standards for roads and vehicles, distribution of information nationwide and policy decisions involving priories both for research and practice.

The Department of Transport covers legislation concerning drunken driving, seat belt wearing, driver and vehicle licensing, construction and use of vehicles, and setting standards for highway design and use. Vehicle standard requirements depend on international agreements and must relate to the European Economic Community (E.E.C) guidance instructions. The Home Office is responsible for developing equipment for use by police, such as breath testers, speed meters, etc. The Health Departments are concerned with looking after the injured and alcohol abuse. The Education Department has an interest in road safety education in schools.

The department of Transport's research wing, the Transport and Road Research Laboratory (TRRL) is responsible for most research on road safety and this programme of research is reviewed annually. The direction of research has been influenced by a periodic review of accident factor. Sabey (1976) reported this at the Traffic Safety Research Seminar in 1976. This particular study had widespread implications for subsequent activities in research and practice in the UK. A number of organisations outside the Government play a major part in improving road safety, such as the Royal Society for the Prevention of Accidents (ROSPA); RAC , SAE, and AA; other Motoring Organization; Cyclist Association; Motorcycle Safety Association; the Medical Commission on Accident Prevention; and the Universities.

C.4 Road Safety Activities Adopted in the UK

The UK statistics indicate that, overall, there has been a steady decline in road accident rates over the last two decades, despite the increase in the number of vehicles. It is therefore of interest to see what major steps were taken during this period which had an influence on the record.

1- A national maximum speed limit was introduced in 1965 and the level was set at 70 miles per hour. At the present time it is 60 miles per hour for single carriageways, and 70 miles per hour for dual carriageways and motorways.

2- The 1967 Road Safety Act set a legal limit of 80mg/100ml alcohol in the driver's blood. In the 70's an upsurge in activities stared in all field to improve road safety.

3-By 1974, remedial measures were introduced to meet the fuel shortage (speed limits, shorter working week, lighting cuts), this had side effects beneficial towards road safety for a short term.

4-Between 1973 and 1982, an addition 1000km of Motorways were constructed.

5-1983: seat belt wearing becomes law for drivers and front seat passengers.

6- In 1989seat belt wearing by rear child passengers becomes law in cars.

7- Seat belt wearing by rear adult passengers became law in cars in 1991 where belts are fitted and available.

Publicity and information campaigns at national and local levels were followed. Vehicle safety was advanced by a programme of improvement in design concerned with mitigating injury severity from impacts both inside and outside the vehicle. Special consideration was given to the construction and use regulations related to types, brakes and vehicle lights. The 1981 Transport Act (HMSO 1981) introduced important legislative measures related to three major issues: wearing of seat belts, drinking and driving, and motor rider testing.

Another body which has a strong interest in road safety is the Institution of Highways and transportation. The Institution has produced guideline for accident reduction and prevention in relation to highway engineering. These guidelines were based on experience of highway authorities nationwide, together with the TRRL procedures for accident investigation. The Institution recommended that the overall policy objectives for improving safety on all roads should be:

A-The application of low cost measures on existing roads as a basis for accident reduction.

B- The application of safety principles in the provision, improvement and maintenance of road as means of accident prevention.

The guidelines set out data processing procedures for identifying hazardous locations, diagnosing problems and identifying low cost remedies. These are based on investigative approaches that deal not only with single sites, but also with route and area problems. Courses on accident investigations for engineers and technicians, together with the production by the Department of Transport of a working manual on accident severity have also helped to advance recommended practice over the last decade. In Libya the major obstacle to adopt and implement similar steps as the UK in the shortage of trained and specialized personnel in respect of all these activities.

C.5 Education, Publicity and Training in Schools

Another important feature of the UK road safety effort is in school training. Police, teachers and road safety experts have all been involved in traffic safety education in schools. The local highway authority appoints Road Safety officers who have the responsibility for promoting road safety education. They have the task of persuading teachers of the varies from one region to another. However, to promote further awareness of the need for traffic education in schools, a review of traffic education has been stared in the UK. It includes assessing the extent and strategies being used, the roles of teachers, RSO's, police. The aim is to produce recommendations for improving road safety education. Road craft training in schools concentrates on pedal cycle training to 9-11 years olds. Such training has been found to result in large improvements in cycling behaviour.

C.6 Accidents to Elderly Pedestrians

An increasing problem in Britain was that of accidents among elderly pedestrians. The main reason behind it was their slower response to change in traffic situations and in some cases uncertainty about the operation of new traffic control equipments, such as , light control crossings, pelican and mini roundabouts. There is an educational problem in that there is difficulty of getting access to the elderly. Many research programmes aimed at informing both pedestrians and road users of hazards particularly relevant to the elderly.

C.7 Transport, Health and Activities.

Health and Transport bodies in the UK had strong links between them for many years, and this has played an important part in research into safety aspects of vehicle design and usage.

Hospital studies linked to police reports of accident circumstances and assessments of vehicle crash severity have led to important findings such as: seat belt effectiveness; occupant protection; injury in relation to crash severity and human tolerance; front end design of vehicles to mitigate pedestrian injury, trucks to have special designs to reduce severity; and incidence of accidents involving vehicles. The stress was on health authorities to play a greater role in accident prevention and that links with transport organizations be extended particularly in areas where health can increase transport activities, such as:

1- Health education amongst young children and elderly who are more accessible to health than to transport authorities.

2- Monitoring drink driving problems and the establishment of criteria for high risk drinking drivers

3-Understanding social and economic aspects of injury from road accidents in relation to the long term effects.

4- Setting up joint working parties with the Institution of Highways and Transportation to explore:

a- The establishment of data links between police and hospital road accident records.

b- Awareness of road design and environment which influence road users behaviour and performance.

The first is closely linked with TRRL research study which has shown the feasibility of computer matching of police and hospital records. In Libya a greater coordination between the health services and other emergency services of the police and traffic department is needed.

C.8 Transport and Health Data Computer Linkage

It has been recognized in the UK for some years that the National Road Accident Statistics based on police reports need to be enhanced by the addition of clinical information on the nature and severity of the injury (Hobbs 1979). The limitation of serious and slight as the only descriptive of injury denies proper assessment of road safety measures. This relates especially: to the effectives of wearing crash helmets, seat belt wearing; and vehicle and road engineering protective devices.
Hospital records in the UK are computerised and they have on record the clinical nature of injury in the form of International Classification of Diseases (ICD) code, feasibility studies of the police and hospital data (Nicholl, 1980; Stone,1984) in order to enhance the police accident records, which contain detailed information on accident circumstances, vehicle involvements and casualties, together with additional information on length of stay. Also, by translating the complex ICD code into the simplified Abbreviated Injury Scale (AIS) (Hills, 1981), related to seven levels of injury and six anatomical locations, a much data set was obtained which was amenable to meaningful analysis to establish patterns of injury for different road

users, of different ages and sexes, in different type of impact, under different accident circumstances. This level of sophistication will be attainable in Libya if computerization drive takes hold in the departments concerned.

C.9 Legislative Measures

Two important new legislative measures have been introduced in the UK as a consequence of the UK as a consequence of the 1981 Transport Act (HMSO, 1981):

1-the wearing of belts by front seat occupants of cars become compulsory by January 1983, the law is extended to make it compulsory for adults and children to belt up in the back in 1991.

2- The introduction and use of breath test device for evidential purposes in 1983.

These measures led to short and long term influences. The short term ones were:

1. Development of a systematic programme of application of low cost road engineering measures.
2. Increase seat belt wearing.
3. Strengthening of the law on drink driving through simplified procedures for enforcement and enhanced publicity.

The long influences expected are:

1. Development of a comprehensive program of traffic education for children.
2. Encouragement of more and better training for car drivers and motorcycle riders.

The short term influences are well established with some indication of a consequent reduction in accidents and injuries. The long term measures are being pursued and will take some years before benefits can be evaluated.

C.9.1 Primary Issues

In the light of recent development in the UK, the current state of art, and the potential for savings, the primary issues which need to be addressed in Libya in the future can be considered in the three categories.

1- Continuing basis for monitoring and evaluation.

a- development of a more broadly based accident system linking health and transport data to provide a better means of determining road safety priorities.

b- Evaluation of the effects of legislation to introduce compulsory seat belt wearing.

2- Engineering and Education.

a- A sustained programme of accident reduction through application of low cost engineering measures, extending the practice to area- wide scheme.

b- Evaluation of the effects of legislation to introduce compulsory wearing of seat belts, motor vehicle test requirements, in parallel with continuing campaigns to promote awareness of the importance of these measures.

c- Development of traffic safety education programme with special emphasis on pre-school children and the elderly.

C.10 Planning and Design Standard in Developed Countries

As a result of many years of detailed accident analysis in developing countries it has become clear that careful planning and design of highways can have a great effect upon the level of road safety within a country.

The layout of roads in residential areas has for example been found to have a major impact upon the level of pedestrian accidents and their safety (Highway Safety, 1981). In the UK, residential roads and footpaths embodied many of the safety principles that have been developed. The most important of these are:

a- Family dwelling should be located on roads closed at one end or short loops.

b- Continuous pedestrian and traffic routes and direct access to dwellings should be avoided where two way peak traffic flows are likely to be in the region of 300 vehicles per hour or more.

The layout arrangements should be self enforcing, minimising opportunities for poor driver behaviour. Vehicles turning into or out of shops, factories and dwellings along major traffic routes could cause accidents, a further planning principle that has developed was that access to such buildings should either be from a service road between the buildings and the major road, or at the back of the buildings via minor roads (HMSO, 1977)

A number of principles of both planning and design involve little additional expenditure if incorporated at the planning stage and therefore should be relevant to developing countries. Correction of safety problems at a later stage can be considerably more expensive. Developing countries thus have an opportunity to avoid some of the mistakes made by developed countries.

C.11 Financial Consideration

The papers presented at an OECD symposium on geometric design standard reflected the increasing impact of economic restriction in many developed countries. The following was perhaps the key conclusion of the meeting (Department of Transport ,1980).

An important issue discussed throughout the Symposium was to what extent a prevailing economic trend should influence road design standards. On this subject the Symposium agreed that in view of the long service life expected from road investment, geometric road design standards should not be compromised by short term adverse economic conditions. This does not mean that efforts aimed at standards can increase the cost of road construction, but this is not always the case. Tarragin (1972) found that European design engineers expressed the view that better standards do not necessarily cost more money.

C.12 High design Standards in Developing Countries

Jacobs (1976) has investigated the relationship between standards of rural highway design and accident rates in developing countries and has established correlations between personal injury accident rates and certain geometric design characteristics. A multiple regression analysis showed that accident rates in Kenya were directly related to the number of junctions per Km and horizontal curvature expressed in degrees per Km, and in Jamaica to the number of junctions/Km and road width. Jacobs and Sayer (1977) have also examined the relationship between monthly accident rates, monthly rainfall and skid resistance in selected urban areas in developing countries. With regard to night driving conditions, Jacobs observed that in cities like Bankok and Nairobi, there was no street lighting or pavements in residential areas. Early research in the UK found that installation of good street lighting reduced night time accidents by average of 30 %, a figure still used in evaluating the costs and benefits of street lighting. However, in view of the major differences in physical conditions and road user behaviour, it is possible that very different figures may apply in some developing countries. Both Jacobs and Fourance (1977) have produced evidence that two wheeled vehicles are very vulnerable in developing countries.

Therefore, in those countries, motorcycle/cycle lanes or routes should be given a higher priority than has the case in the USA and UK. Many continental European countries such as France and Denemark, have broad continuous white lines to delineate cycle lane on each side of urban roads. The main problem in building new roads in developing countries where resources are limited is to decide where to strike the balance between the number and length of roads that are to be built and the standard to be adopted for these roads. Mclean (1978) stated that developing countries should not adopt standards employed in developed countries, but should develop and adopt standards that are appropriate to their own circumstances. He considered, as an example, the design of low cost roads on which high speed passenger cars are a minor proportion of the total traffic. He suggested that for such roads the alignment standards should be reduced, but their should be no reduction in the with of shoulders, as these can be used by pedestrians and cyclists similar to footpaths. Therefore, with different road user mixes, different standards could be appropriate. It is possible that with appropriate low cost safety devices, safety levels could be kept high on low cost roads. The cost effectiveness and life expectancy on these roads of signs, chevron boards on bends, guide posts and the refectorisation of hazards such as bridge or culvert parapets would appear to be an important area of research.

C.12 Remedial Measures of Highway Engineering

It is evident in the UK and USA that the combination of detailed local investigation together with low cost engineering remedial measures can be highly cost effective. With the emphasis on low cost and high effectiveness the experience gained is relevant to developing countries. Jorgensen and Westat (1966) have pointed out that high benefit cost ratios are obtained from spot improvements as compared with continuous widening or modernisation projects. Their data suggested to them that low cost project yield the greatest safety benefit per dollar expended. Local authorities in the UK have their own accident investigation teams with the general emphasis on low cost engineering remedial measures. The US Department of Transport (1978) in its recent review of their highway Safety programme found that there has been a general move towards the identification and correction of hazards at individual sites as opposed to system wide or blanket improvements. However, it drew attention to the need for the full range of improvement types in addition to high accident locations. Current thinking in the UK also stressed the need for multiple approaches to accident investigations and counter measures (Department of Environment, 1974, 1974; Highway safety, 1981)) and draws attention to the following points:
Black-spots- specific high risk locations.
Black-sites – high risk short road lengths.
Mass Action – (multiple Sites) sites with a common type of accident with known remedial measures.
Route Analysis- Longer lengths of road on which more accidents occur than is the normal case for that type of road.
Area Action- areas of high risk.

Generally it has been found that the treatment of black-spots only reduces accidents by 10% but adopting a multiple approach to a sample of black-spots, the reduction was by 20%. For each approach the emphasis in on low cost remedial measures.

C.13 Measures to Improve Pedestrian Safety

Pedestrians accidents are the major concern in both developed and developing countries, particularly in the latter. There are numerous engineering measures available to improve pedestrian safety and there are various safety facilities available for pedestrian Department of Transport, (DOT 1980)). Jacobs (1976) has found that, in relation to the UK experience:

a) When practical, the segregation of pedestrians and motor vehicles is the most effective counter measure possible.

b) Limiting the access of vehicles to predominantly pedestrian areas has been found to be extremely effective from the safety point of view.

c) Light controlled pedestrian crossings have been found to be the safest form of at grade crossing. It is, however, important that pedestrian waiting times are not too long.

d) Numerous studies (Hills 1981) indicate that high risk areas occur in the vicinity of pedestrian crossings. Jacobs (1967) advocates that trials should be undertaken to evaluate the effectiveness of prohibiting parking and overtaking within 20 metres of the crossing.

e) Simplification of the crossing task should be an important objective. Such measures include central refuges and media strips, and possible the introduction of one way streets (one way traffic has generally been effective in improving pedestrian safety even when traffic flows have increased).

f) Street lighting and special lighting at pedestrian crossings improves safety.

g) Measures to reduce speed at vicinities such as schools are effective in reducing both the frequency and the number of accidents.

These conclusions are, however, based on experience in a developed country and the priorities they suggest may not necessarily apply in some developing countries. Recent observations of road user behaviour in developing countries have shown for example that pedestrian crossings are given little respect by drivers in those countries.

C.15 Pedestrian Safety Measures in Developing Countries

Pedestrian fatalities form a high percentage of all road fatalities in developing countries. Jacobs and Fouracre (1977) have previously drawn attention to the high proportion of pedestrian casualties in the third world. There were a number of reasons for these high levels of pedestrian casualties. Among the most commonly quoted were poor road users behaviour; the max of traffic and lack of segregation; speed of vehicles and poor design and maintenance of pedestrian facilities such as pavements.

C.16 Measures for a Safe Vehicle

These are discussed under three groups: vehicle design; inspection and maintenance; seat belts.

C.16.1 Vehicle Design

Improvements in vehicle design have contributed to the reduction of both the incidence of accidents and the consequence of accidents. Recently the design of safe vehicles has been adopted by the International Experimental safety Vehicle Programme, sponsored by the US Department of Transportation (DOT 1976). It was suggested that presently the most promising areas of improvement are anti lock brackets, safety tyres and future occupant protection measures. Analysis are being used to identify features in vehicle design can be expensive to incorporate. The extent to which Libya could affect road safety through vehicle engineering will depend upon local circumstances. If Libya entirely rely upon the import of vehicles, their method of influence would be the use of import controls. But if vehicles are assembled locally, more direct involvement was possible. For some of the developing countries that have their own local manufactures, the possibility for improved road safety, together with better vehicle engineering could be given greater consideration.

Motor vehicles manufacturers should seriously think of safety fittings, together with better quality sheet metal for the body and accessories. The design of heavy goods vehicles (HGV) has been of increasing significance to road safety. Although there have been improvements recently in the UK, the HGV fatality accidents are still twice that of cars (Nelson. 1979). Therefore, further improvements in HGV accidents can be achieved through improvements in, wet road grip, braking system performance, loading and securing techniques, design affecting roll over and compatibility with other vehicles.

C.16.2 Inspection and Maintenance

In developing countries, maintenance and inspection standards appear to be comparatively poor. While it does appear that vehicle testing results in an improvement of the standard of maintenance of the vehicles inspected, it has been found difficult to establish if this also reduced accident rates. Symons (1975) in their study have concluded that the numerous problems involved, the effect of motor vehicle inspection programmes remain elusive. An NHTSA study by (Salinger 1972), on the other hand, concluded that "a motor vehicle inspection programme is cost beneficial based only on safety benefits and state inspection data on cost and effectiveness". In the state of Alabama USA, a recent study found that accident rate of inspected vehicles was 9% less than un inspected vehicles and the accident rate of inspected vehicles was found to decrease 5% after inspection.

Periodic inspection is claimed to reduce maintenance costs through diagnosis of defects. In Sweden, however, the introduction of vehicle inspection was a major factor in the increase in average life expectancy of cars from 9.4 years in 1965 to 11.8 years in 1970 (Salinger 1972). In the USA and UK, accident investigation studies by Sabey (1979) suggest that vehicle defects are the cause of a small proportion of accidents (5-10%). With the poor maintenance standards that generally prevail in developing countries, this proportion could be much higher. Hence periodic vehicle inspection could have a greater impact on accidents. However, in all countries it depends on the vigilance of the inspectors in avoiding corruption. Any vehicle scheme would have to be carefully evaluated, may be by only introducing the scheme in one region of a country.

The studies suggest that avoiding expensive test equipment is desirable in developing countries and using tests requiring visual inspection only plus simple measuring devices, such as tread depth indicators. Buses and (HGV) were the cause of high fatality rates (per 10,000 vehicles) in some developing countries. Studies suggest that 40% of buses on the road are involved in accidents each year, which suggests that vehicle inspection of buses and HGVs should be given a high priority in some developing countries.

C.17 Broad Evaluation of Road Safety Counter Measure in Developed Countries

Smeed (1964) early research (1964) in the UK, is regarded as the most relevant to developing countries, since traffic and safety conditions in developing countries(levels of vehicle ownerships, road users behaviour) were some what similar to the situation in developed two or three decades ago. He derived a formula to predict the expected number of road deaths in a country from the size of the population and the number of motor vehicles, as follows:

$$\left(F/V\right) = 0.0003\left(V/P\right)^{-2/3}$$

where F = fatalities from road accidents

V= number of vehicles in use.

P= Population.

Smeed suggested that the reason that his formula gave such a good predication of road deaths, was that this empirical formula might give some measure of the accident rate that countries were prepared to tolerate. He also discussed the effects of legislation, propaganda, education, enforcement and national characteristics. Four countries (Norway, Japan, Britain and Finland) are compared, where there are more road deaths than would be expected. The main difference seems to be that the countries with fewer deaths have lower speed limits and stricter laws against driving after drinking. Smeed consider three possibilities that may be affecting the number of deaths, these were. The number of traffic, the number of vehicles per kilometre of road, and road conditions. Smeed's formula, although originally fitted to data for 1938, is still applicable for 1986. He used "know methods" for reducing accidents, based on UK research. His studies were used for estimating the potential for reducing accidents if counter measures were fully used.

Height (114) has argued that the effectiveness of a remedial measure could depend on how developed the transport of a particular country was. Propaganda and enforcement could be very effective initially but much less at a later stage of development. (Sabey 1976; Sabey 1979) followed the same approach as Smeed in 1976 and 1979. She reassessed the potential for accident and injury reductions across the full range of road safety measures with 1973 and 1977 as base years for comparison. Her agreement was that the most effective remedy is not necessarily related to the main cause of an accident and that in developed countries there is a possibility of influencing certain type of road user behaviour by engineering means rather than by education or enforcement of the law. This reflects a move towards a system engineering approach to road design that attempts to allow for human error and the concept of a forgetting road system.

Appendix D

D.1 Questionnaire

D1.1 Occupant Injury Form

Accident case No......................
Hospital No............................
1- Gender

Male ☐ Female ☐

2-Age

3-Type of vehicle......................

4-Modal and year of made.........................

5-Data of accident......................

6- Location of the accident.

Urban road ☐ , Motorway ☐ , Main roads ☐ , others, specify ....

7- Type of Accident:

A-Pedestrian☐

Crossing road in urban area ☐, Highway crossing ☐ Near school crossing ☐

In road not crossing ☐, Waking near the road (road without pavement) ☐

Not known ☐

B- Vehicle ☐

Frontal ☐ Lift side Impact ☐ Right side Impact Rear ☐

Others...

8-The injured person:

Driver ☐ Front seat passenger ☐ Rear seat passenger ☐

9-Seatbet use

Belted ☐ Unbelted ☐ N.K ☐

10- Accident speed..................... ☐ ☐

11-Injury Causation

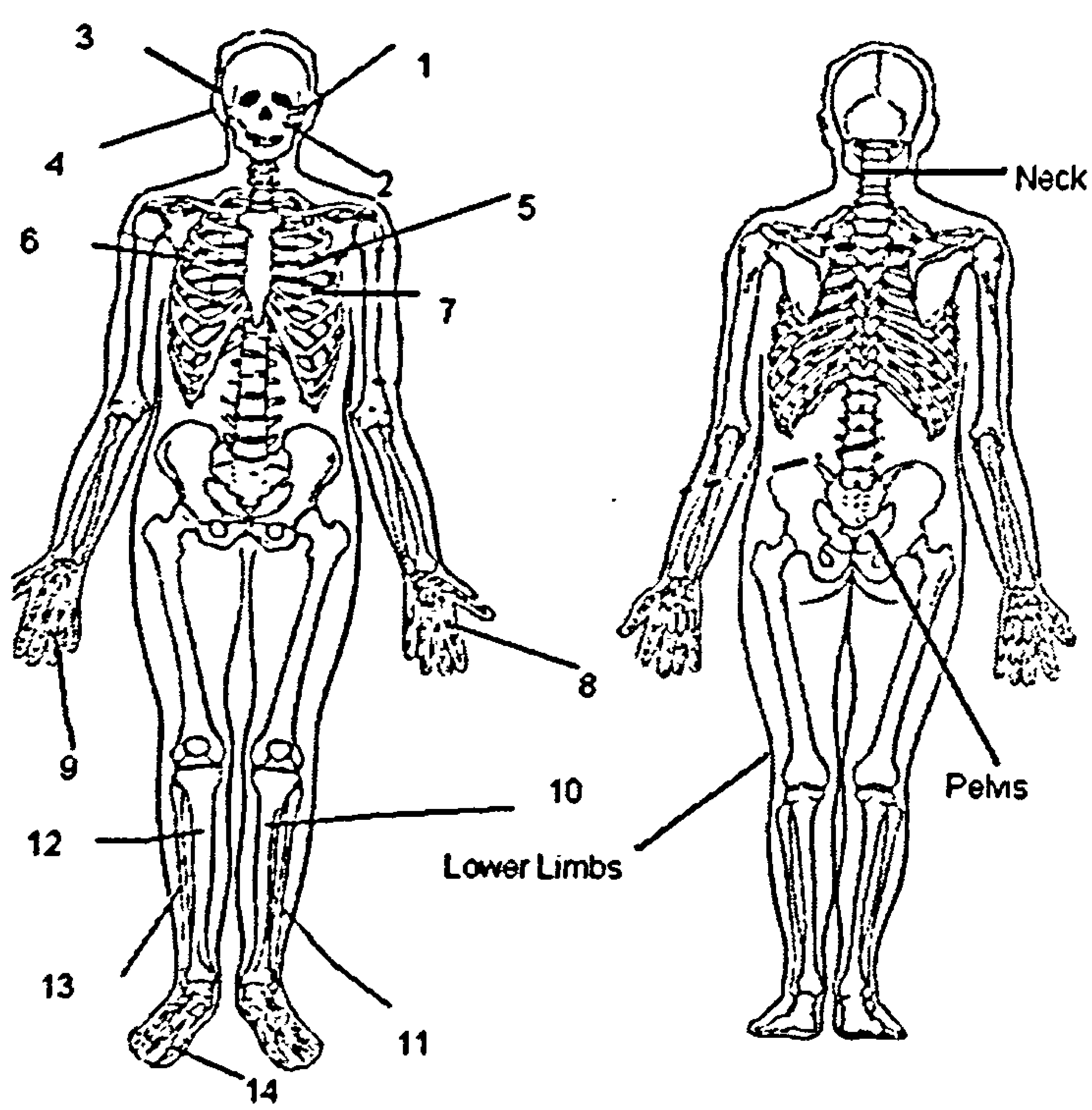
Steering wheel ☐ Windscreen ☐ Adjacent doors ☐ Roof ☐
Pedals/brackets ☐ Seatbelt ☐ Dashboard ☐ Frontal Seats ☐
Door ☐ N.K ☐ External object ☐
Others.......................................

12-Method of transport of casualty to the hospital

Ambulance ☐ Bass by car ☐ Police car ☐
Time took to arrive to the hospital............

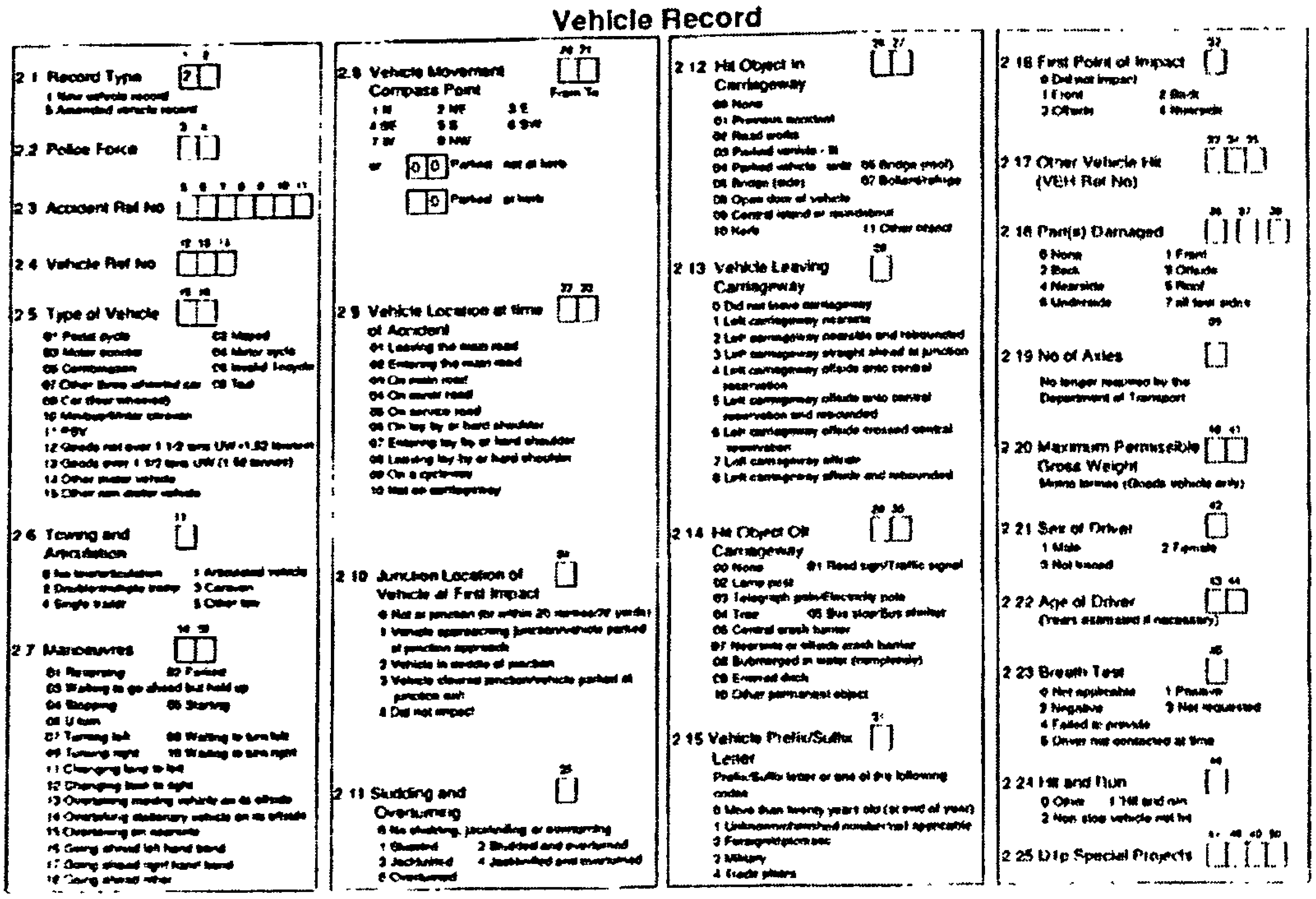
D1.2 Injury Coding

Hospital Ref.



Inj.No	AIS 90 code							AIS	Description of injury
01									
02									
03									
04									
05									
06									
07									
08									

D.2 State 19


Vehicle Record

2.1 Record Type

2.2 Police Force

2.3 Accident Ref No

2.4 Vehicle Ref No

2.5 Type of Vehicle

2.6 Towing and Articulation

2.7 Manoeuvres

2.8 Vehicle Movement Compass Point

2.9 Vehicle Location at time of Accident

2.10 Junction Location of Vehicle at First Impact

2.11 Skidding and Overturning

2.12 Hit Object in Carriageway

2.13 Vehicle Leaving Carriageway

2.14 Hit Object Off Carriageway

2.15 Vehicle Prefix/Suffix Letter

2.16 First Point of Impact

2.17 Other Vehicle Hit (VEH Ref No)

2.18 Part(s) Damaged

2.19 No of Axles

2.20 Maximum Permissible Gross Weight

2.21 Sex of Driver

2.22 Age of Driver

2.23 Breath Test

2.24 Hit and Run

2.25 D1p Special Projects

Department of Transport

Accident Record Attendant Circumstances

Stats 19 (Rev 2.91)

1.1 Record Type [1][ ] (1 2)
1 New accident record
6 Amended accident record

1.2 Police Force [ ][ ] (3 4)

1.3 Accident Ref No [ ][ ][ ][ ][ ][ ][ ] (5 6 7 8 9 10 11)

1.4 Severity of Accident [ ] (12)
1 Fatal 2 Serious 3 Slight

1.5 Number of Vehicles [ ][ ][ ] (13 14 15)

1.6 Number of Casualty Records [ ][ ][ ] (16 17 18)

1.7 Date — Day (19 20) Month (21 22) Year (23 24)

1.8 Day of Week [ ] (25)
1 Sunday 2 Monday
3 Tuesday 4 Wednesday
5 Thursday 6 Friday
7 Saturday

1.9 Time — Hrs (26 27) Mins (28 29)
24 hour

1.10 Local Authority [ ][ ][ ] (30 31 32)

1.11 Location
10 digit reference No
Easting (33 34 35 36 37) Northing (38 39 40 41 42)

1.12 1st Road Class [ ] (43)
1 Motorway
2 A (M)
3 A
4 B
5 C
6 Unclassified
7 Local
8 Authority
9 Use Only

1.13 1st Road Number [ ][ ][ ][ ] (44 45 46 47)

1.14 Carriageway Type or Markings [ ] (48)
1 Roundabout (on circular highway)
2 One way street
3 Dual carriageway - 2 lanes
4 Dual carriageway - 3 or more lanes
5 Single carriageway - single track road
6 Single carriageway - 2 lanes (one each direction)
7 Single carriageway - 3 lanes (two way capacity)
8 Single carriageway - 4 or more lanes (two way capacity)
9 Unknown

1.15 Speed Limit [0][ ][ ] (49 50 51)
mph

1.16 Junction Detail [0][ ] (52 53)
0 Not at or within 20 metres of junction
1 Roundabout
2 Mini roundabout
3 'T' or staggered junction
4 'Y' junction
5 Slip road
6 Crossroads
7 Multiple junction
8 Using private drive or entrance
9 Other junction

Junction Accidents Only

1.17 Junction Control [ ] (54)
1 Authorised person
2 Automatic traffic signal
3 Stop sign
4 Give way sign or markings
5 Uncontrolled

1.18 2nd Road Class [ ] (55)
1 Motorway
2 A (M)
3 A
4 B
5 C
6 Unclassified
7 Local
8 Authority
9 Use Only

1.19 2nd Road Number [ ][ ][ ][ ] (56 57 58 59)

1.20 Pedestrian Crossing Facilities [0][ ] (60 61)
0 No crossing facilities within 50 metres
1 Zebra
2 Zebra crossing controlled by school crossing patrol
3 Zebra crossing controlled by other authorised person
4 Pelican
5 Other light controlled crossing
6 Other site controlled by school crossing patrol
7 Other site controlled by other authorised person
8 Central refuge - no other controls
9 Footbridge or subway

1.21 Light Conditions [ ] (62)
DAYLIGHT
1 Street lights 7 metres or more high
2 Street lights under 7 metres high
3 No street lighting
4 Daylight street lighting unknown
DARKNESS
5 Street lights 7 metres or more high (lit)
6 Street lights under 7 metres high (lit)
7 No street lighting
8 Street lights unlit
9 Darkness street lighting unknown

1.22 Weather [ ] (63)
1 Fine (without high winds)
2 Raining (without high winds)
3 Snowing (without high winds)
4 Fine with high winds
5 Raining with high winds
6 Snowing with high winds
7 Fog (or mist if hazard)
8 Other
9 Unknown

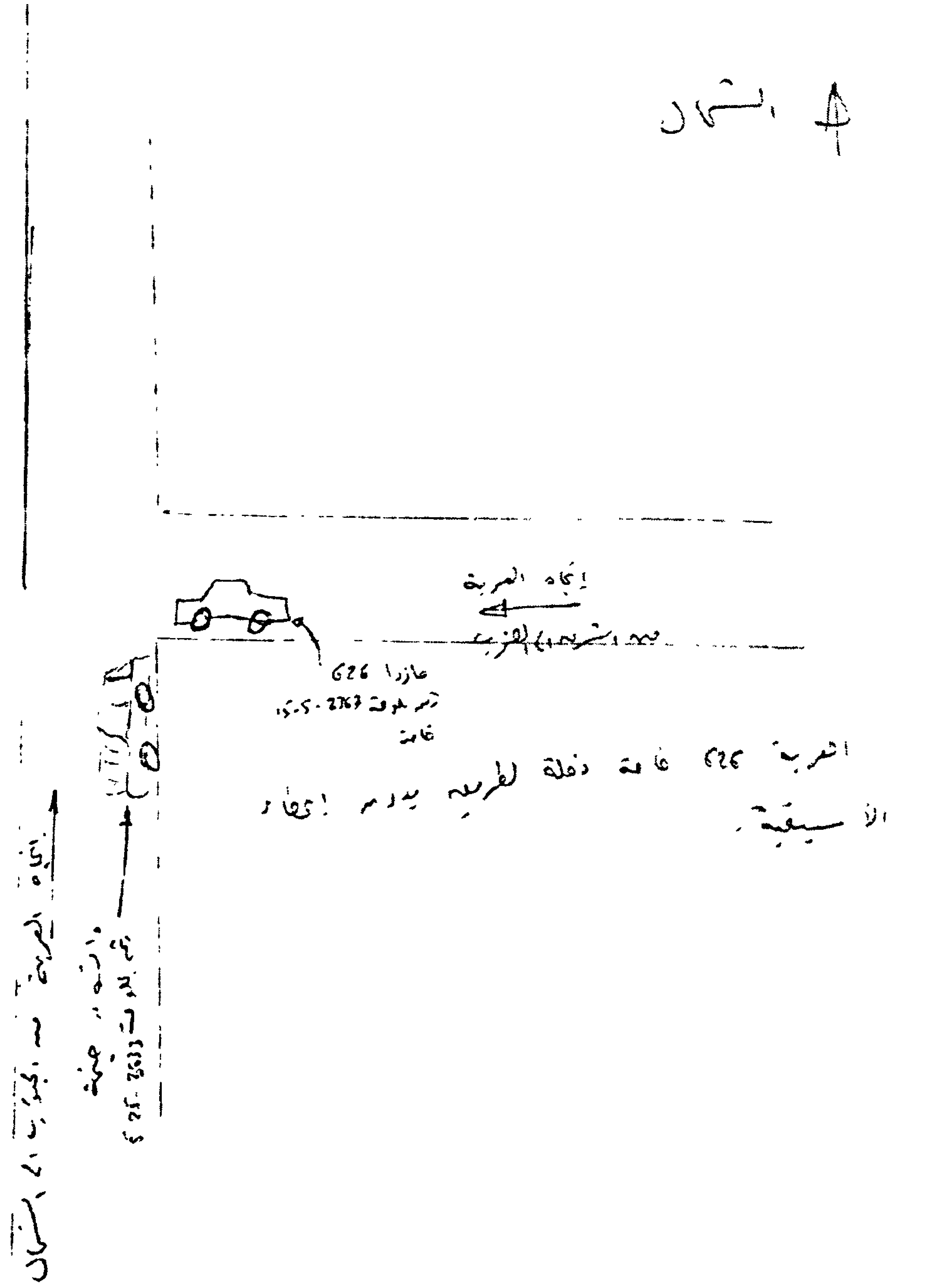
1.23 Road Surface Condition [ ] (64)
1 Dry
2 Wet/Damp
3 Snow
4 Frost/Ice
5 Flood (surface water over 3cms (1 inch) deep)

1.24 Special Conditions at Site [ ] (65)
0 None
1 Automatic Traffic Signal out
2 Automatic Traffic Signal partially defective
3 Permanent road signing defective or obscured
4 Road works present
5 Road surface defective

1.25 Carriageway Hazards [ ] (66)
0 None
1 Dislodged vehicle load in carriageway
2 Other object in carriageway
3 Involvement with previous accident
4 Dog in carriageway
5 Other animal in carriageway

1.26 Overtaking Manoeuvre Patterns [ ] (67)
No longer required by the Department of Transport

1.27 DTp Special Projects [ ][ ][ ][ ] (68 69 70 71)



D.3 An Accident Report Form Libya

Table D1 Road Accidents and Casualties in Libya (1966-2000)

Year	Population (thousands)	Vehicles (thousands)	Number killed	No. of Injured	No. of Accidents	Fatal Accidents	Killed per 100,000 persons	Injured per 100,000 Persons
1966	1,703	78,204	306	4071	8,400	370	18	240
1967	1,776	92,790	353	4390	9,407	447	20	250
1968	1,853	112,557	377	4354	9,652	538	20	240
1969	1,934	124,172	361	4998	10,181	487	19	260
1970	2,017	145,531	423	5828	11,034	581	21	290
1971	2,105	166,327	575	7992	12,413	679	27	380
1972	2,196	190,000	645	9523	13,611	773	29	430
1973	2,291	214,000	713	9588	13,066	853	31	420
1974	2,390	239,436	985	11,775	15,791	1,149	41	490
1975	2,430	278,046	1081	11,908	16,392	1,215	44.5	440
1976	2,530	340,976	1159	11,031	16,093	1,331	46	370
1977	2,634	424,,938	1248	12,313	16,930	1,295	46.7	470
1978	2,743	478901	1210	13,871	17,863	1,453	43.8	510
1979	2,856	562,864	1171	11,222	15,552	1,369	41	390
1980	2,910	635,733	1266	10,700	14,405	1,453	42.6	360
1981	3,004	700,000	1418	10,695	13,550	1,187	46.7	350
1982	3,102	740,000	1296	9,288	12,216	1,106	41.8	300
1983	3,167	790,000	1125	8,827	10,286	985	35.5	280
1984	3,231	835,000	1070	7,647	9,550	914	33.1	230
1985	3,323	865000	1050	8,882	9,489	905	31.6	270
1986	3,416	905,000	1020	7,499	8,307	882	30	220
1987	3,513	950 000	963	5,915	6,698	796	27.4	170
1988	3,613	995 000	1007	6,166	6,810	851	28.7	170
1989	3,715	1,025,000	1925	6,520	7,602	942	25.3	180
1990	3,821	1,050,000	1312	6,665	7,847	1,094	34.3	170
1991	3,929	1085,000	1279	6,342	7,749	1,056	32.5	160
1992	4,041	1,110,000	1435	6,323	8,423	1,195	35.5	160
1993	4,155	1,130,000	1440	7,852	9,009	1,207	34.7	190
1994	4,273	1,161,602	998	7,423	8,400	998	27.6	180
1995	4,394	1,202,929	1071	7,703	8,419	1,071	29.5	180
1996	4,648	1,175,221	927	7,750	8,437	927	24	170
1997	4,648	-	1119	8,076	9,278	969	24.1	170
1998	4,772	2,035,75	1224	8,343	9,393	1,012	25.7	180
1999	4,958	411543	1204	8,394	9,370	1,012	24.2	170
2000	5,125	675257	1504	9,617	10,667	1,273	29.3	190

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