ROAD ACCIDENTS IN DEVELOPING COUNTRIES

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ABSTRACT

The aim of the work described in this thesis was to obtain a greater understanding of the problem of road accidents in developing countries.

The social importance of road accidents in developing countries was identified by comparing deaths from road accidents with deaths from diseases thought to be of concern in the Third World. The economic importance was assessed by reviewing cost-estimates derived in a number of Asian and African countries.

Trends in fatality and casualty rates over various ten-year periods were determined and countries showing abnormalities identified. Reasons for these abnormalities were investigated using disaggregated data from those countries concerned. Fatality rates were found to be related to levels of vehicle ownership, the higher the vehicle ownership the lower the fatality rate. Regression equations derived were compared with those for developed countries.

A detailed study was made of road accidents in Kenya and comparisons made with results from Europe. The high incidence of fatal accidents, single-vehicle accidents and those involving injury to occupants of commercial vehicles were noted.

Regression equations were derived which related rural accidents to geometric design features of the road. Comparisons with results from developed countries indicated the high accident rates pertaining in the developing countries studied. The pattern of road accidents in selected urban areas was examined, areas of high risk identified and relationships

established between accident rates and levels of vehicle and pedestrian flows.

Factors that might be contributory to the high accident rates in developing countries were studied - the road surface, vehicle condition and road-user behaviour.

From these studies, recommendations are put forward for dealing with road accidents on a cost-effective basis, ensuring that what relatively small sums of money are available in these countries can most efficiently be spent in dealing with the problem.

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1. INTRODUCTION

Surprising though it may seem, road safety is a very old problem. In Great Britain, for example, there were over 1,000 deaths a year even before the advent of the motor car. By 1970 this figure had reached 7,500, with over a third of a million people being injured.

In 1974, in those countries of Europe making returns of road accidents to the United Nations, 90,000 persons were killed and 1,800,000 injured by motor vehicles. In the same year in the United States over 55,000 were killed. Despite the enormity of these figures, road deaths and injuries seem to have very little impact on the general public. For some time comfort was taken, in most European countries, in the fact that the accident rate per vehicle-kilometre travelled had been decreasing and it was conveniently forgotten that the absolute numbers of accidents and the economic cost to the community were rising steadily. As late as 1968, Professor John Cohen expressed the view that as a country we had the ability, but not the will, to solve the road accident problem and that this attitude arose because we were not sufficiently moved by disaster on the road.

'The public conscience is more outraged by the discovery of a child stabbed to death in a wood than by a count of 8,000 corpses on the road in a period of twelve months. A fatality on the road is prosaic and unpleasant to think about, the less said about it the better. Further, the effects on the public imagination are not cumulative; 8,000 road deaths do not affect us twice as much as 4,000 road deaths'

During the last decade there has been a growing awareness in Western Europe and North America that the problem to be dealt with has reached epidemic proportions comparable with any earlier mass epidemics

or even war. For example, the United States military forces lost 10,000 lives in the Vietnam war, understandably arousing national concern because of the tragic nature of these losses. Yet a similar number of persons were killed on the roads of the United States in just over two months in 1966.

Throughout Europe and North America we find a new resolve to come to grips with this continuing problem and to bring all our scientific knowledge to bear upon it. It is particularly interesting to note that many of the safety measures suggested in 1968 by Professor Cohen (to save lives) have now been introduced in this country.

In comparison with the countries of Western Europe and North America, the study of road accidents in developing countries has been almost non-existent. Although much research has been carried out on the transport problems of the Third World, mainly under the auspices of international lending agencies, little emphasis has been placed on the problem of road accidents.

There may be a number of reasons to explain why such an attitude should prevail. Firstly, road accidents may be thought to be insignificant compared with the (supposedly) more important problems of poverty, sickness and malnutrition. Secondly, the road accident rate may be considered low in developing countries and although it is likely to rise in the future it is (hopefully) insignificant at present. Thirdly, road accidents may be thought to have little cost at present in developing countries.

The object of much of the work described in this thesis has been directed towards disproving the above points. In other words to show

that road accidents already constitute a serious social problem, that rates are high (and in many countries are increasing) and that accident costs are by no means insignificant. Indeed, the loss to the developing country in economic terms from a road accident may be greater than at first appears, since the population involved is not a representative cross-section. Many of the fatalities occur to vehicle-users who come from the minority of qualified people, such as doctors, teachers, and businessmen, whose loss to the country is particularly serious.

Earlier, figures were quoted which outlined the general accident situation in Europe and the United States. In comparison, the author made a crude estimate that in the Third World there were over 100,000 people killed in road accidents in 1974 and over 1,200,000 injured - figures that cannot, by any standard, be regarded as insignificant.

It is useful at this point to consider what is meant by terms such as 'developing country' or 'Third World'. Whereas it is easy to understand what is implied by such evocative terms, it is quite difficult to provide a clear-cut definition. Most of the poor countries of the world are to be found in Africa, South East Asia and parts of South and Central America. Not all countries in these regions are 'poor' and although geography provides an indication of where they are to be found, it is of little value in providing a definition.

Much of the aid to the poor countries of the world is provided through international lending agencies such as the World Bank, the Asian Development Bank etc. These organisations tend to group countries together according to the average level of gross national product per capita (G.N.P./capita). Thus the poorest countries of the world are

often grouped as those with a G.N.P./capita less than \$100 per annum. The British Ministry of Overseas Development (ODM) regards countries as 'developing' if the average G.N.P./capita is less than \$600 per annum.

Such values are perhaps the best way of defining whether a country is part of the Third World or not, but it is still difficult to decide whether \$600 should be the criterion or whether it should be some other arbitrarily chosen figure. Furthermore, even if a country has a G.N.P./capita greater than, say, \$600 per annum it may still receive aid from donor agencies or countries. The World Bank provides loans at various levels of interest that depend on the relative wealth of the country. Thus another criterion that could be used would be the level of interest charged by the World Bank.

During the early work described in this thesis, the author took the level of vehicle ownership to be the most appropriate criterion and a developing country was taken to be one with a vehicle ownership level of less than one vehicle per 10 persons. Later in the work the ODM criterion - G.N.P./capita less than \$600 per annum - was used. Whatever definition is used, the really poor countries of the world will always be included and it is only countries such as Cyprus, Singapore etc that will appear borderline.

In 1971, during the early stages of this research work, the author soon discovered that there was a lack of reliable road accident data available in developing countries. A detailed survey of data-collection and analysis procedures adopted by developing countries confirmed this. However, total accident statistics were available; that is, the total number of fatalities, casualties and accidents taking place each year.

These data have been used to calculate accident rates and trends in developing countries so that the magnitude of the problem could be identified.

In order to study accidents in urban and rural areas or to investigate road-user behaviour in cities of the Third World, visits were made by the author to Kenya, Malawi, Thailand, Indonesia, Turkey, Ghana and Malaysia during the period 1972-1976. Through official channels, data were obtained from other countries, particularly on such items as accident costs. Finally, questionnaires were sent to over 50 developing countries to obtain basic road statistics, accident statistics and information on subjects such as road accident data collection and vehicle-inspection methods used in developing countries.

The cycle of attitudes to the road accident problem gone through by the countries of Western Europe are now repeating themselves in the Third World. Perhaps twenty years ago the problem hardly existed, a decade ago it was not known to exist. Five years ago there was an awakening to the growing problem, whilst today there is genuine concern and, with their experience built up over years of dealing with the subject, the advice of the developed countries is being actively sought.

Detailed research, similar to that carried out by the author in Kenya, is needed so that more information can be obtained of where accidents occur, to what class of road user and what kind of accident. The thesis describes how areas of high risk in urban and rural areas were identified in Kenya, Jamaica and Indonesia and relationships derived which need to be tested and verified in other parts of the world.

As is shown in the thesis, countries of the Third World face problems virtually unknown in Europe and road safety features used for example in Great Britain are relatively ineffective in these countries. Much more work is needed on the subject, particularly in the developing countries themselves. The work described here is no more than a first step, hopefully in the right direction.

2. LITERATURE REVIEW

2.1 INTRODUCTION

The object of the research described in this thesis was to obtain a greater understanding of the problem of road accidents in developing countries. By studying accident rates and trends, comparing deaths from road accidents with other causes of death and analysing the cost of road accidents in these countries, the problem could be put into perspective. By studying accident statistics in detail, a clearer understanding could be obtained of what type of accident is happening to what class of road user, and the type of vehicle involved. Factors such as the condition of the road, the vehicle and also road-user behaviour needed to be studied so that the major contributory factors in accidents taking place in the Third World could be identified.

Over the period 1971-1976, the author found that very little work had been carried out on the subject of road accidents in developing countries. Indeed, when compared with the amount of research carried out on subjects such as vehicle operating costs, project appraisal etc. it appeared that road safety was a much neglected subject. Consequently, almost all the work described in this thesis on road accidents in developing countries, was carried out by the author.

It was essential, however, that relationships derived in the developing world, be compared with similar relationships obtained in Europe and North America so that they can be put into perspective. For example, a rate of 40 injury-accidents per kilometre of road per annum on a busy shopping street in Indonesia, is only seen as an extremely high rate when compared with shopping streets in Great Britain,

where, for a similar level of vehicle flow, the equivalent value is 15.

Most of the references given in this thesis therefore, are to work carried out in developed countries (mainly Great Britain and the United States) and have been used to make these comparisons.

2.2 ROAD ACCIDENT FATALITIES AND OTHER CAUSES OF DEATH

One of the most comprehensive studies of the health problems of the developing world was carried out by Bryant in 1968 - 69⁵. In this study, Bryant reviews the general health situation and uses the results of World Health Organisation (WHO) surveys⁴ to identify the diseases which are of particular concern throughout Asia, Africa and South America. There was found to be some variation between the different parts of the world but in general, tuberculosis, smallpox, dysentery etc. created serious health problems in most of the developing world.

Having identified the most important causes of death, the author then made comparisons between the number of deaths in selected countries from these diseases and from road accidents.

Information on the number of deaths from the different diseases was obtained from the United Nations Demographic Yearbooks 1963 - 1972². These publications gave (for a selection of countries throughout the world) the total number of deaths taking place in a given year and details of causes of deaths, such as the number of people dying from various diseases or in certain types of accidents. Using these data, information was obtained on the number of deaths from diseases causing particular concern in the Third World in about eleven developing countries.

Information on the number of deaths from road accidents were obtained from the International Road Federation (IRF) publication 'World Road Statistics'¹.

In Bryant's study of the health problems of developing countries, he classified various diseases into groups and in Hong Kong, for example, studied the change in the number of deaths from these groups of diseases over time. The groups of diseases were infectious, intestinal, neoplastic, respiratory, circulatory and diseases of the nervous system. He showed, for example, that over the period 1950 - 1965, that deaths from infectious, intestinal and respiratory diseases were decreasing, whilst those from circulatory and neoplastic diseases was increasing. The author was able to make similar studies in four developing countries, comparing changes in death rates from the above groups of diseases with deaths from road accidents.

After reviewing Bryant's work, the author made detailed analyses of patients receiving in-patient hospital treatment from diseases and also from road accidents in Nairobi by studying unpublished medical records of the three major hospitals in the city.

Havard⁶ made a comparison of deaths from road accidents and other causes of death in European countries, illustrating in particular, the fact that road accidents are the major cause of death for young males in the 16 - 24 years age group. Results obtained by Havard in European countries were compared with those from developing countries, obtained by the author.

2.3 ACCIDENT RATES IN DEVELOPING COUNTRIES

In 1948, Smeed¹³ studied the relationships between road accident fatality rates (per licensed vehicle) and vehicle ownership (per head of population) in 20 developed countries, using data for the year 1938.

An equation was derived as follows:-

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

where

- F = fatalities from road accidents
- V = number of vehicles in use
- P = population

Further research by Smeed^{3, 11, 14}, 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 used this relationship to show that the future number of road deaths in a country can be predicted from a knowledge of the future number of people and vehicles in that country. Thus:-

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

Where F, V, P are as defined above.

In 1972, the author⁸ derived an equation similar to that obtained by Smeed by taking fatality and vehicle ownership levels in 32 different developing countries for the year 1968. It was not the author's intention to use the equation to predict future number of deaths but to use it as a basis for comparison of accident fatality rates in developed

and developing countries.. The equation derived by the author:-

$$\frac{F}{V} = 0.0007 (V/P)^{-0.4}$$

showed that fatality rates were greater in developing countries for similar levels of vehicle ownership.

Smeed¹¹ also found that definitions of road accident fatalities varied in some countries from that recommended by the United Nations Economic Commission for Europe (ECE). Furthermore, he calculated adjustment factors for fatalities for those countries not using the ECE definition. These factors were subsequently used by the author.

Jeffcoate¹⁵ made a detailed analysis of fatality and vehicle ownership rates in Great Britain over the period 1909 - 1938. Similarly, Dondanville¹⁶ made a study of similar relationships in the United States over the period 1912 - 1967 and compared resulting equations with fatality and vehicle ownership rates existing in many different countries throughout the world in the year 1967. Dondanville showed that the relationship between fatality rate and vehicle ownership in the USA 1912 - 1967 was similar to that derived for different countries for 1967. The author used these studies to compare relationships derived in Great Britain and the United States with those in developing countries.

Reasons for the existence of the relationship derived by Smeed^{3, 13} were put forward by Garwood¹⁷. Some explanation is required of the fact that as a country, or group of countries, experience increasing vehicle ownership, there is a decrease in the fatality rate. As Garwood suggests, more vehicles should mean a greater possibility of vehicle-vehicle conflict and hence the likelihood of more accidents.

Garwood¹⁷ suggested that the reasons for the fall in the total number of casualties per vehicle mile in Great Britain were:-

- (1) the decreasing proportion of two-wheeled motor traffic;
- (2) pedal cyclist and pedestrian travel is not included in the assessment of vehicle miles but their casualties are not increasing at as fast a rate as in the total of other casualties;
- (3) the number of pedestrian casualties per motor vehicle mile for the different classes of vehicle is falling.

These and other points were investigated by Garwood and Johnson¹⁸ and Smeed^{11,14}, who confirmed the validity of the above points made by Garwood. Unpublished data from different developing countries were used by the author to see whether the above points also applied to countries of the Third World.

Smeed made a study¹¹ of the changes in fatality 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 found that percentage changes in fatality and casualty rates over this period were not related to changes in vehicle ownership. 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. The analysis was repeated by the author⁸ for a number of developing countries and countries showing abnormal trends in fatality rates were identified.

The severity index, ie the proportion of all casualties that are fatal was studied in detail in Great Britain in the publication

'Research on Road Safety'⁸⁴. Using the United Nations' Yearbooks¹⁰ and the IRF yearbooks¹, similar relationships were obtained by the author⁸ in a number of developing countries. In this analysis, further insight into the reasons for high indices in developing countries were obtained by using information on the medical facilities available in these countries. These data were extracted from the United Nations' Demographic Yearbooks².

In a detailed review of rural traffic census procedures used by developing countries, Howe⁹ found that few countries carried out comprehensive national and trend censuses. Consequently the author was not able to convert numbers of fatalities into fatality rates per million vehicle kilometres travelled.

2.4 COMPARATIVE ACCIDENT COSTS IN DEVELOPING COUNTRIES

The very problem of valuing road accident costs is a contentious economic issue. Mishan¹⁹ and Adams²⁰ have argued that the techniques commonly used have little validity from a theoretical standpoint. It is the inability to ask a person what value he places on his life that forms the basis of Mishan's criticism. There is clearly a difference between costing a certain number of accidents that will probably take place tomorrow, and asking people how much they would pay not to be killed in a road accident. On the valuation of human life, Goodwin²¹ argues that objections may be avoided, if not overcome, only if it clearly specified that the monetary value arrived at is a minimum that society would find it worthwhile spending in order to avoid a fatal accident.

Whatever difficulties there may be in costing road accidents, attempts have been made in Great Britain to derive the overall annual cost of road accidents since before the war. The first estimate at TRRL was derived by Reynolds³⁶ and was based on procedures set down in a report in 1947 to the Minister of Transport. This could be defined as a national income approach and the costs which were included could be divided into two groups: those that cause a diversion of current resources, and the losses of future output because of death or injury. Among the former are, repairing damage to the vehicle and other property, medical treatment and the administration of insurance, police and the law.

In 1967 Dawson²³ produced a comprehensive report on road accident costs in Great Britain, using the methodology outlined by Reynolds³⁶. In this report Dawson suggested that loss of output should be estimated using the 'net' approach. In this method, the measure required of the loss of future output is its net present day value, which is the difference between the future loss of output of those killed and injured, assuming an otherwise normal expectation of working life, and the future consumption of those killed, assuming a normal expectation of life, both having been discounted to give present day values.

A further report by Dawson in 1971²⁴ showed two significant differences from that produced earlier. In the later report, the 'net' approach described above was changed to a 'gross' method where, in the case of a road death, future consumption was not subtracted from future loss of output. Arguments have been put forward for both approaches. Also, in the second analysis, no attempt was made to differentiate between various age and sex groups.

In the later work by Dawson²⁴, an attempt is made to assess the cost of suffering and bereavement experienced by the friends and relatives of road accident casualties. Such assessments can only be made on a subjective basis.

In an attempt to determine how various developing countries cost road accidents, the author reviewed the studies that had been made on this subject in a number of countries. Within the limitations of the different definitions employed, the different factors taken into account, the dates of the studies, the methods of measuring costs and the currency of measurement, the various studies were compared and general conclusions reached.

Most of the studies (apart from those for Ivory Coast²⁶ and South Africa³⁰) were concerned with establishing the number of deaths and injuries associated with road traffic accidents, valuing the resulting loss in output and vehicle damage, and summing the valuation of all injuries and damage to give a total accident cost. The Ivory Coast study²⁶ employed a slightly different data format which meant that total accident costs could not be derived. The South African study³⁰ derived unit costs of injuries and vehicle damage as well as total accident costs; the method of deriving the costs was by sampling the insurance payments made to the accident claimants.

The Kenyan study²⁵ incorporated both accident and casualty information. This was useful since it provided a means of specifying the probable number of persons with different types of injury who will be involved in different types of accidents. In this way, the costs of different types of injuries and accidents can be assessed. In the

Turkish studies,^{33,34} although the total numbers of killed and injured are documented, the number of serious and slight injuries were based on assumptions about the severity index.

Adler²² has suggested that for less developed countries, the valuation of life is not necessary because the reduction in fatalities is likely to be of minor significance compared with other benefits to be derived from transport investment. This approach may be true of road investment in rural areas but is hardly true in urban areas where traffic management schemes are designed specifically to obviate accident black spots. The above studies together with those from Ghana³², Thailand²⁷ and S. Rhodesia in 1963-64²⁸ have all showed that accident costs in developing countries are a significant cost item.

2.5 DATA COLLECTION AND ANALYSIS

Numerous descriptions have been given of the method used in Great Britain to collect and analyse road accident data⁸⁴. In a Paper on accident analyses in Britain, Sabey⁷³ describes the main uses of national data and the role played by the various organisations involved. Thus, information on accidents is collected by the police by means of a booklet, transferred on to a standardised form, the Ministry of Transport STATS 19, 'Report on a road accident resulting in personal injury', and then on to punched cards or data tape for analysis by computer.

Data retrieval is aided by special programs developed for the main forms of analysis required, which are tabulations, listing of accidents with specific details and plotting of locations in map form. Such programs include RATTLE 'Road Accident Tabulation Language'³⁷,

developed at the TRRL and SPSS³⁸, developed at the Edinburgh Regional Computing Centre.

According to Sabey⁷³, the uses of national data are fourfold:-

- (1) to provide a means of assessing the need for and effect of national legislation.
- (2) to provide an overall picture of the accident situation, which in turn gives a guide to where effort should be directed
- (3) to identify trends and to enable forecasts to be made
- (4) to provide a basis for comparison in regional and local studies

The above reasons are also valid in developing countries, and in order to find out what systems, if any, are used by developing countries to collect and analyse road accident data, a survey was carried out of the methods used by 34 countries.

The results of the survey enabled the author to make an assessment of the quality of data collection and analysis procedures adopted by the developing countries⁷.

Those countries responding to the questionnaire have not been referred to separately but replies were received from:-

Bahamas	Kenya
Barbados	Ku wait
Belize	Malagasy
Botswana	Malaysia
Cyprus	Malawi
Dominica	Mauritius
Ethiopia	Montserrat
Fiji	Morocco
Ghana	Nigeria
Gibraltar	St Helena
Guyana	St Lucia
Hong Kong	Sarawak
India	Seychelles
Indonesia	Singapore
Iran	Sri Lanka
Jamaica	Swaziland
Jordan	Zambia

From this survey, it was found that whereas data collection by the police is usually thorough, few developing countries analyse the data collected in any detail and very few do so by means of a computer⁷.

Some idea of the detail that can be extracted from a complete year's accident data can be obtained by an examination of the British Ministry of Transport annual publication 'Road Accidents in Great Britain'⁴⁴. In this publication, an analysis of the personal injury accidents taking place in Great Britain each year are presented in considerable detail. In this way a clear understanding is obtained of the types of accidents taking place, where, when and how they occur and to what class of road user.

A similar analysis was carried out by the author on the personal injury accidents taking place in Kenya in 1972. Data collected by the author were supplemented by those obtained from urban transport studies carried out in Nairobi⁴¹ and Mombasa⁴². Using traffic data from these studies, it was possible to convert numbers of accidents in these urban areas into rates per million vehicle kilometres travelled. Similarly, accidents in rural areas were converted into rates by using the results of rural traffic censuses set up by Howe during the period 1967-1970⁴⁰.

The analysis procedure used was that devised by Harris³⁷ at the TRRL. In this method, data are transferred on to punched cards and each accident has three sets of cards associated with it. Thus details such as the date, time, place and location of the accident are given on one card; details of the persons injured are on a second set of cards, the number, depending on the number of persons involved; finally details of the vehicles involved are on a third set of cards, again with one card being punched for each vehicle involved.

In order to identify unusual accident patterns in Kenya, comparisons were made with results from other countries. Information on basic accident statistics in a number of European countries was obtained from the 1972 report on trends in road accidents from the Conference of Ministers of Transport. Comparisons were made with accident patterns in Great Britain using the annual report described above⁴⁴.

During a visit to Ghana in 1972, the author obtained an unpublished report by Okyere⁴⁶ on road accident problems in Ghana. In this report Okyere analysed both accident rates and the distribution of road accidents taking place in Ghana in 1972. Unfortunately Okyere was not able to obtain the total number of injury accidents taking place

(only about 20 percent) and it is doubtful whether those collected were a representative sample. However the results of this survey were used by the author to make tentative comparisons between accidents in Ghana and Kenya.

2.6 ACCIDENT RATES IN RURAL AREAS

Much work has been carried out in Great Britain to show that accident rates on rural roads can be related to the road geometry. As early as 1937, Bennett⁴⁷, studying fatal accidents in Oxfordshire over a four year period, showed that a large proportion of the accidents were related in some way to the design of the road.

In 1946-47 Coburn^{49,50} studied the effect of road layout on accidents in rural Buckinghamshire, particularly the effects of horizontal curvature. Coburn showed that as the radius of curvature of bends decreased, the injury accidents per million vehicle miles travelled, increased. An extensive investigation of rural accident rates in the United States by Raff⁶⁴ showed that the accident rate was related to radius of curvature, as above and also to the width of the shoulders. Raff also found evidence that accident rates increase with increasing vehicle flow. Thus, on four-lane undivided roads, the number of accidents per million vehicle miles increased by about 50 percent as the mean daily traffic increased from the range 5,000 - 10,000 to 10,000 - 15,000.

Even on roads built to a high standard, relationships have been shown to exist between accident rates and gradient and curvature. Hillier and Wardrop⁵¹ studied personal-injury accident rates on sections of the M1, London to Birmingham motorway in 1963. Where the gradient was up, the accident rate was slightly less than on flat sections; where

it was down, the rate was twice as high as flat sections. A major factor influencing accident rate was found to be that of speed, affected in turn by the gradient.

A comprehensive analysis of the factors affecting rural accident rates was made by Silyanov⁵⁵ in 1972-73. Silyanov combined results obtained by numerous researches in different countries and derived composite equations. For example, the first equation relating accidents per kilometre of road per annum to vehicle flow, combined values obtained in Russia⁵⁶, Sweden⁵⁷ and Australia^{58,59}. The resulting equation was

$$n_N = 0.256 + 0.000408N + 1.36 (10^{-7})N^2$$

where $40 < N < 1600$

where n_N = number of accidents per Km per annum on two-lane roads

N = traffic flow (veh/hr).

Similar equations were derived relating the accident rate (per million vehicle kilometres travelled) to the width of the carriageway, width of shoulder, grade, sight distance, intersection angle and skid resistance coefficient.

The author compared similar relationships derived in Kenya and Jamaica with those derived by Silyanov in developed countries. Accident data in Kenya were collected by the author, whilst data on rural roads in Jamaica were obtained from results of work carried out by the TRRL team based in Jamaica 1962-64^{53,54}.

Manning⁶⁰ made a study of accident rates on roads in rural Buckinghamshire and found relationships between accident rates and the number of junctions per mile of road.

These results were used to compare the effects of junctions per kilometre of road on accident rates on rural roads in Jamaica and Kenya.

The author found that accident rates were consistently greater on the rural roads studied in developing countries than those derived for developed countries over similar levels of road geometry and vehicle flow.

2.7 ACCIDENTS IN URBAN AREAS

In Great Britain, a basic understanding is obtained of accidents taking place in urban areas by analysis of national accident statistics⁷³. Results of these analyses are published annually in the publication 'Road accidents in Great Britain'⁴⁴. In this, the accidents taking place in built-up areas are analysed separately and tables show the type of accident taking place, (vehicle-pedestrian, single vehicle, vehicle-vehicle), the degree of severity (fatal, serious and slight), the type of area ('A' roads, 'B' roads, the presence of street lighting etc.) and the type of road user involved, (pedestrian, pedal cyclist, car driver etc).

Sabey⁶⁵ summarised these findings and showed, for example, that over 65 percent of injury accidents in Great Britain took place at junctions, that 30 percent of all persons injured were pedestrians and that vehicle-vehicle conflict was the commonest type of accident, (45 percent of the total) followed by vehicle-pedestrian accidents (35 percent of the total).

Detailed studies are currently being conducted, at the TRRL, on accidents in six towns, with the object of identifying the underlying factors contributing to accidents and thereby suggesting suitable remedial measures. An interim report has been produced by Faulkner⁶⁶ and further commented upon by Sabey⁶⁵. Accidents have been classified by type of area and it has been shown that up to 30 percent of all accidents take place within the central area. Accidents at junctions have been studied in detail and the numbers taking place at the different types of junctions obtained.

In an attempt to put road accidents in cities of the Third World into perspective, the author has used much of the work described above. Comparison was also made with accident rates in cities in the United States by using data published in the journal 'Traffic Safety',⁷¹.

Road accident data in Nairobi and Mombasa were obtained by the author during visits in 1973 and 1974. Data collected in Mombasa were supplemented by those given in an urban transport study of the city⁴². Information on Kingston, Jamaica were obtained from the reports mentioned earlier^{53, 54}.

Information on cities in India, Bombay, Bangalore and Delhi, were obtained from various publications of the Indian Central Road Research Institute (CRRI)⁶⁹. A particularly useful Paper by Srinivasan and Hingovani⁷⁰, reviewed the problems of the large cities of India. This work showed that accident rates are high in comparison with those in developed countries and that pedestrians form a very high percentage of the people killed and injured (up to 80 percent of the total in some cities). A study of the vehicles involved in accidents showed that in

India, buses and commercial vehicles form a much greater proportion of the total, than in Great Britain.

The analysis by the author, of accidents in urban areas in the developing world, showed that where cities permitted 'low level' or 'intermediate' forms of transport to operate, they formed a considerable proportion of the vehicles involved in accidents. This was confirmed by other studies made of these forms of transport in different cities throughout the developing world. Mochtadi⁷⁴ made a study of Betjaks (cycle rickshaws) in Surabaya, Indonesia and showed they are involved in a considerable proportion of the accidents in that city, due both to the vulnerability of the vehicle and the disregard paid by the drivers to traffic regulations. Similarly, a study by Osdirim⁷⁷ of the dolmus (shared taxi) in Istanbul and Ankara, showed that these vehicles are responsible for a large proportion of the accidents taking place in these cities.

Work has been done in Great Britain to assess the risk to pedestrians in crossing busy shopping streets. Mackie, Older and Jacobs^{80,81,82} devised a method of estimating pedestrian relative risk rate, the number of pedestrian accidents in a given period (say two years) being divided by the number of pedestrians crossing busy shopping streets in a given time period. The relative risk rates obtained, were related to the vehicle flows on the roads studied, the risk increasing with increasing vehicle flow. The author used similar techniques in Surabaya and Nairobi and found that pedestrian risk rates were much greater in those cities than on shopping streets in Great Britain, for similar levels of vehicle flow.

2.8 FACTORS INVOLVED IN ROAD ACCIDENTS

In 1973, Sabey presented a Paper at Zurich to the International Driver Behaviour Research Association⁷³, which described how road accident analysis can be conducted at three different levels, namely, the national, the regional and the local. The importance of national accident statistics were described earlier in this chapter. The essence of regional accident investigation, according to Sabey, is to combine statistical analyses, with on-site investigation thus carrying out more detailed investigations in a limited locality. Examples given of this type of investigation were skidding research in a given area by Sabey⁸⁸ and work on the effectiveness of street lighting in reducing accidents by Tanner⁸⁹ and Sabey⁹⁰. Local studies are necessary, states Sabey⁷³, in order to obtain a basic understanding of the factors leading to road accidents. The author attempted to carry out investigations of the factors involved in road accident at the above three levels.

Detailed investigations by Starks⁸⁵, Mackay⁸⁶, Kemp³⁹ and Ledru⁸⁷ have all showed that road accidents are multifactor events and that there are usually a number of factors, such as the condition and design of the road, the roadworthiness of the vehicle and the behaviour of the road user, contributing to the road accident. Thus preliminary results from the on-the-spot accident investigation team at TRRL³⁹ showed that road factors (including environmental conditions) were contributory in 27 percent of the accidents studied, vehicle design or maintenance in 20 percent of the accidents and road user behaviour in almost 90 percent of all accidents studied.

Attempts were made by the author to show the relative importance of the road, the vehicle and road user behaviour in accidents in developing countries.

Work by Smeed⁹¹ was used to show how accident rates can be reduced by various remedial measures. This work together with that by Allsop⁹² was used to show how accident rates can be reduced by encouraging or enforcing motorcyclists to wear safety helmets.

The effect of speed limits on accident rates was illustrated with reference to work by Newby⁹³, Smeed^{94,95}, Solomon⁹⁵ and Coburn¹⁰⁰. Results obtained in the developing countries were compared with some of these studies.

The effectiveness of introducing safety measures designed to reduce pedestrian accident rates in Great Britain was illustrated by reference to work by Jacobs. It was shown that rates can be reduced by the installation of guard rails⁹⁷ and by the conversion of conventional shopping areas into precinct areas in which vehicular and pedestrian traffic are separated⁹⁸.

It was shown that in Great Britain, rainfall can have a significant effect on road accident rates in work by Codling^{101,102}. In his study of accidents and rainfall he showed that there are significantly more accidents in Great Britain during wet weather, partly as a result of obscured visibility and partly as a result of the increased likelihood of a skid. Investigations were made to determine the effect of rainfall on accidents in Nairobi, Surabaya and Kuala Lumpur.

Work by Salt and Szatowski¹⁰³ showed that the skid resistance of the road surface is also an important factor. In this study, recommendations were made for the minimum desirable levels of skid resistance on sections of the road ranging from 'very difficult' ie. approaching traffic signals

to 'easy' ie. residential roads away from junctions. Skid resistance values were taken in the above cities so that actual values could be compared with those recommended by Salt.

The work mentioned earlier by Mackay⁸⁶ and Kemp³⁹ showed that the condition of vehicle tyres is an important factor in road accidents. Consequently, surveys were carried out in Nairobi of the condition of vehicle tyres in that city. Results were then compared with surveys carried out in Great Britain by Lowne¹⁰⁴.

Much work has been done in Great Britain and other industrialised countries to show the effectiveness of seat belts in reducing the severity of injury to the occupants of motor vehicles^{105,106}. A Paper by Lister and Milsom¹⁰⁷ showed that users of seat belts had 73 percent fewer fatal injuries, 67 percent fewer serious injuries and 33 percent fewer slight injuries than persons not wearing seat belts. A survey was consequently conducted by the author to determine seat belt useage in Nairobi, and results compared with surveys conducted in this country by Farr¹⁰⁹.

Whitlock¹¹⁰ made a study of 'social violence' and showed that road accident fatality rates could be related to other aspects of social behaviour such as murder and suicide rates in a given country. The author attempted a similar analysis in various developing countries but was unable to isolate other major factors such as the level of vehicle ownership and medical facilities available. Other workers in the field of human behaviour such as Tillman¹¹³ have suggested that drivers involved in road accidents may be of a certain type (possibly criminal) but Drew¹¹⁴ has tended to refute this idea.

The effects of alcohol on road accident rates has long been recognised and an article by Beaumont and Newby¹¹⁵ was used to illustrate this fact. In Great Britain legislation was introduced in 1967 making it an offence to drive with more than 80 milligrammes of alcohol per 100 millilitres of blood. Newby points out the difficulties of demonstrating the effectiveness of this legislation alone because other factors were involved at the same time. However it appeared in this country that the legislation had the effect of reducing fatalities by up to 17 percent, and all casualties by 11 percent. Efforts were made to demonstrate the possible effect of alcohol on road accident rates in Nairobi.

In Great Britain, over the period 1962-1967, detailed studies were made of driver behaviour at traffic lights and zebra crossings by Older, Mackie and Jacobs^{116,117}. In these studies, Jacobs investigated driver stopping behaviour on appearance of the amber light at traffic signals and also non-observance of the red signal. Experiments repeated in Nairobi and Surabaya showed driver-behaviour to be poor in these cities. Jacobs and Mackie also studied behaviour at zebra crossings such as the willingness of drivers to stop and the use made by pedestrians of the crossing. Studies by the author in Bangkok and Nairobi again showed user behaviour to be poor in developing countries..

Methods by which developing countries might deal with the accident problem were discussed and were similar to those suggested by Chapman¹¹⁸. Both Chapman and the author suggest that the criterion for assessing the priority for dealing with accidents in different areas of a country should not be numbers of accidents nor even the rates (per million vehicle kilometres travelled) but an estimate of the ratio of savings in money,

obtained by introducing a specific safety measure, divided by the cost of the scheme. In this way projects providing the greatest benefit/cost ratios can be identified.

3. ROAD ACCIDENTS AS A CAUSE OF DEATH IN DEVELOPING COUNTRIES

3.1 INTRODUCTION

In recent years there has been growing realisation in developing countries that the problem of road accidents is becoming increasingly serious. The research work described in Chapter 4 shows that fatality rates and severity indices are higher in developing than in developed countries and perhaps even more important, that unlike the countries of Europe and North America where fatality and injury rates per licensed vehicle tend to be decreasing, the rates in many developing countries are increasing.

Apart from the social problems created by road accidents, an analysis of road accident costs in developing countries (see Chapter 5) has indicated that road accidents cost developing countries each year approximately one per cent of their total gross national product, a sum that these countries can ill afford to lose.

It may be argued that road accidents are relatively unimportant in developing countries when compared with the more immediate concerns of sickness, malnutrition, housing and other social problems. However it was estimated by the author that in the developing world there were over 800,000 road accident casualties in 1973. In the same year the W.H.O. estimated that there were approximately 136,000 cases of smallpox, 109,500 cases of cholera, 130,000 cases of louse-borne typhus and 1,300 cases of polio, with not all of these occurring in the Third World. To illustrate the social problems that already exist as a result of road accidents, comparisons have been made between road accident fatalities and the number of deaths resulting from diseases considered by developing countries to be of particular concern. In order to investigate how death rates are

changing over time, comparisons have been made of death rates from diseases and road accidents over the period 1960-1972 in four developing countries. Also examined were the percentage changes in actual numbers of deaths from road accidents and diseases over the same time period studied.

In order to evaluate how scarce medical resources are taken up by the treatment of road accident casualties, an analysis was made of the proportion of hospital beds in Nairobi Kenya occupied by road accident casualties in 1974. The number of road accident cases was also compared with those receiving treatment for illnesses thought to be of particular concern in developing countries.

3.2 SOURCES OF DATA

The numbers of road accident fatalities taking place in the various countries were obtained from the International Road Federation's (IRF) publication, "World Road Statistics"¹, from official publications produced by the individual countries, or from data collected by the author using questionnaires sent to the developing countries themselves.

The numbers of deaths in specific countries from the selected diseases were obtained from the United Nations (UN) Demographic Yearbooks². According to this publication:

"The statistics presented in the Demographic Yearbooks are official data unless otherwise indicated. They have been assembled by the statistical office of the United Nations from official publications and from data transmitted in monthly or annual questionnaires by the national

statistical services or other appropriate governmental offices of over 220 countries or areas."

Data on population were also obtained from the UN Demographic Yearbooks.

Details of patients requiring hospital treatment in Nairobi in 1974 were obtained from the Nairobi, Aga Khan and Kenyatta hospitals during a visit made by the author to Kenya in 1975.

3.2.1 Definitions

Countries are usually defined by International Agencies such as the International Bank for Reconstruction and Development (IBRD) as 'developing' or 'less developed' according to the average level of gross national product (GNP) per capita (see Chapter 1). Countries studied in this report had GNP per capita levels ranging from as low as \$100 (Kenya) to over \$1,000. As recipients of aid from the IBRD and other agencies those with the higher levels, such as Singapore, were included in this report for comparative purposes.

When defining a road accident fatality, care must be taken that different definitions of death from a road accident do not distort the figures. Some countries consider that death occurs as a result of an accident if the victim dies on the spot, some if he dies within 24 hours and some have a limit of three or seven days, but in this report the Economic Commission for Europe (ECE) recommended limit of 30 days was used. Consequently, adjustments were made to the data from some countries listed in the IRF publication mentioned above in order to obtain an estimate of the number of deaths occurring within 30 days of

an accident. These adjustment factors were originally derived by Smeed³ in an analysis of road accident fatality rates in a number of European countries.

Death from a disease has been defined in the UN Demographic Yearbook² in accordance with the Principles for a Vital Statistics System, as follows:

"Death is the permanent disappearance of all evidence of life at anytime after live birth has taken place (post natal cessation of vital functions without capability of resuscitation)."

'Causes of death' are defined in the UN Demographic Yearbook² as:

"All those diseases, morbid conditions or injuries which either resulted in or contributed to death and the circumstances of the accident or violence which produced any such injuries. (Manual of the International Statistical classification of Diseases, Injuries and Causes of Death, 1965 Revision, Vol 1, p 469.) The underlying, rather than the direct or intermediate antecedent cause, is the one recommended as the main cause for tabulation of mortality statistics. It is defined as a) the disease or injury which initiated the train of events leading directly to death or b) the circumstances of the accident or violence which produced the fatal injury".

3.3 SELECTION AND CLASSIFICATION OF DISEASES

A survey was carried out by the World Health Organisation⁴ to determine which diseases were considered by developing countries to be the most serious. The results of the survey are shown in figure 3.1. The diseases

○	= Fairly serious
●	= Very serious

Major health concerns	Africa	Western Pacific	South East Asia	Americas & Caribbean	Eastern Mediterranean
Malaria	●	○	○	○	●
Tuberculosis	○	●	○		●
Leprosy	○	○	○		
Helminthiasis	○				
Bilharziasis	○				
Diarrhoea Dysentery	○	○	●	●	○
Filariasis		○	○		
Deficiencies in organisation & administration	○		○	○	○
Trypanosomiasis	○				
Onchocerciasis	○				
Venereal Disease	○	○		●	
Malnutrition	○	○	○	●	○
Environmental Deficiencies	○	○	●	●	
Smallpox	○		○		
Cholera		○	○		
Meningitis	○				
Yaws	○				
Enteric Fevers	○				
Trachoma	○		○		○

Fig.3.1 SUMMARY OF A WORLD HEALTH ORGANISATION SURVEY TO DETERMINE THE DISEASES CONSIDERED BY DEVELOPING COUNTRIES TO BE MOST SERIOUS

shown by this survey to be of particular concern were selected as a basis for study in this report.

In an analysis of health problems in the Third World by Bryant⁵, individual diseases were combined into six general groups so that trends in the number of deaths from various types of diseases over time could be identified. With the guidance of Mr E O C Grattan, FRCS, of Accident Investigation Division, TRRL, individual diseases listed in the UN Demographic Yearbooks were selected and combined into four groups (see Appendix Table 3.1 for list of individual diseases) so that comparisons could be made of changes in death rates over time from these groups of diseases and also from road accidents. Diseases were classified as infectious, intestinal, neoplastic and respiratory.

3.4 COMPARISON OF DEATHS FROM ROAD ACCIDENTS AND FROM DISEASES

The number of deaths from nine diseases considered to be of major concern in the Third World occurring in 15 developing countries were compared with the number of road accident fatalities from the same countries for the same year. The year 1972 was used when possible but when data were not available, the latest year for which data were available was taken. Table 3.1 and Figure 3.2 show the results of this comparison.

It can be seen from Tables 3.1 and Figure 3.2 that the combined total of deaths from road accidents in all the fifteen countries is higher than any of the diseases considered to be serious health problems in the Third World with the exception of enteritis (and other diarrhoeal diseases). Although the number of deaths from enteritis is very high, 44 percent of the total studied, road accident fatalities (16.7%) are higher than even tuberculosis (16.4%) and other infective and parasitic diseases (15.6%), while diseases like typhoid, cholera, malaria and dysentery range from 0.004 percent to 3.0 percent. Thus it would appear from this comparison, that road accidents must already be regarded as a serious social problem in developing countries.

TABLE 3.1
NUMBERS OF DEATHS FROM DISEASES AND ROAD ACCIDENTS
IN DEVELOPING COUNTRIES

Disease Country and year	Cholera	Typhoid	Bacillary Dysentery and Amoebiasis	Enteritis (and other diarrhoeal diseases)	Tuberculosis	Smallpox	Malaria	Syphilis and its sequelae	Some other infective and parasitic diseases †	Road accidents	Total
Angola 1971	-	71	95	2368	426	-	298	7	575	539	4379
Egypt 1971	-	483	8	1873	2896	-	15	10	3505	2000*	10790
Kenya 1970	2	2602	140	4631	603	948	731	25	1056	944	11682
Malagasy Rep. 1970	-	6	137	-	730	-	226	10	492	515	2116
Jamaica 1971	-	4	1	688	66	-	2	61	255	364	1441
Puerto Rico 1972	-	-	2	272	276	-	-	1	144	599	1294
Colombia 1969	-	284	595	16356	3240	19	930	92	4840	1170	27526
Peru 1970	-	488	154	10227	5079	-	43	41	2946	1919	20397
Jordan 1972	-	3	-	481	50	-	1	-	31	209	775
M. Malaysia 1971	3	59	33	460	977	-	180	15	432	1158	3317
Singapore 1968	-	5	15	138	496	-	3	20	101	312	1090
Brazil 1970	-	55	129	10598	3743	3	74	256	3690	1569	20117
Venezuela 1971	-	3	315	5085	1058	-	15	82	2474	3081	12113
S. Africa 1970	-	9	44	6676	1308	-	9	27	641	7948	16662
Hong Kong 1972	-	4	4	2	1334	-	-	7	125	441	1917
TOTALS	5	4076	1672	59855	22282	970	2527	654	21307	22768	136116
% of TOTAL	< 0.1	3.0	1.2	44.0	16.4	0.7	1.9	0.5	15.6	16.7	100.0

† Excluding plague, diphtheria, whooping cough, streptococcal sore throat and scarlet fever, meningococcal infection, acute poliomyelitis and typhus and other rickettsial diseases.

* Estimate based on accurate data from Cairo.

Fig.3.2 PERCENTAGE OF DEATHS BY VARIOUS CAUSES IN 15 DEVELOPING COUNTRIES

3.5 TRENDS IN FATALITY RATES FROM ROAD ACCIDENTS AND FROM DISEASES OVER TIME

As stated earlier Bryant⁵ combined information on individual diseases into groups and used the resulting values to study trends in the numbers of deaths from the various types of diseases over time. From this source, accurate medical statistics were available for Hong Kong and in this analysis the most detailed analysis of death rates and changes over time was made using these data. Trends in road accident fatality rates were compared with those for each of the four groups of diseases mentioned above together with those for two further groups, namely circulatory and nervous diseases.

As stated earlier, using the UN Demographic Yearbooks² as a source of data, accurate numbers of deaths from four groups (infectious, intestinal, neoplastic and respiratory diseases) were obtained for three other countries over the period 1960-1972. With the population statistics also obtained from the UN Demographic Yearbooks, deaths per head of population per annum for the various classes of diseases and for road accident fatalities were calculated.

These rates were compared to show the trends over time (see figs 3.3A, 3.4A, 3.5A and 3.6A). In order to show more clearly the changes taking place over the 10 - 12 year period, the yearly percentage change in actual numbers of deaths (over the base year) were calculated for the classes of diseases and for road accidents. The results are shown in figs 3.3B, 3.4B, 3.5B and 3.6B.

From figures 3.3A, 3.4A, 3.5A and 3.6A an identifiable pattern emerges, with deaths per 10,000 head of population from infectious and intestinal

diseases and diseases of the respiratory system showing a downward trend over time. These groups include diseases such as tuberculosis, dysentery, enteritis, malaria, cholera and smallpox. On the other hand, the death rates for road accidents and neoplastic diseases show a definite upward trend. This pattern is most marked in Hong Kong where death rates from diseases of the respiratory system fell from 16.5 per 10,000 head of population to 5.0 during the period 1954 - 1964; death rates from infectious and intestinal diseases dropped from 13.0 and 12.5 to 5.0 and 2.5 respectively. Also shown for Hong Kong are death rates for diseases of the circulatory and nervous systems and also neoplastic diseases, these three groups all showing considerable increases in the death rates.

This pattern is clearly repeated in the other countries studied, particularly Malaysia, where in 1972 the death rates for infectious and intestinal diseases are actually lower than that for road accidents.

Figures 3.3B, 3.4B, 3.5B and 3.6B show the yearly percentage changes in the number of deaths over the base-year (which varies from country to country). It can be seen that there is a clear tendency for the infectious, intestinal and respiratory groups of diseases to show large percentage decreases and for road accidents to show large percentage increases. Thus in Jamaica for example, the number of road accident fatalities in 1974 are 120 per cent greater than in 1958 (which was taken as the base year). Over the same time period the number of deaths from infectious diseases decreased by 60 per cent.

3.6 A STUDY OF MEDICAL RECORDS IN NAIROBI, KENYA

With the cooperation of the three major hospitals in Nairobi, an analysis was made of the diseases and illnesses requiring in-patient treatment

Fig.3.3(a) HONG KONG: DEATHS / 10 000 PERSONS FROM ROAD ACCIDENTS AND VARIOUS TYPES OF DISEASES

Fig.3.3(b) PERCENTAGE CHANGE IN NUMBERS OF DEATHS FROM ROAD ACCIDENTS AND DISEASES BETWEEN 1954-1973: HONG KONG

Fig.3.4(a) WEST MALASIA: DEATHS/10 000 PERSONS FROM ROAD ACCIDENTS AND VARIOUS TYPES OF DISEASES

Fig.3.4(b) PERCENTAGE CHANGE IN NUMBERS OF DEATHS FROM ROAD ACCIDENTS AND DISEASES BETWEEN 1960-1972 IN WEST MALAYSIA

Fig.3.5(a) JORDAN: DEATHS/10 000 POPULATION FROM ROAD ACCIDENTS AND VARIOUS TYPES OF DISEASES.

Fig.3.5(b) PERCENTAGE CHANGE IN NUMBERS OF DEATHS FROM ROAD ACCIDENTS AND DISEASES BETWEEN 1960-1972 : JORDAN

Fig.3.6(a) JAMAICA: DEATHS/10 000 PERSONS FROM ROAD ACCIDENTS AND VARIOUS TYPES OF DISEASES

Fig.3.6(b) PERCENTAGE CHANGE IN NUMBERS OF DEATHS FROM ROAD ACCIDENTS AND DISEASES BETWEEN 1958-74:JAMAICA

during 1974. In addition, the number of in-patients receiving treatment from road accidents were also obtained. These data were collected by the author during a visit to Kenya in 1975.

3.6.1 A comparison of the number of patients receiving treatment for road accidents and various illnesses

As would be the case in Great Britain the large majority of patients were receiving treatment for heart diseases, neoplasms and less critical illnesses such as appendicitis etc. However the diseases most likely to be associated with the Third World were selected with the help of the hospital staff and the number of patients receiving treatment compared with the number of road accident cases.

TABLE 3.2
IN-PATIENTS IN THREE NAIROBI HOSPITALS RECEIVING TREATMENT
FOR SELECTED DISEASES AND ALSO ROAD ACCIDENTS

Diseases	Total	Percentage
Intestinal infectious diseases	869	11.4
Tuberculosis	414	5.4
Bacterial diseases	224	2.9
Poliomyelitis	77	1.0
Viral diseases	441	5.8
Rickets and other arthropod borne diseases	202	2.7
Endocrine, nutritional and metabolic diseases	1194	15.7
Diseases of blood and blood forming organs	1048	13.8
Diseases of central nervous system and nerves	1053	13.9
Diseases of skin and subcutaneous tissue	418	5.5
Diseases of musculoskeletal system and connective tissue	539	7.1
Road traffic accident cases	1121	14.8
TOTAL	7600	100.0

It can be seen from table 3.2 that there were more in-patients receiving treatment for road accidents than for all but one of the illnesses associated with the Third World.

3.6.2 The utilization of medical and financial resources by road accident patients

From the hospital records of the Kenyatta and Aga Khan hospitals, estimates were obtained of the total number of in-patient days available throughout the year (for all types of illnesses and treatments) and the number of patient-days taken up with road accidents. The results are given in Table 3.3

TABLE 3.3
NUMBER OF PATIENT-DAYS TAKEN UP WITH ROAD ACCIDENT
CASES 1974

	Kenyatta Hospital	Aga Khan Hospital
Total number of patient-days available	195,640	66,430
Number of road traffic accident patients	315	452
Average length of stay of road accident cases	30.0	8.5
Number of patient-days for road accident cases	9,450	3,854
Percentage of patient days taken up by road accident cases	4.8	5.8

It was found that on average 5.3 per cent of all the in-patient days available throughout 1974 were taken up with road accident cases. Estimates of the cost of medical treatment were obtained from the three hospitals and it was calculated that the cost of treatment for road accident casualties in these hospitals in 1974 was over £160,000.

3.6.3 The age-distribution of in-patients

Road accidents are much more important in terms of loss of expectation of life than might be expected merely from an evaluation of basic road accident statistics. Thus it has been found in many countries that there is a disproportionate mortality rate for persons in the 15 - 24 years age group.

TABLE 3.4

NUMBERS OF DEATHS CAUSED BY MOTOR VEHICLES TO MALES IN 1967 BY COUNTRY
FOR ALL AGES COMBINED AND FOR THE 15 - 24 YEARS AGE GROUP⁶

Country	Numbers of deaths caused by motor vehicle accidents per 100 deaths from all causes	
	All ages (%)	15 - 24 years (%)
Fed. Rep Germany	3.6	50.2
Netherlands	3.8	47.3
Denmark	3.2	45.6
Belgium	2.9	44.2
France	3.6	43.8
Austria	3.7	43.3
England & Wales	1.8	41.9
Sweden	2.0	35.5
Switzerland	3.8	34.2
Scotland	1.8	33.2

Table 3.4 shows that in many countries road accidents account for up to 50 percent of all deaths among males in the 15 - 24 years age group and people in this age group would appear to be particularly at risk. The economic value to the community of young men in this age group should also not be overlooked.

In the past it has proved difficult to obtain details of the distribution of road accident casualties in developing countries because

of deficiencies in the data collection systems employed by these countries⁷. However, data collected by the hospitals in Nairobi enabled the author to obtain an age distribution of patients receiving treatment for road accidents to be obtained.

TABLE 3.5
THE AGE DISTRIBUTION OF PATIENTS RECEIVING TREATMENT
FOR ROAD ACCIDENTS IN KENYATTA AND AGA KHAN HOSPITALS
NAIROBI 1974

Age group	Number	Percentage
5 - 14	65	11.4
15 - 24	149	26.1
25 - 34	189	33.1
35 - 44	96	16.8
45 - 54	45	7.9
55 - 64	20	3.5
> 64	7	1.2
Total	571	100.0

From Table 3.5 it can be seen that the majority of patients were in the 15 - 24 and 25 - 34 years age groups. This distribution is fairly similar to that found for all road casualties in Great Britain, the main difference being that in Great Britain, the percentage in the 15 - 24 years age group is somewhat greater than that found in Kenya. This difference could be due to the greater usage of motorcycles in Great Britain, or to differences in population or income distributions. (Note: the age distribution of the population of Nairobi was found to be significantly different from that of hospital patients given above)

However it would appear that in Nairobi, as in almost all the countries of Western Europe, a large proportion of accidents occur to young people; for this reason road accidents are far more important in terms

of loss of expectation of life than seems to be the case from the overall mortality statistics.

3.7 CONCLUSION AND DISCUSSION

From the comparison of road accident fatalities and the number of deaths from diseases considered by developing countries to be of particular concern, it would appear that road accidents must already be regarded as a serious social and economic problem. Thus in fifteen countries there were more deaths from road accidents than from the various diseases studied with the exception of enteritis (and other diarrhoeal diseases).

As might be expected the situation is becoming worse with road accident rates increasing over time whilst death rates from infectious and intestinal diseases are on the decrease.

The analysis of medical records from the three major hospitals in Nairobi, Kenya also indicate the importance of road accidents when compared with diseases of the Third World. More people were treated as in-patients from road accidents than received treatment for all but one of the diseases thought to be of particular concern in developing countries. Further, over 5 per cent of all patient-days available were taken up with the treatment of road accidents at an estimated cost of over £160,000. Although the analysis of the hospital records in Nairobi cannot be regarded as representative of the entire Third World it tends to confirm the broad analysis carried out with the use of data published by the United Nations and World Health Organisation.

As in developed countries, the problem is more severe in terms of loss of expectation of life than might be expected merely from an

analysis of basic road accident statistics because of the large percentage of accidents that occur to the young adult. The economic value to the community of young men in the age groups 15 - 24 and 25 - 34 should not be underestimated.

Indeed the loss in economic and social terms in developing countries from a road fatality may be greater than at first appears since the population involved is not a representative cross-section. In the author's opinion many of the fatalities occur to vehicle users who generally come from the minority of qualified people, the doctors, teachers and businessmen whose loss to the country is serious. This opinion is subjective and was formed during the author's investigation of road accident casualties in the Nairobi hospitals.

4. A STUDY OF ROAD ACCIDENT RATES IN DEVELOPING COUNTRIES

4.1 INTRODUCTION

As was seen in Chapter 3, road accidents already constitute a serious social problem in developing countries. The magnitude of this problem obviously varies from country to country in the developing world, just as it does in Europe and North America. In any particular country little progress can be made with improving the road accident situation until the problem itself has been clearly defined. Thus road accident statistics must be collected over a period of time so that some understanding is obtained of where accidents are occurring, to what class of road-user and in what type of accident. Unfortunately, in most developing countries, accident information collected by the police is rarely tabulated and analysed in any detail⁷ (see Chapter 6) and the only data available are the number of personal-injury accidents by degree of severity taking place each year.

In this chapter, an analysis is made of the basic road accident data available from a number of developing countries and attempts are made to assess the general situation in these countries.

The analysis was first made in 1972⁸. To determine how accident rates change with time, data over the 10-year period 1958 - 1968 were obtained for a number of countries (including some developed ones for comparative purposes). The percentage change in number of vehicles per person, fatalities and casualties per person and per vehicle were calculated and abnormal trends identified.

The analysis was repeated in 1975 using data over the period 1961 - 1971 so that results obtained in the earlier analysis could be

updated and confirmation obtained on the countries that showed abnormal trends.

Having identified countries showing abnormal trends over the 10-year periods 1958 - 68 and 1961 - 71, the analysis in 1975 took the process one stage further. Disaggregated data were obtained for the countries showing the abnormal trends and attempts made to determine why, for example, accident rates should be increasing in these countries, instead of decreasing as in the majority of both developed and developing countries.

In the earlier analysis data were obtained for 32 developing countries for the year 1968, the latest year for which comprehensive figures were available. The basic statistics collected were population, vehicles in use and road casualties, and from these, other statistics were derived to try to determine underlying patterns. For each country, the vehicles per 10,000 persons, fatalities per 10,000 vehicles, injuries per 10,000 vehicles and severity index (ie the proportion of all accidents that are fatal) were calculated.

In the later analysis, data for 27 developing countries were obtained for the year 1971 and results from the two analyses were compared. A survey⁹ of census procedures in developing countries showed that very few developing countries carry out a satisfactory national census to determine average vehicle-kilometres travelled. Therefore although it would seem more meaningful to calculate the number of fatalities and injuries per vehicle-kilometre travelled, the data derived would be very inaccurate.

4.2 DATA SOURCES

The basic data for the analyses described in this chapter were obtained from published sources including the International Road Federation's publication, World Road Statistics¹ and the United Nation's Statistical¹⁰ and Demographic² Yearbooks. Some information was also obtained from questionnaires sent by the Overseas Unit to individual countries in 1974.

The collection of data presented several problems. First, for the sake of accuracy, only countries whose fatalities totalled at least 20 were included. The other difficulties arose from a need to use consistent and unambiguous definitions.

4.2.1 Definitions

For the purposes of this report the following definitions were used.

Developing country: In the earlier investigation, vehicle ownership level was considered to be the most appropriate criterion. Originally a developing country was taken to be one with a vehicle ownership level of less than 1,000 vehicles per 10,000 population but Cyprus, Kuwait, Singapore and South Africa were later added to the list. As already stated, the division between developed and developing countries is by no means clear and many different definitions are in use. In the second analysis the definition commonly used by the Ministry of Overseas Development was taken; that is, a developing country is one with a GNP per capita of less than \$600 per annum. According to this definition four countries included in the earlier work (Kuwait, Portugal, South Africa and Yugoslavia) were excluded from the second analysis.

Vehicles in use. Overall vehicle totals can be misleading since definitions vary from country to country. Some countries may include motorcycles, scooters, tractors and trailers in their totals whereas other may exclude some or all of these. To try and keep the data as uniform as possible, tables giving a breakdown into type were used. Total vehicles in use were taken as the sum of cars, buses and coaches, goods vehicles, tractors, motorcycles, scooters and mopeds.

Fatalities. As stated earlier, care must be taken that different definitions of death from a road accident do not distort the figures. Some countries considered that death occurred as a result of an accident if the victim died on the spot, some, if he died within 24 hours and some have a limit of 3 days or 7 days but in this work the Economic Commission for Europe (ECE) recommended limit of 30 days was used. Consequently adjustments were made to the data from some countries listed in the IRF publication¹, in order to obtain an estimate of the number of deaths occurring within 30 days of an accident. Adjustment factors used were those calculated by Smeed in 1953³.

Injuries. Injuries were taken as the reported number of persons seriously or slightly injured in road accidents.

Serious injury: An injury for which a person is detained in hospital as an 'in-patient' or any of the following injuries whether or not he is detained in hospital; fractures, concussions, internal injuries, crushings, severe cuts and lacerations, severe general shock requiring medical treatment.

Slight injury: An injury of minor character such as a sprain, bruise or a cut or laceration not judged to be severe.

Casualties: Casualties were taken as the total number of fatalities and injuries resulting from road accidents.

The study of the methods used by developing countries to collect and analyse road accident data described in Chapter 6 showed that the quality of reporting accidents by the police and subsequent analysis by other government departments varied considerably from country to country. Discussions with various bodies in developing countries have indicated that the more serious accidents, particularly fatal ones, are reported with accuracy and in this work the detailed comparisons of international accident rates have been made using road accident fatality rates.

4.3 TRENDS IN VEHICLE OWNERSHIP, FATALITY AND INJURY RATES

In order to determine the changing patterns in vehicle ownership and fatality and injury rates with time, data on the vehicles, population, fatalities and injuries were obtained for a number of countries over the 10-year period 1958-68 or as near to this period as possible. The number of countries for which such information was available was limited and does not correspond exactly with those used later. For comparison, a number of developed countries were included. Injury totals were not available from the USA.

For the appropriate 10-year period, the percentage change per person in numbers of vehicles owned, average number of fatalities and injuries per head of population and fatalities and injuries per vehicle licensed were obtained. The results are shown in Table 4.1. The basic data used to obtain these changes are given in the Appendix.

TABLE 4.1
PERCENTAGE CHANGE IN VEHICLE OWNERSHIP, FATALITY AND INJURY RATES OVER
A 10-YEAR PERIOD (1958 used as base-year)

Country	Vehicles per head of population	Fatalities per head of population	Injuries per head of population	Fatalities per licensed vehicle	Injuries per licensed vehicle
Australia	+ 38	+ 23	+ 18	- 11	- 14
Bahamas, The	+ 32	+ 38	+ 92	+ 5	+ 46
Barbados	+ 87	+ 26	+ 4	- 34	- 45
British Honduras	+ 108	+ 74	+ 4	- 15	- 49
Cyprus	+ 65	- 6	+ 56	- 43	- 4
Great Britain	+ 67	+ 4	0	- 38	- 41
Guyana	+ 73	+ 45	+ 21	- 18	- 32
Hong Kong	+ 115	+ 44	+ 18	- 30	- 43
Jamaica	+ 89	+ 212	+ 48	+ 59	- 24
Japan	+ 814	+ 78	+ 309	- 80	- 54
Kenya	+ 11	+ 76	+ 29	+ 71	+ 24
Malawi	+ 1	+ 3	+ 19	- 1	+ 9
Mauritius	+ 47	+ 21	+ 3	- 19	- 31
New Zealand	+ 48	+ 13	+ 27	- 24	- 14
Singapore	+ 127	+ 24	+ 85	- 47	- 19
Trinidad and Tobago	+ 46	+ 15	+ 9	- 22	- 26
Uganda	+ 28	+ 29	+ 8	- 1	- 26
USA	+ 37	+ 29		- 6	
Zambia	+ 29	+ 239	+ 209	+ 169	+ 134

It can be seen that, as might be expected, in all countries there was an increase in the number of vehicles per person over the 10-year period.

The number of fatalities per head of population increased in all countries except in Cyprus where it fell by six percent. The number of injuries per head of population also rose in all countries except in Britain where there was no change. The percentage changes in fatalities and injuries do not appear to be closely related to changes in vehicle ownership. (Calculations of rank correlation coefficients indicated values of approximately zero). Thus Uganda and Zambia had similar increases in vehicle ownership (28 and 29 percent respectively) yet fatalities in Zambia increased by 239 percent over the 10-year period whilst there was an increase in Uganda of only 29 percent. Similarly, in these countries the changes in injury rates per person were 209 percent in Zambia and 8 percent in Uganda.

Table 4.1 also shows changes in fatalities and injuries per licensed vehicle. This is a more useful indication of the accident situation in any country over a period of time since it introduces an effect of 'exposure' to the vehicle population. It can be seen that there is a tendency for both rates to decrease with time. Out of the 19 countries studied 15 showed a decrease in fatalities per vehicle and 14 a decrease in injuries per vehicle. Similar analysis by Smeed¹¹ showed decreases in 15 out of 16 countries studied (only three countries were the same as those studied here). If there is a tendency for fatality and injury rates per licensed vehicle to decrease with time, those countries not showing this tendency may be experiencing unusual conditions. Zambia, Jamaica and Kenya in particular had considerable increases in the number of fatalities per licensed vehicle, and in these countries it might well be that some of

the many features necessary to reduce accident rates, for example, driver training, enforcement of regulations, improvement of vehicle safety standards and of road design, are not being introduced, whilst at the same time vehicle ownership is increasing rapidly. Thus, by examining trends over a period of time it may be possible to identify countries where the road accident situation is not improving.

The analysis was repeated in 1975 using data over the period 1961-71. Changes in vehicle ownership, fatality and casualty rates are given in Table 4.2, and the basic data used given in Appendix Table 4.2.

It can be seen that there is again a tendency for both fatality and injury rates (per vehicle) to decrease with time. The earlier work on developing countries showed that Kenya, Jamaica and Zambia were notable exceptions to this trend and in these countries the fatality rates per licensed vehicle increased over the 10-year period. In this analysis these countries again exhibit this trend as does Nigeria.

It is interesting to note that in Kenya and Jamaica the fatality rate per vehicle has, in fact increased at a much greater rate than the increase in vehicle ownership. An analysis of road accidents taking place in Kenya¹² in 1972 (see Chapter 7) showed that over 80 percent of all accidents involved a single vehicle, a pedestrian or a cycle and thus under 20 percent involved two or more vehicles. As an approximation therefore, it might be assumed that fatality rates might increase in direct proportion to the increase in vehicles. In Kenya, however, the increase in fatalities per vehicle was over two and a half times the increase in vehicle ownership.

Later in this chapter a study is made of disaggregated data in an attempt to identify why the fatality rate per vehicle should be increasing in these countries.

TABLE 4.2 PERCENTAGE CHANGE IN VEHICLE OWNERSHIP FATALITY AND INJURY RATES. (1961 - 1971)

Country	Vehicles per person	Fatalities per person	Injuries per person	Fatalities per vehicle	Injuries per vehicle
Australia	+ 38	+ 18	+ 24	- 15	- 10
Botswana	+ 44	+ 69	+ 36	+ 16	- 7
Br. Honduras	+ 205	+ 95	+ 32	- 37	- 57
Ceylon	+ 36	+ 26	- 31	- 10	- 50
Cyprus	+ 104	+ 17	+ 105	- 43	- 1
Great Britain	+ 41	+ 5	- 5	- 26	- 33
Guyana	+ 85	+ 74	+ 70	- 7	- 9
Hong Kong	+ 128	+ 42	+ 45	- 40	- 39
Jamaica	+ 26	+ 95	+ 16	+ 55	- 33
Japan	+ 461	+ 14	+ 176	- 80	- 51
Kenya	+ 30	+ 123	+ 43	+ 78	+ 14
Malawi	+ 11	+ 37	+ 22	+ 22	+ 10
Malaya	+ 123	+ 70	+ 37	- 24	- 38
New Zealand	+ 48	+ 13	+ 28	- 24	- 14
Nigeria	+ 33	+ 58	- 12	+ 27	- 28
Singapore	+ 113	+ 41	+ 16	- 34	- 46
Sabah	+ 173	+ 103	+ 128	- 28	- 18
St. Lucia	+ 180	+ 165	- 21	- 4	- 72
Tanzania	+ 50	+ 32	+ 23	- 2	- 10
Turkey	+ 140	+ 59	+ 44	- 28	- 35
Zambia	+ 47	+ 125	+ 127	+ 52	+ 54

4.4 Fatality rates

The previous section examined the changes over time in the number of vehicles, fatalities and injuries in different countries. However it is worth-while examining the absolute values of these quantities.

Using data for road fatalities, vehicles and population for the year 1938 from 20 developed countries Smeed¹³ derived the relationship

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

where

F = fatalities from road accidents

V = number of vehicles in use

P = population

Thus according to this equation, in a group of countries, the greater the level of vehicle ownership, the lower the fatality rate. The equation was also a good fit for data collected by Smeed for 16 developed countries ranging over the period 1957 - 66¹¹ and also for 68 different countries over the period 1960 - 67¹⁴. In order to determine whether the fatality rate per vehicle in developing countries is similarly related to the level of vehicle ownership, an analysis was carried out by the author⁸ in 1971 on 32 developing countries, using data for the year 1968. In order to derive a linear relationship the logarithmic values of the fatality rates were regressed against the logarithmic values of the vehicle-ownership rates and the following equation derived:

$$(F/V) = 0.00077 (V/P)^{-2/5}$$

The data and line are given in Figure 4.1, and the basic data used in Appendix Table 4.3

Fig.4.1 VEHICLE OWNERSHIP AND FATALITY RATES FOR DIFFERENT DEVELOPING COUNTRIES, 1968

It can be seen that the equation derived for developing countries differs somewhat from the Smeed equation. With a doubling of vehicles per person the Smeed equation implies a decrease in fatalities per vehicle of 37 percent whilst the relationship for developing countries implies a decrease of 24 percent. Thus the Smeed equation predicts a larger decrease in fatalities per vehicle as vehicle ownership rises.

The 90% confidence limits were calculated for the regression equation derived for the developing countries, see Fig. 4.1 (90 percent of the points would be expected to fall within these limits.) Some points lie below the lower limit, suggesting that they have unusually low rates. (It should be noted however, that on average one or two points would be expected to lie outside the 90% confidence limits, and care should be taken in drawing conclusions from these points.)

Data were then obtained for Britain for the years 1909 - 38¹⁵ and the vehicles per 10,000 persons and fatalities per 10,000 vehicles were calculated. During this period vehicle ownership levels in Britain were similar to those of the developing countries for 1968, with vehicle ownership rising from 33 vehicles per 10,000 persons in 1909 to 670 vehicles per 10,000 persons in 1938. Fatalities per 10,000 vehicles were calculated and the relationship plotted on the same graph as the data for the developing countries (see Appendix, Table 4.4 and Fig. 4.2). It can be seen that all the points lie within the 90% confidence limits and are fairly close to the line. This implies that the fatality rates experienced in the developing countries in 1968 are not dissimilar to those experienced by Britain in her early stages of road transport development.

(A similar analysis by Dondanville¹⁶ found that the relationship between fatalities per vehicle and vehicles per person in the US

Fig.4.2 VEHICLE OWNERSHIP AND FATALITY RATES FOR BRITAIN 1909-1938 AND DEVELOPING COUNTRIES 1968

for 1912 - 67 was comparable with that for various countries of the world for 1967).

Care must be taken in drawing conclusions from these relationships, since differences in the distribution of population in Britain and the developing countries could be an important factor, as could average annual vehicle distance travelled or vehicles per kilometre of road, for example.

In the earlier work, developing countries were, as stated above, defined according to the level of vehicle ownership. The analysis was now repeated for a group of countries using the Ministry of Overseas Development definition given earlier (ie that of income level) again using data for 1968 (see Appendix Table 4.5). The equation derived was:-

$$(F/V) = 0.00074 (V/P)^{-0.43}$$

As can be seen, this is very similar indeed to the equation derived earlier, the exclusion of the richer countries having relatively little effect.

In order to see whether the relationship changes with time, the analysis was repeated for the same group of countries, using data for the year 1971. (See Appendix Table 4.6). The relationship derived was as follows:-

$$(F/V) = 0.000914 (V/P)^{-0.43}$$

The two regression equations (together with the values for 1968 and 1971) are given in Figure 4.3. It can be seen that the slope of

Fig.4.3 FATALITY AND VEHICLE OWNERSHIP RATES FOR DEVELOPING COUNTRIES
1968 and 1971

the line has remained exactly the same, whilst at the same time, the line itself has moved upwards. In other words, the equation gives higher fatality rates in 1971, than in 1968, for the same level of vehicle ownership. By comparing the two regression coefficients for 1968 and 1971, it can be seen that there has been an average 24 percent increase in fatality rates for the same level of vehicle ownership.

Thus, over the short period 1968 to 1971, the situation worsened in the developing countries, with the fatality rates actually increasing in over two-thirds of the countries studied.

In order to determine whether the Smeed equation has changed with time, almost exactly the same group of countries used by Smeed in 1938 were taken and relationships derived for the years 1950, 1960 and 1970. The equations were found to be as follows:-

$$\begin{array}{lll} 1950 & (F/V) & = 0.00034 (V/P)^{-0.58} \\ 1960 & (F/V) & = 0.00034 (V/P)^{-0.60} \\ 1970 & (F/V) & = 0.00039 (V/P)^{-0.56} \end{array}$$

The actual values for the different countries, (see Appendix Tables 4.7, 4.8 and 4.9) and the regression equations are illustrated in Figure 4.4. It can be seen that there was little variation in the equations over the 20 year period. Figure 4.5 shows the three regression lines calculated for developed countries, for the years 1950, 1960 and 1970, together with that derived by Smeed using 1938 data. Again, it can be seen that there is little variation between the four equations, the Smeed equation fitting very closely indeed, data for the year 1970.

Fig.4.4 FATALITY AND VEHICLE OWNERSHIP RATES FOR DEVELOPED COUNTRIES.
1950, 1960 and 1970

Fig.4.5 FATALITY AND VEHICLE OWNERSHIP RATES FOR DEVELOPED AND DEVELOPING COUNTRIES FOR THE YEARS INDICATED

It is not suggested that the fatality rate in a country can be 'explained' simply by the level of vehicle ownership or that the equation is a completely satisfactory predictor of changes in fatality rates over time, since so few parameters are involved. For example the equation makes no allowances for changes in vehicle composition, the distribution of traffic on an urban/rural basis or for changes in social behaviour. In the above analysis it has been used simply to show that the relationship derived for developing countries would appear to be different from that for developed countries (see Figure 4.5). Perhaps even more important, in developing countries, the relationship changed over the short 3-year period, with fatality rates per vehicle being greater in 1971 than in 1968 (for the same levels of vehicle ownership), whereas in developed countries the relationship between the fatality rate and vehicle ownership has hardly changed in over 30 years.

4.5 · INJURY RATES

For each of the 32 developing countries selected in the initial analysis, the number of injuries (serious and slight) per 10,000 vehicles in 1968 was calculated, see Appendix Table 4.10. The logarithms of the values obtained were regressed against the logarithms of vehicles per 10,000 persons in each country but in this case no statistically significant relationship was obtained, even at the 10 percent level. The scatter of the points using logarithmic scales is given in Fig. 4.6. Thus although fatality rates were found to be significantly related to the vehicle ownership levels, the injury rates were not so related.

Values of injuries per 10,000 vehicles and vehicles per 10,000 persons were obtained for Great Britain for the period 1909-1938, see Appendix Table 4.11. The logarithmic values of these data were found to be significantly related at the 5 percent level. Thus, although no

significant relationship was found for the 32 different developing countries, a significant relationship was found to exist for Great Britain over a number of years.

Further relationships were examined for the developing countries and injuries per 10,000 vehicles were regressed in turn against population density, percentage of population in urban areas, vehicles per kilometre of paved road and finally vehicles per kilometre of total road. The only statistically significant relationship was obtained (at the 5 percent level) for (log) injuries per 10,000 vehicles and (log) vehicles per 10 kilometres of road. This relationship is shown in Fig. 4.7 and the data in Appendix Table 4.12. It is quite likely therefore that the injury rates in each country depend on other physical and social characteristics which are not easy to measure, and for this reason no relationship was obtained between injury rate and vehicle ownership for the different countries, whilst such a relationship was found to exist for one country, namely Great Britain, over a number of years.

Furthermore whilst fatal accidents are fairly well recorded, the accuracy and reliability of recording falls drastically with the severity of the accident. Therefore if it had been possible to analyse serious accidents and slight accidents separately, a significant correlation might have been found between serious accidents and vehicle ownership for the different countries. Unfortunately serious and slight accidents were grouped together in all the data sources and this analysis was not possible.

Fig.4.6 VEHICLE OWNERSHIP AND INJURY RATES FOR BRITAIN 1909 - 1938 AND DEVELOPING COUNTRIES 1968

Fig.4.7 VEHICLES PER 10km OF ROAD AND INJURY RATES FOR DIFFERENT DEVELOPING COUNTRIES

4.6 SEVERITY INDEX

The severity index is a measure of the proportion of all casualties that are fatal. It was calculated for each developing country for 1968, as the number of fatalities divided by the number of casualties (fatal, serious and slight), and expressed as a percentage. Thus a country with a high severity index has a high proportion of fatal injuries. These results are given in Table 4.3. The severity index was plotted against vehicles per 10,000 persons using logarithmic scales and the regression line was found to be significant at the 0.1 percent level, see Fig. 4.8. It can be seen that as vehicle ownership rises the severity index falls. Confidence limits were calculated at the 90% level and all but two countries were within these limits. The point for Iraq lies above the upper limit, suggesting that it has an abnormally high severity index for its vehicle ownership level, that is, a very high proportion of road injuries are fatal. On the other hand Cameroon has an unusually low severity index and lies below the lower limit.

The severity index must not be misinterpreted however as it is only a measure of the proportion of injuries that are fatal. A country may have a low severity index even if it has a large number of fatalities, simply because it has a high number of casualties. The severity index should not therefore be studied in isolation.

It is unlikely that the severity index is causally related directly to vehicle ownership, but more likely that it is related to other factors which also change as vehicle ownership increases.

TABLE 4.3
SEVERITY INDEX FOR DIFFERENT DEVELOPING COUNTRIES 1968

Country	Fatalities	Total casualties	Severity index	Vehicles/ 10,000 persons
1. Botswana	20	229	8.73	77
2. Cameroon	90	2,247	4.01	99
3. Ceylon	589	8,337	7.17	118
4. Chile	1,448	25,485	5.68	303
5. Cyprus	117	3,148	3.72	1,090
6. Dahomey	102	554	18.41	68
7. Ethiopia	583	3,598	16.20	22
8. Gambia, The	27	317	8.52	95
9. Guyana	125	2,080	6.01	452
10. India*	9,734	61,111	15.93	23
11. Indonesia	2,328	13,338	17.45	54
12. Iraq	827	2,407	34.36	157
13. Ivory Coast	362	4,688	7.72	204
14. Jordan	197	2,267	8.69	123
15. Kenya	670	5,599	11.97	100
16. Kuwait	206	2,829	7.28	1,917
17. Madagascar	148	2,778	5.33	111
18. Malawi	152	1,699	8.95	40
19. Malaysia (W)	719	8,553	8.41	591
20. Mauritius	80	1,928	4.15	257
21. Morocco	1,305	21,775	5.99	187
22. Niger	79	516	15.31	16
23. Pakistan	1,650	6,779	24.34	18
24. Portugal	1,183	24,716	4.79	830
25. Rhodesia	480	6,133	7.83	603
26. Singapore	312	9,576	3.26	1,241
27. South Africa	5,810	60,321	9.63	1,006
28. Swaziland	72	548	13.14	263
29. Syria	337	2,002	16.83	93
30. Tunisia	214	3,687	5.80	212
31. Yugoslavia	2,703	41,427	6.52	443
32. Zambia	617	5,660	10.90	178

* Figures for 1967

Fig.4.8 SEVERITY INDEX AND VEHICLE OWNERSHIP FOR DIFFERENT DEVELOPING COUNTRIES 1968

4.6.1. Severity index and medical facilities

A comparison was made between the severity index and the level of medical facilities available (see Appendix, Table 4.13). As medical facilities improve, casualties which would previously have been fatalities may now only be injuries, thus lowering the severity index. For each country the severity index was plotted against the total population divided by the number of hospital beds in each country and a regression line, significant at the 0.1 percent level was obtained. The results are shown in Fig. 4.9. It can be seen that the severity index rises as the population per available hospital bed increases, i.e., as medical facilities become worse. Tolerance limits at the 90% level were calculated (see Fig. 4.9) and four points were found to lie outside the limits. The points for Iraq and Niger lie above the upper tolerance limit, their indices being high for their levels of population per hospital bed.

Another measure of medical facilities, population per physician, was compared with the severity index (see Appendix, Table 4.13). The points were plotted (see Fig. 4.10) and the correlation found to be significant, this time at the 5 percent level. There is again a general increase in the severity index as the population per physician becomes larger, i.e. as medical facilities become poorer. Tolerance levels at the 90% level were added and here the point for Pakistan lies just outside the upper limit while the point for Iraq lies well outside. It is likely that many other factors govern the overall index of severity of road accidents in any country, the degree of medical facilities provided being important but only one of many factors.

Fig.4.9 SEVERITY INDEX AND POPULATION PER HOSPITAL BED FOR DEVELOPING COUNTRIES 1968

Fig.4.10 SEVERITY INDEX AND POPULATION PER PHYSICIAN FOR DEVELOPING COUNTRIES 1968

4.7 FACTORS AFFECTING ACCIDENT RATES

It might, at first, appear reasonable to assume that as the number of vehicles increases in a country, the fatality and injury rates will also increase, since more vehicles implies that vehicle-vehicle, or even vehicle-pedestrian conflicts become more likely. However, the analysis in Section 4.4 shows that there is a tendency for the number of fatalities and injuries per vehicle to fall with increasing ownership. Reasons for this tendency were put forward by Garwood and Munden¹⁷ in 1968. They showed that in Great Britain, whereas the total number of casualties per vehicle-mile travelled fell over time, the rate per vehicle-mile for drivers of cars, other four-wheeled vehicles, motorcyclists and pedal cyclists actually rose. The reasons suggested for this were:

1. riders and passengers of two-wheeled vehicles have much the highest casualty rates per mile travelled, but over time they become a decreasing proportion of the total traffic.
2. pedal cyclist and pedestrian travel are not included in the assessment of motor vehicle miles, but their casualties are not increasing at as fast a rate as is the total of other casualties.
3. the number of pedestrian casualties per motor vehicle-mile for the different classes of vehicle is falling.

Thus, the decrease in fatality rates per vehicle over time in most countries could mainly be due to the fact that vehicles with the highest accident rates are decreasing in numbers, and that pedestrian accident

rates per vehicle of various kinds are also decreasing possibly because of pedestrianisation of central shopping areas, and also to better pedestrian-crossing facilities. Using data from a number of developed countries, Professor Smeed⁴ was able to confirm that the above points suggested by Garwood do have a significant effect on changes in fatality and casualty rates over time.

As was seen earlier, Kenya, Jamaica, Zambia and Nigeria showed an upward trend in fatality rates per vehicle over time, as opposed to the downward trend exhibited by most other developed and developing countries. Applying the reasons suggested by Garwood above, to these countries, it is possible for example, that the increases in fatality rates are due to rapid increases in motorcycle ownership, or possibly to the fact that pedestrian fatality rates are not falling as is the case in most countries. In order to investigate these and other factors, a limited amount of disaggregated road accident data were obtained from the above countries, mainly in the form of annual statistical abstracts.

4.7.1 Changes in fatality rates and motorcycle ownership

Table 4.2 gave the changes in fatality rates per licensed vehicle over the 10-year period, 1961-71. An attempt was made to determine the changes in the proportion of two-wheeled motor vehicles over this period. This proved somewhat difficult, because in early years, some countries listed only the number of motorcycles (as opposed to total two-wheeled motor vehicles), but then listed all two-wheeled motor vehicles at a later date. However, comparable data were obtained for 16 countries over the period 1962 - 1971.

Out of the 16 countries for which comparable data were available, the number of two-wheeled vehicles expressed as a percentage of the

total vehicle population increased in seven countries and decreased in nine. Those showing the greatest increase were those where the fatality rate had increased over time, namely Kenya, Jamaica, Zambia and Malawi: Changes for these countries are illustrated in Figure 4.11.

A rank correlation analysis was carried out on changes in fatality rates and motorcycle, moped and motor scooter ownership over time, and the two were found to be significantly related (at the 5 percent level). There would appear, therefore, to be a relationship between increasing fatality rates per vehicle and increasing motorcycle ownership in these countries.

4.7.2 Pedestrian fatalities

In order to investigate changes in the proportion of total fatalities and casualties that are pedestrian plus pedal cyclist, deaths and injuries to different classes of road user need to be recorded separately. Of the countries with increasing fatality rates per vehicle, such a breakdown was obtained from Jamaica, Zambia and Malawi: but not for Kenya. Over varying periods of time, ranging from six to nine years, it was found that the ratio remained constant for Jamaica, decreased for Zambia and increased considerably for Malawi. A similar result was obtained by comparing pedestrian fatalities with the total (ie excluding pedal cycle casualties).

In a similar analysis, Smeed¹¹ found that the ratio of pedestrian plus pedal cycle to total fatalities and casualties decreased in seventeen out of eighteen developed countries, over a 10-year period. During this period, the total fatality rate per licensed vehicle fell in all countries but one. It would seem, therefore, that the second reason

Fig.4.11 FATALITIES /10 000 POPULATION AND MOTOR CYCLES AS A PERCENTAGE OF TOTAL VEHICLE POPULATION FOR KENYA,JAMAICA,ZAMBIA AND MALAWI 1954-1972

put forward by Garwood and Munden, for the decrease in fatality rates per licensed vehicle, applied to a large number of countries but conversely, in Jamaica and Malawi, where the ratio did not decrease over time, the fatality rate per licensed vehicle showed an increase.

Garwood and Munden also pointed out that although the overall fatality rate decreased over time in Great Britain between 1957 and 1966, the risk to a number of individual categories of road user per mile travelled was increasing. Smeed also noted this trend in a number of European countries, and one of the reasons for this apparent discrepancy is that although most rates per vehicle-kilometre travelled for motor traffic were not decreasing, the rate for pedestrian casualties decreased considerably. (The rates for pedestrians were not true risks but were the number of casualties divided by the motor vehicle kilometres travelled). The overall effect was for the total fatality and casualty rates for all classes of road-user combined, to fall. In Great Britain and other countries, the fall in pedestrian casualty rates is probably due to improved pedestrian facilities, pedestrianisation of main shopping areas, and possibly to an overall decrease in pedestrian movement.

In Jamaica, Zambia and Malawi, road fatalities were categorised by type, and it was possible to compare changes in pedestrian and non-pedestrian fatalities per licensed vehicle over the 10-year period. In Jamaica, the pedestrian rate increased over the 10-year period, and did so at the same rate as the non-pedestrian fatalities. In Zambia, the pedestrian fatality rate increased, but not as rapidly as the non-pedestrian rate, whilst in Malawi, the pedestrian rate increased at a greater rate than the non-pedestrian fatalities.

Thus, another important factor in the overall increase in fatality rates in these countries might be that (as opposed to most other countries), the fatality rate for pedestrians is increasing, and not decreasing.

4.7.3 Changes in the average number of casualties per accident

All the work described so far has examined numbers of people killed and injured, and not the actual number of accidents taking place. For some of the countries listed in Appendix Table 4.2 the personal-injury accidents taking place in 1961 and 1971 were obtained, and the rates per licensed vehicle calculated. (Most developing countries listed total accidents i.e. including damage-only, and did not give the number of accidents involving personal-injury).

For all the countries, except Kenya, the percentage change in accident rate over the ten-year period altered in the same manner as the fatality and injury rates. Thus, in most countries, the fatality, injury and accident rates per licensed vehicle fell, over the ten-year period, whilst in Jamaica, Malawi and Zambia, the rates all increased. As was seen earlier, the fatality and injury rates per licensed vehicle increased in Kenya; it was found, however, that over the same period of time, the accident rate decreased.

If the injury and fatality rates are increasing, whilst the accident rate is decreasing, the number of casualties per accident must be increasing over time. In other words, more people are being killed and injured per accident in 1971 than in 1961. The number of casualties per accident for the years 1960 to 1972, in Kenya, were calculated, and the results are given in Figure 4.12. For comparison,

Fig.4.12 THE NUMBER OF CASUALTIES PER ACCIDENT OCCURRING IN KENYA, GREAT BRITAIN, AND JAMAICA, 1960-1972

results from Jamaica and Great Britain are also illustrated.

It can be seen that the rate increased almost 60 percent in Kenya, whilst remaining fairly constant in other countries. Thus, the increase in fatality and injury rates per licensed vehicle in Kenya, from 1961 to 1971, might be due, in part, to a higher vehicle occupancy rate in 1971, than existed in 1961, or possibly to a certain type of accident becoming more prevalent. For example, an analysis of all personal-injury accidents taking place in Kenya, in 1972, (see Chapter 7) showed that the number of casualties who were occupants of commercial vehicles expressed as a percentage of the total was almost 17 percent. In European countries, the equivalent value is of the order of 5 percent. This high rate to users of commercial vehicles is probably due to the use of open-sided lorries to transport workers to and from their places of work. When such a vehicle is involved in an accident, large numbers of casualties frequently result. It is possible, with increasing urban development in Kenya, that this type of accident has increased in recent years.

4.7.4 Accidents during daylight and darkness

The road accident data in Kenya provided information on the number of casualties occurring during daylight and darkness. From 1960 to 1972, the percentage of casualties injured during darkness increased from 24 percent, to 33 percent (see Figure 4.13). This increase is almost certainly due to a corresponding trend in the proportion of night-time traffic. As the accident rate is higher at night, this could contribute to the overall accident rate increasing over this period.

Little information was available from other countries on the proportion of accidents occurring during daylight and darkness, but

Fig.4.13 THE PROPORTION OF CASUALTIES DURING THE HOURS OF DARKNESS IN KENYA AND GREAT BRITAIN

data were obtained for Great Britain from 1958 to 1969¹⁸. This is also shown on Figure 4.13. It can be seen that the proportion of casualties in dark hours also increased in Great Britain, from 1958 to 1966. The proportion of fatal and serious casualties in the dark fell in 1967, and again in 1968, possibly due to the introduction of the breath tests (Road Safety Act, 1967) in October 1967.

4.8 CONCLUSIONS AND DISCUSSION

This analysis shows that there was a continuing downward trend in fatality and injury rates per licensed vehicle, over the periods 1958 to 1968 and 1961 to 1971 in the majority of the countries studied, but that Kenya, Jamaica, Zambia and Malawi were notable exceptions to this.

Detailed research in these countries is needed to obtain a full understanding of the accident patterns that exist, but disaggregated data have been used to illustrate some of the factors that may be leading to increasing, as opposed to decreasing, fatality and injury rates.

In the countries studied, there was found to be close correlation between changes in the proportion of two-wheeled motor vehicles on the road, and the changes in fatality and injury rates. Thus, countries showing the greatest increases in fatality rates per vehicle also had the largest increases in the ownership of two-wheeled motor vehicles. Research in Great Britain and other European countries has shown that this type of vehicle has a very high accident rate (per vehicle-kilometre travelled), and every effort should be made to ensure that the risks to users of two-wheeled motor vehicles are minimised. It is suggested that if it does not already exist, legislation be introduced on the use of safety helmets. If legislation already exists, efforts should be made to enforce the regulations.

In most countries, over recent years, there had been a tendency for the fatality and injury rates to pedestrians to show a considerable decrease. Zambia, Jamaica and Malawi did not show this decrease, and pedestrian rates increased often at a greater rate than that to other road users. With increasing road traffic in urban areas, the pedestrian is particularly vulnerable, and if segregation by the use of pedestrian precincts is not possible, then adequate provision should be made for pedestrians to cross the road safely. Most countries of the Third World use uncontrolled pedestrian crossings; studies in Kenya and Thailand showed poor road user behaviour at these crossings. This work, detailed in Chapter 10, could be a major influence on casualty rates.

An analysis of road accidents and casualties in Kenya (see Chapter 7) showed that the average number of casualties per injury-accident taking place has increased by sixty percent, over the last ten years. Efforts should be made to ensure that the over-loading of vehicles does not take place. Users of commercial vehicles in Kenya seem to have a high risk rate, and the transportation of workers to and from their place of work in open lorries should perhaps be regulated.

In Kenya, the percentage of casualties occurring during darkness increased considerably between 1960 and 1972. This is almost certainly due to an increase in night traffic. Accident and casualty rates are higher during the hours of darkness so a change in the proportion of traffic at night will have an effect on the overall accident or casualty rates. The work on road-user behaviour in urban areas, referred to above,

has shown that very few pedal-cyclists in particular show any lights at night (either front or rear). The author concludes that efforts should be made to ensure that vehicles are properly equipped for night-time journeys, and if the community can afford it, that main roads have adequate street-lighting.

Fatality rates for developed and developing countries were found to be significantly correlated with vehicle ownership, the higher the level of vehicle ownership, the lower the fatality rate. The equation derived by Professor Smeed, using data from different developed countries, for the year 1938, was found to be a very good predictor of fatality rates for the years 1950, 1960 and 1970. The equation for developing countries is clearly different from that derived by Smeed, the regression line having a lower slope.

The regression line calculated for developing countries for the year 1971 was above that calculated for 1968, the slopes of the two lines being almost exactly the same. In other words, the fatality rates were greater in 1971, than in 1968, for all levels of vehicle ownership. This implies that over the short period, 1968 to 1971, the situation has worsened in developing countries. Apart from the reasons put forward above, such as changes in vehicle composition, or increases in night-time driving, it is possible that the many factors needed to reduce accident rates, such as improved junction design, vehicle maintenance and inspection, education and enforcement are not keeping abreast with the larger increases in vehicle ownership.

The severity indices in 32 developing countries for the year 1968 were found to be correlated with the vehicle ownership level, the lower the vehicle ownership, the greater the severity index. As has already been pointed out, the quality of accident reporting varies greatly from

country to country with the quality of reporting falling with the severity of the accident. The severity indices in developing countries therefore may not be as high as they at first appear. Since they are up to 20 times higher than in Great Britain for example, they are, without doubt high by European standards even when quality of reporting is taken into account.

Severity indices were found to be related to the medical facilities available in these countries. As might be expected, the better the hospital facilities or the number of doctors able to provide immediate treatment, the less were the chances of a serious injury becoming a fatality.

5. COMPARATIVE ACCIDENT COSTS IN DEVELOPING COUNTRIES

5.1 INTRODUCTION

The purpose of this work was to collate in comparative form such information as exists on accident cost analysis in developing countries, to discuss briefly the methodologies employed and to indicate some of the problems, particularly as regards data sources and definitions, which have been identified. There is clearly no definitive methodology for assessing accident costs but it is the intention of this work to show what techniques might be usefully adopted to indicate the level of accident costs in developing countries.

Accident cost analysis is a well-established part of road project investment appraisal. A transport investment which, among other effects, reduces accidents is clearly providing an economic benefit which should, if possible, be measured.

The problems of measuring the benefits provide a contentious economic issue. Mishan¹⁹ and Adams²⁰ have argued that the techniques commonly used have little validity from a theoretical standpoint. This analysis is presented in the full knowledge that limitations exist; but for the purposes of comparing road investment projects or safety equipment and procedures, the use of accident cost data provides a useful measuring tool for analysing death, destruction and injury. On the valuation of life, Goodwin²¹ argues that "objections may be avoided (if not answered) only if it is clearly specified that the money value arrived at is a minimum that society would find it worthwhile spending in order to avoid a fatal accident". It is this argument which has been adopted to justify the content of this chapter.

There is a further observation raised by Adler²²; he has suggested that for less developed countries the valuation of life is not necessary because the reduction in fatalities is likely to be of minor significance compared to the other benefits to be derived from transport investments. While this argument may be true of road investments (new construction, realignment and resurfacing) it cannot be levelled against traffic management schemes designed specifically to obviate accident black spots. It is also evident, as this work shows, that accident costs in developing countries are a significant cost item.

5.2 ACCIDENT COST RESULTS

5.2.1 The studies surveyed

Information from seven studies in developing countries has been collated by the author. Data for Great Britain^{23,24} have been included to give a comparative order of magnitude and also because the methodology employed in the British studies provides a good base for discussing the other studies. (To all intents and purposes the study by Dawson²⁴ provides the methodology currently being used by the Department of the Environment in Britain). The eight countries surveyed are Kenya²⁵ (1965), Ivory Coast²⁶ (1970), Thailand²⁷ (1963 and 1964), S Rhodesia²⁸ (1961), S Africa^{29,30} (1963), Israel³¹ (1967), Ghana³² (1970) and Turkey^{33,34} (1971).

5.2.2 Study results

Within the limitations of the different definitions employed, the different factors taken into account, the dates of the studies, the methods of measuring costs and the currency of measurement, Tables 5.1 and 5.2 set out the main results that each study has produced.

Table 5.1 describes the costs associated with each type of injury and the average material damage costs incurred in a road accident. Blanks in the Table indicate that the study concerned has either not considered these particular costs or has included them under another cost heading. In no instance is any cost included for the grief and suffering caused through a fatality. (Estimates have been made for Britain^{23,24} but are not included in the figures given here).

Distinction is made between the value of life and the value of livelihood, the valuation of the former being a possibly insoluble problem. The value of livelihood, therefore, presents only a partial and minimum sum that a person would forego in the event of his being fatally injured. (It is this inability to ask a person what value he places on his life that forms the basis of Mishan's¹⁹ criticism of the techniques described here).

Table 5.2 indicates the average cost of different types of road accident and estimated total accident costs for the country concerned. Blanks in the table indicate that results cannot be presented in that form because the base data did not exist in the study report which would permit the necessary analysis.

Table 5.3 gives the percentage total costs by major category, viz. loss in output, medical costs and vehicle damages. The Ivory Coast and S African data cannot be presented in this form.

It should be noted that the Kenyan study employed cost data at 1961 prices and accident data in 1965. Similarly the cost estimate for Britian (1970) is based on 1968 accident figures and 1970 prices. As regards the Israel study only the aggregate figures shown in Tables 5.2 and 5.3 have been obtained.

TABLE 5.1
UNIT COSTS⁽¹⁾ OF INJURIES (LOSS IN OUTPUT, ASSOCIATED MEDICAL, ADMINISTRATIVE AND DAMAGE EXPENSES)

		KENYA (1961)	IVORY COAST (1970)	THAILAND (1963) (1964)		S RHODESIA (1961)		S AFRICA (1963)		GHANA (1970)	TURKEY (1971)	BRITAIN (1963) (1970)	
				(1963)	(1964)	African	Non- African	African	Non- African			(1963)	(1970)
LOSS IN OUTPUT	Fatality	£740 ⁽²⁾	£6750 ⁽³⁾	£240 ⁽²⁾	£260 ⁽²⁾	£112 ⁽²⁾	£2500 ⁽²⁾	£655 ⁽⁴⁾	£1190 ⁽²⁾	£1190 ⁽²⁾	£3170 ⁽³⁾	£2880 ⁽²⁾	£9960 ⁽³⁾
	Serious Injury	£423	£420	£210 ⁽⁵⁾	£220 ⁽⁵⁾	£95	£1093	£565	£870		£419	£150	£310
				£8 ⁽⁶⁾	£8 ⁽⁶⁾					£4 ⁽⁶⁾			
MEDICAL EXPENSES	Slight Injury	£32	-	£4	£4	£6	£69	£120	£104	£2	£112	£2	£15
	Fatality	-	-	-	-	-	-	-	-	-	-	£13	£80
	Serious Injury	-	-	£35	£25	£66		-	-	£2	£50	£91	£150
DAMAGE TO VEHICLES & PROPERTY/ ADMIN. COSTS	Slight Injury	-	-	-	-	£9		-	-	£1	£13	£6	£15
	Injury Accident	£352	£760	£25		£273				£120 ⁽⁷⁾	£685		£210
	Non-Injury Accident	£85	£95		£33	-	-	-	-	£175 ⁽⁷⁾		£70	£90

Notes: (1) Exchange Rates employed 1 SA Rand = £0.58, 1 Thai Baht = £0.025, 1 Ivory Coast CFA = £0.0017
1 Israeli Pound = £0.13, 1 Ghanaian Cedi = £0.32, 1 Turkish Lira = £0.03

- (2) Net loss in output
(3) Gross loss in output
(4) Insurance payment
(5) Injury involving permanent disablement
(6) Injury not involving permanent disablement
(7) Payment per vehicle involved in accident

TABLE 5.2
AVERAGE ACCIDENT COSTS⁽¹⁾

	KENYA (1965)	IVORY COAST (1970)	THAILAND (1963) (1964)	S RHODESIA (1961)	S AFRICA (1963)	ISRAEL (1967)	GHANA (1970)	TURKEY (1971)	BRITAIN (1963) (1970)
Total Accident Cost	£2.9m	-	£6.3m £10.2m	£4m	£40m	£26m	£2.8m	£29.8m	£196m £300m
Cost of Fatal Accident	£1840	-	-	-	-	-	-	-	£3430 £11,310
Cost of Serious Accident	£1010	-	-	-	-	-	-	-	£480 £640
Cost of Slight Accident	£150	-	-	-	-	-	-	-	£150 £205
Average Personal Injury Accident Cost	£640	£3450	-	£577	£330	-	£260	£1100	£310 £580
Damage-only Accident Cost	£96	£95	-	-		-			£70 £90

Note 1: See Table 1 for exchange rates employed

TABLE 5.3
Relative costs by category (1)

	KENYA (1961)			THAILAND (1963)			S RHODESIA (1961)			ISRAEL (1967)			GHANA (1970)			TURKEY (1971)			GREAT BRITAIN (1963)			GREAT BRITAIN (1970)		
	Costs	% of Total		Costs	% of Total		Costs	% of Total		Costs	% of Total		Costs	% of Total		Costs	% of Total		Costs	% of Total		Costs	% of Total	
Loss in output	£1.0m	40		£0.3m	5		£0.7m	18		£17.9m	69		£0.7m	25		£11.2m	37		£ 34m	17		£ 84m	28	
Medical costs	-	-		£0.6m	9		£0.1m	2		£ 3.7m	14		£0.1m	4		£ 0.5m	2		£ 10m	5		£ 15m	5	
Damage to vehicles & property/ admin costs	£1.5m	60		£5.4m	86		£3.2m	80		£ 4.4m	17		£2.0m	71		£18.1m	61		£152m	78		£201m	67	
Total accident costs	£2.5m	100		£6.3m	100		£4.0m	100		£26m	100		£2.8m	100		£29.8m	100		£196m	100		£300m	100	

Notes: 1. See Table 1 for exchange rates employed
2. Data included under damage to vehicles and property/admin costs

5.2.3 Interpretation of the comparative results

Direct comparison of the absolute values given in Tables 5.1 and 5.2 would be misleading for the reasons to which reference has already been made. For example, even some of the British figures for 1963 and 1970 are not directly comparable, and not simply because of the time difference. The 1963 cost of fatality (£2880) was measured on the basis of a net loss in output (future income less future consumption) while the 1970 figure (£9960) was measured on the basis of a gross loss in output (future income) of the fatally injured person. The Ivory Coast and Turkish studies have similarly used gross loss valuation while the other studies, apart from S Africa, have adopted the net loss valuation. The S African study is based on insurance payments paid out to cover loss of income, medical expenses, legal costs, vehicle damage costs, etc on third party policy claims.

Apart from differences in the measurement of the losses there are also differences in actual definitions of what is being measured. For Thailand a serious injury involves either permanent disablement or a short period in hospital followed by convalescence and complete recovery. The Kenyan and S Rhodesian studies do not include definitions of the different categories. The Ivory Coast data do not distinguish between slight and serious injuries, although it may be inferred (because the results are based on hospital information) that the figures quoted concern mainly serious accidents.

Differences in date of study and currency measurements are self-evident. Dawson²³ noted that some comparison can be made using official exchange rates to convert local currencies to sterling but that these rates are frequently not appropriate.

Despite such great disparities in study output, valuation and definition, some general conclusions have been drawn from the figures given. The average personal injury accident cost (Table 5.2) for developing countries tends to be high compared with Britain. This is probably due to the high severity indices (ratio of fatalities to total injuries on the roads) found in developing countries and probable under-recording of minor accidents as mentioned earlier in this Thesis. The latter distortion will bias the severity index upwards. Even if the bias were removed, it is still likely that the severity indices for developing countries would be high compared with the UK index. It is likely that one of the major reasons is the differences in the medical facilities available.

Material damage unit costs (Table 5.1) show a fair consistency in order of magnitude from country to country apart from Thailand. The source for the Thailand figures are insurance payments made against damage claims and represent the cost per vehicle rather than the cost per typical accident. It might be expected that in developing countries material damage would be a significant cost item; spare parts will be expensive, if only because they have to be imported, and the skilled labour necessary to effect repairs will be at a premium. Some supplementary information on vehicle damage unit costs for Kenya and S Africa is presented in Table 5.4. The former were collected by the author in Kenya in 1974 with the cooperation of the Guardian Assurance Company Ltd.

TABLE 5.4

AVERAGE VEHICLE REPAIR COSTS FOR S AFRICA AND KENYA

(Sources: National Institute for Road Research, S Africa
Guardian Assurance Co (Kenya))

	Vehicle type	Slight damage	Heavy damage	Write off
S. AFRICA (1963)	Motor car	£120	£430	£550
	Lorry	£ 38	£334	£705
	Bus	£ 14	£ 83	£565
KENYA (1970)	All vehicles	£185		£880

Both sets of figures underline the high cost of vehicle repair. In this respect the damage unit costs reported for Thailand seem very low. Despite such low unit costs, however, reference to Table 5.3 shows that vehicle damage total costs represent a high proportion of total accident costs in Thailand. This is true of all those countries analysed, apart from Israel where only 17 percent of total accident costs is accounted for by vehicle damage and administration. Thus, in general, while unit damage costs are small in comparison to loss-in-output unit costs, the former are going to be very important in assessing total accident costs.

5.2.4 Comparison of road accident costs with gross domestic product

In Table 5.5 the aggregate figure for accident costs is compared with the GDP (at market prices) of the respective countries.

There is no reason to suppose any direct causal relationship between GDP and total accident costs; a high GDP may imply heavy traffic but there are many other factors involved in determining the accident rate and numbers besides the level of traffic. Any conclusions drawn from Table 5.5 can only be used as an initial guideline in view of the previously noted

TABLE 5.5
TOTAL ESTIMATED ACCIDENT COSTS AS A PERCENTAGE OF GDP⁽¹⁾

	KENYA (1965)	THAILAND (1963)	THAILAND (1964)	^S RHODESIA (1961)	^S AFRICA (1963)	ISRAEL (1967)	GHANA (1970)	TURKEY (1971)	GREAT BRITAIN (1963)	GREAT BRITAIN (1970)
Estimated total cost of accidents	£2.9m	£6.3m	£10.2m	£4m	£40m	£26m	£2.8m	£29.8m	£196m	£300m
G.D.P.	£300m	£1720m	£1900m	£310m	£3800m	£1710m	£810m ⁽²⁾	£2780m ⁽²⁾	£26700m	£45000m
Total accident cost as % of G.D.P.	1.0	0.4	0.5	1.3	1.0	1.5	0.3	1.1	0.7	0.7

NOTES: (1) See Table 1 for exchange rates employed

(2) Gross National Product

limitations and the small size of sample presented. For those developing countries under review the total accident costs represent about 1 percent of GDP - a sum which is by no means insignificant.

5.3 SOME POINTS OF METHODOLOGY

Having examined the outputs from some accident cost analyses for developing countries, this section discusses briefly the methodologies employed. In essence most of the studies (apart from those for Ivory Coast and S Africa) have been concerned with establishing the number of deaths and injuries associated with road traffic accidents, valuing the resulting loss in output and vehicle damage, and summing the valuation for all injuries and vehicle damage to give a total accident cost. The Ivory Coast study employed a slightly different data format which has meant that total accident costs cannot be derived. The S African study derived unit costs of injuries and vehicle damage as well as total accident costs; the method of deriving the costs was by sampling the insurance payments made to the accident claimants.

The study output format will obviously be very dependent on the scope and accuracy of the base data and the method of placing a valuation on these data.

5.3.1 Base data

The data of the number of accidents and/or injuries by category is most often to be found in police or insurance company records. Both sources are subject to errors. Police records often under-record minor accidents, while insurance records obviously only relate to those vehicles which are insured. (Vehicle insurance cover is not mandatory in all

countries). Most studies have identified the shortcomings of the base data and have attempted to employ cross-checking techniques to overcome the deficiency. In the Thailand study the number of fatalities taken from police records did not accord with road accident fatality data taken from Ministry of Health sources. The researchers resorted to using the latter data because they were more consistent with the number of fatalities determined theoretically using Smeed's formula³ adjusted for developing countries³⁵. In the Ivory Coast study the national statistics were checked by implementing a small sample survey of accidents in two sub-regions. Results from this survey were compared with statistics from other surveys carried out in previous years and with records kept by both the Road Transport Department and the Police Headquarters.

In all studies, apart from that of the Ivory Coast, the form of the base data has been the number of persons involved in each defined category of injury, the definition of such categories often being peculiar to the country concerned. The Ivory Coast data take the form of the numbers of deaths per accident, the number of injured per accident and the number of accidents per million vehicle kilometres. The Kenyan study incorporates both types of data and this makes it possible to specify the probable number of persons with different types of injury who will be involved in defined categories of accidents (fatal, serious or slight). This is useful in that it provides a secondary output format. (See Table 5.2). Not only can the average cost of different types of injury be assessed but also of different types of accident. (This is also a feature of the British studies which have a better data base). In the Turkish studies, although the total numbers of killed and injured are documented, the number of serious and slight injuries are based on assumptions about the severity index.

5.3.2 Valuation of accident statistics

It is the method of valuing accident statistics that probably provides the most controversy in accident analysis. The main argument revolves around measuring the benefits of life. Valuation of property damage, medical expenses incurred and other administrative costs are relatively easy to establish by, for example, sampling insurance records of payments in respect of such items.

Apart from the S African study, all the studies collated in this document used either a gross or a net valuation of lost output as being the direct cost of a fatality (A net valuation is future income less future consumption of the fatally injured person and a gross valuation is future income only). As previously indicated, the 1963 GB study employs the net output approach while the 1970 GB study employs the gross output approach. Adopting similar terminology to Mishan's¹⁹, these two approaches can be expressed in mathematical terms as:

$$L_1 = \sum_1^t y_t P_t (1 + r)^{-t} \quad \text{(Gross output)}$$

$$L_2 = \sum_1^t P_t (Y_t - C_t) (1 + r)^{-t} \quad \text{(Net output)}$$

where L_1 and L_2 are the loss to the economy resulting from an individual's death calculated in gross and net terms respectively. y_t is the individual's expected gross earnings in year t (exclusive of any income on assets), C_t his expected personal expenditure in that year. P_t is the probability in the current year of the person being alive during the t^{th} year and r is the social rate of discount expected during the t^{th} year. (In his criticism of valuation techniques Mishan cites two other valuation methods that have

been employed or discussed: the use of insurance premiums as being an indicator of how a person values his life; the use of past political decisions on investment expenditures that have had an effect on death rates and have implicitly used, therefore, a value for human life).

The gross output method is justified²⁴ on the basis of the benefit that the individual expects to get out of livelihood, ie the material benefit that he would have to forego in the event of his death. The net output approach has been justified²³ on the basis that the community suffers as a result of an individual's death, and that consequently one should measure the community loss incurred after the event. Unfortunately the net output method can in some cases, such as housewives and old-age pensioners, suggest that a community would gain from an individual death. This in itself is no reason not to employ it as a measure of economic loss. It is, however, criticised because it gives no regard to an individual's standing prior to his decease. There is also the subtle argument that the benefits of new safety devices derive from those accidents that are averted; individuals who would have been killed remain alive and able to enjoy the full benefits of their production, including that portion spent on consumption.

In general, the average wage or earnings is used as a measure of output. Aside from the question of whether the wage rate measures the marginal value of an individual's output (and hence whether there is a need for shadow wage rates) there is a further point raised by Goodwin²¹ that the total output produced in a year by individuals (as given by the sum of their earnings) is less than the total value of output of the economy. The average wage is less than the average value of output because of the unearned income element (undistributed profits, interest, dividends, rent, etc). Consequently, on average the wage earners contribution to production is greater than his wage and the extent of the

divergence will depend on the proportion of national income distributed as unearned income. Reynold's study³⁶ is the most obvious example of the use of the national income definition to measure output. He used net domestic product to determine an average gross output for male and female workers.

Shadow wage rates are frequently used to value the effort of housewives; the average wage of women in employment is used as the shadow rate. Similarly for those studies which have been conducted in developing countries where the average wage has been used to measure output, a shadow wage rate equivalent to the average wage rate has been used to measure the output of the numerous unemployed or under-employed.

It was common in early work on road accident costs to include detailed analysis of the characteristics of persons involved in accidents. Thus Reynolds³⁶ split the accident population by sex and age range and determined a total net loss for each category of persons. Dawson²³ went through a similar exercise for the 1963 survey but in the 1970 study differences in sex and age grouping were ignored because no differentiation of this sort is normally made in the practical use of accident costs. As Goodwin²¹ says, "reasonably accurate prediction may be made about the total number of fatal accidents but very little can be said in advance about the particular characteristics of the individual concerned".

Reynold's approach³⁶ was adopted in a very much cruder form in the S Rhodesian study. Annual net contribution per head (equivalent to net domestic product per head less total private consumption per head) was used as an estimate of net loss in output per fatal injury. No account was taken of sex and age groupings, but a distinction was made between African and non-African.

In the Ghanaian study some attempt was made to analyse the difference in work life expectancies of the different age groups within which fatalities occurred. Estimates of loss in output was based on the personal per capita consumption expenditure and the average monthly earnings per head. Again, the Thailand study analysed the age structure of fatalities in order to assess total loss in output, but did not take into account the relative number of men and women involved. Net output per capita was measured in terms of the national income per capita less an estimate for consumption per capita based on a previously conducted household survey. The Ivory Coast study was similar to the S Rhodesian study in that no account was taken of either age or sex structure for fatalities. Thus the costs were based on an average life expectancy for all victims. The gross loss in output was computed by estimating the average income of the occupants of four typical types of vehicle; (the source for this information is not given). The life income expectancy was assessed and when each was associated with a probability of a fatality, a total average cost of one death was determined.

In the Turkish studies distinction was made between the age groups 0-15 years, 15-65 years and those older than 65 years. No financial losses were calculated at all for the latter group. For those killed in the first group an investment loss was calculated based on an average age of 7 years and the per capita national income. The seriously injured in this group were assumed to incur income losses at the standard rate (gross national product per worker) from the age of 15 years up to an assumed life expectancy age. The Turkish studies took no account of sex differentiation. They did take specific account of losses in revenue due to a vehicle's inaction and also court costs.

In discounting future output losses most studies, for convenience of calculation, assumed that the whole of the loss due to any one life occurs at the mid-point of the remaining expectation of life, ie the discount factor applied to the total loss for a particular age group was $(1 + r)^{-\frac{n}{2}}$ where r is the discount rate and n the expectation of life for that age group. Some values of r used were: S Rhodesia - 6 percent, Ghana - 7 percent, Thailand - 12 percent, GB (1970) - 10 percent, Ivory Coast - 10 percent, Turkey - 5 percent,

In the GB studies, estimates were included (not recorded here) of non-resource costs, ie the costs associated with the suffering and grief from bereavement caused to the relatives and friends of the fatally injured party. Such costs are value judgements and none of the studies for the developing countries has considered this item. It should be clear, however, that the costs which have been measured form only one facet of the value of life. By basing the cost of a fatality on the loss in output (either net or gross) of the average man the implicit assumption is that the objective in life is to maximise either national output or personal savings. On this basis the State will continue to invest in accident prevention schemes up to the margin where the value of either output or personal savings of the individual who is saved no longer exceeds the extra cost of the accident prevention). Needless to say, this is an extremely limited outlook on life's objectives which ignores the quality of life.

5.4 CONCLUSIONS

It has been shown in this chapter that accident costs are significant in developing countries; total accident costs are of the order of 1.0 percent of gross domestic product. This figure is similar to that for Britain. This conclusion is only tentative because there have not been

enough studies published and the data inputs for those studies which have been conducted are so diverse as to make the outputs non-comparable on a rigorous basis. This is not a criticism of these studies; in the circumstances of poor data sources it is necessary to be flexible in the approach adopted to measure accident costs. Expressed quantitatively, this ratio of 1.0 percent of GDP means that road accidents may have cost India and Nigeria for example £200 million and £40 million respectively in 1973 - large sums of money that these countries can ill afford to lose.

There is no definitive methodology for measuring accident costs. It is apparent that the soundest arguments favour the use of a gross valuation for measuring output. The use of aggregate data (making no distinction between sex, age or race) is to be preferred because it has the merit that it does not emphasise any specific category of persons. Furthermore, historic data sources cannot be relied upon to give disaggregated information and, of more importance, predicting what category of person is going to be involved in accidents is difficult, if not impossible. The decision to use an average wage rate or the national output per head of working population to value output may well be resolved by the presence or absence of the appropriate data. The latter definition for valuing output should be used where the data exist; however, the use of an average wage rate will not make a significant difference in the context of developing countries.

The collection of comparative inter-country statistics on accident cost data is not an end in itself. Such data are useful in that they give a guideline on the orders of magnitude to be expected; in exceptional circumstances (eg the complete absence of suitable data) one might be able to provide a rough estimate of accident costs for a

given country by comparison with another country with known costs. The real need, though, is for efficient accident cost analysis to be conducted in association with accident analysis. Efficiency implies making the best use of available source data and applying the resulting cost data in a consistent manner. With a knowledge of the relevant cost data it should be easy to identify which are the most important types of accidents from the point of view of how to spend limited resources in accident prevention most effectively.

6. ROAD ACCIDENT DATA COLLECTION AND ANALYSIS IN DEVELOPING COUNTRIES

6.1 INTRODUCTION

In any particular country, little progress can be made with improving the road accident situation until the problem itself has been clearly defined. Thus, accident statistics must be collected over a period of time so that some understanding is obtained of where accidents are occurring, to which class of road user, at what time of day, or in what month or season. In fact most of the data described in this Thesis were actually collected by the author due to the lack of information available in developing countries.

6.2 THE NEED FOR ACCIDENT RECORDS IN ROAD SAFETY WORK

Reports and statistics on road accidents are of importance to several bodies each of which require them for different purposes. A heavy volume of work falls on the organisation that makes the original accident reports and collects the data together, ie the police. Much of these data are needed for the police forces own activity, primarily, enforcing the law and carrying out prosecutions for motoring and other offences. Some of the data they collect are, however, of no direct interest or use to the police themselves and one can sympathise with the reluctance of a small force when asked to undertake extra work of this nature on behalf of other bodies.

It is as well therefore to emphasise the value of road accident statistics in the work of other organisations concerned with prevention

of accidents. Accident statistics are of value to the following organisations;

- 1) the police,
- 2) the government departments responsible for roads,
- 3) local highway authorities,
- 4) propaganda offices,
- 5) National records departments,
- and 6) research institutions

The essential police functions of enforcement have already been mentioned but the police are also interested in traffic control and the design of regulations to make roads safer and less congested.

It is important that government departments, concerned with general policy and legislation in connection with roads, should have reliable information on the accident situation on which to base their decisions.

Comprehensive accident statistics would enable the administrator to judge the importance of the road accident problem and the need for expenditure on its alleviation. They also enable him to determine which general measures are likely to improve the situation and where money can best be spent.

Local highway authorities can also play a large part in reducing accidents by carrying out engineering measures designed to do this. In designing and constructing new roads and road improvements, a knowledge of what road features are associated with high accident rates is important. The preparation of 'accident maps' which should always

be part of the process of recording statistics, is also an invaluable guide to highway engineers in improving conditions at places where accidents are most frequent.

Propaganda designed to reduce accidents is carried out by various agencies. National propaganda is normally used on an extensive scale by the government department concerned with roads but voluntary societies for the prevention of accidents and, in some countries, motoring organisations also work in this field. On a more local basis, police, schools and road safety organisations set up by local authorities, publicise the need for care on the roads and give general guidance in personal road safety. In all this work, factual information on accident statistics is essential.

Accident statistics in the UK have been of value in a number of ways which can be classified as follows:-

- 1) Information has been obtained which has resulted in or contributed to changes or recommendations for change in policy concerning road conditions, vehicle design, etc. Other changes in policy have been recommended but have not so far been implemented or they are under consideration.
- 2) The effects of changes in policy on accidents have been studied to assess the benefits and to provide a guide for further policy.
- 3) Basic knowledge concerning the circumstances and trends of accidents, has been acquired as a background to other research.

4) Information has been obtained which has propaganda value.

It is thus clear that much can be gained from analysis of detailed accident statistics. The chief limitation to the collection of such data lies, in practice, in the amount of work which is involved for police forces.

The first essential of an accident reporting system is that data should be collected in a standard manner. The data should be as factual as possible and statements of opinion should be kept quite distinct from factual matter. Clear distinctions should be made between different categories, for example, serious injuries should always be distinguished from slight injuries on a well-defined and consistent basis. Valid comparisons between two sets of data for, say, different years of different road conditions can then be made.

Not only is it of prime importance that a standard and consistent method of reporting should be adopted throughout one country, it is also desirable that, where possible, different countries should adopt a uniform system of accident reporting. International comparisons can then be made. Although such comparisons are likely to be difficult to interpret, due to the often totally different circumstances in the countries concerned, they can sometimes provide an opportunity for the effects of proposed measures in one country to be assessed. They can also serve as a general indication of the effectiveness of road safety standards and of any particular field in which scope exists for improvement.

Apart from the form of accident reports which should naturally be designed for ease of completion and of transcription for either manual

or machine analysis, according to the system employed, attention should be paid to the possibility of recording the data required by all the organisations concerned on one form.

6.3 TYPES OF DOCUMENT USED FOR THE REPORTING AND ANALYSIS OF ROAD ACCIDENTS

6.3.1 Accident reporting

There are 5 alternative types of document commonly used by police forces for reporting road accidents. There is considerable variation within each type, mainly in the amount of information required to be recorded. The most usual types are as follows:-

- (i) Booklet; a document bound in book form and small enough to be carried either in the police officer's pocket or in the glove compartment of a car. This is subsequently referred to as a police report booklet.
- (ii) Detailed form; the detail required is sufficiently closely defined to allow for short answers to factual matters.
- (iii) Simple form; the information is entered by descriptive statements under the headings printed on the form.
- (iv) File cover; A variation on the detailed form. In this case the form is printed on stiff card in such a way that it can later be used to contain any further paper

related to the accident, ie details of legal proceedings arising from it.

- (v) Damage only form; an extra document for use in the case of a 'damage only' accident, usually less detailed than an injury accident report form.

6.3.2 Accident analysis

There is only one basic type of document used for analysis of road accidents, a coded sheet on which information is entered as a tick or a number in the space provided. The information can then be transferred to punch cards or whichever analysis system is being used.

Many developing countries also produce a summary - yearly or quarterly - of numbers of accidents occurring during the period, classified to a certain degree into type of road user, degree of injury etc. These are not to be confused with analysis forms:

6.3.3 The UK System of accident reporting and analysis

A system generally used in the UK appears to fulfil the requirements of design mentioned earlier. It consists of a police report booklet filled in at the site of a road accident and contains a section for duplicated information which will be required for analysis. This section can be filled in at a later date, detached, and sent to a central office where the information is entered on a coded form entitled "Report of a road

accident resulting in personal injury", this is usually referred to as Stats.19. (See Fig. 6.1). The coded information can then be easily transferred to punch cards etc., analysed and tabulated by computer.

The information remaining in the booklet deals with purely police matters, ie details leading to legal action being taken, statements and information for police records which need not or cannot be analysed.

6.4 SURVEY OF EXISTING DATA COLLECTION AND ANALYSIS METHODS IN DEVELOPING COUNTRIES

In order to find out what systems, if any, are employed in developing countries, a survey was made to determine to what extent these countries record and analyse road accident data and also what kind of statistics are produced.

A letter and questionnaire sent in October 1972, requested information from 42 developing countries on statistics of vehicle ownership, licensing and road accidents. The letter also requested information on the extent to which road accidents are reported and analysed in the developing countries, by which organisations and what kind and quantity of statistical information is acquired as a result. Also requested were examples of any documents used for the reporting and analysis of road accidents. Thirty-four countries replied to this questionnaire ie over 80 percent.

MINISTRY OF TRANSPORT
SCOTTISH DEVELOPMENT DEPARTMENT
WELSH OFFICE

REPORT OF ROAD ACCIDENT RESULTING IN PERSONAL INJURY

POLICE REFERENCE No.

Form Stats. 19 (Rev. 1968)

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Driver or rider				1st	2nd	4th	1st	2nd	4th	27				28				29				30				31				32				33				34				35				36				37				38				39				40				41				42				43				44				45				46				47				48				49				50				51				52				53				54				55				56				57				58				59				60				61				62				63				64				65				66				67				68				69				70				71				72				73				74				75				76				77				78				79				80				81				82				83				84				85				86				87				88				89				90				91				92				93				94				95				96				97				98				99				100				101				102				103				104				105				106				107				108				109				110				111				112				113				114				115				116				117				118				119				120				121				122				123				124				125				126				127				128				129				130				131				132				133				134				135				136				137				138				139				140				141				142				143				144				145				146				147				148				149				150				151				152				153				154				155				156				157				158				159				160				161				162				163				164				165				166				167				168				169				170				171				172				173				174				175				176				177				178				179				180				181				182				183				184				185				186				187				188				189				190				191				192				193				194				195				196				197				198				199				200				201				202				203				204				205				206				207				208				209				210				211				212				213				214				215				216				217				218				219				220				221				222				223				224				225				226				227				228				229				230				231				232				233				234				235				236				237				238				239				240				241				242				243				244				245				246				247				248				249				250				251				252				253				254				255				256				257				258				259				260				261				262				263				264				265				266				267				268				269				270				271				272				273				274				275				276				277				278				279				280				281				282				283				284				285				286				287				288				289				290				291				292				293				294				295				296				297				298				299				300				301				302				303				304				305				306				307				308				309				310				311				312				313				314				315				316				317				318				319				320				321				322				323				324				325				326				327				328				329				330				331				332				333				334				335				336				337				338				339				340				341				342				343				344				345				346				347				348				349				350				351				352				353				354				355				356				357				358				359				360				361				362				363				364				365				366				367				368				369				370				371				372				373				374				375				376				377				378				379				380				381				382				383				384				385				386				387				388				389				390				391				392				393				394				395				396				397				398				399				400				401				402				403				404				405				406				407				408				409				410				411				412				413				414				415				416				417				418				419				420				421				422				423				424				425				426				427				428				429				430				431				432				433				434				435				436				437				438				439				440				441				442				443				444				445				446				447				448				449				450				451				452				453				454				455				456				457				458				459				460				461				462				463				464				465				466				467				468				469				470				471				472				473				474				475				476				477				478				479				480				481				482				483				484				485				486				487				488				489				490				491				492				493				494				495				496				497				498				499				500				501				502				503				504				505				506				507				508				509				510				511				512				513				514				515				516				517				518				519				520				521				522				523				524				525				526				527				528				529				530				531				532				533				534				535				536				537				538				539				540				541				542				543				544				545				546				547				548				549				550				551				552				553				554				555				556				557				558				559				560				561				562				563				564				565				566				567				568				569				570				571				572				573				574				575				576				577				578				579				580				581				582				583				584				585				586				587				588				589				590				591				592				593				594				595				596				597				598				599				600				601				602				603				604				605				606				607				608				609				610				611				612				613				614				615				616				617				618				619				620				621				622				623				624				625				626				627				628				629				630				631				632				633				634				635				636				637				638				639				640				641				642				643				644				645				646				647				648				649				650				651				652				653				654				655				656				657				658				659				660				661				662				663				664				665				666				667				668				669				670				671				672				673				674				675				676				677				678				679				680				681				682				683				684				685				686				687				688				689				690				691				692				693				694				695				696				697				698				699				700				701				702				703				704				705				706				707				708				709				710				711				712				713				714				715				716				717				718				719				720				721				722				723				724				725				726				727				728				729				730				731				732				733				734				735				736				737				738				739				740				741				742				743				744				745				746				747				748				749				750				751				752				753				754				755				756				757				758				759				760				761				762				763				764				765				766				767				768				769				770				771				772				773				774				775				776				777				778				779				780				781				782				783				784				785				786				787				788				789				790				791				792				793				794				795				796				797				798				799				800				801				802				803				804				805				806				807				808				809				810				811				812				813				814				815				816				817				818				819				820				821				822				823				824				825				826				827				828				829				830				831				832				833				834				835				836				837				838				839				840				841				842				843				844				845				846				847				848				849				850				851				852				853				854				855				856				857				858				859				860				861				862				863				864				865				866				867				868				869				870				871				872				873				874				875				876				877				878				879				880				881				882				883				884				885				886				887				888				889				890				891				892				893				894				895				896				897				898				899				900				901				902				903				904				905				906				907				908				909				910				911				912				913				914				915				916				917				918				919				920				921				922				923				924				925				926				927				928				929				930				931				932				933				934				935				936				937				938				939				940				941				942				943				944				945				946				947				948				949				950				951				952				953				954				955				956				957				958				959				960				961				962				963				964				965				966				967				968				969				970				971				972				973				974				975				976				977				978				979				980				981				982				983				984				985				986				987				988				989				990				991				992				993				994				995				996				997				998				999				1000				1001				1002				1003				1004				1005				1006				1007				1008				1009				1010				1011				1012				1013				1014				1015				1016				1017				1018				1019				1020				1021				1022				1023				1024				1025				1026				1027				1028				1029				1030				1031				1032				1033				1034				1035				1036				1037				1038				1039				1040				1041				1042				1043				1044				1045				1046				1047				1048				1049				1050				1051				1052				1053				1054				1055				1056				1057				1058				1059				1060				1061				1062				1063				1064				1065				1066				1067				1068				1069				1070				1071				1072				1073				1074				1075				1076				1077				1078				1079				1080				1081				1082				1083				1084				1085				1086				1087				1088				1089				1090				1091				1092				1093				1094				1095				1096				1097				1098				1099				1100				1101				1102				1103				1104				1105				1106				1107				1108				1109				1110				111			

It was decided to use the U.K. system as a base for a detailed comparison between countries both with accident reporting and analysis. However, in the case of accident reporting a comprehensive list of questions that might be asked in a booklet or detailed form was drawn up to give a more comprehensive analysis because of the greater quantity and complexity of information required to be reported than analysed.

As can be seen from Table 6.1, 22 countries (65 percent of those who replied) gave a clear indication that accident reporting was carried out by them and only one of these failed to supply an example of the document used. Of the 12 remaining countries who replied, 10 did not clearly state whether or not an accident reporting system was used and 2 stated that no system of accident reporting was used in their country. On a regional basis, data collection was best carried out by the Caribbean countries listed. The Asian countries were least effective with under half the countries replying operating a data collection system.

It can be seen that far less analysis than reporting of accidents is carried out in developing countries. In only 5 cases was a form equivalent to the U.K. Stats. 19 supplied (15 percent) and at least 10 countries definitely have no system of accident analysis. Five countries supplied examples of annual accident summary sheets but these, as stated earlier, are not equivalent to analysis forms and no accident analysis was carried out by these countries.

Table 6.2 indicates which countries supplied examples of documents or stated whether or not accident reporting or analysis was carried out.

TABLE 6.1
SUMMARY OF RESULTS FROM QUESTIONNAIRE (42 COUNTRIES CONTACTED; 34 REPLIES RECEIVED)

A) The use of accident report documents by the police

Examples of police accident report forms or booklets supplied	21
Definite information that forms or booklets are not used	2
Forms or booklets used but not supplied	1
No clear information whether forms or booklets are used	10

B) Accident analysis forms (equivalent to the UK Stats. 19)

Forms used and examples supplied	5
No analysis forms used	11
No analysis form used but summary sheet of annual road accidents prepared	5
No clear information whether analysis forms used or not	13

TABLE 6.2

A) The use of accident report documents by the police

Countries which supplied examples	Countries which have no system of reporting accidents	Countries which use a document for recording accidents but have not supplied examples	Countries which have not clearly stated whether any document is used or not	Countries which have not replied
Botswana Gibraltar Hong Kong Swaziland Zambia Guyana Sarawak Bahamas Belize Sri Lanka Cyprus Fiji Montserrat St Helena St Lucia Malawi India Kenya Jamaica Singapore Ghana	Indonesia Nigeria	Ethiopia	Mauritius Malaysia Iran Kuwait Dominica Jordan Barbados Madagascar Seychelles Morocco	Gambia, The Ivory Coast Sierra Leone Tunisia Syria Niger Pakistan Malta

B) Accident analysis forms

Countries which have supplied examples of a form equivalent to the UK Stats. 19	Countries which do not use an analysis form	Countries which do not use an analysis form but have supplied an accident summary sheet	Countries which have not stated clearly whether or not they use an analysis form
Sri Lanka Cyprus Hong Kong Morocco Singapore	Bahamas Belize Guyana Indonesia Montserrat Nigeria Sarawak Seychelles St Helena Zambia	Fiji India Jordan Swaziland Kenya	Barbados Ethiopia Gibraltar Iran Jamaica Kuwait Malaysia Malawi Mauritius Botswana St Lucia Dominica Madagascar

6.4.1 Examination of police report forms or booklets

In order to make a comprehensive examination of examples of accident reporting documents supplied by developing countries, the complete list of all possible questions that might be asked was divided into 5 sections (corresponding roughly to the sections in which an accident would, in reality, be reported). These were:-

- 1) "Administrative details and records of immediate action"
- 2) "details of persons injured"
- 3) "drivers, vehicles and passengers"
- 4) "space allowed for statements" and
- 5) "site and statistical information."

As can be seen from Table 6.3, of the samples of police report documents provided, 8 are in booklet form, 13 are forms or file covers and 4 have an additional document for 'damage-only' accidents. If the numbers of items covered (see Table 6.4) are examined with regard to the type of document used, it can be seen that of the 13 examples of forms or file covers, only 3 include more than half the items included in the U.K. booklet. On the other hand all except two of the police report booklets include 60 or more items - nearly two thirds of the number of items included in the U.K. booklet.

TABLE 6.3
TYPE OF ACCIDENT REPORT DOCUMENT USED BY THE POLICE

Police report booklet used	Form or file cover used	Extra form used for 'damage only' accidents
Cyprus Gibraltar Guyana Jamaica Malawi Montserrat Swaziland Zambia	Bahamas Belize Sri Lanka Fiji *Hong Kong x 3 India Sarawak Singapore St Helena St Lucia Botswana Kenya Ghana	Cyprus Gibraltar Hong Kong* Singapore

* The Hong Kong Police use 4 file covers, one each for fatal, serious and slight injury accidents and one for 'damage only' accidents.

Some countries have documents which are almost as comprehensive as the U.K. booklet, whilst others include only the barest minimum of detail in their reporting documents.

There are a number of items that are consistently excluded from the documents supplied. For instance, although many countries do ask for the site of an accident to be stated, very few ask for a map reference or indeed define any positive method of describing a site. Thus many documents are quite likely to state that an accident occurred on a given road which may be several miles long. While most of the more comprehensive documents cover details of injured persons fairly adequately, some required very little information on that subject. Very few countries refer to skidding, driver's manoeuvres or excessive speed of a vehicle involved in an accident.

Table 6.5 shows a comparison of the average number of questions covered by countries using booklets and those using forms (and files). It can be seen that the number of items covered is consistently higher when a booklet is used. This Table also shows the average number of questions covered expressed as a percentage of the number covered in the number covered in the U.K. police booklet. It appears that even the booklets used in developing countries are particularly deficient in the number of questions asked about the site of the accident and other statistical information such as weather conditions, day of week etc. Although this information is relatively unimportant as far as prosecutions and other action that might be taken by the police are concerned,

TABLE 6.4

COMPARISON OF ALL POSSIBLE QUESTIONS TO BE COVERED COMPARED WITH
INFORMATION ACTUALLY COLLECTED

	Section 1 Administrative details and records of immediate action	Section 2 Details of persons injured	Section 4 Drivers, vehicles and passengers	Section 5 Space for statements	Section 6 Site and statistical information	Total
Number of possible questions	31	58	76	5	18	188
Questions actually covered by						
Great Britain	20	19	36	5	14	94
Bahamas	10	10	15	2	5	42
Barbados						
Belize	14	14	14	3	4	49
Cyprus	22	34	23	5	10	104
Ethiopia						
Fiji	6	1	0	0	11	18
Ghana						
Gibraltar	9	14	21	4	2	50
Guyana	16	14	25	4	6	65
Hong Kong	11	4	20	4	10	49
India	4	7	9	0	6	26
Indonesia						
Iran						
Ivory Coast						
Jamaica	11	21	26	4	6	68
Jordan						
Kenya						
Kuwait						
Malaysia						
Malawi	7	7	26	5	11	56
Mauritius						
Montserrat	14	15	26	4	5	64
Morocco						
Nigeria						
Sarawak	4	0	0	1	0	5
Seychelles						
Singapore	12	1	18	3	7	41
Sri Lanka	10	3	0	0	7	20
St Helena	4	0	7	0	0	11
St Lucia	13	14	22	2	4	55
Swaziland	10	14	27	5	5	61
Zambia	12	14	27	5	5	63
Botswana	4	0	3	0	0	7
Ghana	8	9	17	1	11	46

TABLE 6.5
COMPARISON OF THE NUMBER OF ITEMS COVERED IN ACCIDENT REPORTING BY THE USE OF
BOOKLETS OR FORMS (AND FILES)

Section covered	Average number of questions asked		Average number of questions asked as a percentage of the number asked in the UK police booklet
	With booklets	With forms or files	
Administrative details and immediate action	13	8	40%
Details of persons injured	17	5	26%
Details of driver, vehicles and passengers	25	10	27%
Space for statements	5	1	28%
Site and statistical information	6	5	34%

it is important when trying to determine the contributory factors concerned in the accident.

A police booklet has been designed for use in developing countries. Although this has been kept as concise as possible, the number of questions on the site of the accident is almost as many as in the U.K. police booklet.

6.4.2 Examination of the accident analysis forms

As explained earlier, only five countries appear to use an accident analysis form similar to the U.K. Stats. 19, whereas twenty-one used a police booklet or form for reporting. In addition, the analysis forms were much less comprehensive than the accident-reporting documents. So although data collection is carried out in a reasonable manner, data coding and analysis is poor.

From Table 6.6 it can be seen that there was considerable variation between the analysis forms used by the various countries.

In Table 6.6, the data provided by the forms has been examined under the following categories as used in the U.K. Stats. 19.

- (i) casualties involved
- (ii) vehicles involved
- (iii) drivers and riders
- (iv) attendant circumstances

TABLE 6.6
COMPARISON BETWEEN THE U.K. STATS. 19 AND THE CODED REPORT SHEETS PROVIDED BY DEVELOPING COUNTRIES

Subject	No. of coded items used by:-		
	UK	Developing country - max	Developing country - min
Casualties	36	21	7
Vehicles involved	42	112	3
Drivers and riders	24	28	0
Attendant circumstances	76	201	30

As can be seen there was considerable variation between the forms used by the various countries. In the U.K. "Casualty" is described by using 36 alternative classifications, the developing countries using between 7 and 21 classifications. Details of "vehicles involved" are described by as few as 3 and as many as 112 on the report sheets used by the developing countries, the U.K. using 42 items.

6.5 THE DESIGN OF A DATA COLLECTION AND ANALYSIS SYSTEM FOR DEVELOPING COUNTRIES

As can be seen from the previous analysis there is considerable variation in the design of the documents used by the various countries to collect and analyse road accident data. Whilst some of the forms used could be criticised for being either too simple in design or too complicated it should be remembered that these countries have at least attempted to document road accident information.

In designing an accident reporting system, there must be a balance between the collection of a considerable amount of data as in the U.K. and a simplified system where only the most basic data are collected. If over-complication can be avoided, the system stands a much better chance of being implemented in a developing country. If fewer, but essential questions are asked then it is reasonable to assume that these questions will be answered thoroughly and accurately. Alternatively, if many questions are demanded there will be less readiness to complete the document.

It was decided that a system based on the method used in the U.K. but considerably simplified would best meet the needs of police forces and those organisations requiring statistical information and analysis, in

developing countries. This system would consist of a booklet for the use of policemen reporting an accident, and an analysis form on which relevant data can be coded. The booklet and analysis forms so designed are illustrated in Figs. 6.2 and 6.3.

6.5.1 Recommended Police accident report booklet

The U.K. Accident report booklet on which the recommended booklet is based, consists of a booklet small enough to fit into a pocket and covered with fairly stiff card. This was considered to be ideal because it is easily carried around and presents few difficulties when filled in at the site of an accident. One booklet is completed for each personal-injury accident. The front cover deals with identification of the accident by time, place, date and class (ie fatal, serious or slight), with the person reporting the accident and with details of the police station and division concerned.

The recommended booklet for developing countries follows the same pattern but contains extra information concerning medical aid that may have been called. Wherever possible, for ease of completion the information required can be entered with a tick or simply entered in a box (ie time at which accident was reported). (See Fig. 6.2)

The inside cover and following five pages deal with persons involved. These cover details for 3 persons - personal details, injury details, details of drivers and vehicles and details of pedestrians and passengers. Apart from personal details, most of the information can be filled in with a mark in the appropriate box or a 'yes' or 'no' answer. There is a page for 'site details' which include road classification and junction details, type and condition of road surface, speed limits, visibility and weather. There is also a section for damage to other property or animals.

A blank page is available for a sketch map of the site and the remaining parts of the booklet are for statements, police officer's comments and report, cautions given and various legal and administrative details as required by the police force of the country concerned.

This booklet appears to conform with the requirements stated earlier. It is simple to complete and information can easily be found when needed. The type of information required to be entered includes administrative details, details likely to be used in analysis by statistical organisations and the legal points which need to be entered.

Table 6.4 gives the number of questions asked in the police report booklets used by the U.K. and developing countries and Table 6.5 shows the average number of questions asked by the various countries expressed as a percentage of those in the U.K. booklet. Table 6.7 compares these with the newly designed booklet suggested for use in developing countries.

It can be seen that there are almost as many questions in the suggested booklet as there are in the U.K. one, apart from the section on details of vehicles and passengers where 17 questions are asked. Apart from simply the number of questions asked, the proposed booklet has been designed in such a way as to make completion particularly easy, in most cases simply a matter of ticking the appropriate box.

Also the U.K. booklet is so arranged that it is likely that personal details (ie Name and address etc) are frequently entered several times. Thus if a casualty were also the driver of a vehicle, his personal details would be entered once under 'casualty' and again under 'driver'. The recommended booklet has been designed to avoid this repetition.

TABLE 6.7
COMPARISON OF NUMBERS OF QUESTIONS IN POLICE BOOKLETS

Section covered	U.K. Police Booklet	Average of developing countries replying to questionnaire	Booklet designed for use in developing countries
Identifying information and immediate action	20	13	20
Details of person injured	19	17	18
Details of drivers vehicles and passengers	36	10	17
Site and statistical information	14	6	11

The main disadvantage of the use of a booklet is the limited space available for large numbers of persons and vehicles which may be involved in one accident. This problem could be overcome either by using an extra booklet or by having a sheet of paper which could be attached to the booklet.

6.5.2 Recommended accident analysis form

The form which has been designed for the analysis of accident (see Fig. 6.3) is effectively a simplified version of the U.K. Stats. 19. There is no information on the analysis form that cannot be found in the completed report booklet. As with the booklet, it is divided into the sections on persons involved, vehicles, site details and identification of the accident. There is space for coded information on 6 pedestrians, 6 passengers and 4 vehicles.

Table 6.6 showed the total number of coded alternatives used by the U.K. and the developing countries. The newly designed analysis form uses about 34 alternatives to describe 'persons involved', the U.K. Stats. 19 uses 36 alternatives to cover 'casualties' and 24 to cover 'drivers and riders'. The design of the new form thus being more concise. 'Vehicles involved' and 'attendant circumstances and site details' are covered by 19 and 40 alternatives respectively in the recommended analysis form which is a sensible balance between the extremes used in developing countries.

It is hoped that the form would be simple enough for the person responsible to complete without taking too much time. This in turn would mean considerable saving in manpower as the completed forms could then be sent monthly, or even weekly, to a central office where machine analysis could immediately be carried out. It would also mean

that records required for police use need not be sent away and that transcription of information could be kept to a minimum. With this system working efficiently, delays would not be incurred in extracting useful statistics from the machine analysis and these could be used quickly and efficiently. Following this work, the information sent to various countries contained a detailed account of how to complete the form and which definitions to apply to the various terms.

It is of course essential that police, and any other organisations involved, receive adequate training in the completion of the booklet and analysis form.

The form has been designed so that coded information can be transferred directly onto a punch card system. On the form itself are numbers from 1 - 48. For example 'degree of injury for pedestrians', has a '1' located above the space provided to describe the degree of injury to the pedestrian. This refers to the fact that on transfer of data to a punch card, the appropriate code is punched in column one on the card. In total 48 columns on the card would be used to code the data contained on the form, the 48th column containing information on the visibility pertaining.

The U.K. Stats. 19 uses 63 columns of the punch card. The system suggested for use by developing countries uses 48, as explained above and is therefore more concise than that used in the U.K. The 'standard' card for use on a Hollerith sorter or computer has 80 columns available. Thus if any country wished to include additional data there would be ample space available.

6.5.3 Data Processing

In order to make full use of the data collected, it is essential that an adequate data-processing system be used. None of the countries replying to the questionnaire used such a system and consequently little detailed data analysis was carried out.

The data collected should be transferred to a system of punch cards so that it can be processed manually, mechanically or by computer, depending on facilities available in the particular country.

The most simple device in common use is a system of cards where the edges are clipped or punched with holes according to a given code. Rods can then be inserted into the holes and lifted. The cards with clipped edges will remain and the ones with complete holes will be lifted out.

A more advanced system is the Hollerith card sorter, whereby punched cards are inserted into a machine which automatically sorts the coded alternatives on any particular column. This is an efficient system as long as complicated analyses are not required but reasonably comprehensive tabulation can be built up using a card sorter and an automatic tabulator.

If computer facilities are available, data can be transferred to punch cards or data tape and stored in the computer. These data can then be analysed using an appropriate program. Considerable work has been carried out at the Laboratory on the designs of such programs.

"RATTLE"³⁷ (Road Accident Tabulation Language) is a program suitable for System 4 computers and is designed for use by people with little computer experience. It will select and tabulate records as requested and present the results in tabular form. It will not perform statistical tests, but for provision of basic tables and relationships it is an extremely useful program. "SPSS", (Statistical Package for Social Sciences)³⁸ is a more sophisticated computer package and will carry out sub-programs eg frequency distribution, correlation coefficients, regression analyses etc, as required.

As explained in Section 6.2, accident records are needed by a number of different organisations. The police collect information in order to enforce the law whilst other organisations need statistics so that decisions can be made on legislation and road improvement schemes etc, aimed at reducing road accidents. It would therefore be reasonable that a government department other than the police should be responsible for the detailed analysis of road accident data. It follows logically that this work should be carried out by the department responsible for the analysis of other national statistics. A comprehensive report produced annually could then be published and circulated to the various government departments concerned.

6.6 DISCUSSION

Few accidents have a single cause³⁹ and considerable detail is needed before remedial measures can be formulated. As was seen from the analysis described in this report very few developing countries operate an adequate road accident data collection and analysis system. A number of countries collect accident data reasonably efficiently but few analyse the data so collected. Thus only five developing countries

were found to use an analysis form equivalent to the U.K. Stats. 19 'report of a road accident resulting in a personal injury'. The analysis forms provided by these countries tended to be either inadequate or over complicated. Finally, none of the countries replying to the questionnaire transferred data collected on to punch cards so that mechanical sorting and tabulation could be carried out.

In order to assist developing countries set up a sound data collection and analysis system, both a police booklet and analysis form have been designed. Both are based on the system used in the U.K. but emphasis has been placed on simplicity and ease of completion. Guidance has also been given on the methods that can be used to tabulate the data so collected. It is hoped that the system so described will be adopted so that much more information can be obtained on the type, location and persons involved in road accidents in developing countries. Only with this information can effective remedial measures be introduced.

Suggested Police Booklet for use in developing countries

FRONT COVER

POLICE ACCIDENT REPORT	
Police Division	Ref. No.....
Name and No. of Reporting Officer	
DAY	DATE MONTH YEAR TIME
ROAD NUMBER MAP REFERENCE	
NAME OF ROAD	
Distance from well defined landmarkmiles/kilometres	
from	
CLASS OF ACCIDENT:- Fatal ☐ Serious ☐ Slight ☐	
Name of person who reported accident	
Address	
.....	
* Was he/she a witness YES/NO	
* Delete where inappropriate	

PERSONS INVOLVED	
*Name MR/MRS/MISS	
Address	
Age years	
INJURY DETAILS	DETAILS OF DRIVER/RIDER *
Fatally injured ☐	Driving Licence No ☐
Seriously injured ☐	Licence full:- ☐
Slightly injured ☐	Provisional:- ☐
Was first aid given YES/NO	Not available:- ☐
Was injured person removed to hospital YES/NO	Length of time licence heldyrs
Was person detained in hospital YES/NO	Insurance certificate held YES/NO
Name of Hospital	Name of Insurance Company
Was young child unaccompanied YES/NO	Address
Name of person to be informed	
.....	Policy No
Address	HGV/PSV Licence held? YES/NO
.....	Licence No.....
.....	Licence full:- ☐
.....	Provisional:- ☐
.....	Not available:- ☐
.....	If Driver holds provisional licence was he accompanied by the holder of a full licence. YES/NO
* Delete where inappropriate. PAGES 2, 4 & 6	

VEHICLE DESCRIPTION		DETAILS OF VEHICLE	
Vehicle Registration No.....		DEFECTS	
Owner's name if different from driver		Tyre defects	☐
Address		Mechanical defects	☐
.....		Brakes defective	☐
Road Fund Licence in order.	YES/NO	Lights } Front	☐
		defective } Rear	☐
		Brake	☐
		Visual Impairment	☐
		Not known	☐
Make of Vehicle		Was Vehicle Overloaded with	☐
Model		Goods	☐
*Age 1-3 yrs 4-7 yrs 8-10 yrs Older than 10 yrs.		Passengers	☐
		Both	☐
TYPE OF VEHICLE		Was Vehicle moved before arrival of Police. YES/NO	☐
Pedal Cycle	☐	Was Damage to Vehicle, Extensive/Slight*	☐
Motor Scooter	☐	Going ahead	☐
Motor Cycle	☐	Turning right	☐
Motor Car	☐	Turning left	☐
Public Service Vehicle	☐	Overtaking	☐
Light Commercial (Van)	☐	Reversing	☐
Lorry - 2 axle	☐	Stopped or moving off	☐
Lorry - 3 axle	☐	Parked	☐
Lorry - 4 or more axle	☐		
Lorry - Articulated	☐		
Tractor	☐		
Taxi	☐		
Other	☐		
IF PERSON A PASSENGER		IF PERSON A PEDESTRIAN	
Was person travelling in a Public service vehicle?	YES/NO	Was he:-	☐
was he: boarding?	☐	crossing road at zebra crossing	☐
alighting?	☐	crossing road at traffic lights	☐
		crossing road at junction	☐
		crossing road masked by vehicles walking in the road	☐
		were his movements unknown	☐
		Was he:-	☐
		known to be deaf	☐
		known to be blind	☐
		known to be otherwise infirm	☐
		Not known	☐
* Delete where inappropriate. PAGES 3, 5 & 7			

ROAD CLASSIFICATION		SITE DETAILS	
URBAN ROAD		TYPE OF ROAD SURFACE	
Rural trunk class I	☐	*Concrete/Bitumen	☐
Rural trunk class II	☐	Gravel	☐
Provincial road	☐	Earth	☐
Forestry or admin. road	☐	Other	☐
ROAD TYPE		ROAD SURFACE CONDITION	
Single lane	☐	Dry - hard	☐
Two lane	☐	- loose	☐
Dual carriageway	☐	- dusty	☐
Hard shoulders	☐	Wet - muddy	☐
		- hard	☐
JUNCTION DETAILS		Flooded	☐
Uncontrolled	☐	Icy	☐
Signal controlled	☐	Not known	☐
Roundabout	☐	Other	☐
"Stop" or "Give Way" sign	☐	WEATHER	
Authorised person	☐	High wind	☐
Not at junction	☐	Dust or Sand storm	☐
SPEED LIMIT		Fog	☐
Up to 30 MPH	☐	Rain	☐
30 to 40 MPH	☐	Snow	☐
Over 40 MPH	☐	Not known	☐
		Fine	☐
		VISIBILITY	
		Daylight	☐
		Darkness	☐
		Street Lights lit	☐
		Damage to other property or to animals	
Owner's name	Address		
Details			
* Delete where inappropriate. PAGE 8			

Fig.6.2 (cont.)

Sketch Map

PAGE 9

STATEMENTS OF PERSONS INVOLVED

PAGE 10

STATEMENT OF INDEPENDENT WITNESSES

*NAME MR/MRS/MISS AGE Years
ADDRESS

***Delete where inappropriate**

PAGE 11

Police officers report

Any Cautions given

To whom

For what reason

PAGE 12

This page may be used for records of laws infringed, charges made, documents required or issued and records of Administrative and legal action taken.

Fig.6.2 (cont.)

SUGGESTED FORM FOR ANALYSING AN ACCIDENT INVOLVING PERSONAL INJURY

REPORTING OFFICER:-

POLICE STATION :-

POLICE REFERENCE NO.:-

DEGREE OF INJURY Columns 1-3	CODING 1 Fatal 2 Serious 3 Slight 4 Not injured	PEDESTRIANS 1st 2nd 3rd 4th 5th 6th	PASSENGERS 1st 2nd 3rd 4th 5th 6th	DRIVERS 1st 2nd 3rd 4th
SEX Columns 4-6	1 Male 2 Female	1 4	2 5	3 6
AGE GROUP Columns 7-9	1 0-6 years 2 7-16 years 3 17-29 years 4 30-45 years 5 46-60 years 6 Over 60 years	7	8	9
PEDESTRIAN ACTIONS Column 10	1 Crossing at ped. crossing 2 Crossing elsewhere 3 Not crossing road	10		
PASSENGERS AND DRIVERS OF VEHICLE TYPES:- Columns 11-12	1 Pedal cycle 2 Motor scooter 3 Motor cycle 4 Motor car 5 Bus 6 Van (light commercial) 7 Lorry 2 axles 8 Lorry 3 axles 9 Lorry 4 axles or more 10 Lorry articulated 11 Tractor 12 Taxi 13 Other		11	12
PS V PASSENGER Column 13	1 Boarding 2 Alighting		13	
DRIVER'S EXPERIENCE Column 14	1 Learner 2 Licence held less than 1 year 3 Licence held more than 1 year			14

AGE OF VEHICLE Column 15	CODING 1 New - 3 years 2 4-7 years 3 8-10 years 4 Over 10 years	VEHICLES 1st 2nd 3rd 4th
SKIDDING AND JACK-KNIFING Columns 16 & 17	Did Did not Skidded 1 2 Jack-knifed 1 2	15 16 & 17
VEHICLE DEFECTS Columns 18-23	Were Were not Brakes 1 2 Steering 1 2 Tyres 1 2 Lights 1 2 Overload 1 2 No known defects 1 2	18-23
VEHICLE MANOEUVRES AT TIME OF ACCIDENT Column 24	1 Going ahead 2 Turning right 3 Turning left 4 Overtaking 5 Reversing 6 Stopping or moving off 7 Parked	24

ACCIDENT IDENTIFICATION Columns 25-40			
Day	Month	Hour	Location-Map Ref.No- Road Number

DAY OF WEEK Column 41	
Mon	1
Tues	2
Weds	3
Thurs	4
Fri	5
Sat	6
Sun	7

ROAD CLASSIFICATION Column 42	SITE DETAILS CODING	
1 Urban road 2 Rural road-trunk class I 3 Rural road-trunk class II 4 Provincial road 5 Forestry or other admin. road		42
JUNCTION DETAIL Column 43	1 Uncontrolled 2 Signal controlled 3 Roundabout 4 'Stop' or 'Give way' sign 5 Authorised person 6 Not at junction 7 Crossroads	43
SPEED LIMIT Column 44	1 Up to 30 mph 2 30-40 mph 3 Over 40 mph 4 No speed limit	44
TYPE OF ROAD SURFACE Column 45	1 Surfaced (concrete or bitumen) 2 Gravel 3 Earth	45
ROAD SURFACE CONDITION Column 46	Dry - 1 Hard 2 Loose 3 Dusty 4 Muddy 5 Flooded 6 Icy 7 Wet Wet - 1 Muddy 2 Flooded 3 Icy 4 Wet	46
WEATHER Column 47	1 High wind 2 Dust or sand storm 3 Fog 4 Rain 5 Snow 6 Fine and dry	47
VISIBILITY Column 48	1 Daylight 2 Dark 3 Street lighting lit	48

Fig.6.3

7. AN ANALYSIS OF ROAD ACCIDENTS IN KENYA

7.1 INTRODUCTION

As was seen in Chapter 6, few developing countries, if any, undertake a comprehensive analysis of their accident records, yet it is only by making such an analysis that the most important aspects of the problem can be identified.

In 1973 a visit was made by the author to Kenya to collect road accident data. These data, together with that from other parts of the Third World have been used to investigate urban and rural accident rates and the factors involved, such as vehicle flow, road geometry and road user behaviour. This work is described in later chapters.

As well as using the data in the manner described above it was thought that a detailed analysis of one complete years' accident records would be particularly useful in providing a greater understanding of where road accidents occur in Kenya, to what class of road user and in what type of accident. Wherever possible, comparisons have been made with accident patterns in Great Britain and other European countries.

Although the accident patterns in Kenya cannot be taken as typical of the entire Developing World it is fairly typical of countries in East and Southern Africa. Further, where the analysis indicates, for example, that gravel-surfaced roads have high accident rates, or the high incidence of single-vehicle accidents it is more than likely that these situations are common in many developing countries.

7.2 DATA COLLECTION

Kenya has a fairly high standard of road accident data collection, with accidents involving personal injury being reported by the police using a form known as the P41; an example of this form is shown in Figure 7.1. These forms are stored at the provincial police headquarters, the locations of which are illustrated in Figure 7.2. Throughout August 1973 the provincial police headquarters were visited by the author and the front page of each form was photocopied (the reverse giving details of legal proceedings etc). Before photocopying the form, a careful check was made to ensure that the accident involved injury to a person and not damage to an animal or property only. A check was also made to ensure that the report of an accident was not duplicated. By this process a number of accidents were eliminated and the total number remaining was found to be 5443 road accidents involving injury to 8637 persons.

The police headquarters at Garissa, regional capital of North Eastern Province was not visited because there were fewer than fifty accidents in the whole of the province in 1972. A visit to collect information on these few accidents would have taken several days.

7.3 DATA ANALYSIS

A coding system for the information provided on the P41 road accident forms was devised and the data then transferred to punched cards. The information coded was as follows:

ACCIDENT REPORT

Charge Reg. No. _____

Acc. Reg. No. _____

O.B. No. _____

Reporting Officer _____ Division _____ Station _____

Location of Accident _____

Highway Authority _____

Date _____ Day _____ Time _____

Types of Vehicles concerned	Registration Numbers	Names and Addresses of Owners and or Drivers (state which)	Brief details of damage
1			
2			
3			

Certificate of Competency	If in order state "Yes" If endorsed or not in order give details overleaf		
	1.	2.	3.
Driving Licence			
Road Tax			
Insurance			
T.L.B. Licence			
P.S.V. or Taxi Licence			

Name and Address of injured persons	Class of person	Age	Sex	Fatal Serious Slight	From Vehicle No.	Tribe or Nationality

Names and Addresses of witnesses:—

Nationality or Tribe of vehicle driver primarily responsible _____

ROAD SURFACE: Tarmac/Murram/Unmade. Speed limit of _____ m.p.h.
Wet/Dry. Street lighting—Yes/No.

Apparent Cause Code No. _____ Special Features if any _____

Are Court proceedings Contemplated—Yes/No.
When a Police vehicle is involved, this form must be despatched to the Commissioner of Police and the Divisional Transport Officer within 24 hours.

Class of Person: "p" Pedestrian. "D" Driver. "MC" Motor Cyclist. "PS" Passenger. "C" Cyclist. "pp" Pillion Passenger. "O.P." Other Person.
In case of Fatal Accident give Date of Death.

Fig.7.1 ACCIDENT REPORT FORM, KENYA

Fig.7.2 LOCATION OF PROVINCIAL POLICE HEADQUARTERS

province
district
date of accident
day of accident
time of accident
type of accident (single vehicle, vehicle/vehicle etc)
number of vehicles involved
road surface
type of area (built-up, non built-up)
severity of accident (fatal, serious, slight)
road condition (wet or dry)
class of road user (pedestrian, car driver etc)
age of road user (classified as juvenile or adult only)
sex of road user
severity of injury (fatal, serious, slight)
type of vehicle (car, motorcycle, cycle etc)

The punched cards were analysed using the Transport and Road Research Laboratory computer program 'RATTLE' (Road Accident Tabulation Language)³⁷ devised specifically for analysing road accidents.

7.4 RESULTS

7.4.1 The location of road accidents and casualties in Kenya

Table 7.1 shows the number of accidents and casualties occurring in each province in 1972. As can be seen, the greatest number of accidents occurred in Nairobi, being almost 40 percent of the total. The number of casualties was also greatest in Nairobi Province, being about 30 percent of the total.

TABLE 7.1
ACCIDENTS AND CASUALTIES BY PROVINCE

Province	Accidents		Casualties	
	No	%	No	%
Central	960	17.6	1760	20.4
Coast	784	14.4	1170	13.6
Eastern	363	6.7	771	8.9
Nairobi	2070	38.0	2558	29.6
Nyanza	292	5.4	422	4.9
Rift Valley	817	15.0	1686	19.5
Western	157	2.9	270	3.1
TOTAL	5443	100	8637	100

Using traffic flow data obtained as part of a research programme on rural census design in Kenya⁴⁰, an estimate was obtained of the total vehicle-kilometres travelled each day in all provinces except the mainly urban Nairobi province. An estimate of the daily vehicle-kilometres travelled in Nairobi was obtained by using data from a comprehensive urban land-use transport study of the city⁴¹. In addition, results from an urban study of Mombasa⁴² were added to the rural flow values obtained during the census research to provide an estimate of total travel in Coast Province. The accidents and casualties given in Table 7.1 were divided by the estimated daily vehicle-kilometres travelled to give the accidents and casualties per million vehicle-kilometres travelled per day. These are given in Table 7.2.

It can be seen that the lowest accident and casualty rates occurred in Nairobi Province, the casualty rate in particular being considerably lower than the other provinces. These lower rates are probably due to the fact that almost all the vehicle mileage travelled took place in built-up

areas where vehicle speeds are, on average much lower than in any other province. The next lowest casualty rate occurred in Coast Province where almost 30 percent of all vehicle-kilometres travelled were in Mombasa, the second largest town in Kenya.

TABLE 7.2
INJURY ACCIDENTS AND CASUALTIES PER MILLION VEHICLE-KILOMETRES
TRAVELLED

Province	Injury accidents per million vehicle-kilometres	Casualties per million vehicle-kilometres
Central	2.36	4.33
Coast	2.68	4.01
Eastern	2.98	6.34
Nairobi	2.27	2.80
Nyanza	3.84	5.55
Rift Valley	2.27	4.66
Western	3.74	6.44
Kenya	2.48	3.95

TABLE 7.3
CASUALTIES PER ACCIDENT BY PROVINCE

Province	Casualties per accident
Central	1.8
Coast	1.5
Eastern	2.1
Nairobi	1.2
Nyanza	1.4
Rift Valley	2.1
Western	1.7
TOTAL	1.6

Table 7.3 shows the number of casualties per accident by province and for the whole country. It can be seen that the ratio was particularly high in Eastern and Rift Valley Provinces and was lowest in Nairobi Province. These differences are most likely to be due to the types of accident occurring in the different provinces. Thus in Nairobi almost 50 percent of all accidents involve a pedestrian. In these accidents there is usually only one person injured - the pedestrian. In the other provinces accidents occur most frequently in rural areas (see Table 7.4) and could involve high speed vehicle to vehicle collisions. In this type of accident there are often numerous casualties.

TABLE 7.4

THE DISTRIBUTION OF URBAN AND RURAL CASUALTIES BY PROVINCE

Province	Urban		Rural		Unknown	
	No	%	No	%	No	%
Central	148	8.5	1603	91.0	9	0.5
Coast	634	54.2	521	44.5	15	1.3
Eastern	73	9.5	694	90.0	4	0.5
Nairobi	2195	85.8	322	12.6	41	1.6
Nyanza	150	35.5	269	63.8	3	0.7
Rift Valley	249	14.8	1391	82.5	46	2.7
Western	24	8.9	246	91.1	-	-
TOTAL	3473	40.2	5046	58.5	118	1.3

From Table 7.4 it can be seen that most of the provinces, particularly Central, Eastern and Western, had a large majority of the casualties occurring in rural areas (ie on roads without a 30 m/hr or 45 km/hr speed limit). As would be expected most of the casualties in Nairobi Province occurred in built-up areas, the province being comprised largely of the city itself.

Casualties in Coast Province are more evenly distributed between urban and rural areas where, as mentioned earlier, almost 30 percent of all vehicle-kilometres travelled were estimated to occur in the town of Mombasa.

7.4.2 Road casualties in Kenya

TABLE 7.5

INJURIES BY SEVERITY IN URBAN AND RURAL AREAS

	Urban		Rural		Unknown		TOTAL	
	No	%	No	%	No	%	No	%
Fatal	368	10.6	816	16.2	14	11.9	1198	14.0
Serious	847	24.4	1535	30.4	31	26.3	2413	28.0
Slight	2166	62.4	2570	50.9	69	58.5	4805	55.5
Unknown	92	2.6	125	2.5	4	3.4	221	2.5
TOTAL	3473	100	5046	100	118	100	8637	100

Casualties in urban and rural areas: Fourteen percent of all road accident casualties in Kenya were fatal and 28 per cent were serious (see Table 7.5). The equivalent figures in Great Britain in 1971, were 2.2 and 25.4 percent. These differences are statistically significant at the 5 percent level. The detailed analysis of fatality indices (ie the percentage of all accidents that are fatal) in developing countries indicated that the index is significantly related to vehicle ownership, the higher the level of vehicle ownership in a country, the lower the fatality index. In addition it was found to be significantly related to the medical facilities available in the various countries. Thus inevitably most of the developing countries studied had high fatality indices compared with countries in Western Europe and North America. Whilst this may partly be a reflection of the fact that non-fatal

accidents are in general less well recorded than fatal accidents, it is nevertheless clear that most developing countries have high severity indices. From Table 7.5 it can be seen that over 10 percent of all casualties in urban areas were fatal whilst the equivalent value in rural areas was over 16 percent. This greater level of accident severity in rural areas is found in many countries including Great Britain, and is probably due to the fact that accidents occur at higher speeds in rural areas and that medical treatment is less readily available

Road casualties by class of road user: From Table 7.6 it can be seen that 38 percent of all road casualties occurred to car occupants, which is low compared with most European countries. The proportion of pedestrian casualties in Kenya (26 per cent of the total) is similar to that occurring in Great Britain, Yugoslavia and Spain but rather high compared with other European countries such as Germany, France and Italy⁴³. However the rate of pedestrian casualties per head of population is low in Kenya compared with Great Britain and other European countries. Road accidents in Nairobi have been studied in detail and will be discussed in Chapter 9. An analysis of these accidents indicates that the pedestrian casualties per head of population is slightly higher in Nairobi than the average value for urban users in Great Britain. In most European countries the percentage of total casualties who were occupants of commercial vehicles are quite low, of the order of 5 percent, whilst in Kenya the equivalent figure is over 16 percent. Conversely, by European standards the proportion of two-wheeled motor vehicle casualties is very low, under 5 percent of the total. As can be seen from Table 7.6, 45 percent of all fatalities were pedestrians.

TABLE 7.6

ROAD CASUALTIES BY CLASS OF ROAD USER

Class of road user \ Severity	Fatal		Serious		Slight		Unknown		TOTAL	
	No	%	No	%	No	%	No	%	No	%
Pedestrian	539	45.0	693	28.7	982	20.4	48	21.7	2262	26.2
Car driver	95	8.0	352	14.6	747	15.6	22	10.0	1266	14.7
Car passenger	173	14.4	593	24.6	1238	25.8	29	13.2	2033	23.6
Motor cyclist	22	1.8	69	2.9	210	4.4	5	2.3	306	3.5
Pillion passenger	7	0.6	28	1.7	43	0.9	4	1.8	82	1.0
Cyclist	113	9.4	150	6.2	391	8.4	11	5.0	665	7.7
Occupants of passenger service vehicles	70	5.8	97	4.1	229	4.8	48	21.7	444	5.2
Occupants of commercial vehicles	147	12.3	379	15.7	859	17.9	32	14.5	1417	16.5
Others	32	2.8	52	2.2	56	1.2	22	10.0	162	1.9
TOTAL	1198	100	2413	100	4805	100	221	100	8637	100

The age distribution of casualties: In Kenya, accidents are recorded as occurring to adults or to persons under 15 years of age. Table 7.7 shows the accident severity for these two age groups.

TABLE 7.7
SEVERITY BY AGE

	Adult		Juvenile		Unknown		TOTAL	
	No	%	No	%	No	%	No	%
Fatal	1013	13.9	174	19.2	11	2.6	1198	14.0
Serious	2100	28.8	249	27.4	64	15.0	2413	28.0
Slight	4188	57.4	485	53.4	132	30.8	4805	55.5
Unknown	-	-	-	-	221	51.6	221	2.5
TOTAL	7301	100	908	100	428	100	8637	100

The overall percentage of juvenile casualties was found to be almost 11 percent of the total; the equivalent figure for Great Britain being 18 percent. An unpublished analysis of road accidents in Ghana gives the percentage of child casualties as 23 percent of the total studied. The percentage of child casualties in Kenya would thus appear to be particularly low. It is possible however that the less severe accidents to children are less likely to be reported.

It can be seen that over 19 percent of all juvenile casualties were fatal whilst the equivalent adult value was almost 14 percent (the difference being statistically significant at the 5 percent level). In Great Britain the reverse is found to occur with 2 - 3 percent of adult casualties being fatal and 1.4 percent of juvenile casualties (under 15 years of age) being fatal. Thus in Kenya not only is the proportion of all casualties that are fatal greater than in Great Britain but the fatality rate for juvenile casualties would appear to be particularly high.

The casualty distribution during daylight and darkness: Over 12 percent of all casualties occurring during daylight were fatal, whilst during darkness the equivalent figure was 17 percent (see Table 7.8). The percentage seriously injured was the same during daylight and darkness.

TABLE 7.8
SEVERITY BY DAYLIGHT AND DARKNESS

	Daylight		Darkness		Unknown		TOTAL	
	No	%	No	%	No	%	No	%
Fatal	840	12.4	322	17.0	36	16.1	1198	13.9
Serious	1815	27.7	533	27.7	65	29.2	2413	27.9
Slight	3700	57.0	990	51.4	115	51.6	4805	55.6
Unknown	131	2.0	83	4.3	7	3.1	221	2.6
TOTAL	6486 (75.1%)	100	1928 (22.3%)	100	223 (2.6%)	100	8637 (100%)	100

Seventy-five percent of all casualties were injured during daylight and 22.3 percent during darkness. In Great Britain, a greater percentage of all casualties occur during darkness (36 percent), a difference that might be attributed to proportionately more driving being done during darkness in Great Britain than in Kenya.

The distribution of casualties by hour, day and month: As can be seen from Table 7.9 and Figure 7.3, the incidence of road accident casualties in Kenya rises sharply between 6am and 7am and continues to rise throughout the day, reaching a peak at 5pm. The casualty rate then decreases sharply until the following morning.

The casualties in Great Britain also reach a peak at 5pm (see Figure 7.3) but differences between the two countries clearly exist. Thus in the UK there is clear evidence of a peak occurring at midnight.

Fig.7.3 THE DISTRIBUTION OF ROAD ACCIDENT CASUALTIES THROUGHOUT THE DAY IN KENYA AND GREAT BRITAIN

TABLE 7.9
CASUALTIES BY TIME OF DAY

Hourly period commencing	Kenya		Great Britain	
	No	%	No	%
12 midnight	129	1.5	9 353	2.60
1 am	92	1.1	7 240	2.01
2 am	79	0.9	4 748	1.32
3 am	105	1.2	2 143	0.59
4 am	43	0.5	1 417	0.39
5 am	63	0.7	1 618	0.45
6 am	109	1.3	3 010	0.83
7 am	342	4.0	11 209	3.12
8 am	375	4.3	19 149	5.33
9 am	355	4.1	12 251	3.41
10 am	404	4.7	13 072	3.64
11 am	404	4.7	16 233	4.52
12 noon	377	4.4	19 985	5.56
1 pm	450	5.2	19 076	5.31
2 pm	482	5.6	20 478	5.70
3 pm	515	6.0	23 866	6.64
4 pm	544	6.3	30 796	8.57
5 pm	788	9.1	30 467	8.48
6 pm	625	7.2	21 002	5.85
7 pm	716	8.3	18 181	5.06
8 pm	536	6.2	14 260	3.97
9 pm	375	4.3	13 614	3.79
10 pm	312	3.6	19 339	5.38
11 pm	194	2.2	26 493	7.37
Unknown	223	2.5	-	-
TOTAL	8 637	100	359 000	100

This might be due to a greater proportion of travel at night or to a greater incidence of drinking and driving in Great Britain than in Kenya.

TABLE 7.10
CASUALTIES BY DAY OF WEEK

Day of week	Kenya		Great Britain	
	No	%	No	%
Sunday	1 466	17.0	49 658	13.8
Monday	1 144	13.2	46 678	13.0
Tuesday	1 077	12.5	45 339	12.6
Wednesday	1 075	12.5	44 554	12.4
Thursday	1 052	12.2	47 728	13.3
Friday	1 170	13.5	60 885	17.0
Saturday	1 562	18.1	64 158	17.9
Unknown	91	1.0	-	-
TOTAL	8 637	100	359 000	100

The distributions of casualties in each day of the week in Kenya and Great Britain are shown in Table 7.10 and Figure 7.4. In Kenya the highest number of casualties occurred on Saturdays and Sundays whereas in Great Britain the highest numbers occurred on Fridays and Saturdays (the differences being statistically significant at the 5 percent level). Social patterns obviously account for these differences; for example in Kenya Saturday mornings are working periods for most of the population and Sundays are days of increased leisure activity.

Casualties by month for Kenya and Great Britain are shown in Table 7.11 and Figure 7.5. In Kenya the greatest number of casualties occurred in March, April and September: in Great Britain numbers of casualties were highest in November and December, a pattern also shown by Sweden, Germany, Yugoslavia etc. In Great Britain these periods when

Fig.7.4 ROAD ACCIDENT CASUALTIES BY DAY OF WEEK IN KENYA AND GREAT BRITAIN

a high number of casualties occurred do not coincide with high traffic flows⁴⁴, other factors, such as short hours of daylight and extreme weather conditions having greater effect.

TABLE 7.11
CASUALTIES BY MONTH IN KENYA AND GREAT BRITAIN

Month	Kenya		Great Britain	
	No	%	No	%
January	623	7.3	29 388	8.2
February	657	7.6	26 279	7.3
March	793	9.2	28 805	8.0
April	772	8.9	27 259	7.6
May	703	8.1	30 828	8.6
June	710	8.2	29 687	8.2
July	738	8.5	31 324	8.7
August	674	7.8	29 286	8.1
September	774	9.0	27 719	7.7
October	727	8.4	30 911	8.6
November	672	7.8	33 661	9.4
December	683	7.9	34 532	9.6
Unknown	111	1.3	-	-
TOTAL	8 637	100	359 679	100

Howe⁹, found no evidence of a regular pattern of seasonal variation in traffic flow in Kenya; and the author found no evidence that traffic flows were greatest in the month containing the highest number of casualties. In Kenya the climate follows a strong seasonal pattern with high rainfall in March or April and a secondary less severe rainy period in November. The first of these periods coincides with the months when casualty figures are highest. However casualties do not seem high during the secondary less severe rainy season.

Fig.7.5 ROAD ACCIDENT CASUALTIES BY MONTH IN KENYA AND GREAT BRITAIN

7.4.3 Road accidents in Kenya

Note. The accidents referred to in this chapter are those which involved a personal injury and do not include damage-only accidents.

Accident types: Accidents were categorised according to the vehicles or persons involved and results are given in Table 7.12.

TABLE 7.12
ACCIDENT TYPES IN KENYA

Type of injury accident	Number	Percent
Single vehicle	1490	27.4
Vehicle - vehicle	989	18.2
Vehicle - motorcycle	195	3.4
Vehicle - cycle	631	11.6
Vehicle - pedestrian	2133	39.2
Unknown	5	0.1
TOTAL	5443	100

Vehicle-pedestrian accidents in Kenya were the most frequent, being over 39 percent of the total; in Great Britain the equivalent figure is 29 percent. The most common accident in Great Britain is the vehicle-vehicle type, being over 45 percent of the total, but in Kenya only 18.2 percent of accidents were of this type. As can be seen from Table 7.12, single-vehicle accidents in Kenya were 27.4 percent of the total, the equivalent figure in Great Britain being 19.5 percent. Differences between the two countries are statistically significant at the 5 percent level.

Accidents in urban and rural areas: A further analysis of accident types was carried out and as can be seen from Table 7.13 most accidents

involving a vehicle and a pedestrian, cycle or motorcycle occurred in urban areas, with vehicle-vehicle accidents divided almost equally between urban and rural areas.

TABLE 7.13
TYPE OF ACCIDENT IN URBAN AND RURAL AREAS

Type of injury accident	Urban		Rural		Unknown		TOTAL	
	No	%	No	%	No	%	No	%
Single vehicle	363	24.4	1108	74.4	19	1.3	1490	100
Vehicle - vehicle	475	48.0	505	51.1	9	0.9	989	100
Vehicle - motorcycle	161	82.6	30	15.4	4	2.0	195	100
Vehicle - cycle	405	64.2	217	34.4	9	1.4	631	100
Vehicle - pedestrian	1363	63.9	728	34.1	42	2.0	2133	100
Unknown	2	40.0	1	20.0	2	40.0	5	100
TOTAL	2769	50.9	2589	47.6	85	1.5	5443	100

Almost 75 percent of all single-vehicle accidents were found to occur in rural areas in Kenya; in Great Britain the equivalent figure is 42 percent. With the relatively low vehicle flows existing on rural roads in Kenya, vehicles are less likely to collide with one another and single-vehicle accidents might be expected to predominate. Thus in Kenya where rural roads are narrower, with greater extremes of horizontal and vertical curvature and where light vehicles travel at greater speeds on average⁴⁵ than in Great Britain, the single vehicle accident would appear to be a particularly serious problem.

The severity of the various types of accident: As might be expected vehicle-pedestrian accidents were those with the highest proportion being fatal (see Table 7.14). The fact that single-vehicle accidents had a higher fatality rate than vehicle-cycle or vehicle-motorcycle might at first seem surprising. However, as was seen in Table 7.13, almost three-quarters of these accidents occurred in rural areas, where vehicle speeds are greater and where medical aid might be less readily available.

TABLE 7.14

TYPE OF ACCIDENT BY SEVERITY

Severity of accident Type of injury accident	Fatal		Serious		Slight		Unknown		TOTAL	
	No	%	No	%	No	%	No	%	No	%
Single vehicle	273	18.3	454	30.5	734	49.2	29	2.0	1490	100
Vehicle - vehicle	119	12.0	252	25.5	604	16.1	14	1.4	989	100
Vehicle - motorcycle	16	8.2	45	23.1	130	66.7	4	2.0	195	100
Vehicle - cycle	109	17.3	154	24.4	355	56.3	13	2.0	631	100
Vehicle - pedestrian	520	24.4	657	30.3	913	42.8	43	2.0	2133	100
Unknown	-	-	-	-	-	-	5	-	5	-
TOTAL	1037	19.1	1562	28.7	2736	50.3	103	1.9	5443	100

TABLE 7.15

TYPE OF ROAD ACCIDENT AND ROAD SURFACE

Type of road surfacing Type of injury accident	Tarmac		Murrum		Unmade		Unknown		TOTAL	
	No	%	No	%	No	%	No	%	No	%
Single vehicle	842	20.0	546	55.8	63	49.6	39	30.7	1490	27.4
Vehicle - vehicle	843	20.0	91	9.3	18	14.2	37	29.1	989	18.2
Vehicle - motorcycle	181	4.3	13	1.3	-	-	1	0.8	195	3.4
Vehicle - cycle	536	12.7	76	7.6	5	3.9	14	11.0	631	11.6
Vehicle - pedestrian	1803	42.8	253	25.8	41	32.3	36	28.4	2133	39.2
Unknown	5	0.12	-	-	-	-	-	-	-	-
TOTAL	4210	100	979	100	127	100	127	100	5443	100

Accident types on various road surfaces: In Kenya, roads are classified as 'surfaced' (those with a bituminous surface), 'murram' (those with an engineered gravel surface) and 'unmade' (with an earth surface). Table 7.15 shows the number of accidents occurring on these types of roads.

On surfaced roads, vehicle-pedestrian accidents were most common whereas on murram and unmade roads single vehicle accidents were most common. Over 77 percent of all accidents occurred on surfaced roads and 18 percent on murram roads. It was estimated that about 5 percent of the total vehicle kilometres travelled in Kenya took place on murram roads. The accident rate per vehicle-kilometre is thus much higher on these roads than on surfaced roads.

7.4.4 The vehicles involved in road accidents in Kenya

TABLE 7.16

Vehicle type	Number	Percent
Car	3917	54.8
Motorcycle	394	5.5
Cycle	690	9.7
Commercial	1342	18.8
Land Rover	366	5.1
Bus	336	4.7
Tractor	82	1.1
Other	17	0.2
TOTAL	7144	100

As can be seen from Table 7.16, cars and Land Rovers were involved in 60 percent of all injury accidents reported in Kenya. An estimate was obtained of the total annual vehicle-kilometres travelled by cars, buses and commercial vehicles in Kenya¹ thus enabling the accident rates for these types of vehicles to be estimated. (see Table 7.17).

TABLE 7.17

VEHICLE ACCIDENT RATES PER MILLION VEHICLE-KILOMETRES

Vehicle type	Estimated vehicle-kilometres travelled (millions)	Vehicles involved in accidents	Vehicles involved in accidents per million vehicle-kilometres
Cars	552	3917	7.1
Buses	107	336	3.1
Commercial	607	1342	2.2
Motorcycle	33	394	12.0

Motorcycles were found to have the highest accident rates with commercial vehicles having the lowest rates, a pattern commonly found in most European countries. In Great Britain, however, public service vehicles have a higher accident rate than private cars (probably due to the fact that most psv journeys are made in heavy traffic with high occupancy rates).

7.5 CONCLUSIONS AND DISCUSSION

This analysis has shown that although the greatest number of accidents and casualties occurred in Nairobi Province, the accident rates per million vehicle kilometres travelled were lowest in this province. Nairobi Province also had the lowest ratio of casualties per accident. Fourteen percent of all casualties in Kenya were fatal, which is high compared with countries in Western Europe. (As stated earlier this in part may be due to the fact that serious and slight accidents may not be as well reported as fatal accidents).

There were proportionately fewer casualties to users of two-wheeled vehicles in Kenya than in European countries, which reflects the low usage of these vehicles in Kenya. The proportion of all casualties that were occupants of commercial vehicles was very much higher in Kenya than in Europe. This might well be due to the fact that commercial vehicles are used in Kenya to transport workers to and from building sites and other work places and it is common to see open lorries with up to thirty men being carried. Examples of this are shown in Figs. 7.6a and 7.6b. When such vehicles are involved in accidents there are likely to be many casualties.

Social patterns which differ from those in Great Britain were reflected in the distribution of road casualties. Thus in Kenya the

number of casualties were greatest on Saturdays (Saturday morning being a normal working day) and Sundays, a period of increased leisure activity. In Kenya the proportion of casualties occurring during darkness was lower than in Great Britain which may reflect proportionately less travel at night.

Forty percent of all accidents involved a pedestrian and almost thirty percent involved a single-vehicle only. The incidence of single vehicle accidents was particularly high in rural areas where almost three-quarters of this type of accident took place.

Eighteen per cent of all accidents occurred on murram roads which were estimated to carry only five percent of the vehicle-kilometres travelled in Kenya. The lower geometric standards, the effect of dust on visibility and also their deterioration in wet weather see Fig. 7.7 probably account for the high accident rate on these roads.

As stated earlier, very few developing countries make a detailed analysis of their road accidents. However it is only by carrying out an analysis such as that described here that the real situation is made apparent. Thus although the Kenya Government realise that they have an increasing accident problem, it was never fully appreciated that, for example, single-vehicle accidents or accidents to occupants of commercial vehicles were so prevalent.

(a)

(b)

Fig.7.6 COMMERCIAL VEHICLES BEING USED TO TRANSPORT
MEN TO PLACES OF WORK

(a) Poor visibility caused by dust

(b) Surface deterioration caused by heavy rainfall

Fig.7.7 PROBLEMS ON MURRAM ROADS IN KENYA

8. A STUDY OF ACCIDENT RATES ON RURAL ROADS IN DEVELOPING COUNTRIES

8.1 INTRODUCTION

The analysis of road accidents in Kenya,¹² together with studies in other developing countries⁴⁶ indicated that accident rates tend to be particularly high on rural roads. As was noted in the previous chapter, single-vehicle accidents were particularly prevalent on rural roads in Kenya, being almost 50 percent of the total number of accidents occurring. In this situation it is probable that design features of the road are a significant factor. Even in Great Britain where the standard of road construction is high compared with most developing countries, the road layout, surface or furniture was found to be a contributory factor in almost 30 percent of all accidents occurring on mainly rural roads within a defined study area³⁹. Work carried out in Oxfordshire⁴⁷ in 1937 (when vehicle flows were probably of the order of those in some developing countries at present) concluded that 75 percent of the accidents would not have occurred had the road conformed to the (then) current Ministry of Transport Memorandum 575 on the Layout and Construction of Roads.

In order to study the relationships between personal injury accident rates and geometric design of the road, data have been collected from Kenya and Jamaica. The primary objective of the investigation was to attempt to correlate the number of accidents per million vehicle-kilometres on a length of road with the design characteristics of the road in order to obtain information which would be of use in formulating principles for the design of safer roads in developing countries. However, relationships derived in this investigation need to be verified by studies on roads in other countries. In particular it is hoped that

the relationships derived here and in other countries could eventually be incorporated into the Road Transport Investment Model⁴⁸ developed by the Overseas Unit. This Model attempts to minimise the total transport cost of a given project by devising the optimum standard of road construction and design.

8.2 DATA COLLECTION

In order to correlate accident rates with road design it is necessary to have, for each section of road, the precise location of each personal injury accident taking place over a given period of time, an accurate measurement of traffic flow throughout the year and measurement of factors such as road width, horizontal and vertical curvature, surface irregularity etc. There were very few developing countries where such data were available but it proved possible, by using data from various research studies, to obtain the required information for Kenya and Jamaica.

8.2.1 Kenya data

During 1973 a visit was made to Kenya by the author to collect information on all personal injury accidents taking place in 1972. In 1975, following meetings with the Kenya Ministry of Works, details of all injury accidents taking place in 1973 on the Nairobi-Mombasa Road (see Figure 8.1) were obtained by the author. With this extra road accident data and with accurate traffic flow data available, it was decided to use this road for detailed study.

The Road Transport Investment Model⁴⁸, designed by the Overseas Unit to minimise total transportation costs on a given road project, was based on data collected in Kenya over the period 1969-1974. Test

sections were set up throughout Kenya, particularly on the Nairobi-Mombasa Road, and the traffic flow and geometric design data collected during that period have been used for this investigation of road accident rates. The road in question was divided into various sections (see Figure 8.1) with the following information available for each road length:

- 1) personal injury accidents occurring in 1972 and 1973
- 2) the length of each section
- 3) the average annual daily traffic flow
- 4) the average road width (metres)
- 5) the number of junctions (per kilometre)
- 6) the average horizontal curvature (degrees per km)
- 7) the average vertical curvature (metres per km)
- 8) surface irregularity (millimetres per km).

From 1) and 2) personal injury accidents per kilometre per annum were obtained, and from 1), 2) and 3) accidents per million vehicle-kilometres were obtained.

Geometric design parameters

The road width was the width of the surfaced section of the road excluding the gravel shoulders.

The vertical curvature of a road can be described most easily by its 'average gradient' or its total vertical 'rise and fall'. Neither measure is fully satisfactory but rise and fall was preferred. A method of measuring it from a specially designed and instrumented moving vehicle was developed for the study in Kenya. The development of this technique allowed a high degree of accuracy to be obtained even on roads with irregular surfaces.

Horizontal curvature is simply the 'bendiness' of a road. A particular bend can be defined either by the radius of curvature measured in metres or by the degree of curvature, defined as the angle in degrees between the straight sections of road which are joined by the curve. Although the latter definition does not differentiate between bends of different radii, it is the most suitable for evaluating the overall effect of a series of bends on accident rates because it is additive and easier to measure. In developed countries where similar studies have been carried out^{49,50,51} the accident rate has frequently been correlated with the existing radius of curvature. On busy roads where numerous accidents occur and where high levels of vehicle flow exist, this is probably the most convenient dimension to use.

Surface irregularity is sometimes called the 'riding quality' of the road. A method of measuring surface irregularity was developed from the principles of the 'bump integrator'⁵² in which the vertical movements of the axle of a single-wheel trailer are summed over a test section by an integrating clutch. Though necessarily arbitrary, the system that was developed provided an index of the irregularity which was useful for comparing the surface conditions of the test sections.

The parameters obtained for the sections of road used in this analysis are given in Table 8.1.

Fig.8.1 MAP OF SOUTHERN KENYA (Showing Nairobi-Mombasa road and sections)

TABLE 8.1

DATA FOR SECTIONS ON NAIROBI-MOMBASA ROAD, KENYA

Section Number	Personal Injury Accidents/ Million Veh-km/ annum	Average Road Width (metres)	Vertical Curvature (m/km)	Horizontal Curvature (deg/km)	Surface irreg (mm/km)	Junctions/ km
1	2.93	6.1	10.02	19.42	2300	0.66
2	2.17	6.1	1.36	4.59	2300	0.39
3	2.32	6.1	0	0.73	3030	1.43
4	2.82	6.1	5.40	12.54	3264	0.67
5	3.54	6.1	5.40	35.53	3086	0.43
6	1.67	6.1	14.6	40.72	3086	0.56
7	2.83	6.1	14.6	49.74	3308	0.32
8	2.67	6.1	14.6	16.98	3308	0.35
9	1.08	6.1	15.0	2.08	3308	0.12
10	2.11	6.1	15.0	31.5	3308	0.43
11	2.42	6.1	1.41	1.19	3308	0.32
12	1.88	7.0	2.62	5.07	3308	0.17
13	4.60	7.0	8.88	53.79	3308	1.94
14	1.96	7.0	5.59	12.73	1633	0.14
15	1.33	7.0	4.45	4.78	1633	0.12
16	1.54	7.0	5.04	7.22	1633	0.26
17	1.91	7.0	13.02	38.90	1633	0.21
18	1.67	7.0	1.91	10.42	1633	0.31
19	2.29	7.5	11.12	30.44	1488	0.56

8.2.2 Jamaica data

In 1962 a team was sent by the Laboratory to carry out urban and rural research work in Jamaica. During this period an unpublished report was produced⁵³ which gave details of accident rates and 'black spots' on rural 'A' and 'B' roads on the island. The accident rates (per million vehicle-miles) were calculated for almost the entire 'A' road network on the island (see Figure 8.2) and have been used in this present report after converting the rates into metric units. A detailed investigation was also carried out on the deficiencies of the rural road network in Jamaica⁵⁴, with detailed inventories being made of the existing rural road system. For each section of rural 'A' road the following parameters were obtained:

- 1) average width (feet)
- 2) profile and gradients (percent)
- 3) average vertical curvature (ft/mile)
- 4) average horizontal curvature (degrees/mile)
- 5) average surface irregularity (in/mile)
- 6) average sight distance (ft)
- 7) the number of junctions (per mile)

Geometric design parameters

Average road width was obtained by taking five measurements at equal intervals every mile.

The vertical curvature was obtained by measuring the elevation at every crest and hollow and accurately measuring the distances in between. Thus, as in Kenya, the 'rise and fall' per unit length of road was

obtained. The gradient was obtained by using an Abney level mounted in a survey car and modified to read grade directly.

As in Kenya, the horizontal curvature was measured in terms of degree of curvature or 'bendiness' per unit length of road, but in this case was obtained by taking measurements from 1 : 12,500 scale land valuation maps.

The average surface irregularity (see above) for each section of road was obtained by using a towed bump integrator where, as described above, the vertical movement of a wheel relative to its mountings was measured, thus providing a measure of the unevenness of the road surface.

The average sight distance of each section was obtained by measuring how far ahead a driver could see an obstruction on the road. Measurements were made by putting down markers at 100ft intervals along the road and, at each marker, counting how many markers could be seen on the road ahead. Twelve-inch high rubber cones were used as markers. This method has the advantage of simplicity and speed. The average sight distance was calculated from the total of the numbers of cones counted in the section and the number of observations made within the section.

The parameters obtained for the sections of road used in this analysis are given in Table 8.2.

Fig.8.2 MAP OF JAMAICA (Showing Class A roads and sections)

TABLE 8.2
DATA FOR SECTIONS OF RURAL A ROADS, JAMAICA

Section	Total Injury Accidents per million veh-km	Average width (metres)	Vertical Curvature (metres/ km)	Horizontal Curvature (deg/km)	Surface irreg. (mm/km)	Sight Distance (metres)	Junctions per kilometre
1	2.16	7.32	2.43	25.40	2822.8	237.29	4.80
2a	3.05	6.92	3.27	47.70	3879.4	209.54	6.64
2b	1.96	6.10	12.41	134.41	4904.5	126.58	6.81
3a	3.70	6.13	9.29	102.86	4809.9	146.40	7.73
3b	3.71	5.89	35.93	274.16	5109.5	96.38	8.32
4a	2.47	6.25	51.36	322.42	4557.5	106.75	4.84
4b	1.37	6.68	19.10	130.62	4368.3	139.69	5.88
5a	1.04	6.34	8.93	111.12	3122.5	168.67	2.51
5b	3.01	5.64	7.56	124.66	4604.8	133.29	3.18
6	6.17	5.43	8.09	184.66	4967.6	127.80	8.19
8	2.78	6.22	11.23	199.63	4257.9	122.00	5.40
9	1.61	6.41	1.77	97.95	3800.6	163.79	3.76
10a	1.95	6.50	14.73	148.32	4872.9	134.81	3.12
10b	2.25	6.59	6.08	106.71	3311.7	169.58	4.61
11a	1.85	5.86	11.31	133.04	4683.7	131.76	4.49
11b	3.37	5.22	20.94	249.63	4967.6	110.41	7.17
12	1.52	5.09	12.79	273.04	6103.0	110.41	3.27
13a	1.88	5.37	11.50	243.48	5850.7	105.84	6.50
13b	4.06	5.09	15.68	339.57	6039.9	95.47	4.53
14a	3.02	4.97	18.89	250.75	4731.0	92.11	5.75
14b	3.19	5.34	13.36	180.62	4857.2	118.34	4.24
15a	5.00	5.43	15.58	138.32	5456.4	135.73	4.42
15b	3.31	5.76	17.21	219.13	6087.2	111.63	6.37
16	2.25	5.55	29.79	368.32	4936.0	80.52	8.01
17a	1.73	6.65	8.87	161.18	4321.0	117.73	2.83
17c	0.95	7.59	22.31	38.32	2192.0	149.45	4.35
17d	1.17	5.98	39.56	423.60	6087.2	68.63	1.17
17e	3.40	5.43	29.62	346.34	6986	71.98	3.88
18	2.61	5.40	40.87	232.42	5945.3	96.99	2.61

8.3 ANALYSIS PROCEDURE

Regression analysis was used by the author to establish and quantify relationships between one dependent variable and one or more independent variables. (The first variable, which is the quantity under study, is known as the dependent variable and the others are defined as the independent variables).

In this investigation four dependent variables were studied separately.

- 1) personal injury accidents per kilometre per annum - Kenya
- 2) personal injury accidents per kilometre per annum - Jamaica
- 3) personal injury accidents per million vehicle-kilometres - Kenya
- 4) personal injury accidents per million vehicle-kilometres - Jamaica.

The choice of independent variables implied that they were 'sensibly' related to the dependent variable. In this study, a further condition in choosing independent variables was that they should be simple to define and, for an engineer working in the field, reasonably easy to measure. They should, of course, be measuring different elements of the road geometry.

As a preliminary investigation of which variables were most closely correlated with accident rate, simple regressions of accident rate on each of the road features individually, were performed. Equations derived were of the form:

$$y = a + b_1x_1$$

where

y = independent variable

x_1 = dependent variable

a = regression constant

b_1 = regression coefficient

However because many of the road design features are inter-related simple regression analysis may give a misleading impression of the relationships that they have with accident rate. Multiple regression, in which the accident rate is expressed as a function of several 'independent' variables simultaneously, is likely to be a better guide.

Equations derived were then of the form:

$$y = a + b_1x_1 + b_2x_2 + b_3x_3 \dots\dots\dots b_nx_n$$

where

$y, x_1, x_2, x_n, b_1, b_2, b_n$ were as above.

For these estimates to be acceptable it was necessary to test the hypothesis that the value computed for each regression coefficient was unlikely to have arisen by chance. To check this, the standard error of each regression coefficient was computed and tested for significance; variables with non-significant coefficients were eliminated from the analysis.

The computer programme used was part of a statistical package and had an automatic procedure for eliminating non-significant variables and for testing such variables with other combinations and replacing them where necessary. This technique is known as 'stepwise' regression analysis.

Data obtained on rural roads in Kenya and Jamaica were analysed separately.

8.4 RESULTS

From the analysis, equations were derived which related accidents per kilometre per annum to vehicle flow and accidents per million vehicle-kilometres to the geometric parameters. These equations should only be used in other developing countries where the data are similar in range and magnitude to those found in Kenya and Jamaica. Table 8.3 gives the maximum, minimum and means of the parameters obtained on the rural roads studied. The standard deviation, which measures the variance about the mean, is also given.

TABLE 8.3
VARIATION IN PARAMETER VALUES

Parameter	Maximum	Minimum	Mean	Standard Deviation
<u>KENYA</u>				
Average width (metres)	7.50	6.10	6.50	0.500
Vertical curvature (m/km)	15.00	0	7.91	5.41
Horizontal curvature (deg/km)	53.80	0.73	20.0	17.33
Surface irregularity (mm/km)	3308	1488	2625	770.5
Junctions/km	1.94	0.12	0.49	0.460
<u>JAMAICA</u>				
Average width (metres)	7.6	4.97	6.00	0.68
Vertical curvature (m/km)	51.35	1.77	17.26	12.33
Horizontal curvature (deg/km)	423.6	25.4	193.4	102.86
Surface irregularity (mm/km)	6991.1	2193.0	4783.0	1081.7
Junctions/km	8.32	1.17	5.01	1.89
Average sight distance (metres)	237.3	68.6	126.9	37.60

8.4.1 The relationships between accident rate and vehicle flow

The number of injury-accidents per kilometre of road per annum occurring on rural roads in Kenya and Jamaica were regressed separately against the vehicle flow per hour occurring on each test section of road (averaged over a 12-hour 7am - 7pm period). In both cases the accident rate was found to be related to the vehicle flow (with results being statistically significant at the 5 percent level). The equations derived were as follows:

$$\text{For Kenya} \quad y = 0.116 + 0.0091x$$

$$\text{For Jamaica} \quad y = 0.158 + 0.0126x$$

where y = personal injury accidents per km per annum

x = average vehicle flow/hour.

Figure 8.3 illustrates how the accident rate in both countries increases with increasing flow. (Figure 8.3 also shows a relationship derived for a number of developed countries; this is discussed later). It can be seen from Figure 8.3 that, for a similar rate of vehicle flow, Jamaica has a higher accident rate than Kenya.

In order to investigate relationships between geometric design and accident rates, the number of accidents per kilometre of road per annum were divided by the vehicle flow per annum on each section of road, to obtain the number of personal-injury accidents per million vehicle-kilometres. In this way the relationship between vehicle flow and the accident rate is taken into account.

Fig.8.3 COMPARISON OF ACCIDENT RATES AND VEHICLE FLOW FOR VARIOUS COUNTRIES

8.4.2 The results of the simple regression analysis

The results of the simple regression analysis are given in Table 8.4. The 't' value is the ratio of the regression coefficient to the standard error and was used to test whether the relationship was statistically significant (ie were unlikely to have occurred by chance). The tables indicate the relationships which were found to be significant at the 5 or 10 percent level. (Note: 5 percent is the level usually accepted in statistical analysis, ie there is only a 5 percent probability that the relationship could have occurred by chance. Bearing in mind the many factors affecting accident rates, a relationship found significant at the 10 percent level in this study could be considered satisfactory). The correlation coefficient 'r' is also given. The value r^2 provides a measure of the proportion of variability in y that is accounted for by variability in the appropriate x value. Thus, for example in Kenya, junctions per kilometre was found to be the most significant independent variable. The r^2 value of 0.49 indicates that 49 percent of the variation in accident rate is 'explained' by variation in the number of junctions per kilometre alone.

In both countries the most significant parameter of those considered in this study was found to be the number of junctions per kilometre. The correlation between the junctions and the accident rate was greater on the Nairobi-Mombasa road, Kenya, than in Jamaica but as can be seen from Figure 8.4, the ranges were quite different in the two countries. In Kenya where there were never more than two junctions per kilometre an addition of one junction per kilometre was associated with an increase in the accident rate of over one accident per million vehicle-kilometres. In Jamaica, where there were often as many as eight junctions per

TABLE S.4
RESULTS OF SIMPLE REGRESSION ANALYSIS

a) Kenya

Independent Variable	Regression Constant a	Regression Coefficient b	Correlation Coefficient r	t value	Level of Statistical Significance
Av width (m)	3.9166	- 0.2482	0.1507	- 0.6287	not sig at 10%
Vertical curvature (m/km)	2.2846	0.0022	0.0145	0.0601	not sig at 10%
Horizontal curvature (deg/km)	1.7674	0.0268	0.5645	2.8201	sig at 5%
Surface irregularity (mm/km)	1.1837	0.0004	0.3984	1.7907	sig at 10%
Junctions per kilometre	1.6855	1.2476	0.6968	4.0061	sig at 5%

b) Jamaica

Independent Variable	Regression Constant a	Regression Coefficient b	Correlation Coefficient r	t value	Level of Statistical Significance
Av width (m)	7.6658	- 0.8418	0.4802	- 2.8445	sig at 5%
Vertical curvature (m/km)	2.6969	- 0.0033	0.0346	- 0.1798	not sig at 10%
Horizontal curvature (deg/km)	2.3654	0.0014	0.1224	0.6407	not sig at 10%
Surface irregularity (mm/km)	0.7750	0.00039	0.3643	2.10	sig at 5%
Av sight distance (metres)	3.1711	- 0.0042	0.1324	- 0.6941	not sig at 10%
Junctions per kilometre	1.1082	0.3054	0.4847	2.8797	sig at 5%

kilometre, an increase of three junctions per kilometre would increase the accident rate by one accident per million vehicle-kilometres.

On the Jamaican 'A' roads, road width was also a very significant factor, the wider the road the lower the accident rate (see Figure 8.5). On the Nairobi-Mombasa road, there was very little variation in the road width and the small amount of variation (see Table 8.3) has not provided a significant relationship with accident rate.

In both countries the surface irregularity was related to the accident rate: the rougher the road the higher the number of accidents per million vehicle-kilometres. In Jamaica the relationship was statistically significant at the 5 percent level whilst in Kenya it was significant at the 10 percent level. (Again, in Jamaica, the range was greater than in Kenya). The effect of surface irregularity was very similar in both countries; an improvement in roughness of 2000 millimetres per kilometre was associated with a reduction in the accident rate of 0.8 accidents per million vehicle-kilometres per annum.

In Kenya the horizontal curvature was found to be significantly related to the accident rate, a decrease of 35 degrees per kilometre reducing the accident rate by one accident per million vehicle-kilometres. In Jamaica neither horizontal curvature nor sight distance was found to be a significant factor. This is a somewhat surprising result since the range of horizontal curvature is much greater in Jamaica than in Kenya.

8.4.3 Multiple regression analysis

The results obtained in the previous section show how various features of the road considered separately were related to the accident

Fig.8.4 COMPARISON OF ACCIDENT RATE AND FREQUENCY OF JUNCTIONS FOR KENYA
JAMAICA AND BUCKINGHAMSHIRE, UK

Fig.8.5 ACCIDENT RATE/ROAD WIDTH

rate. In order to determine how the combined factors are associated with the accident rate, multiple regression analyses as described in Section 8.3 were carried out.

Parameters were given the following notation

- y = accident rate per million vehicle-kilometres
- x_1 = road width (metres)
- x_2 = vertical curvature (m/km)
- x_3 = horizontal curvature (deg/km)
- x_4 = surface irregularity (mm/km)
- x_5 = junctions per kilometre
- x_6 = sight distance (metres)

The regression equation of factors related to the accident rate, (significant at the 5 percent level) in Kenya was as follows:

$$y = 1.45 + 1.02x_5 + 0.017x_3$$

The independent variables in this equation and those below are listed in order of significance; thus, in Kenya, junctions per kilometre was found to be the variable which had greatest 'effect' on the accident rate.

Other parameters were not significant at the 5 percent level but were at the 10 percent level. Although 5 percent is the level normally accepted in statistical analysis, in this case, taking into account the limitations of the data, the 10 percent level might be considered acceptable. The equation for Kenya then becomes

$$y = 1.09 + 0.031x_3 + 0.62x_5 + 0.0003x_4 + 0.062x_2$$

The 'effects' of surface irregularity and vertical curvature are considerably less than those of junctions per kilometre and horizontal curvature. Nevertheless they are worth including, particularly surface irregularity where, for example, the improvement under consideration is the upgrading of a gravel road to a bituminous-surfaced road and the change in riding quality may be considerable.

The multiple regression equation for Jamaica (with parameters significant at the 5 percent level) was as follows

$$y = 5.77 - 0.755x_1 + 0.275x_5$$

In this equation, road width was the variable most closely associated with the accident rate. In section 8.4.2 it was seen that, in Jamaica, the accident rate was related separately to road width, junctions per kilometre and surface irregularity (all at the 5 percent level). In the multiple regression analysis however, it was found that surface irregularity was not significant (even at the 10 percent level). The reason for this is that surface irregularity and road width were themselves related, the correlation between the two variables being significant at the 5 percent level. (This correlation should not be extrapolated to data from other countries). The most significant factor (road width) enters the equation first and since this is closely related to surface irregularity, it also 'explains' most of the variation associated with surface irregularity, which was therefore found to be non-significant.

8.4.4 Comparison of the Kenya and Jamaica results with those from other countries

In January 1973 Silyanov published the results of a comparison of accident rates on roads of different countries⁵⁵. This work has enabled

a comparison to be made between the relationships derived in Kenya and Jamaica with those obtained on rural roads in developed countries.

Silyanov examined the relationships between accidents per kilometre of road per annum and traffic flow derived by workers in Russia⁵⁶, Sweden⁵⁷ and Australia^{58,59} and, grouping the results from the different countries together, found that the relationship between accidents and vehicle flow could be expressed by the formula:

$$y = 0.256 + 0.000408N + 1.36 (10^{-7})N^2$$

for $40 < N < 1600$

where y = number of personal injury accidents per km/pa

N = vehicle flow/hour

This equation has been plotted on Figure 8.3 and, as can be seen, the accident rate in Kenya and Jamaica is very much greater than in the above developed countries for a similar level of vehicle flow. For example, at a flow level of 100 vehicles/hour, the accident rate in Kenya is over three times greater than in the developed countries and the rate in Jamaica is almost five times greater. These greater accident rates could, in the author's opinion, be due to the quality and condition of the road or possibly to driver behaviour. (see Chapter 10).

The number of junctions per kilometre was found to be significantly related to accident rates in Kenya and Jamaica and this has been compared with results of early work carried out in Great Britain in 1946-48⁶⁰.

The result of this work has been plotted on Figure 8.4 and it shows that for the same number of junctions per kilometre the accident rate per million vehicle-kilometres was similar in Great Britain and in Jamaica.

(The accident rate in Kenya, however, was very much higher than in either

Jamaica or Great Britain but the range of the number of junctions per kilometre is obviously different from that in the other two countries and comparisons are not really valid).

In Jamaica the road width was an important factor and, by combining results from Great Britain, France⁶¹, Hungary⁶², West Germany⁶³ and the United States⁶⁴, Silyanov also related accidents to road width according to the formula:

$$y = 1/(0.173B - 0.21)$$

where y = number of accidents per million vehicle-kilometres

B = road width in metres ($4 < B < 9$)

This relationship has been plotted on Figure 8.5 and it can be seen that, for the same road width, the accident rate is greater in Jamaica than in the developed countries. This difference is greatest at low road widths; for example with a road width of 5 metres, the accident rate in Jamaica is over twice that of the developed countries.

Although sight distance was not found to be a significant factor in Jamaica it is interesting to compare the accident rates in Jamaica for different levels of sight distance with those found by Silyanov. According to Silyanov the sight distance can be related to accidents by the formula:

$$y = 1/(0.20 + 0.0011d + 0.0000009d^2)$$

for $25 < d < 800$

where y = accident rates per million vehicle-kilometres

d = sight distance (metres)

According to the formula, at sight distances of 100 and 200 metres, the accident rates would be about 3.0 and 2.0 per million vehicle-kilometres

per annum respectively. Over this range of sight distance in Jamaica, most of the sections had accident rates of between 3.0 and 4.0 accidents per million vehicle-kilometres.

Thus from this comparison it would seem that the accident rates in Kenya and Jamaica are considerably greater than in developed countries for similar levels of geometric design.

8.5 CONCLUSIONS

From data obtained from various sources in Kenya and Jamaica, it has proved possible, using multiple regression analysis to relate the accident rates on rural roads in these countries to certain design characteristics of the road. In Kenya, the accident rate per million vehicle-kilometres was significantly related to the number of junctions per kilometre, the horizontal curvature, the vertical curvature and the surface irregularity. In Jamaica, it was found to be related to road width, and, again, junctions per kilometre. Engineers and planners may wish to use these regression equations in other developing countries to obtain estimates of changes in accident rate following given road improvements where traffic and road conditions are similar to those described here. However since the equations derived are different in Kenya and Jamaica it would be difficult to decide which was the more appropriate.

Where conditions were similar to those on the Nairobi-Mombasa road, (see Fig. 8.6) the equation derived here would appear the more appropriate. Similarly, where there were greater extremes of horizontal and vertical curvature and surface irregularity (see Fig. 8.7) the equation derived for Jamaica may be more appropriate. One difficulty might be that there

was little variation in road width on the Nairobi-Mombasa road and this did not appear to be a significant parameter, whereas in Jamaica it was the most important parameter. Thus where a road was being widened it might be difficult to decide which was the most sensible equation to use particularly if conditions were similar to those on the Nairobi-Mombasa road.

Before the equations can be used with certainty and, for example built into the Road Transport Investment Model, they need to be verified and adjusted by carrying out similar analyses on other roads in other countries.

It would appear from the comparison of results obtained in Kenya and Jamaica with those from developed countries that the accident rate in the two developing countries was considerably higher than in the developed ones for similar levels of vehicle flow and geometric design. It is quite likely therefore that other factors are involved, such as road user behaviour and vehicle condition and maintenance. The effect of these factors are discussed in Chapter 10.

(a)

(b)

Fig.8.6 TYPICAL SECTIONS OF THE NAIROBI-MOMBASA ROAD, KENYA

(a)

(b)

Fig.8.7 TYPICAL SECTIONS OF RURAL ROAD IN JAMAICA

9. ROAD ACCIDENTS IN URBAN AREAS

9.1 INTRODUCTION

In Great Britain, as in other countries, widespread publicity is often attached to the motorway pile-up or the high-speed crash, but in fact the major road-accident problem lies in the urban areas. Thus in this country almost 75 percent of all injury-accidents occur on roads with 30 or 40 mile/h speed limits.

Research workers in Great Britain are able to use the detailed accident data recorded on 'STATS 19' (see Chapter 6) or the information recorded on the police booklets. Much work has been done to identify where the majority of these accidents take place, to what class of road-user etc^{65, 66}. Results show, for example, that nearly two-thirds of all urban injury-accidents occur at junctions, although in terms of road mileage, junctions make up only a quarter of the road system. In the developing countries for which urban road accident data were available, detail such as whether or not the accident occurred at a junction or on or near a pedestrian crossing was not available. However the author was able to collect information from a number of cities throughout the Third World which has enabled the accident rates in these cities to be compared with those in Great Britain and the United States. In some of these cities, further analysis indicated the distribution of accidents by region, (central area, main traffic routes, residential areas etc), the type of accident taking place and the category of road-user involved.

In four cities, Nairobi and Mombasa (Kenya), Surabaya (Indonesia) and Kingston (Jamaica) accidents were located street by street, accident rates (per kilometre of road) calculated and compared with factors such as

vehicle and pedestrian flows. Wherever possible, comparisons have been made with results obtained in Great Britain and other industrialised countries.

9.2 DATA COLLECTION

In 1973, a visit was made by the author to Kenya to collect detailed road accident data. (see Chapter 7). Subsequent visits to Nairobi were made in 1974 and 1975 to collect further accident data and to measure vehicle and pedestrian flows, particularly on roads within the central area of the city. Data collected in Mombasa in 1973 was supplemented by that given in an urban land-use transportation study of the city⁴².

Visits were made to Surabaya, the second city of Indonesia in 1974 and 1975 to collect road accident data and to carry out traffic surveys on roads within the central area.

Data for Ankara, Turkey were obtained when the author attended the International Road Safety Congress held in that city⁶⁷ in April 1975.

Information on Kingston was obtained from the unpublished study⁵³ of road accidents in Jamaica carried out by the team from the Transport and Road Research Laboratory in 1962-64. (see Chapter 8).

Information on the cities of India was obtained from various publications of the Central Road Research Institute (C.R.R.I.) New Delhi^{68, 69, 70}.

9.3 ACCIDENT RATES IN CITIES OF THE THIRD WORLD

The basic road accident, vehicle and population statistics for the cities studied are given in Table 9.1.

TABLE 9.1
PERSONAL-INJURY, POPULATION AND VEHICLE STATISTICS
FOR THE CITIES STUDIED

City	Accidents	Casualties	Fatalities	Licensed vehicles	Population
ANKARA (1972)	2921	3480	214	100,000	1,240,000
BANGALORE (1970)		1868	152	42,200	1,750,000
BOMBAY (1970)		9624	645	120,000	6,750,000
DELHI (1970)		4291	534	135,000	4,500,000
KINGSTON (1963)	1521	1977	42	40,000	112,000
MOMBASA (Average 1972/73)	566	700	50	20,000	317,000
NAIROBI (1972)	2072	2560	279	70,000	700,000
SURABAYA* (1974)	4078	5523	413	130,600	1,556,250

* Data used being obtained from both police and hospital records

Using the data in Table 9.1, estimates of casualty, injury and fatality rates per 10,000 licensed vehicles were obtained. These rates for the cities in the Third World were compared with those for Great Britain and the United States.

Results of research work^{65, 66} still in progress has shown that urban casualty rates vary in the different regions of Great Britain. The highest casualty rate (per licensed vehicle) was found to be in the towns and cities of Scotland, the lowest rates in the South West. The overall average for the country was 249 casualties per 10,000 vehicles and this is the value used for comparative purposes. Fatality rates in the United States were obtained using data provided in the journal 'Traffic Safety'⁷¹. The results are given in Table 9.2 and Figures 9.1, 9.2 and 9.3.

TABLE 9.2
ACCIDENT RATES IN VARIOUS CITIES THROUGHOUT THE WORLD

City	Casualties per 10,000 vehicles	Injury-accidents per 10,000 vehicles	Fatalities per 10,000 vehicles
Ankara (1972)	348	292	21
Bangalore (1970)	445	-	36
Bombay (1970)	800	-	53
Delhi (1970)	318	-	40
Kingston (1963)	494	380	11
Mombasa 1972/73	350	283	25
Nairobi (1972)	366	296	40
Surabaya (1974)	425	314	32
Average of urban areas Gt. Britain	249	200	4.2
Average of cities in U.S.A.	-	-	1.6

Fig.9.1 CASUALTY RATES IN VARIOUS CITIES THROUGHOUT THE WORLD

Fig.9.2 ACCIDENT RATES IN VARIOUS CITIES THROUGHOUT THE WORLD

Fig.9.3 FATALITY RATES IN VARIOUS CITIES THROUGHOUT THE WORLD

As can be seen, there was considerable variation in the rates obtained for the different cities. The highest casualty rate was found in Bombay followed by Kingston, Bangalore and Surabaya. With the exception of Bombay where the casualty rate was particularly high, the rates in these cities were of the order of sixty percent greater than the average value for urban areas in Great Britain.

Personal-injury accidents were not recorded separately in the Indian cities (ie the figures available included damage-only accidents) and the highest accident rate in other cities for which data were available occurred in Kingston. Again, the accident rates in these cities were about 50 percent greater than the average value for urban areas in Great Britain.

The fatality rates were found to be greatest in the three Indian cities and in Nairobi. The fatality rate in Kingston was surprisingly low, (as seen above, the casualty and accident rates being amongst the highest). This relatively low rate could be due to the low vehicle speeds in the central area of that city⁷². Under such conditions, although the possibility of conflict between vehicles is high, the likelihood of an accident being a fatal accident is lessened.

On comparison with values derived for cities in Great Britain and the U.S.A. the fatality rates in the cities of the Third World seem very high indeed. Thus the rate in Bombay is over 12 times greater than in Great Britain and in most of the cities studied is of the order of 8 times greater. On comparison with the average value for cities in the United States, the rates in the cities in the developing countries are up to 30 times greater.

Then it would seem that although the casualty and accident rates are, on average 50-60 percent greater than in Great Britain, the fatality rates are very much greater than in this country or the United States. This might well reflect the fact that the less serious accident is less well reported in developing countries but the large difference is probably a true indication of the situation in these cities.

In Europe and North America the medical facilities are, as might be expected better than in the large majority of developing countries (see Chapter 4). Thus when a serious accident occurs in Europe and America the chances of the injured person dying is less than in the developing countries.

The type of accident taking place in a city will also have an effect on the fatality rate. As shown later, the cities in developing countries have a greater proportion of pedestrian casualties than cities in Great Britain. Since the pedestrian is the most vulnerable of all road-users the proportion of fatal accidents is also likely to be high.

9.4 THE DISTRIBUTION OF ACCIDENTS

Investigations of the pattern of accidents in urban areas can be conveniently separated into distinct areas with different characteristics. In an analysis of the distribution of accidents in 1971 occurring in three towns in Great Britain the numbers of accidents in the central areas, on A roads (urban arterial routes), B roads (primary distributor routes), residential roads and other roads were obtained⁷³. The results from the three towns are given in Table 9.3 together with that from the cities

TABLE 9.3
ACCIDENT DISTRIBUTION IN THE CITIES STUDIED

<div> <div>Type of area</div> <div>City</div> </div>	Central area		A Roads		B Roads		Other		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%
Kingston 1962	901	59.0	<div> <div>620</div> <div>41.0%</div> </div>						1521	100
Mombasa 1972/73	188	33.2	100	17.7	112	19.8	166	29.3	566	100
Nairobi 1972	540	26.1	392	18.9	668	32.2	472	22.8	2072	100
Surabaya 1974	* 969	23.8	637	15.6	405	9.9	2067	50.7	4078	100
Average of 3 towns in Gt. Britain 1971	398	20.3	661	34.5	288	15.0	579	30.2	1917	100

* including shopping and business districts

in the developing countries. Further work⁶⁶ showed that for towns of about 100,000 population, approximately 25 percent of the accidents occurred in a central area of about 2 sq KM, and in towns of 200,000 population roughly 17-20 percent occurred in a central area of about 3 sq KM. From Table 9.3 it can be seen that in the cities of the Third World studied, the percentage of accidents taking place in the central areas tended to be more than in Great Britain; the number occurring in the central area of Kingston being particularly high.

This large proportion of accidents in the central areas of these cities is probably a function of land-use and social activity. Thus

developing countries tend to have the large majority of the shops, businesses and even industry concentrated in the centres of their major cities with less activity on the periphery than is the case in Great Britain.

The average accident rate per kilometre of road per annum was calculated for the A and B roads of the towns studied in Great Britain⁷³. Estimates were also obtained for the cities in developing countries and the results given in Table 9.4.

TABLE 9.4
AVERAGE ACCIDENT RATES ON A AND B ROADS

City	Accident rate per kilometre of road per annum	
	A roads	B roads
Kingston	8.0	9.0
Mombasa	8.5	9.0
Nairobi	9.0	9.5
Surabaya	12.0	24.0
Average of 3 town in Gt. Britain	5.0	7.0

It can be seen that the accident rates on these classes of road are greater in the cities of the Third World than in Great Britain. The rates for Surabaya seem particularly high with that for B roads, being over three times greater than for Great Britain. Factors affecting rates, such as vehicle flow are examined later in this chapter.

9.5 AN ANALYSIS OF THE TYPE OF ACCIDENT TAKING PLACE IN THE VARIOUS CITIES

9.5.1 Casualties by class of road user

Table 9.5 shows the proportion of casualties occurring to the various classes of road-user and as might be expected there is considerable variation between the areas studied. In most of the Third World cities the proportion of pedestrian casualties is higher than in Great Britain. In Bombay over 70 percent of all urban casualties are pedestrians which is over twice as high as in Great Britain. It is worth noting that the proportion of pedestrian casualties in this country is quite high compared with most of the countries of Western Europe⁴³.

Surprisingly, when compared with Great Britain, the proportion of pedal cyclist casualties does not seem very high in many of the cities in developing countries, particularly when compared with the average value in the six towns selected for detailed study by the TRRL.

There is considerable variation in the proportion of casualties using two-wheeled motor vehicles. In Bombay, the percentage was under one percent whilst in Surabaya it was almost 50 percent of the total. This high value is perhaps not surprising since in this city over 50 percent of all licensed vehicles are motorcycles, mopeds or scooters.

In Surabaya over 17 percent of all casualties were drivers or passengers of betjaks (cycle rickshaws see Figure 9.4 (a)). According to recent surveys⁷⁴ there are over 70,000 of these operating in the city of which 41,000 are unregistered. The operators and passengers of these cycle rickshaws are often in a somewhat vulnerable position, not only

TABLE 9.5
CASUALTIES BY CLASS OF ROAD-USER (EXPRESSED AS PERCENTAGE OF TOTAL)

Class of road user City	Pedestrians	Pedal cyclists	Users of 2-wheeled motor vehicles	Car/Taxi occupants	PSV users	Commercial vehicle occupants	Other	TOTAL
Bangalore	35.0	15.0	16.0	34.0				100
Bombay	70.4	7.6	0.9	21.1				100
Delhi	46.8	18.7	13.8	20.7				100
Mombasa	42.0	17.2	15.4	15.3	1.2	6.9	2.3	100
Nairobi	43.0	10.4	6.5	28.4	3.9	5.7	2.1	100
Surabaya	19.2	4.6	49.2	5.2	-	4.5	17.3*	100
6 Towns in Gt. Britain selected for detailed study by TRRL	26.0	13.0	22.0	32.0	3.0	4.0	-	100
All built-up areas Gt. Britain	31.0	8.0	15.0	35.0	5.0	6.0	-	100

* Users of betjaks (cycle rickshaws)

because the vehicles offer little protection but also because the operators frequently ignore all traffic laws and regulations and proceed over red traffic signals or travel down one-way streets in the wrong direction.

Numerous other 'low level' or 'intermediate' forms of public transport operate in cities of the Third World^{75, 76} with passengers and drivers being exposed to varying levels of risk. One form in common use throughout south-east Asia is constructed around a scooter, sometimes with the driver seated at the front, sometimes at the rear. This form of transport in Jakarta and Surabaya is known as the helijak (see Figure 9.4 (b)). Perhaps some idea of the known risk of riding in these can be gauged by the fact that they are known locally as 'flying coffins'!

In many cities in the developing world the most common form of public transport is the shared taxi, known by many different names throughout Asia, Africa and South America⁷⁶. One of the most well-known of these forms of transport is the dolmus of Turkey (see Figure 9.5 (a)). This is a modified American saloon car carrying up to seven passengers. Detailed studies⁷⁷ of these vehicles in Istanbul and Ankara have shown that they are involved in over 50 percent of all urban accidents taking place in these cities. Drivers stop whenever they see a prospective customer, often swerving across busy traffic lanes or stopping suddenly. It has been suggested that these ubiquitous vehicles should be removed from the streets of Ankara for safety reasons alone.

In other cities in the developing world, the shared taxi is based on a pick-up with passengers seated in two rows facing inwards; protection for passengers again being minimal. Further, since regulations are lax, these vehicles are often overloaded with both passengers and goods, with

Fig.9.4(a) BETJAKS IN SURABAYA, INDONESIA

Fig.9.4(b) A HELIJAK IN JAKARTA, INDONESIA

Fig.9.5(a) A DOLMUS IN ANKARA, TURKEY

Fig.9.5(b) A SILOR IN BANGKOK, THAILAND

people hanging on the back of the vehicle (see Figure 9.5(b)). These vehicles also have a relatively high risk associated with them⁷⁸.

9.5.2 Types of vehicles involved in urban accidents

Table 9.6 shows the proportion of vehicles involved in road accidents in the cities for which data were available.

Again, it can be seen that there are considerable differences between the various cities. As might be expected, with the relatively low level of car ownership existing in the Third World, the proportion of cars and taxis involved in accidents is considerably less than in Great Britain; Nairobi being the exception. The proportion of two wheeled motor vehicles is fairly similar in all areas, again with the exception of Surabaya where motorcycles formed over 50 percent of all the vehicles involved in road accidents.

In the two cities where cycle rickshaws operate, the proportion is considerable, (almost 13 percent of the total in Surabaya, for example). As mentioned earlier there is a tendency for the drivers of these to disobey regulations and the vehicles themselves are somewhat vulnerable.

In the Indian cities, public service and commercial vehicles form a very high proportion of the total number of vehicles involved in accidents. This fact has already been noted by the Central Road Research Institute at Delhi and recommendations have been put forward for improving the safety record of these vehicles in the cities of India⁷⁰. The fault is usually not that of the bus companies who are often operating under severe financial difficulties. Because the demand is so large for public transport in cities of the Third World^{75, 79},

TABLE 9.6
VEHICLES INVOLVED IN URBAN ROAD ACCIDENTS

(expressed as percentage of total)

Vehicle Type City	Pedal cycles	All 2-wheeled motor vehicles	cars and taxis	Commercial vehicles	PSV's	Rickshaws	Other	TOTAL
Bangalore	-	9.2	11.5	40.2	20.7	9.2	9.2	100
Bombay	-	4.4	43.0	30.8	16.0	-	5.8	100
Delhi	-	7.5	20.7	37.2	22.2	5.2	7.2	100
Mombasa	14.7	14.1	48.0	17.3	2.7	-	3.2	100
Nairobi	9.1	6.2	61.0	13.4	5.4	-	4.9	100
Surabaya	3.9	57.0	13.0	13.2	-	12.9	-	100
Average of built up areas in Gt Britain ⁴⁴	6.4	11.5	63.4	12.0	5.2	-	1.5	100

(a) India

(b) Thailand

Fig.9.6 OVERLOADED BUSES IN DEVELOPING COUNTRIES

the buses are often grossly overloaded with passengers travelling in a manner totally unknown in the cities of Europe and North America (see Figure 9.6). Inevitably, passengers travelling in this way, on the outside of the vehicles are exposing themselves to considerable risk.

9.6 A STUDY OF RELATIONSHIPS BETWEEN ACCIDENT RATES AND VEHICLE AND PEDESTRIAN FLOWS

As was seen earlier there was considerable variation in the accident rates per licensed vehicle in the various cities studied, with those in the developing world all being greater than in Great Britain. The composition of traffic within the city or even the way the various types of transport are used affect the accident rate or the pattern of accidents taking place within any urban area. At an even more basic level, it is likely that the vehicle flow along any shopping street or the number of pedestrians crossing the road will affect the accident rate on that street. This section describes research carried out by the author in cities of the developing world which relates accident rates to vehicle and pedestrian flows.

As mentioned in the beginning of this chapter, the data available in the cities selected for study were not sufficiently detailed to locate an accident at or within 20 yards of a junction or at or near a zebra crossing etc. However, in all cities, the records indicated the street where the accident took place and described the person or persons injured. It was thus possible to locate the accidents on a street-by-street basis and to identify those involving injury to a pedestrian. For comparative purposes, streets were classified as being within the central area or on the A and B roads (i.e. urban arterial or primary distributor routes).

Traffic flow data for Kingston and Mombasa were extracted from the urban transport studies carried out in these cities. Traffic flow data for Nairobi and Surabaya were collected by the author during visits made in 1974 and 1975, supplemented by data from the Traffic Engineering Units set up in these cities. Traffic flow data were collected over the time period 07.00 hrs to 18.00 hrs Monday to Saturday. On each road studied an overall average hourly traffic flow value was attained which is an estimate of the average traffic flow per hour throughout the working day.

On each of the roads studied, the injury-accidents were located on maps which showed the accidents by type and severity. An example of the accident pattern obtained for the central area of Nairobi is given in figure 9.7. On each road studied, the number of accidents taking place was divided by the road length thus giving the accident rate per kilometre of road per annum. Comparisons were then made of the accident rates and vehicle flows measured on these roads. Simple regression analysis was used in order to derive equations relating accident rate to vehicle flow.

In order to obtain a measure of the risk which pedestrians run in crossing the road, the flow of pedestrians crossing streets in the central areas of Nairobi and Surabaya were measured. The pedestrians crossing each road were counted in the off-peak periods 10.00 - 12.00 hrs and 14.00 - 16.00 hrs. (Counts were made during off-peak periods so that comparison could be made with results from Great Britain in which counts were made during mid-morning and mid-afternoon). A measure of risk was obtained by dividing pedestrian accidents by pedestrian flow across the road. The absolute level of risk cannot, of course be measured,

(a) Fatal

(b) Serious

(c) Slight

Fig.9.7(i) ALL INJURY-ACCIDENTS, CENTRAL AREA NAIROBI

(a) Fatal

(b) Serious

(c) Slight

Fig.9.7(ii) PEDESTRIAN ACCIDENTS, CENTRAL AREA NAIROBI

since this would require a knowledge of the total pedestrian flow across the road in a year. The relative risk rate was calculated as:-

$$\text{risk} = \frac{\text{pedestrian accidents in 2 years}}{\text{average pedestrian flow per hour}}$$

This method of assessing risk to pedestrians on various parts of the road (on or near zebra crossings etc) has been used for some time in this country^{80, 81, 82}. The risk rates obtained were related to the vehicle flows on these streets using simple regression analysis and results obtained on central shopping streets in Nairobi and Surabaya compared with those from shopping streets studied in Great Britain.

The results of the regression analyses are given in Figures 9.8 - 9.13 and details of the streets studied in Appendix Tables 9.1 - 9.9. In each of the areas studied, a relationship was derived between accident rate and vehicle flow, statistically significant at least at the 5 percent level.

Relationships derived in Kingston and Nairobi (see Figures 9.8 and 9.10) show that the accident rate per kilometre of road per annum is greater in central area streets than on A and B roads for similar levels of vehicle flow. The slopes of the regression lines for the central areas is also greater, indicating that accident rates on these streets increase at a greater rate, with increasing vehicle flow than on A and B roads in these cities.

The regression line with greatest slope occurred on the central area streets of Surabaya. According to the equation derived here, a doubling of the average vehicle flow from 1000 to 2000 vehicles per hour would mean a 130 percent increase in the number of personal-injury accidents per kilometre of road per annum.

Fig.9.8 KINGSTON JAMAICA (1962) - TOTAL INJURY ACCIDENT RATES

Fig.9.9 MOMBASA KENYA (1972/73) - TOTAL INJURY ACCIDENT RATES

Fig.9.10 NAIROBI KENYA (1969-72) – TOTAL INJURY ACCIDENT RATES

Fig.9.11 SURABAYA INDONESIA (1974) — TOTAL INJURY ACCIDENT RATES

Fig.9.12 INJURY ACCIDENTS IN THE CENTRAL AREAS OF THE CITIES STUDIED COMPARED WITH GREAT BRITAIN

Fig.9.13 CENTRAL AREAS – SURABAYA (1974) AND NAIROBI (1972/73)
 – PEDESTRIAN RELATIVE RISK RATES

Figure 9.12 shows the regression lines derived in all the cities studied, together with that calculated using data from a number of shopping areas in Great Britain over the period 1949 - 1968. It can be seen that the accident rates in Great Britain were less than in the cities in the Third World for similar levels of vehicle flow. (Apart from some results over the range 400 - 600 vehicles per hour). Furthermore, the slope of the regression line obtained for Great Britain was less steep than that for the cities in the Third World. Thus at 1000 vehicles per hour for example, the accident rate in Great Britain is 41 percent and 150 percent less than in Nairobi and Surabaya respectively; at 2000 vehicles per hour, it is 65 percent and 160 percent less than in Nairobi and Surabaya.

From these relationships it can be seen that when the level of vehicle flow is taken into account, the shopping streets in the cities of the Third World have a higher accident rate than streets in Great Britain.

Another factor investigated was the number of pedestrians crossing the road on these busy streets.

Figure 9.13 shows the relationships derived of relative pedestrian risk rates and vehicle flow in Nairobi, Surabaya and shopping streets in Great Britain for which data were available. The levels of risk in Nairobi and Surabaya were much greater than in Great Britain for similar levels of vehicle flow; the slope of the regression line calculated from the data in Great Britain was again less steep than for the cities in the Third World.

At a flow of 1500 vehicles per hour for example, the risk rates are 86 and 172 percent greater in Nairobi and Surabaya respectively than in Great Britain; at a flow of 3000 vehicles per hour the rates are 180 and 260 percent greater.

These results indicate that when both pedestrian and vehicle flows are taken into account, the accident rates in busy streets in cities of the Third World are greater than in Great Britain.

9.7 CONCLUSIONS AND DISCUSSION

The work described in this chapter has shown that accident and casualty rates (per licensed vehicle) are greater in cities of the Third World than in Great Britain or the United States; the fatality rates were found to be very much greater in developing countries. It is quite likely that the less severe accident is less well reported in developing countries but the result is probably a true reflection of the situation in cities of the developing world. Since medical facilities are less readily available than in cities in Western and North America, there is a greater likelihood of a seriously injured person becoming a fatality.

An analysis of the type of accident taking place also provides an indication of why fatality rates should be particularly high in cities in developing countries. It was found that in these cities there was a greater proportion of pedestrian casualties than in Great Britain; the pedestrian being amongst the most vulnerable of all road-user.

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 Great Britain, for similar levels of vehicle flow. There are many possible reasons why this should be so and the factors involved could be poor road design or street furniture, poor vehicle maintenance or poor road-user behaviour.

Some of the factors contributing to high accident rates in developing countries are discussed in the next chapter but the analysis carried out here of the type of vehicle involved showed that 'low level' or 'intermediate' forms of public transport, unknown in Great Britain and North America, are frequently involved in road accidents in developing countries. These types of vehicle often built around a bicycle or a moped offer little protection to either operator or user. The analysis also showed that the more conventional forms of public transport are involved in proportionately more accidents than in Great Britain. Unlike the developed countries, the demand for public transport is extremely high in the cities of the Third World and buses are often overcrowded with people travelling on the outside of the vehicle. Under such conditions, it is hardly surprising that these vehicles have a high level of risk associated with them.

A measure of pedestrian risk in crossing busy shopping streets was obtained, compared with the levels of vehicle flow on these streets and regression equations derived. It was found that the relative risk rate was much higher in Nairobi and Surabaya than in shopping areas of Great Britain for similar levels of vehicle flow. In other words pedestrians run a greater risk in these cities than in Great Britain. This could, in part, be due to a general lack of pedestrian facilities such as zebra or light controlled crossings etc. but as is shown in the next chapter, even when facilities exist they are incorrectly used or ignored completely often placing the pedestrian at considerable risk.

Methods by which the accident rates can be reduced in cities of the Third World, particularly on a cost-effective basis are discussed in Chapters 10 and 12.

10. THE FACTORS INVOLVED IN ROAD ACCIDENTS

10.1 INTRODUCTION

Much work has been done in recent years in Europe and North America to determine the factors involved in road accidents^{39, 84, 85, 86, 87} and to investigate the complex inter-relationships existing between the road, user, the environment, the road network and the vehicle. Large multidisciplinary teams were needed to carry out these investigations, often taking a number of years and requiring specialised equipment. With the author's limited resources it was not possible to mount such an investigation in any particular country in the Third World. However, over the last five years attempts were made to investigate road-user behaviour, the condition of vehicles and the effect of the environment in developing countries and this work is described later in this chapter. In particular, much can be gained from an examination of aggregate statistics, compiled on a national or regional basis and examples are given of work where specific causal factors can be identified from such analyses. The author stresses the need for caution in describing causes of road accidents.

Rarely, if ever, is there a single 'cause' of a road accident; as stated in an OECD Research Group Report⁸³, 'accidents are multifactor events'. An example, albeit a somewhat simplified one to illustrate the multifactor approach is as follows:

If a driver misjudges the sharpness of a bend, approaches too fast and enters a skid which he cannot control, three main factors are present:-

(1) The driver's failure to select a safe speed to enter the bend.

(2) The sharpness of the bend.

(3) The drivers inability to control the skid.

Subsidiary factors might be the condition of the road, weather, the vehicle's tyres etc. It may be felt intuitively that the accident had more than one cause and that these three factors are no more than three such causes, each of which contributed its own particular element to the total risk on this occasion. It might also be felt that if sufficient information were provided, the element of risk attached to each factor might be quantified. Closer examination of the problem reveals that this is not so.

Thus, if factor (1) had not been present and the vehicle speed selected was low enough to ensure the safe negotiation of the bend, the sharpness of the bend would be of little consequence and the measure of risk attached to the presence would be negligible.

Similarly, if either factors (1) or (2) were absent, the risk of the skid would be negligible. Hence any measure of risk attached to the drivers inability to control the skid would be negligible on this occasion.

Thus the three factors are not individual 'causes' in their own right because there is only a high accident risk when all three are present. When any single one is removed, the element of risk attached to the others is diminished sharply; that is, all these factors interact. This phenomenon must be the foundation upon which any detailed investigation of road accidents is built: this approach must be adopted

in carrying out an investigation of the factors involved in specific road accidents. A general study carried out at a much broader level (see below), could however be based on an analysis of basic accident statistics.

Because certain factors only become significant when accompanied by certain other factors, there can be no simple means of classification. The most that can be said, for example, is that in 95 percent of the accidents in a given sample, 'driver error' was one of the multiplicity of factors; or similarly that in 52 percent of the accidents in the same sample, 'road characteristics' was one of the factors. Clearly, the first classification is associated with the human element and the second with the environment within which the accident took place. Moreover, these two classifications must overlap to a considerable extent. Detailed work carried out in this field is discussed later.

To attempt to assign one 'cause' or to apportion 'blame' is a fruitless task which the accident investigator should leave to the philosophers or to the courts. It is sufficient to appreciate that an improvement in the road-users ability to deal with a situation, and a simplification of the situation itself will both lead to a reduction in accident risk. That is, environmental engineering and road-user education must go hand in hand.

10.2 ACCIDENT INVESTIGATION ON A REGIONAL BASIS

For an understanding of the many factors contributing to road accidents, from which may be established priorities for remedial action, it is necessary to examine the accident situation over a wide range of levels. Thus it is important to examine accidents on a national basis, on a

'district' basis such as in a particular city or along a specific road, and on a local basis ie to study road accidents as they actually take place on the road.

10.2.1 National studies

10.2.1.1 Objectives

The need for national road accident statistics has already been discussed in Chapter 6. However it is worth emphasising that the main uses of national data are as follows:-

- (i) They provide a means of assuring the need for and the effect of national legislation.
- (ii) An overall picture of the accident situation can be obtained which will give a guide to where more effort should be directed to improve road safety, whether that be concerned with the environment, the road or vehicle design or the road-user.
- (iii) Trends can be examined and forecasts made which will assist in future planning, and from the combination of accident data with traffic data, accident rates can be evaluated and used in cost-benefit appraisals.
- (iv) National data provides a basis for comparison in regional and local studies, particularly in the assessment of the effectiveness of remedial measures ('before' and 'after' studies). Thus in Great Britain national skidding rates were used to assess the significance of skidding accident clusters⁸⁸ and national data on accidents during darkness, to assess the

effects of street lighting⁸⁹. The latter area of study illustrates the importance of making allowance for the influence of national actions on local schemes. Thus reduction in road accidents could falsely be attributed to installation of lighting if the effects of the 'drink and driving' legislation were not adequately allowed for⁹⁰.

- (v) National accident statistics have been used by the author to put into perspective road accident rates in developing countries as a whole. In other words national accident statistics can be used to show whether a specific country or even a group of countries have a particularly high or low accident rate.

10.2.1.2 International comparisons

Much of the work described in Chapter 4 would come under this category. Developing countries as a whole were shown to have high accident rates when compared with those in Europe and North America. This was shown to be so even when the level of vehicle ownership was taken into account. Further, it was shown that the situation in many countries of the Third World was deteriorating, as opposed to improving, as is the case in most of the countries of Europe.

The international accident data was also used to show that the severity indices (ie the percentage of all accidents that are fatal) was extremely high in developing countries and could be related to the medical facilities available in these countries. Thus if medical aid to road accident casualties could be improved, particularly by means of better ambulance services then far fewer fatal accidents would result.

A study of the disaggregated road accident data available in those countries showing increasing, as opposed to decreasing accident rates, showed that increases in the number of motorcycles on the road could be a significant factor. Smeed showed that in Great Britain in 1964, the total number of injury accidents could be reduced by 34 percent if the vehicle-mileage travelled by motorcycles was travelled by cars instead⁹¹. It has also been shown that by wearing safety helmets, injuries to the heads of motorcyclists could be reduced by 30-40 percent and that the risk of death could be reduced by 25 percent in built-up areas and by 50 percent in non-built up areas⁹².

Legislation was introduced in Great Britain making it compulsory for motorcyclists to wear crash helmets. Surveys carried out before legislation, showed that only 57 percent of motorcyclists wore helmets despite numerous propaganda campaigns. The author carried out a survey in Nairobi on the proportion of motorcyclists wearing crash helmets and it was found that only about 30 percent did so. Thus it would seem that there is a strong case in developing countries for legislation on the wearing of crash helmets by motorcyclists.

10.2.1.3 Road accidents in Kenya

As described in Chapter 7, a detailed analysis was made of one complete year's accident data in Kenya. The results showed that occupants of commercial vehicles were a surprisingly high proportion of the total road casualties. As was described in Chapter 7, this could be due to the fact that commercial vehicles are used to transport men to and from places of work. Thought should be given to controlling the operation of open lorries in this way. The study of road accidents in Kenya showed that the proportion of night-time accidents was increasing. This is almost certainly due to a greater proportion of

night-time driving and efforts should be made to reduce the growing number of accidents occurring at night. To this end, the author spent several nights driving around Nairobi (and other cities, including Blantyre, Bangkok and Surabaya) trying to identify deficiencies in the quality of street or vehicle lighting. The level of street lighting on the main roads seemed to be adequate but was usually non-existent on residential roads. The lack of street lighting, together with no pavements, made a particularly hazardous situation for the pedestrian on these residential roads.

In most of these cities it was found that pedal cyclists usually showed no lights at all, thus increasing their vulnerability since with no street lighting and being dark skinned, they were not easy to see even when showing a front or rear light. In these countries, legislation exists which states that pedal cyclists must show front and rear lights. The fact that the large majority of them do not, indicates the need for stronger enforcement.

The analysis of the national accident statistics of Kenya by the author also indicated that the accident rate on murram (ie gravel surfaced) roads is surprisingly high. As suggested in Chapter 7 this could be due to the poor geometry of these roads, to their deterioration in wet weather or to reduced visibility caused by dust. In Great Britain detailed information is usually available on each injury-accident that takes place, recorded in the police booklets or 'STATS 19' accident analysis forms. Using these data a greater insight is obtained on the factors involved in a road accident than is possible in developing countries. Thus although the analysis of the Kenya accidents has indicated the high accident rate on murram roads there is little information to indicate why this should be so. However it can be seen from the above, that although data is limited much is to be gained from an analysis of existing national road accident statistics.

10.2.2 District Studies

The concept of district or regional accident investigation is to conduct more thorough examination of accidents in a limited locality, combining statistical analyses with on-site observations of road features, traffic, vehicle manoeuvres and road-user movements. The object is usually to identify common factors or common situations. There is also a tendency in regional accident investigation to use the results to identify remedial measures in the form of improvements in road design. Whilst this is certainly a most important application, the potential also exists to use regional studies to examine vehicle movements and road usage in greater depth, with a view to recommending changes in traffic management and land-use in order to reduce accidents. In particular, much more attention could be given to the study of the interaction between the road, vehicle and road-user.

As with the the national road accident data, it is worth reviewing the district or regional studies that have already been discussed in this thesis.

10.2.2.1 Rural studies

As was seen in Chapter 8, accident rates can be clearly related to the design of the road on which the accidents took place. The number of accidents per million vehicle kilometres of travel on selected rural roads in Kenya and Jamaica were statistically related to such features as road width, roughness, curvature and the number of junctions per kilometre. As has already been discussed, it should be possible to reduce the injury-accident rate on rural roads by improving the road design and layout.

When one considers the vast number of variables that could affect the accident rate on rural roads, it is perhaps surprising that statistically significant relationships such as those described above were derived at all. For example even when a road is adequately designed, much will depend on how well the road is maintained. The level of routine maintenance which takes place which includes road marking, sign posting, clearing of ditches etc, can obviously affect the accident rate.

Figures 10.1 and 10.2 show how some factors can be significant yet difficult to quantify. Figure 10.1(a) show how objects in the road can constitute a hazard particularly if encountered at night or after a bend. Terrain where such objects are likely to be frequently encountered such as areas prone to falling rocks, trees or even landslides can have an effect on the accident rate.

Figure 10.1(b) shows how a road with considerable horizontal curvature can be even more dangerous than might be expected from the degree of curvature alone. Thus even a slight loss of control under such conditions can mean the death, possibly by drowning, of all the occupants of a vehicle. With a suitable guard rail such accidents can be prevented at relatively low cost.

Figure 10.2(a) shows the type of drainage ditch commonly found along rural roads in developing countries. Again it is easy to see how loss of control and driving into one of these ditches could result in a serious accident. If these ditches were covered the accident might be much less serious. Figure 10.2(b) shows the situation frequently encountered on the outskirts of many towns in developing countries. People live alongside the road, pedestrian

Fig.10.1(a) TYPICAL HAZARD IN JUNGLE AND FOREST AREAS

Fig.10.1(b) LACK OF SAFETY PRECAUTIONS WITH ROAD ALONGSIDE HARBOUR

Fig.10.2(a) DRAINAGE DITCHES AS A HAZARD WHEN VEHICLES LEAVE THE ROAD

Fig.10.2(b) LACK OF PAVEMENTS AND STREET LIGHTING CREATING A DANGEROUS SITUATION FOR PEDESTRIANS

movements are high but there is usually no pavement. Such a situation is particularly hazardous for the pedestrian at night, in the absence of street lighting.

Much work has been done in Europe and North America to show that the number and severity of road accidents on rural roads increases with increasing vehicle speed (other things being equal),^{93, 94, 95, 96} but data on vehicle speeds were not available for the study of rural accident rates. As was mentioned in Chapter 7, vehicle speeds on rural roads in Kenya⁴⁵ were greater than in Great Britain yet the roads are narrower, with greater extremes of both horizontal and vertical curvature. It is likely that the accident rates could be reduced on these roads by imposing a speed limit which of course would have to be accompanied by effective enforcement. As was seen earlier, the single-vehicle accident is very common indeed on the rural roads in Kenya. With the enforcement of speed limits, this type of accident in particular should be less prevalent.

10.2.2.2 Urban studies

The studies of various urban areas described in Chapter 9 are another illustration of the effectiveness of regional studies, the 'region' in this case being a particular city. As was seen in Chapter 9, although the casualty and accident rates were higher in cities of the Third World than in Europe and North America, the fatality rates were very much greater. This again shows the problem of high severity indices in developing countries and the need for improved medical facilities.

The analysis also showed that the proportion of pedestrian casualties was greater in the cities of the Third World than in Europe. Since the pedestrian is particularly vulnerable, a reduction in the

pedestrian casualty rate should result in a decrease in the proportion of fatal accidents in these cities.

There are numerous ways in which the pedestrian can be protected in urban areas and much work has been done in this country to show where the pedestrian is at particular risk. By installing pedestrian crossings in Great Britain, the pedestrian accident rate can be reduced on busy shopping streets^{81, 82}. Zebra crossings (or their equivalent) exist in most of the cities studied in Chapter 9. However road-user behaviour was found to be extremely poor at these crossings and work carried out by the author to illustrate this is described later in this chapter. The effectiveness of zebra crossings and indeed the safety of an entire shopping area can be improved by the installation of guard rails⁹⁷. Even when safety features are installed, care must be taken to ensure that their effectiveness is not lost.

Figure 10.3(a) shows a site where both guard rails and a pedestrian footbridge were installed to improve pedestrian safety (the photograph having been taken from the footbridge). However it was forgotten to move a bus stop to some point further down the road and a dangerous situation was created where people waiting for buses have to stand on the road on the 'wrong side' of the guard rail. Thus even with good intentions a hazardous situation can be created.

Figure 10.3(b) shows the site of a zebra crossing which (supposedly) no longer exists. Pedestrians attempting to cross the road here, encounter a central barrier and find themselves trapped in the centre of an extremely busy road.

Thus, even when a regional analysis has been carried out, and a particular problem identified - such as pedestrian accidents in a city, detailed investigations are necessary to ensure that adequate facilities have been provided and that their effectiveness is not lost by mismanagement or poor user behaviour.

Fig.10.3(a) A BUS STOP SITED OUTSIDE A GUARD RAIL—BANGKOK

Fig.10.3(b) 'IS THIS A ZEBRA OR ISN'T IT?' SITUATION

Perhaps the most effective way of all of reducing the accident rate in a city is to pedestrianise the central shopping area thus removing the conflict for roadspace that exists between the pedestrian and motor vehicle. Work carried out by the author in 1967-68⁹⁸ showed that precinct shopping areas were safer places than 'ordinary High Street' areas. It is hoped that as the standard of living improves in cities of the Third World with more time and money spent on improving the environment, that precinct shopping areas would come into being, thus improving not only the accident rate of a city but also the quality of life within.

In an article on road safety in India⁹⁹, Srinivasan makes the point that vehicles have to keep away from pedestrians often taking evasive action (as opposed to vice versa) because pedestrians show poor road sense. He suggests that strenuous efforts should be made to educate not only the motor vehicle user but also the pedestrian and cyclist.

As on rural roads, the accident rate on roads in urban areas is affected by the speed of vehicles travelling on them. A good illustration of this was in Northern Ireland¹⁰⁰ where a speed limit of 30 mile/h was introduced in built-up areas in 1956. This was followed by a reduction of 7 miles/h in the mean speed of cars in the suburbs of Belfast and a reduction in injury-accidents (all urban areas) of 24 percent.

Vehicle-speed measurements were taken by the author on Central-Area, and 'A' (primary distributor) roads in Nairobi. Accident rates (per million vehicle kilometres travelled) were regressed against the average vehicle speeds on these roads but no significant relationship

was derived. It is quite likely that other factors such as pedestrian flow, road width, number of zebra crossings, frequency of junctions etc are all influencing the accident rate and the only effective way of identifying the effect of vehicle speed would be by carefully controlled experiments in selected streets where conditions such as those mentioned above were similar.

The results of the Nairobi analysis are given in Figure 10.4 and as can be seen there is no significant relationship between accident rate and vehicle speed. The author noted with interest however, that the streets with the highest rates were those on the outskirts of the central area where the type of shop was different from that found for example on Kenyatta Avenue, Mama Ngina Street, etc, which sold quality goods, as opposed to the 'essential' goods sold in shops on the periphery. The shops in the streets with the high accident rates tend to be used by people of a lower income level than those in the middle of the central shopping area. Thus the type of land-use and the type of shopper and worker frequenting an area could have an influence on the accident rate in a particular street or area.

Although it is difficult to catch the atmosphere of a shopping streets in a photograph, Figure 10.5 attempts to show the difference between central shopping streets (eg Kaunda Street) and those in the outskirts of the central area found to have high accident rates (eg River Road).

As was seen in Chapter 9, commercial and public service vehicles were involved in proportionately more accidents in cities in developing countries than in Great Britain. The type and quality of public transport operating in cities in developing countries has

Fig.10.4 ESTIMATED ACCIDENT RATE (PER MILLION VEHICLE KILOMETRES PER ANNUM) AND AVERAGE VEHICLE SPEED ON CENTRAL AREA STREETS IN NAIROBI

(a) River Road

(b) Kaunda Street

Fig.10.5 DIFFERENT TYPES OF SHOPPING STREET WITHIN THE CENTRAL AREA OF NAIROBI

already been discussed in Chapter 9. It is worth emphasising again that the 'low level' or 'intermediate' forms of public transport such as the betjak, helijak and silor offer little protection to the passenger and the situation is worsened by the fact that drivers show little regard for existing traffic regulations. Again, a regional study would show a high PSV accident rate; this must be related to both user behaviour and facilities provided.

The conventional bus is often overcrowded with passengers hanging on the outside of the vehicle. Under such conditions it is hardly surprising that many accidents take place and it is self-evident that poor public transport is a major contributory factor in the accident problem of these cities. By improving public transport facilities and prohibiting (and actively preventing) passengers from travelling on the outsides of buses the casualty rates could be substantially reduced.

10.2.3 Local studies

As has already been shown, the district or regional investigation can add considerably to the understanding of features of road design and vehicle useage which contribute to accidents. The basic understanding of factors leading to accidents can, however, only be obtained by more local investigations which enable detailed studies of the design of the vehicle, the type of injury incurred and road-user behaviour to be made.

The ultimate in local depth investigations is attendance at the scene of accidents augmented by the follow-up examinations of vehicles and persons involved. A number of such studies have been made in Great Britain and elsewhere^{39, 85, 86, 87} and it is worth examining some of the findings from these studies.

The 'on-the-spot' accident investigation team at the Transport and Road Research Laboratory studied over 3000 accidents in Berkshire over the period 1970-75. Results from the first two years' work involving 1164 accidents indicate the following results:-

Road - 461 factors contributory in 316 accidents

Vehicle - 283 factors contributory in 238 accidents

Human factors:-

(a) Driver - 2068 factors contributory in 948 accidents

(b) Pedestrian - 150 factors contributory in 71 accidents

This subdivision into the road, the vehicle and the road-user is very common in accident investigation procedures. Preliminary results from this analysis indicate the road to be a factor in 27 percent of the accidents investigated, the vehicle in 20 percent and the road-user in 87 percent of the cases⁷³.

Further examples of detailed investigations also illustrate the importance of the road-user.

Birmingham University study⁸⁶

Environment	4.3 %
Vehicle	4.3 %
Road user	44.7 %
Environment/Vehicle	1.0 %
Environment/Road user	31.0 %
Vehicle/Road user	7.1 %
Environment/Vehicle/Road user	7.6 %

Driver errors	95 %	}	Human element
Pedestrian errors	15 %		
Drivers' physical failings	6 %		
Pedestrians' physical failings	2%		
Road characteristics	52 %	}	Environment
Slippery wet surface	22 %		
Atmospheric conditions	15 %		
Traffic flow	31 %		
State of the vehicle	12 %		

Above figures indicating the percentage involvement of the various factors (or groups of factors) in the accidents studied.

As stated earlier, it was not possible to carry out detailed studies such as those mentioned above in any country of the Third World. It was not possible therefore to make any detailed investigations at the site of an accident. What the author attempted to do was to investigate, as best he could with the limited resources available, the three main elements involved in a road accident as described above, namely, the road surface, the vehicle and the road-user and to identify particular problems and faults. Results obtained from these studies have, wherever possible been compared with findings in Great Britain and elsewhere. (Taking into account the results from the studies described above, the emphasis was placed on studies of road-user behaviour in developing countries).

10.3 THE ROAD SURFACE AS A FACTOR IN ACCIDENTS

The on-the-spot accident investigation at TRRL described earlier showed that the road condition was a contributory factor in 27 percent of the accidents studied. The most important features were poor visibility due to layout, inadequate junction design, poor general layout, lack of maintenance, poor lighting, inclement weather and a slippery road surface.

Most of these aspects have already been covered in Chapter 8 and section 10.2 of this chapter; features such as weather, slippery roads and the incidence of skidding are considered here.

During visits to Nairobi and Surabaya, the opportunity was taken to take skidding measurements, using the portable skid pendulum, and to try to determine the effect of rainfall in these cities. Rainfall and accident data were also obtained for West Malaysia, specifically Kuala Lumpur.

In Great Britain it has been estimated that the accident rate increases by 53 percent in wet weather with the increase being particularly high during the hours of darkness. The increased accident rate is due to both impaired visibility (particularly in winter) and to slippery roads (particularly during summer months) ^{101, 102}.

Information on rainfall and accidents were obtained for Kenya, West Malaysia and in detail for Nairobi, and Surabaya. Results were as follows:

TABLE 10.1 *

RAINFALL AND ACCIDENTS IN KENYA 1972

Month	Inches of rainfall	Accidents
JAN	30	426
FEB	34	424
MARCH	62	445
APR	124	465
MAY	108	458
JUNE	49	445
JULY	45	472
AUG	51	431
SEPT	42	503
OCT	57	440
NOV	76	427
DEC	59	434

* (Note. Howe⁴⁰ found no relation between weather and traffic flow)

A rank correlation coefficient showed that there was no association of rainfall with accidents in Kenya. Detailed rainfall and accident data were obtained for the central area of Nairobi in 1972 and 1973. Most of the countries in the developing world have a pattern of rainfall quite different from that of Western Europe. There are fewer wet days, but when it does rain, the volume is frequently fairly high. Advice was taken on what level of rainfall constitutes a 'wet day' (since a considerable volume could fall in a very short space of time, and a strong sun would then dry the roads in a very short time). It was suggested that a 'wet day' in Kenya (or in any tropical or sub-tropical country) could be taken as one with more than 10mm rainfall or possibly one with more than 20mm rainfall. Both levels were taken for the central area of Nairobi 1972 and 1973; results were as follows:

TABLE 10.2
ACCIDENTS AND RAINFALL - NAIROBI CENTRAL AREA 1972, 73

Weather	Accidents	Days
Wet	67	48
Dry	1036	682
TOTAL	1103	730

(a) Wet days = more than 10mm rainfall

Wet	34	26
Dry	1069	704
TOTAL	1103	730

(b) Wet days = more than 20mm rainfall

Chi-square tests carried out on the above data showed that there were not significantly more accidents during wet days (whatever definition was used of a 'wet day') than during dry days.

A similar analysis was carried out on ^{those} road accidents for Surabaya (where the day of the accident was known). Results were as follows:

TABLE 10.3
RAINFALL AND ACCIDENT DATA SURABAYA 1974

Weather	Accidents	Days
Wet	289	45
Dry	2250	320
TOTAL	2539	365

(a) Wet days = more than 10mm rainfall.

Wet	138	23
Dry	2401	342
TOTAL	2539	365

(b) Wet days = more than 20mm rainfall

Chi-square tests on the above data again showed that there were not significantly more accidents during wet days than during dry days.

Similar data were obtained for West Malaysia for the year 1965. Since the rainfall data deals with a large part of a country and not a city, the results may not be as accurate as the previous two examples. In this case rainfall data were available not only in inches per day but also as hours of rain per day; both values were used.

TABLE 10.4
RAINFALL AND ACCIDENT DATA W.MALAYSIA 1965

Weather	Accidents	Days
Wet	2,167	42
Dry	13,512	323
TOTAL	15,679	365

(a) Wet day = more than 0.8" rainfall

Wet	2,167	33
Dry	13,512	322
TOTAL	15,679	365

(b) Wet day = more than 4 hours rainfall

Wet	2,167	11
Dry	13,512	354
TOTAL	15,679	365

(c) Wet day = more than 6 hours rainfall

In this case the chi-square tests (on the three sets of data) indicated that there were statistically significantly more accidents during 'wet' days than during 'dry' days.

Thus in two results no relationship between rainfall and accidents was found whilst a significant relationship was found in the third country. An attempt has been made to examine the reasons for this.

It is possible that the accident rate during rainfall is affected more by slipperiness of the road surface in these countries than by impaired visibility and that values of skid resistance of the road surface might indicate this.

In Nairobi and Surabaya skid values were obtained by the author at selected sites using the portable skid meter (see Figure 10.6). In Kuala Lumpur values were obtained from (unpublished) work carried out by colleagues over the period 1964-66. Sites were classified according to the recent work¹⁰³ on this subject as either 'very difficult' eg approaching traffic signals, 'difficult' eg roundabout approaches 'average' eg straight sections on trunk and principal roads or 'easy' eg generally straight sections of lightly trafficked roads. Results are given in Table 10.5 and 10.6

TABLE 10.5
SKID METER RESULTS IN SURABAYA

Site and classification	Average values of readings taken across the road			
	At junction	25 M from junction	50 M from junction	75 M from junction
Very difficult (Traffic signals at JALAN PEMUDA)	0.50	0.53	0.56	0.55
Difficult (Roundabout at JALAN SURDIMAN/EMBONG SAWO)	0.60	0.44	0.50	0.62
Easy (JALAN EMBON-TANJUNG)	0.52	0.53	0.49	0.54

In Tables 10.5 to 10.8 all figures quoted are SFC values (at 50Km/h).

Fig.10.6 MANY HELPING HANDS WITH THE PORTABLE SKID METER—SURABAYA

TABLE 10.6
SKID METER RESULTS IN NAIROBI

Site and classification	Average values of readings taken across the road		
	At junction	25 M from junction	50 M from junction
Very difficult (signals at Government Road, arm 'A')	0.51	0.52	0.50
Very difficult (signals at Government Road, arm 'B')	0.50	0.56	0.55
Difficult (roundabout Government Road) J/W Haile Selassie Avenue	0.59	0.61	0.61
Difficult (Roundabout J/W Uhuru Highway/ Haile Selassie Avenue, arm 'A')	0.49	0.49	0.48
Difficult (Roundabout J/W Urhuru Highway/ Haile Selassie Avenue, arm 'B')	0.52	0.54	0.55
Average (Ngong Road site A)	0.48	0.45	} Actually points along the road away from all junctions
Average (Ngong Road site B)	0.48	0.52	
Easy (Nairobi-Karen Road)	0.41	0.40	0.43

In the above tables, up to 55 readings were taken at eleven different points across the road width, with five values taken at each point (as was done in the Kuala Lumpur study). All values have been corrected to 35°C, a value recommended for roads in developing countries.

A recent report on skidding and safety made recommendations for skid resistance values at various types of sites with varying levels of accident risk; these were as follows: (with values corrected to 20°C).

TABLE 10.7
RECOMMENDED SKID VALUES AT VARIOUS TYPES OF SITES

Type of site	Risk rating								
	1	2	3	4	5	6	7	8	9
Very difficult						0.55	0.60	0.65	0.70
Difficult				0.45	0.50	0.55	0.60	0.65	
Average	0.20	0.35	0.40	0.45	0.50	0.55			
Easy	0.30	0.35	0.40	0.45					

It can be seen that the values obtained at the different sites in Nairobi and Surabaya compare favourably with the recommended values given in Table 10.7. In these cities the aggregate used for road building is known to be quite satisfactory.

Skid values obtained in 1965 in Kuala Lumpur by the TRRL research team were as follows:

TABLE 10.8
SUMMARY OF SKID MEASUREMENTS KUALA LUMPUR 1965

Site and category	Type of aggregate	Average skid value (corrected to 35°C)
Ipoh Road (average)	Granite	0.46
Bentong Road (average)	"	0.49
Federal Highway (average)	Limestone	0.32
Federal Highway (difficult)	"	0.29
Bentong Road (average)	"	0.32
Housing estate roads (easy)	"	0.44
Urban main roads (average)	"	
Pehehiling	"	0.28

It can be seen that these values are considerably less than values obtained in Nairobi and Surabaya particularly on sections of road built with a limestone aggregate, and are less than the median values recommended in Table 10.7.

Thus one important reason why accidents were significantly greater in W Malaysia on wet days but not in Nairobi and Surabaya could be that the aggregate used on roads in these cities was satisfactory whereas that used in Malaysia, particularly in Kuala Lumpur in 1965 was often a limestone aggregate with poor skid resistance.

Since the research on the aggregates used in road construction in West Malaysia was carried out, all new surfacings constructed by the Public Works Department have used granite aggregates. It is ~~understood~~ understood that the number of accidents involving skidding has decreased in Kuala Lumpur since 1965.

The work described above suggests that the effect of bad weather may be less in developing countries which are mainly in tropical and sub-tropical regions, than in Western Europe, where the effects of ice and snow can also be significant. However if the aggregate used in road construction is easily polished giving low skid resistance, this in conjunction with heavy rainfall can have an adverse effect on the road accident situation.

10.4 VEHICLE FACTORS IN ROAD ACCIDENTS

Results from the TRRL 'on-the-spot' accident investigation⁷³ indicated that in 20 percent of the accidents studied, a vehicle defect was a contributory factor. The majority of the defects noted concerned

either the tyres or the brakes of the vehicle involved. The Birmingham University Study⁸⁶ also showed that over 40 percent of the vehicles involved had incorrect tyre pressures which in many cases was a contributory factor in the accidents and that 25 percent of all vehicles had at least one tyre with less than 1/16 inch tread.

As stated earlier, no on-the-spot work was possible in the developing countries visited but the author was able to make surveys of some important aspects of vehicle safety in a number of countries particularly (considering the above results), that of tyre condition.

10.4.1 Vehicle-testing in developing countries

In order to obtain a general assessment of the condition of vehicles in the Third World, and to see if vehicles have to undergo a test of roadworthiness, a questionnaire was sent to 50 developing countries. Some of the questions asked were:-

(1) Are vehicles inspected on a routine basis?

If so:-

(2) What types of vehicles are tested?

(3) How frequently?

(4) What parts of the vehicle are inspected?

(5) How many vehicles were tested in 1973, 74 and 75?

(6) How many passed and failed the test?

(7) If vehicles were not tested on a routine basis were random spot checks carried out at roadside?

27 replies were received.

From the replies it was obvious that it was not simply a question of vehicles 'passing' or 'failing' the test because in a number of the

countries, if defects were noted the owner was asked to re-submit the vehicle having corrected the faults. If the vehicle was again found to be unroadworthy he was said to have failed the test, but he was not issued with a failure certificate when the defects were first noted.

Results of the questionnaire are given in Tables 10.9, 10.10 and 10.11. From Table 10.9 it can be seen that the large majority of countries operated a system of routine vehicle inspection. Table 10.10 shows that almost all the countries tested commercial vehicles whilst about 60 percent tested private cars and motorcycles. The failure rate varied greatly from over 75 percent in Swaziland to 5 percent in Jordan. Since very little is known about the testing procedures on the equipment used etc, the failure rate might well be a better indication of the thoroughness of the testing procedure used than of the condition of vehicles in the different countries. Tables 10.11 shows the most common causes of failure which were brakes, lighting and then tyres.

Although little can be said about the thoroughness and quality of the individual testing it does seem that most developing countries replying to the questionnaire make an attempt to ensure that vehicles are roadworthy.

During a visit to Kenya in 1975, the author took the opportunity to analyse in detail results from the Kenya vehicle testing centre. In Kenya only commercial and public service vehicles are tested on an annual routine basis (ie not private cars and motorcycles). All vehicles involved in accidents however are tested to see if the vehicle contained any serious defects. Results of this analysis are given in Tables 10.12, 10.13 and 10.14.

VEHICLE TESTING IN DEVELOPING COUNTRIES

Table 10.9
ADMINISTRATION OF TESTS

Country	Regular test carried out		Spot checks carried out also		Authority responsible for organisation of tests	Length of time between tests
	X. Yes	O. No	X. Yes	O. No		
Bahamas	X		X		Ministry of transport	1 year
Barbados	X		X		Ministry of Works	1 year
Belize	X		X		Police	
Brunei	X		X		Other	6 months 1 year ⁽¹⁾
Cyprus	X		X		Police	6 months 2 years ⁽²⁾
Ethiopia	X		X		Various municipalities	1 year
Ghana	X		X		Ministry of Transport	6 months
Gibraltar	X		X		Licensing department	6 months 1 year ⁽³⁾
Guyana	X		X		Police	6 months 1 year ⁽⁴⁾
Hong Kong	X		X		Commissioner for Transport	1 year
India	X		O		Inspectors of regional transp. authorities	6 months - 2 years
Iraq	X		O		Traffic Police	1 year
Jamaica	X		X		Ministry of Works	12 - 16 months
Jordan	X		X		Police	1 year
Lesotho	O		X*			
Malaysia	X		X		Road Transport dept.	6 months
Malawi	X		X		Ministry of Transport and communications	6 months 1 year ⁽⁵⁾
Mauritius	X		X		Ministry of Works	1 - 12 months
Montserrat	X		X		Police	1 year
St. Lucia	X		O		Police	6 months
Sarawak	X		X		Land Transport dept.	1 year ⁽⁶⁾
Singapore	X		X		Ministry of Communications	6 months 1 year
S. Africa	X		X		Local Registering Authorities	6 months ⁽⁷⁾
Swaziland	X		X		Police	6 months ⁽⁷⁾
Trinidad	X		X		Ministry of Works	1 year
Turkey	X		X		Police	4 months 6 months ⁽⁸⁾
Zambia	X		X		Police	3 months
TOTAL 27	26		24			

* Spot check only

- (1) Commercial, PSV and Taxis, 6 months and oftener after 8 yrs. old. Motorcycles and cars, yearly after 5 yrs. old.
- (2) PSV and commercial, 6 months, Private vehicles 2 years after 8 yrs. old.
- (3) PSV 6 months.
- (4) PSV and Taxis, 6 months.
- (5) Taxis, 6 months. Other yearly - private cars over 10 years old.
- (6) Commercials, yearly. Others when considered necessary.
- (7) PSV and heavy duty, 6 months. Others on change of ownership or registering authority.
- (8) Motorcycles, private cars and registered tractors, 6 months. Others, 4 months.

TABLE 10.10

VEHICLE TESTING IN DEVELOPING COUNTRIES - TYPES OF VEHICLES TESTED

Country	Types of vehicle tested						Vehicles tested in 1974	Vehicles failed in 1974	% of vehicles failed
	PSV	Commercial	Taxis & hire cars	Private cars	Motor-cycles	Other			
Bahamas	X	X	X	X	X	X			
Barbados	X	X							
Belize	X	X	X	X	X	X	6,576	*	
Brunei	X	X	X	X	X	X			
Cyprus	X	X	X	X	X	X	36,144	2,103	5.8
Ethiopia		X		X	X		49,414	*	
Ghana	X	X	X	X	X	X	129,780		
Gibraltar	X	X					661	370	56.0
Guyana	X	X	X	X	X	X	38,476	7,020	18.2
Hong Kong						X	28,463	7,537	26.5
India		X							
Iraq	X	X	X	X	X	X			
Jamaica	X	X	X	X	X	X	71,540	16,293*	22.8
Jordan	X	X	X	X	X	X	37,000	1,850	5.0
Lesotho									
Malaysia		X					145,380	10,633*	7.3
Malawi	X	X	X	X			13,252	*	
Mauritius	X	X	X	X	X	X	24,821	2,104*	8.5
Montserrat	X	X	X	X	X	X	1,297	286	22.0
St. Lucia		X	X				3,322		
Sarawak	X	X	X	X	X	X	13,703		
Singapore	X	X	X				51,853	*	
S. Africa	X	X	X	X	X	X	1,100,000	390,000	35.5
Swaziland	X	X	X	X	X	X	700	525	75.0
Trinidad	X	X	X				52,226		
Turkey	X	X	X	X	X	X	1,500,000		
Zambia	X	X	X	X	X	X			
TOTAL 27	21	25	20	18	17	17	3,979,908	438,721	

* Vehicles found to be defective were permitted a limited period in which to rectify the defects and to submit the vehicle for retesting. Consequently these vehicles were not classified as 'failing' the test. Those countries in this category which give a figure for 'failures' in 1974 have indicated the number of vehicles retested.

TABLE 10.11
DEFECTS LISTED AS MOST COMMON CAUSES OF FAILURE OF TESTS

Country	Exhaust system	Steering mechanism	Suspension	Body work, Chassis/ frame	Brakes, Hand & foot	Lights & electrical	Tyres	General condition & legality OTHER
Bahamas					X	X		X
Barbados			X		X	X	X	
Belize								
Brunei				X	X	X		
Cyprus		X	X		X	X	X	
Ethiopia					X	X	X	X
Ghana				X	X	X	X	X
Gibraltar	X	X		X	X			X
Guyana		X		X	X	X	X	
Hong Kong				X	X	X		X
India		X	X		X	X	X	
Iraq								X
Jamaica	X	X			X	X	X	X
Jordan	X	X		X	X	X		
Lesotho								
Malaysia								X
Malawi		X	X	X	X	X	X	
Mauritius					X			X
Montserrat						X	X	
St. Lucia					X	X		
Sarawak								
Singapore		X	X		X	X		
S. Africa		X	X		X	X	X	
Swaziland								X
Trinidad		X			X		X	
Turkey					X	X	X	
Zambia							X	
TOTAL 27	3	10	6	7	19	17	13	10

TABLE 10.12
VEHICLE INSPECTION KENYA
(ROUTINE TEST)

Type of Vehicle	Vehicles with no faults		Vehicles with faults		TOTAL	Percent
	Number	Percentage	Number	Percentage		
Saloons/Station - wagons	30	22.5	103	77.5	133	100
Vans; Pick-ups; Mini-buses	92	21.2	342	78.8	434	100
Lorries	65	18.5	283	81.5	348	100
Buses	20	23	67	77.0	87	100
TOTAL	207	20.7	795	79.3	1002	100

VEHICLE INSPECTION KENYA - ROUTINE TEST

TABLE 10.13
DEFECTS NOTED

FAULTS TYPE VEHICLE TYPE	Speed-ometer		Engine/exhaust system		Gearbox/transmission		Steering mechanism		Axles Front/Rear		Suspension Front/Rear		Cab/Body-work		Chassis/frame		Braking systems		Electrical system/lights		Reflectors/Warning signs		Wheels		Tyres		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Saloons & S/wagons	0	0	12	4.9	13	5.3	55	22.2	3	1.2	23	9.3	6	2.4	4	1.6	54	21.9	39	15.8	33	13.4	0	0	5	2.0	247	100
Vans, P/ups & M/buses	6	0.7	51	5.9	41	4.7	177	20.4	5	0.6	90	10.4	24	2.7	31	3.6	146	16.9	119	13.7	147	17.0	6	0.7	23	2.7	666	100
Lorries	7	0.8	60	7.4	52	6.4	117	14.5	18	2.2	99	12.2	38	10.9	23	2.8	131	16.3	102	12.7	119	14.8	15	1.8	24	2.9	625	100
Buses	0	0	12	6.3	16	8.4	29	15.2	3	1.6	28	14.7	15	7.8	6	3.1	23	12.0	17	8.9	23	12.0	3	1.6	16	8.4	191	100
All combined	13	0.6	125	5.9	122	5.8	378	17.9	29	1.4	240	11.4	83	4.0	64	3.0	354	16.8	277	13.1	322	15.3	24	1.2	68	3.3	2109	100

INSPECTION OF VEHICLES INVOLVED IN ACCIDENTS - KENYA

TABLE 10.14

PRE-ACCIDENT FAULT ANALYSIS

FAULTS VEHICLE TYPE	Speed-ometer		Engine/ exhaust system		Gearbox/ transmission		Steering mechanism		Axles Front/Rear		Suspension Front/Rear		Cab/Body- work		Chassis/ frame		Braking systems Front/Rear		Electrical system/ lights Front/Rear		Reflectors/ warning signs		Wheels		Tyres		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Saloons & S/Wagons	14	3.0	57	10.0	10	1.8	65	11.6	23	4.0	44	7.9	11	2.0	23	4.0	54	9.6	99	17.7	49	8.8	28	5.0	82	14.6	559	100
Vans, P/ups & M/buses	4	1.2	28	8.0	20	5.7	39	11.2	27	7.6	37	10.6	18	5.2	19	5.5	47	13.5	40	11.5	24	7.0	19	5.5	26	7.5	348	100
Lorries	7	2.4	26	9.1	19	6.6	29	10.1	29	10.1	31	10.8	22	7.7	13	4.5	30	10.5	29	10.1	27	9.4	16	5.6	9	3.1	207	100
Buses	6	2.7	20	8.9	11	4.9	20	8.9	15	6.6	26	11.5	24	10.6	8	3.5	20	8.9	24	10.6	15	6.6	12	5.3	25	11.1	226	100
All combined	31	2.2	131	9.2	60	4.2	153	10.8	94	6.6	138	9.7	75	5.3	63	4.4	151	10.6	192	13.5	115	8.2	75	5.3	142	10.0	1420	100

From Table 10.12 it can be seen that about 80 percent of all vehicles tested were defective (having either serious or minor faults) and only 20 percent had no faults. Further, there seemed to be little difference between the various types of vehicle tested. This did not mean however that 80 percent failed the test for roadworthiness (although this might have been so in other countries, Great Britain for example) because the owners were asked to correct the defects and re-submit the vehicles for a second test.

Table 10.13 shows that the major defects were concerned with steering and brakes.

Results were also obtained from vehicles involved in accidents and the number of pre-accident defects summarised, (see Table 10.14). As with the vehicles undergoing routine testing, the defects in brakes, steering and electrical items were common but in this case defects in wheels and tyres were over 15 percent of the total noted whereas they were under 5 percent in the routine test. Wheel and tyre defects were particularly common in cars involved in accidents; almost 20 percent of the total noted.

Thus it would appear that in Kenya, as has been found in the much more detailed on-the-spot investigations, tyre defects may be an important contributory factor in road accidents.

10.4.2 Tyre condition in Nairobi

During the visit to Nairobi in 1975 a survey was carried out of the condition of vehicle tyres to see if they were in significantly worse condition than those in Great Britain. Survey teams were equipped

with a number of tread-depth gauges and measurements were taken of all four tyres of vehicles selected randomly in car parks and on streets in various parts of Nairobi. When a tyre seemed to be uniformly worn, four readings were taken across the width of the tyre; when the tyre was unevenly worn, up to 16 readings were taken of each tyre. The results obtained in this survey were compared with findings obtained in Great Britain¹⁰⁴. The results (for cars) are given in Figure 10.7.

It can be seen that the condition of tyres in Nairobi was worse than average values found in Great Britain. In Nairobi 4.5 percent of all tyres were under 1mm tread depth, the equivalent value in Britain being 2.5 percent. In Nairobi there were proportionately fewer tyres with more than 5mm depth, 40 percent, compared with about 56 percent in Britain. From these results it would seem likely that defective tyres would be even more important as a factor in accidents in Kenya than in Great Britain.

10.4.3 The importance of seat belts

In many countries over recent years, there has been an increasing interest in the possibility of reducing accidents by the wearing of seat belts. In Great Britain at present, the law states that all cars registered in 1965 or later and vans registered after 1967 must have seat belts fitted for front-seat occupants. In other countries such as Australia, and New Zealand, legislation has been introduced to make the wearing of seat belts compulsory.

Although the results of such legislation will not be known for some time, a number of analyses have been made of the effectiveness of

Fig.10.7 DISTRIBUTION OF TYRES BY TREAD DEPTH (FOR CARS)

wearing seat belts in reducing injury^{105,106}. A Paper by Milsom and Lister¹⁰⁷ found a reduction of 73 percent in fatal injuries, 67 percent in serious injuries and 33 percent in slight injuries. From these figures Smeed⁹¹ estimated that a reduction of 15 percent in the total number of casualties per annum could be effected if front seat belts were worn by car occupants at all times.

Other safety devices have been produced which can reduce accidents to vehicle-users, such as anti-locking brakes, and hydraulic bumpers but not only is the seat belt simple in concept and easy to instal but on a cost-effective basis it is far better than other methods of improving vehicle safety.¹⁰⁸

Surveys carried out in Great Britain¹⁰⁹ have shown that as a result of legislation, the percentage of cars fitted with front seat belts has risen rapidly since 1964. In 1964 about 15 percent of cars in London and the Thames Valley were fitted whilst in 1970 the figure was over 70 percent. The number of car seat belt wearers as a percentage of all front seat occupants has not shown such a rapid increase however. On motorways the figure increased from about 10 percent in 1964 to about 30 percent in 1970. On all 'A' roads studied the equivalent increase was from about 10 to 20 percent. In town centres in 1970 the useage was still only 10 percent.

The author carried out a survey of seat belt fitting and useage in Nairobi. Observations were carried out at four sites in the city (using four different observers) over two working days.

TABLE 10.15
SEAT BELT USAGE - NAIROBI

	cars without front seat belts	seat belts fitted but not in use	seat belts in use	TOTAL	Percent of cars fitted	Seat belt wearers as percent of all front seat occupants
A Roads (North)	1110	1208	653	2971	63	22
A Roads (West)	1336	1025	501	2892	53	17
Outskirts of central area	911	915	121	1947	53	6
Residential	490	404	224	1118	56	20
TOTAL	3877	3552	1499	8928	57	17

As might be expected, without legislation the percentage of cars with front seat belts is less than in Great Britain. Seat belt wearers as a proportion of all front seat occupants however, is fairly similar to Great Britain in 1970, about 20 percent on 'A' roads and 6 percent on town roads.

Further surveys are obviously necessary in other countries before positive conclusions can be reached about seat belt useage. It is likely that behaviour observed in Great Britain and elsewhere would repeat itself in the developing world, that is, compulsory fitting of seat belts does not encourage the majority of car occupants to use them and it is only by introducing legislation for the compulsory wearing of seat belts that useage is increased.

10.5 THE HUMAN ELEMENT AS A FACTOR IN ROAD ACCIDENTS

As was seen from the on-the-spot investigation carried out by the TRRL and Birmingham University teams, road-user behaviour is the most common factor in a road accident. The area studied by the TRRL team, (Berkshire) was not representative of the whole country, with fewer accidents in built-up areas; nevertheless, human factors were present in 87 percent of the accidents studied. In the author's opinion, if urban areas had had proportionately greater representation, this value could have been even larger.

Much work has been done on the human element in road accidents without even studying accidents on-site or road user behaviour. For example, work has been carried out to show that a state, city or region has a certain pattern of social behaviour and that road accidents reflect this pattern, and can be compared with suicide

rates, murder rates and other acts of 'aggression'. Whitlock¹¹⁰ investigated these factors in the fifty States of America and derived significant relationships. The author made an attempt to carry out a similar investigation in about 40 developing countries but there were far too many variables involved. For example it was seen in Chapter 4 that fatality rates can be significantly related to levels of vehicle ownership, the proportion of vehicles that are motorcycles and also to medical facilities available in a country. All these aspects would have to be removed or nullified before a comparison could be made of road accident rates and patterns of social behaviour such as suicide and murder rates. Nevertheless, it is possible that a country has a high accident rate not only because of the number of motorcycles or (lack of) doctors but also because the people are more 'aggressive' than in other countries.

Another contentious issue is that of 'accident proneness' ie that certain groups of people have more than their 'share' of accidents and that they are of a certain social type. McFarland^{111,112} showed that road accident-prone people studied in the United States contained a significantly larger proportion of persons known to such agencies as the courts, debt collectors, and welfare clinics than do groups of accident-free drivers, matched to them on such variables as age, sex, experience etc.

Work of this nature has been summarised by the oft-quoted dictum:-

*'a man drives as he lives'*¹¹³

This attitude has also been criticised and led Professor Drew to comment¹¹⁴

'This is the kind of remark of which, in my opinion, we hear far too much in Psychology. It is epigrammatic, but tends to stifle rather than encourage research with its air of spurious explanation'.

10.5.1 Alcohol and road accidents

One aspect of human behaviour that has been universally accepted as being a major contributor in road accidents is that of drinking and driving. In Great Britain legislation was introduced in 1967 that made it an offence to drive with more than 80mg of alcohol per 100ml of blood. This brought about the biggest reduction in Britain's road casualties that has occurred in recent years. Other factors were also involved which make it difficult to give a precise quantitative estimate of its effect¹¹⁵ but it was estimated that in 1968 there was a 17 percent reduction in the fatality rate and an 11 percent reduction in the casualty rate that might have been 'expected' without the drinking and driving legislation.

Although most of the senior policemen and doctors in developing countries with whom the author discussed the road accident problem thought that alcohol might be a significant factor, it was difficult to prove. For example in none of the countries visited were breath, alcohol or urine tests carried out.

Some idea of the importance of drinking in Nairobi was obtained by an analysis of the days on which the accidents took place within the central area in 1972 and 1973. In Nairobi workers are paid on the weekends at the middle and end of each month. The accidents taking place on these days were compared with the accidents taking place on other days throughout the year, (see Table 10.16).

TABLE 10.16

ACCIDENTS ON DIFFERENT DAYS - CENTRAL AREA NAIROBI 1972/73

Time of year	Accidents	Days
Mid and end of month	186	96
Other	917	634
TOTAL	1103	730

A chi-square test showed that there were significantly more accidents over pay-day periods than during other days of the year. It is possible that there may be significantly more accidents on any Friday and Saturday in the year than during other days, so the number of accidents on pay-day weekends were compared with non pay-day weekends; results are given in Table 10.17

TABLE 10.17

ACCIDENTS ON 'PAY-DAY' AND NON PAY-DAY WEEKENDS

Type of weekend (Friday & Saturday)	Accidents	Days
Pay day	186	96
Non pay day	140	96
TOTAL	326	192

A chi-square test showed there were significantly more accidents during pay-day weekends than during non pay-day weekends. Discussions with the City Traffic Engineering Department and British Consultants engaged on the transportation study of the city indicated that there was no evidence of increased traffic flow within the city on pay days. It is quite likely therefore that a detailed study of drinking and driving behaviour together with an analysis of the pattern of road

accidents, would indicate a relationship in Nairobi (and most probably many other developing countries) between drinking and road accidents.

10.5.2 Driver behaviour at traffic signals

Since the large majority of accidents in any country occur in urban areas and most of them take place at or near junctions, the author singled out for special study the behaviour of drivers at traffic signals. Measurements were taken in Nairobi, Surabaya, Bangkok and Ankara (see Figure 10.8) and compared with results obtained in towns and cities of Great Britain.

The study falls into two sections, firstly, non-observance by drivers of the red signals, and secondly, driver stopping behaviour on appearance of the amber signal.

10.5.2.1 Non-observance of the red signal

Early work carried out in Great Britain showed that few drivers pass through a red traffic signal; studies made at sites in the suburbs of London in 1964/65 showed that only 2.5 percent of all drivers did so. This early work gave no indication of precisely when, after the start of the signal the drivers passed the red light and the author, supervising a small team, made observations in 1975/76 at numerous sites in London, Reading and smaller towns such as Wokingham to obtain this information.

Over the period 1974-76 studies were made in the above four cities of the developing world and the results are given in Table 10.18 and Figures 10.9 to 10.13.

(a) Junction studied in Bangkok

(b) Junction studied in Ankara

Fig.10.8 THE SITES WHERE OBSERVATIONS WERE MADE OF DRIVER BEHAVIOUR

TABLE 10.18
DRIVER BEHAVIOUR AT TRAFFIC SIGNALS

City	Vehicles stopped at red signal	Vehicles not stopped at red signal	% vehicles not stopping at red signal	Average time after start of red that vehicles pass signal	% passing red signal after 5 secs
Central London (eleven sites)	342	22	6.0	2.2 secs	5
Reading area (nineteen sites)	696	30	4.1	4.7 "	12
Ankara (two sites)	65	36	35.6	5.1 "	25
Nairobi (two sites)	102	101	50.0	6.2 "	38
Surabaya (six sites)	161	92	36.0	4.5 "	29
Bangkok (nine sites)	363	391	52.0	-	-

Fig.10.9 LONDON—NON OBSERVANCE OF RED SIGNAL

Fig.10.10 READING/WOKINGHAM-NON OBSERVANCE OF THE RED SIGNAL

Fig.10.11 ANKARA-NON OBSERVANCE OF THE RED SIGNAL

Fig.10.12 ~~NAIROBI~~ NON OBSERVANCE OF THE RED SIGNAL

Fig.10.13 SURABAYA-NON OBSERVANCE OF THE RED SIGNAL

Fig.10.13 SURABAYA—NON OBSERVANCE OF THE RED SIGNAL

From Table 10.18 and the various Figures, it can be seen that there was a large difference in behaviour between drivers at traffic signals in Great Britain and cities in developing countries. In London and Reading, the percentage of drivers not stopping at the traffic signals were about 6 and 4 percent respectively. In the cities of the Third World, the figures were very much greater with, in Bangkok, a remarkable 52 percent of all drivers passing the red signal.

Some of the Figures perhaps need some descriptive explanation. In Ankara, the sites studied were two arms of a cross-roads. Vehicles turning right (note: Vehicles in Turkey drive on the right) virtually ignored the signals and 'crept around the corner' if few vehicles were coming in the opposite direction. Those drivers turning left or proceeding over the cross-roads paid much more attention to the signals.

In Kenya, the main site studied was a T-junction; drivers on the main road continued on their route again paying little attention to the signals. Those drivers turning right off the main road or coming off the minor road onto the main road, paid greater attention to the traffic signals.

The figures quoted above which indicate the proportion of vehicles crossing a red signal do not fully indicate how poor driver behaviour really was in those cities because it does not show, for example, precisely when, after the start of the red signal, they cross the red light. This effect can be seen in Figures 10.9 to 10.13.

In London, drivers on average, passed the red signal after it had been on for just over 2 seconds. Of those that passed the red light, only 5 percent did so after it had been on for longer than 5 seconds. Around the Reading area behaviour was poorer with 12 percent passing after the signal had been on for more than 5 seconds. This difference is quite likely to be a function of vehicle flow. Thus at the junctions in London, flows were heavier and drivers possibly felt less inclined to risk collision by crossing the red signal.

In the cities of the Third World, behaviour was very much worse with drivers disobeying the red signal long after it had come on. In the three cities in which measurements were made it can be seen that up to 38 percent of those passing the red signal did so after it had been on for more than 5 seconds.

It would seem that a different logic exists for drivers in the cities of the Third World. In Great Britain drivers at busy junctions might be prepared to 'jump' the lights which may have just turned red if they are approaching at speed, the tendency to do so being greater when flows at the junction are relatively light. Most of these pass the signal during an 'all red' phase thus minimising the danger. In Nairobi, Ankara and Surabaya, many drivers seem to ignore the signals completely and pass through the red light even when it has been on for 20 or 30 seconds. When drivers on all arms of a busy junction are operating this way, a very hazardous situation results.

10.5.2.2 Stopping behaviour on appearance of the amber signal

In the countries studied, the amber signal means, the same as it does in Great Britain. Obviously if a driver is very

near to the signals it is unrealistic to expect him to stop. Indeed with other vehicles close behind him it may be more dangerous for him to do so than to cross the amber signal. When a driver is a 'sufficient' distance away from the signals he might reasonably be expected to stop. Studies were made in Great Britain¹¹⁰ of driver stopping behaviour on appearance of the amber signal and curves were derived that showed that few drivers stopped on appearance of the amber if they were very close to the signal whilst the majority did so when they were several hundred feet away. Only vehicles with a free choice were included in the study, in other words, if a vehicle stopped because the one in front stopped, it was not included in the analysis.

This study of stopping behaviour was repeated by the author at traffic signals in Nairobi, Surabaya and Ankara using a small team of observers.

In the U.K. study, results were obtained separately for cars and vans (as opposed to heavy commercial vehicles). Results were also obtained separately for vehicles which had no other vehicle between them and the signal when it turned amber, (leading vehicles) and those that did (following vehicles). In the overseas study insufficient data were available for each 10-ft section from the lights if vehicles were sub-divided as above and all vehicle types were grouped together. The results obtained were then compared with those obtained in Great Britain, again combining all the various classes of vehicle. The results are shown in Figure 10.14.

It can be seen that driver-stopping behaviour was much worse in Ankara, Nairobi and Surabaya than in London. Some idea of the differences in behaviour at the different signals can be gauged by examining the

Fig.10.14 DRIVER STOPPING BEHAVIOUR ON APPEARANCE OF THE AMBER SIGNAL IN DIFFERENT COUNTRIES

threshold distance, ie the distance at which 50 percent of the vehicles stop. In London this occurred at about 97 ft, in Nairobi at about 120 ft, Ankara at 140 ft, whilst in Surabaya, even at 170 ft only about 30 percent stopped.

10.5.3 Driver behaviour at zebra crossings

As was seen in Chapter 9, pedestrian casualties represent a high proportion of all persons injured in cities in developing countries and it is essential to provide crossing facilities so that conflict between the pedestrian and the motor vehicle is minimised. It was also seen in Chapter 9, that even when pedestrian and vehicle flows were taken into account, the relative risk to pedestrians crossing busy roads in Surabaya and Nairobi was considerably greater than in Great Britain. Since Nairobi, in particular, possesses adequate crossing facilities it would seem that a difference in road-user behaviour would account for the greater risk to pedestrians.

On three busy crossings in Nairobi driver stopping behaviour was measured in a similar way to that described in the previous section. The method follows that used by the author in Great Britain in 1964/65.

To measure driver stopping behaviour at a zebra crossing and to derive relationships similar to those shown in Figure 10.14, it is necessary to define a point in time comparable with the beginning of the amber phase. When a pedestrian steps onto a zebra crossing he immediately has legal precedence over vehicular traffic. It is possible therefore to measure driver stopping behaviour at different distances from a zebra crossing at the moment that a pedestrian steps clearly onto the zebra crossing. Only pedestrians stepping from the nearside

Fig.10.15 DRIVER STOPPING BEHAVIOUR AT ZEBRA CROSSINGS

were considered. Results from Nairobi are given in Figure 10.15 together with that derived on zebra crossings in London. One of the zebra crossings studied in Nairobi is shown in Figure 10.16(a).

It can be seen that behaviour varied greatly in the two cities. Thus in London there is a steady increase in the number of drivers stopping at increasing distances from the crossing, the threshold distance being at about 108 ft from the crossing. In Nairobi, the maximum percentage of drivers stopping, about 22 percent occurred at about 70 feet from the crossing. Beyond this distance the percentage of drivers stopping for pedestrians fell. This odd result could be due to the fact that when drivers are more than 80 feet from the crossing, they expect pedestrians to run across before they arrive at the crossing. If the pedestrian does not 'seize' this opportunity the driver does not stop. Whatever the explanation it does seem that driver stopping behaviour at zebra crossings is very poor in Nairobi.

Whilst in Bangkok in 1976, the author took the opportunity of making a somewhat different study of behaviour at a zebra crossing. (The crossing in Bangkok is shown in Figure 10.16(b)). Careful measurements were taken of pedestrian delay-times at the kerb, crossing times (which started the instant the pedestrian stepped off the kerb even though he was further delayed at points on the road), pedestrian and vehicle flows and also the number of vehicles given a free choice who actually stopped whilst a pedestrian was on the crossing. Results are given in Table 10.19.

From Table 10.19 it can be seen that the average kerb delay time was quite long, at 14.0 seconds. This could well be a function of vehicle flow. The overall average crossing time was 14.0 seconds with an average in a 15 minute period of over 25 seconds, with some individual

(a) Zebra crossing in Nairobi
(Showing team making observation)

(b) Zebra crossing in Bangkok

Fig.10.16 ZEBRA CROSSINGS STUDIED IN KENYA AND THAILAND

TABLE 10.19
ROAD USER BEHAVIOUR AT A ZEBRA CROSSING - BANGKOK

Time:	Average waiting time at kerb	Average zebra crossing time	Average of total time	Percentage of vehicles stopping at zebra crossing (%)
AM	(Sec.)	(Sec.)	(Sec.)	
9.30 - 9.45	16.3	12.9	29.2	4.2
9.45 - 10.00	17.9	11.3	29.2	3.7
10.00 - 10.15	15.3	12.6	27.9	12.8
10.15 - 10.30	17.8	11.0	28.8	16.3
10.45 - 11.00	18.0	11.6	29.6	15.2
11.00 - 11.15	23.6	11.7	35.3	11.5
11.15 - 11.30	6.9	8.0	15.0	11.1
11.30 - 11.45	9.0	12.5	21.5	25.0
11.45 - 12.00	12.4	15.1	27.6	13.2
PM				
1.45 - 2.00	13.1	20.1	33.8	23.9
2.00 - 2.15	4.3	25.3	29.7	11.0
2.15 - 2.30	9.0	17.3	26.3	45.4
2.30 - 2.45	13.3	20.0	33.3	20.0
OVERALL	14.0	14.2	28.2	17.0

pedestrians taking over 80 seconds. Such behaviour is unknown in Great Britain; once on a crossing the pedestrian takes the time taken to cross the road without being interrupted. Since this was about 7 seconds in Bangkok it is clear that pedestrians experience considerable further delays whilst actually on the crossing. Reasons for this can be seen from the last column in Table 10.19. Of those vehicles given a completely free choice to stop or not stop for a pedestrian on the crossing only 17 percent did so. In some busy periods only 3 percent of all drivers who could have stopped did so. In Great Britain studies¹¹⁷ showed that over 75 percent of drivers stop willingly at zebra crossings. Some pedestrians in Bangkok experienced particularly hazardous journeys across the road with up to 30 vehicles driving either side of them as they were attempting to cross the road. The author was left with the clear impression that trying to cross the road in Bangkok was an extremely dangerous business. This seems to have been recognised by the authorities who now recruit groups of students armed with flags and whistles to force vehicles to stop, thus allowing pedestrians to cross the road.

10.5.4 Pedestrian useage of zebra crossings

Work carried out in Great Britain¹¹⁷ showed that pedestrian useage of zebra crossings is extremely good, with about 80 percent of all pedestrians crossing on and within 50 yards of a zebra crossing, actually using the crossing itself.

Surveys were made of pedestrian useage of crossings in Nairobi and results were as follows:

TABLE 10.20
USEAGE OF ZEBRA CROSSINGS, NAIROBI

Site	Flow on zebra crossing	Flow 50 yards either side of crossing	percent using crossing
River Road	8,043	8,711	48
River Road	2,034	2,078	49
Government Road	2,660	2,450	52
Haile Selassie Ave.	2,236	1,828	55
Kimathe Street	2,576	5,776	31
Kimathe Street	6,212	6,603	48
Ronald Ngala St.	8,481	3,794	69
Tom Mboya	2,850	4,018	41
TOTAL	35,092	35,258	50

Average useage of crossings for those people crossing on and within 50 yards either side was found to be 50 percent ie proportionately less people using the crossings than in Great Britain. Work in this country^{80,82} showed that within 50 yards of a crossing is a particularly dangerous place for pedestrians to cross the road. Relative risk here was found to be up to six times greater than on the crossing itself. If the same is true for Nairobi, then proportionately more people are putting themselves at greater risk by not using the crossings.

10.6 CONCLUSIONS

In this chapter, the author has attempted to show that road accident investigation can be carried out at three different levels, namely by means of national, regional and local studies.

By the use of national data (as covered in detail in Chapter 4) problems were identified broadly. It was shown, for example, that developing countries as a whole have high fatality rates and severity

indices and that a lack of medical facilities, the proportion of motorcycles on the road, the misuse of vehicles or an increase in the proportion of night-time driving could all be contributing to these high rates.

Analysis of Kenya national accident statistics showed the high proportion of accidents involving commercial vehicles, the high incidence of single-vehicle accidents, and the high accident rate on murram roads.

The detailed studies of rural roads (Chapter 8) and urban areas (Chapter 9) were used to show the value of regional studies.

Although it was not possible to carry out detailed on-the-spot accident investigations, selected studies were made to show the importance of the road (and environment), the vehicle and the road-user as factors in road accidents.

Rainfall and accident data were obtained in three developing countries. Measurements taken with the portable skidmeter in these countries showed that where accident rates did not increase during wet weather, the skid resistance of the road surface was adequate, whereas in the country where accidents increased significantly during wet weather the skid resistance was frequently found to be low. In countries of the Third World where the number of rainy days are usually less than in Western Europe and where ice and snow are almost unknown, it is likely that the effect of climate on accidents is less than in Europe, especially if the skid-resistance of the road surface is adequate.

A survey conducted to find if developing countries check on the roadworthiness of vehicles showed that the majority of countries make efforts to supervise the condition of vehicles particularly commercial and public service vehicles.

A survey of the condition of vehicle tyres in Nairobi showed that cars have significantly less tread depth than those in Great Britain. Further surveys in the developing world are necessary before positive statements can be made of the condition of vehicles in these countries and the likelihood of vehicle defects being a major factor in road accidents.

Road-user behaviour was found to be particularly poor in a number of developing countries. Large percentages of motorists drive through red signals even when the signal has been showing for 20 seconds or more. Stopping behaviour on appearance of the amber signal at different distances from the crossing was also found to be poor in comparison with Great Britain. Using a zebra crossing was particularly hazardous for pedestrians in Nairobi and Bangkok with many drivers failing to stop for people actually using the crossing. If road-user behaviour is a major factor in road accidents in Great Britain it must be even more so in developing countries where driver behaviour was not only poor but frequently dangerous.

11. CONCLUSIONS

Since very little work has been done on road accidents in developing countries, the object of much of the research was simply to identify the basic problem, to gain an understanding of the factors involved and to put road accidents in the Third World (both nationally and in urban and rural areas) into perspective by making comparisons with results from Europe and North America.

Conclusions have been given at the ends of each of the chapters in this thesis and whilst it is not proposed to repeat them in detail here, it is well worth emphasising some of the main points arising.

1. From the comparison of road accident fatalities and the number of deaths from diseases considered by developing countries to be of particular concern, road accidents must already be regarded as a serious social problem. Further, whilst deaths from these diseases are decreasing, those from road accidents are rapidly increasing.
2. The study of accident rates in developing countries showed that fatality rates (per licensed vehicle) were higher than in Europe and North America and, unlike the developed countries, were increasing as opposed to decreasing. Severity indices were high (ie the proportion of all accidents that are fatal) and were clearly related to the lack of medical facilities available.
3. A review of accident cost studies carried out in specific countries showed that, as in Great Britain, road accidents cost developing countries approximately one percent of their total gross domestic

product each year. Thus for example road accidents may already be costing India and Nigeria £200 million and over £40 million each year. These figures cannot by any means be regarded as insignificant.

4. Accident rates were shown to be high in both urban and rural areas of the Third World. Rural accident rates were related to road design and the equations derived compared with similar relationships obtained in developed countries. Rates were always greater in the rural roads in developing countries for similar levels of vehicle flow and for similar levels of geometric design. In addition, accident rates were greater on busy shopping streets in cities of the Third World than in Great Britain, again for similar levels of vehicle and pedestrian flows. Other factors such as poorly maintained vehicles or poor road-user behaviour are obviously contributing to these high rates.

5. Surveys showed that accident data collection and analysis procedures varied greatly in the different countries. Most of them operated, a fairly effective accident collection system which is perhaps not surprising because the information collected by the police is used mainly for legal purposes. Few countries analysed the road accident data in any great detail, failing therefore to obtain a clear understanding of the road accident situation. Thus few were able to say where accidents happened, to what class of road user and in what type of accident. Without such information it is difficult to introduce effective remedial measures.

6. A detailed study by the author of road accidents in Kenya, showed the high incidence of single-vehicle accidents, the

high proportion of accidents involving occupants of commercial vehicles and the high accident rates on murram (ie gravel) surfaced roads. Such information would not have been available without a detailed analysis.

7. In order to identify what may be the major factors in road accidents, selected studies were made of the effects of weather and condition of the road surface on accidents, the condition of vehicles and finally road-user behaviour in developing countries. In comparison with Great Britain, road-user behaviour at pedestrian crossings and traffic signals was found to be particularly poor.

12. RECOMMENDATIONS

Having done much to identify basic problems and some of the major factors involved, it is inevitable that some thought must be given to the question of introducing effective remedial measures for dealing with the accident problem.

In Chapters 8 and 9, accident rates were derived for the various urban and rural roads studied but it must be recognised that merely being in possession of such rates does not immediately enable the engineer to know to which roads remedial measures should be applied first. This difficulty is illustrated with the hypothetical data given in Table 12.1.

From Table 12.1 it can be seen that neither the casualty nor accident rates indicate which is the more dangerous road nor which should be treated first. Perhaps road A with over twice the number of accidents as road B offers the greatest potential for accident reduction. But if road A is a dual carriageway with accidents scattered along its length it may require greater expenditure of funds than road B to achieve a similar reduction. Thus more information is required about the type of road and type of accident taking place and it should be borne in mind that an accident rate derived for one purpose may not be suitable for another. As stated by Chapman:¹¹⁸

'What matters in selecting locations for treatment is not the present rate of accidents per unit of vehicle distance nor the present rate of accidents per year (both of which may vary widely) but the saving in accidents per year that could be achieved by available methods within a given budget'

TABLE 12.1
ACCIDENT DATA ON TWO ROADS

Details	Road A	Road B
Length (Km)	5	6
Average annual daily traffic	10,000	4,000
Number of accidents in 3 years	30	14
Number of casualties in 3 years (fatal and serious)	38	18
Average number of accidents/Km/PA	2.0	0.78
Rate 1. Casualties/million Veh. Kms.	0.69	0.68
Rate 2. Accidents/million Veh. Kms.	0.55	0.53

In developing countries where financial resources are particularly scarce, it is essential that the savings in accident costs are maximised. This could be achieved as follows:-

At a number of locations, the number of accidents that could be prevented following an appropriate remedial measure could be estimated together with the cost of applying such measures. If the average cost of an accident in a particular country is known (see Chapter 5), the savings in accident costs can be assessed at each location. By dividing savings by costs, a cost-effective ratio can be obtained; these can then be listed from the highest to the lowest and implemented until the budget is expended. In this method it is neither the accidents per unit vehicle-distance nor the number of accidents per year that is used, but the expected saving in accident costs per unit spent that is used as an index for site selection.

The problem of having to estimate a reduction in the number of accidents following a given road improvement remains. Much work has been done on this subject in the developed world but there is no

guarantee that similar results could be obtained in developing countries. In Britain it has been estimated that accidents can be reduced at busy junctions by 60 percent by installing a roundabout, or 40 percent by installing traffic signals: or that on a busy shopping street, pedestrian accidents can be reduced by 50 percent by introducing a zebra crossing. It was seen in Chapter 10 that road-user behaviour is poor at light controlled signals and at zebra crossings in developing countries and it is unlikely that percentage reductions in accidents as large as these could be achieved in the developing world without improving road user behaviour. It would be extremely useful if changes in accidents at junctions etc could be carefully monitored as signals etc were installed so that their effectiveness from a road safety point of view could be assessed.

Some idea of where the expenditure would be likely to take place can be obtained by examining some of the results obtained earlier. Rural accident rates in Jamaica and Kenya were of the order of 3.0 per million vehicle Kms. Urban accident rates in Nairobi were of the order of 20 per million vehicle Kms. Hypothetical values of number of accidents, vehicle flows and road lengths leading to such values might be as follows:-

TABLE 12.2
HYPOTHETICAL URBAN AND RURAL ACCIDENT RATES

Area Value	Urban	Rural
Injury accidents P.A.	146	22
Road length (Km)	1	10
Average annual daily traffic	20,000	2,000
Total veh. Kms P.A (million)	7.3	7.3
Accidents per million vehicle Kms	20.0	3.0

It can be seen that the total number of vehicle kilometres travelled on the two roads is the same, 7.3 million. The accident rates, (per, million vehicle kilometres travelled) are typical of urban and rural roads in developing countries ie 20 and 3 respectively but the numbers of accidents are very much different, 146 on one kilometre of urban road and 22 on ten kilometres of rural road.

The methods by which accidents might be reduced on these roads is obviously different. From relationships derived in Chapter 8 it can be seen that major improvements to the geometry and design of the rural road would have to be effected at considerable cost to reduce etc number of accidents by 30 percent. (Thus saving on this example, a total of about 7 accidents).

The methods mentioned above that can be used to reduce accidents in urban areas can also be applied in cities of the Third World but as already stated, they are likely to be less effective. If the

effectiveness is only half that found in Great Britain, the reduction in the number of accidents is nevertheless still considerable. In the example given in Table 12.2 it might be possible to reduce by 20 - 25 percent, the number of urban accidents by installing traffic signals and zebra crossings. In this example 30 - 40 accidents might be prevented at a much lower cost than redesigning a rural road. In other words, the ratio of accident cost savings to expenditure is likely to be greater for improvements introduced in towns and cities than on rural roads, and it is perhaps in this area that effort should be directed. Methods could of course be refined, especially where the expected lives of the measures vary, by the use of discounted costs and benefits.

The problem still remains of knowing what safety measures to adopt and in consequence how to allocate scarce financial resources. For example should efforts be directed solely at improving infrastructure or should money and effort be spent on education, research, propaganda or enforcement? As stated by Sabey⁷³:-

'One important facet of interacting factors can already be illustrated in relation to remedial action. Human factors play the largest part in contributing to accidents. Yet it is important to recognise that it may be easier and cheaper to effect engineering or environmental remedies to counter human failing than to influence human behaviour'.

Whilst this is withoutdoubt true in Great Britain where road-user behaviour must be regarded as of a generally high standard, it may not be so in developing countries. As was shown in Chapter 10,

traffic signals and zebra crossings lose a great deal of their effectiveness because of extremely poor user-behaviour and there may be little point in spending considerable sums of money in improving these facilities. In the author's opinion, strenuous efforts should be made to improve road-user behaviour by better safety education, a more stringent driving test and by improved enforcement. Only by so doing, will the road accident problem in the developing world be brought to manageable proportions.

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APPENDICES TO CHAPTERS

3, 4 and 9.

APPENDIX 3.1

DATA ON DISEASES COLLECTED FROM UNITED NATIONS' DEMOGRAPHIC YEARBOOKS

From the 1969 edition onwards, the table showing causes of death is divided into two parts, A & B. Part A shows deaths and death rates classified according to the "Abbreviated list of 50 causes for tabulation of mortality", recommended by the International Conference for the Seventh revision of the International Lists of Diseases and Causes of Death. The 1955 (Seventh revision) is known or assumed to have been used by all the countries or areas for whom data have been included in part A and in Demographic Yearbooks previous to 1969.

Part B includes data classified according to the "Abbreviated list of 50 causes for tabulation of mortality", recommended by the International Conference for the Eight revision of the International Lists of Diseases and Causes of Death, adopted by the 19th World Health Assembly.

DISEASES FOR WHICH DATA WERE COLLECTED FROM UNITED NATIONS' DEMOGRAPHIC YEARBOOKS

Group into which disease was classified	Disease
1: Infectious diseases	<ul style="list-style-type: none"> - Cholera - Typhoid fever - Plague - Diphtheria - Whooping Cough - Meningococcal infection - Poliomyelitis (Acute) - Smallpox - Measles - Typhus and other ricksetial diseases - Malaria - Syphilis and its sequelae - All other diseases classified as infectious and parasitic - Rheumatic fever - Influenza

Diseases for which data was collected from United Nations' Demographic Yearbooks (Continued)

Group into which disease was classified	Disease
2: Intestinal diseases	<ul style="list-style-type: none"> - Dysentery, all forms - Enteritis and other diarrhoeal diseases - Ulcers of stomach and duodenum - Appendicitis - Cirrhosis of liver
3: Diseases of the respiratory system	<ul style="list-style-type: none"> - Tuberculosis of the respiratory system - Pneumonia - Bronchitis
4: Neoplastic diseases	<ul style="list-style-type: none"> - Malignant neoplasms - Benign neoplasms and neoplasms of unspecified nature

APPENDIX TABLE 4.1

Fatality and injury rates over a 10-year period
(1958 - 68)

Country	Year	Fatalities	Injuries	Vehicles	Population (000's)	Vehicles per person	Fatalities per 10,000 person	Injuries per 10,000 person	Fatalities per 10,000 vehicles	Injuries per 10,000 vehicles
Australia	1958	2,147	54,193	2,526,692	9,500	0.266	2.26	57.05	8.50	214.48
	1968	3,382	82,210	4,463,000	12,173	0.367	2.78	67.53	7.58	184.20
Bahamas The	1957	9	277	9,768	98	0.100	0.92	28.41	9.21	283.58
	1967	21	902	21,788	165	0.132	1.27	54.67	9.64	413.99
Barbados	1958	29	950	9,087	236	0.039	1.23	40.25	31.91	1045.45
	1968	39	1,056	18,500	252	0.073	1.55	41.90	21.08	570.81
British Honduras	1957	7	266	1,311	85	0.015	0.82	31.20	53.40	2030.00
	1967	16	365	3,540	112	0.032	1.43	32.59	45.20	1031.01
Cyprus	1958	112	1,719	36,950	558	0.066	2.00	31.31	30.31	465.22
	1968	117	3,031	67,789	622	0.109	1.88	48.72	17.20	447.10
Great Britain	1958	5,970	313,797	7,902,313	50,500	0.156	1.18	62.14	7.55	397.10
	1968	6,810	342,398	14,446,000	55,283	0.261	1.23	61.94	4.71	237.02
Guyana	1958	65	1,218	13,829	540	0.026	1.20	22.56	47.00	880.76
	1968	125	1,955	32,495	719	0.045	1.72	27.19	38.47	601.63
Hong Kong	1958	170	7,000	37,777	2,806	0.013	0.61	24.95	45.00	1852.98
	1968	347	11,596	109,736	3,925	0.028	0.88	29.54	31.62	1056.72
Jamaica	1955	78	3,039	29,024	1,554	0.019	0.50	19.54	26.87	1047.06
	1965	279	5,175	65,300	1,791	0.036	1.56	28.89	42.73	792.50
Japan	1958	8,243	185,390	1,317,000	92,000	0.014	0.90	20.15	62.59	1413.03
	1968	16,038	828,071	12,870,000	100,510	0.128	1.60	82.39	12.46	643.41
Kenya	1958	282	2,853	73,358	7,652	0.009	0.37	3.73	38.44	388.89
	1968	670	4,929	101,972	10,209	0.010	0.65	4.82	65.70	483.30
Malawi	1958	92	856	10,100	2,800	0.004	0.34	3.13	90.34	840.48
	1968	152	1,547	17,005	4,286	0.004	0.35	3.71	89.40	909.73
Mauritius	1957	55	1,693	11,300	597	0.019	0.92	28.30	48.60	1500.21
	1967	87	2,270	21,821	782	0.028	1.11	29.00	40.02	1040.10
New Zealand	1958	379	11,480	610,000	2,282	0.267	1.66	49.99	6.21	187.02
	1968	522	17,698	1,100,000	2,776	0.396	1.88	63.75	4.75	160.89
Singapore	1958	193	3,817	82,584	1,515	0.054	1.27	25.19	23.36	462.70
	1968	312	9,264	246,798	1,988	0.124	1.57	46.60	12.64	375.40
Trinidad & Tobago	1956	93	2,890	30,206	743	0.041	1.25	38.92	30.79	956.76
	1966	143	4,213	59,951	995	0.060	1.44	42.34	23.85	703.74
Uganda	1956	310	3,846	30,312	6,046	0.005	0.51	6.36	102.27	1268.80
	1966	514	4,536	51,000	8,000	0.006	0.66	5.67	100.80	889.41
USA	1958	37,000	2,000,000	68,298,000	174,882	0.391	2.12	99.43	5.42	185.19
	1968	55,200	2,000,000	108,000,000	201,152	0.537	2.74	99.43	5.11	185.19
Zambia	1958	131	1,234	42,330	3,000	0.014	0.44	4.11	30.95	291.52
	1968	617	5,043	74,000	4,144	0.018	1.49	12.69	83.30	681.49

APPENDIX TABLE 4.2
FATALITY AND INJURY RATES OVER A 10-year PERIOD
(1961 - 71)

Country	Year	Fatalities	Injuries	Vehicles	Population (000's)	Vehicles per person	Fatalities per 10,000 person	Injuries per 10,000 person	Fatalities per 10,000 vehicles	Injuries per 10,000 vehicles
Australia	1961	2,524	60,749	3,001,903	10,508	0.286	2.40	57.81	8.41	202.37
	1971	3,590	91,036	5,006,446	12,730	0.394	2.82	71.51	7.17	181.84
Botswana	1961	14	133	2,883	332	0.009	0.42	4.01	48.56	461.33
	1971	44	336	7,798	618	0.013	0.71	5.44	56.42	430.88
British Honduras	1961	7	220	1,835	93	0.020	0.75	23.66	38.15	1198.91
	1971	18	383	7,440	123	0.061	1.46	31.14	24.19	514.78
Ceylon	1961	434	9,625	102,886	10,168	0.011	0.43	9.47	42.18	935.50
	1971	688	8,416	180,249	12,849	0.015	0.54	6.55	38.17	466.91
Cyprus	1961	105	1,900	44,316	581	0.077	1.81	32.70	23.69	428.74
	1971	135	4,287	100,479	640	0.157	2.11	66.98	13.44	426.66
Great Britain	1961	6,908	342,859	9,906,300	52,676	0.189	1.31	65.09	6.97	346.10
	1971	7,696	344,390	14,910,000	55,910	0.267	1.38	61.60	5.16	230.98
Guyana	1961	81	1,200	18,027	561	0.033	1.44	21.39	44.93	665.67
	1971	184	2,666	44,111	732	0.061	2.51	36.42	41.71	604.38
Hong Kong	1961	209	7,801	53,675	3,130	0.018	0.67	24.92	38.94	1453.38
	1971	383	14,580	164,710	4,045	0.041	0.95	36.04	23.25	885.19
Japan	1961	12,865	308,697	4,282,542	94,050	0.046	1.37	32.82	30.04	720.83
	1971	16,278	949,689	26,944,000	104,660	0.258	1.56	90.74	6.04	352.47
Jamaica	1961	177	4,300	56,057	1,635	0.034	1.08	26.30	31.60	767.85
	1971	401	4,180	8,200	1,900	0.043	2.11	22.00	49.00	509.63
Kenya	1961	329	3,701	84,540	8,300	0.010	0.40	4.46	38.92	437.78
	1971	1,045	7,509	150,697	11,800	0.013	0.89	6.36	69.41	498.28
Malawi	1961	108	1,218	12,700	3,580	0.0035	0.30	3.40	85.03	959.06
	1971	185	1,884	17,800	4,550	0.0039	0.41	4.14	103.93	1058.43
Malaya	1961	587	6,671	211,830	7,137	0.030	0.82	9.35	27.71	314.92
	1971	1,548	14,344	739,165	11,160	0.067	1.39	12.85	20.94	194.06
New Zealand	1958	379	11,480	610,000	2,282	0.267	1.66	49.99	6.21	187.02
	1968	522	17,698	1,100,000	2,776	0.396	1.88	63.75	4.75	160.89
Nigeria	1961	1,313	10,614	95,562	36,200	0.003	0.36	2.93	137.40	1110.69
	1971	3,206	14,592	183,100	56,510	0.004	0.57	2.58	175.10	796.94
Singapore	1961	194	6,804	117,907	1,687	0.070	1.15	40.33	16.45	577.06
	1971	341	9,836	314,190	2,110	0.149	1.62	46.62	10.85	313.06
Sabah	1961	14	170	10,159	475	0.022	0.29	3.58	13.78	167.34
	1971	40	554	40,342	680	0.060	0.59	8.15	9.92	137.33
St. Lucia	1961	6	136	1,347	91	0.015	0.66	14.95	44.54	1009.65
	1971	20	134	4,692	114	0.042	1.75	11.75	42.63	285.59
Tanzania	1959	277	2,905	38,527	9,076	0.004	0.31	3.20	71.90	754.02
	1969	523	5,095	74,979	12,926	0.006	0.41	3.94	70.42	679.52
Turkey	1961	1,822	10,327	142,119	28,602	0.005	0.64	3.61	123.20	726.64
	1971	3,679	18,849	400,000	36,160	0.012	1.02	5.21	91.98	471.23
U.S.A.	1958	37,000	2,000,000	68,298,000	174,882	0.391	2.12	99.43	5.42	185.19
	1968	55,200		108,000,000	201,152	0.537	2.74		5.11	
Zambia	1961	273	1,634	54,436	3,300	0.017	0.83	4.95	50.15	300.17
	1971	794	4,794	103,910	4,250	0.025	1.87	11.28	76.41	461.36

• 1961 - 1971 figures not available

APPENDIX TABLE 4.3
VEHICLE OWNERSHIP AND FATALITY RATES FOR DIFFERENT DEVELOPING COUNTRIES 1968
(as used in initial analysis)

Country	Vehicles	Population (000's)	Fatalities	Vehicles per 10,000 persons	Fatalities per 10,000 vehicles
1. Botswana	4,685	610	20	77	43
2. Cameroon	53,547	5,414	90	99	17
3. Ceylon	142,260	11,964	598	118	42
4. Chile	283,240	9,351	1,448	303	51
5. Cyprus	67,789	622	117	1,090	17
6. Dahomey	16,626	2,574	102	68	58
7. Ethiopia	53,200	24,200	583	22	110
8. Gambia, The	3,326	350	27	95	81
9. Guyana	32,495	719	125	452	38
10. India*	1,153,586	501,760	9,734	23	84
11. Indonesia	623,174	114,640	2,328	54	37
12. Iraq	138,406	8,766	827	157	60
13. Ivory Coast	83,462	4,100	362	204	44
14. Jordan	26,290	2,133	197	123	75
15. Kenya	101,972	10,209	670	100	66
16. Kuwait	134,188	700	206	1,917	15
17. Madagascar	79,960	7,199	148	111	19
18. Malawi	17,005	4,286	152	40	89
19. Malaysia (W)	526,485	8,914	719	591	14
20. Mauritius	20,405	795	80	257	39
21. Morocco	277,360	14,580	1,305	187	47
22. Niger	5,852	3,640	79	16	135
23. Pakistan	203,165	113,000	1,650	18	81
24. Portugal	738,229	8,894	1,183	830	16
25. Rhodesia	151,153	4,860	480	603	32
26. Singapore	246,798	1,988	312	1,241	13
27. South Africa	1,929,000	19,167	5,810	1,006	30
28. Swaziland	10,395	395	72	263	69
29. Syria	50,747	5,460	337	93	66
30. Tunisia	101,826	4,807	214	212	21
31. Yugoslavia	893,555	20,154	2,703	443	30
32. Zambia	74,000	4,144	617	170	83

* Figures for 1967

APPENDIX TABLE 4.4
VEHICLE OWNERSHIP AND FATALITY RATES FOR BRITAIN 1909 - 1938

Year	Vehicles (000's)	Population (000's)	Fatalities	Veh. per 10,000 Popn.	Fatalities per 10,000 Vehs.
1909	133	40,133	1,101	33	82.6
1910	155	40,529	1,277	38	82.3
1911	204	40,831	1,490	50	73.0
1912	257	41,068	1,712	63	66.7
1913	318	41,302	2,018	77	63.4
1914	402	41,714	2,284	96	56.8
1915	419	40,155	2,931	104	70.0
1916	441	39,437	2,755	112	62.5
1917	354	39,007	2,361	91	66.7
1918	242	38,836	2,154	62	89.0
1919	343	40,247	2,559	85	74.6
1920	663	42,111	2,782	157	42.0
1921	860	42,769	2,755	201	32.0
1922	966	43,103	2,847	224	29.5
1923	1,119	43,337	3,064	258	27.4
1924	1,314	43,657	3,735	301	28.4
1925	1,523	43,802	4,085	348	26.8
1926	1,729	43,978	4,886	393	28.3
1927	1,900	44,138	5,329	430	28.0
1928	2,053	44,330	6,138	463	29.9
1929	2,196	44,433	6,696	494	30.5
1930	2,287	44,629	7,305	512	31.9
1931	2,214	44,831	6,691	494	30.2
1932	2,240	45,084	6,667	497	29.8
1933	2,297	45,262	7,202	507	31.4
1934	2,417	45,401	7,343	532	30.4
1935	2,581	45,598	6,502	566	25.2
1936	2,769	45,805	6,561	605	23.7
1937	2,938	46,008	6,633	639	22.6
1938	3,094	46,208	6,648	670	21.5

APPENDIX TABLE 4.5
VEHICLE OWNERSHIP AND FATALITY RATES FOR DIFFERENT DEVELOPING COUNTRIES 1968
(Using ODM criterion for developing countries)

Country	Vehicles (000's)	Population (000's)	Fatalities	Vehicles per 10,000 persons	Fatalities per 10,000 vehicles
1. Botswana	4,685	610	20	77	43
2. Ceylon	142,260	11,964	598	118	42
3. Chile	283,240	9,351	1,448	303	51
4. Cyprus	67,789	622	117	1,090	17
5. Dahomey	17,626	2,574	102	68	58
6. Ethiopia	53,200	24,200	583	22	110
7. Gambia. The	3,326	350	27	95	81
8. Guyana	32,495	719	125	452	38
9. India	1,153,586	501,760	10,654	23	92
10. Indonesia	623,174	114,640	2,328	54	37
11. Iraq	138,406	8,766	827	157	60
12. Ivory Coast	83,462	4,100	362	204	43
13. Jordan	26,290	2,133	197	123	75
14. Kenya	101,972	10,209	670	100	66
15. Malagasy	79,960	7,199	148	111	18
16. Malawi	17,005	4,286	152	40	89
17. Malaysia (W)	526,485	8,914	1,438	591	27
18. Mauritius	20,405	795	80	257	39
19. Morocco	277,360	14,580	1,305	187	47
20. Niger	5,852	3,640	79	16	135
21. Pakistan	203,165	113,000	1,650	18	81
22. Singapore	246,798	1,988	312	1,241	13
23. Swaziland	10,395	395	72	263	69
24. Syria	50,747	5,460	337	93	66
25. Thailand	535,381	33,552	1,765	160	33
26. Tunisia	101,826	4,807	214	212	21
27. Turkey	311,000	33,539	3,747	93	120
28. Zambia	74,000	4,144	617	178	83

APPENDIX TABLE 4.6
VEHICLE OWNERSHIP AND FATALITY RATES FOR DIFFERENT DEVELOPING COUNTRIES 1971
(Using OCNI criterion for developing countries)

Country	Vehicles (000's)	Population (000's)	Fatalities	Vehicles per 10,000 persons	Fatalities per 10,000 vehicles
1. Botswana	7,798	668	44	117	56
2. Ceylon	180,249	12,762	688	141	38
3. Chile	323,100	8,992	1,871	359	58
4. Cyprus	100,479	639	135	1,572	13
5. Dahomey	17,626	2,574	102	68	58
6. Ethiopia	42,063	25,248	871	17	207
7. Gambia, The	3,326	350	27	95	81
8. Guyana	44,111	736	184	599	42
9. India	1,426,004	550,374	12,638	26	89
10. Indonesia	925,240	124,894	3,364	74	36
11. Iraq	123,892	9,750	768	127	62
12. Ivory Coast	98,500	4,420	380	223	39
13. Jordan	25,814	2,383	259	108	100
14. Kenya	135,210	11,694	1,046	116	77
15. Malagasy	91,394	7,400	257	124	28
16. Malawi	23,205	4,549	164	51	71
17. Malaysia (W)	739,165	8,979	1,548	823	21
18. Mauritius	25,317	822	110	308	43
19. Morocco	221,690	15,234	1,838	146	83
20. Niger	9,904	4,126	82	24	83
21. Pakistan	220,000	113,500	1,780	20	80
22. Singapore	314,190	2,110	341	1,489	11
23. Swaziland	10,893	421	100	259	92
24. Syria	60,900	6,451	824	94	137
25. Thailand	831,800	35,335	2,404	235	29
26. Tunisia	118,000	5,240	528	225	45
27. Turkey	400,000	36,110	3,679	111	92
28. Zambia	103,910	4,275	791	243	76

APPENDIX TABLE 4.7
VEHICLE OWNERSHIP AND FATALITY RATES FOR DIFFERENT DEVELOPED COUNTRIES 1950

Country	Vehicles (000's)	Population (000's)	Fatalities	Vehicles per 10,000 persons	Fatalities per 10,000 vehicles
1. Gt. Britain	4,118	49,004	5,012	840.3	12.2
2. N. Ireland	101	1,371	144	736.7	14.3
3. Eire	138	2,959	213	466.3	15.4
4. United States	49,143	151,132	33,250	3,251.6	6.8
5. Australia	1,492	8,300	1,839	1,797.6	12.3
6. Canada	2,291	13,549	2,275	1,690.9	9.9
7. New Zealand	381	1,840	232	2,070.6	6.1
8. Denmark	241	4,252	363	566.8	15.1
9. Finland	72	4,231	375	170.2	52.1
10. Norway	138	3,248	158	424.9	11.4
11. Sweden	505	7,016	595	719.8	11.8
12. Belgium	558	8,700	1,442	641.4	25.8
13. France	2,032	41,180	4,054	493.4	20.0
14. Netherlands	267	9,955	910	268.2	34.1
15. Italy	1,290	46,433	2,454	277.8	19.1
16. Germany (W)	1,911	47,847	6,324	400.0	33.0
17. Portugal	96	8,490	388	113.1	40.4
18. Spain	171	27,868	1,070	61.4	63.0
19. Switzerland	264	4,694	797	562.4	30.2

APPENDIX TABLE 4.8
VEHICLE OWNERSHIP AND FATALITY RATES FOR DIFFERENT DEVELOPED COUNTRIES 1960

Country	Vehicles (000's)	Population (000's)	Fatalities	Vehicles per 10,000 persons	Fatalities per 10,000 vehicles
1. Gt. Britain	7,953	50,933	6,880	1,553.4	8.6
2. N. Ireland	213	1,420	154	1,500.0	7.2
3. Eire	304	2,824	220	1,072.7	9.2
4. United States	73,768	120,684	36,230	4,082.7	4.9
5. Australia	2,900	10,275	2,605	2,822.4	9.0
6. Canada	5,017	17,909	3,283	2,801.4	6.5
7. New Zealand	745	2,372	374	3,140.8	5.0
8. Denmark	624	4,581	838	1,352.1	13.4
9. Finland	366	4,430	765	826.2	20.9
10. Norway	595	3,581	366	1,661.5	6.2
11. Sweden	1,428	7,480	1,020	1,909.1	7.6
12. Belgium	1,400	9,153	2,144	1,529.5	15.3
13. France	12,500	45,684	10,952	2,736.2	8.8
14. Netherlands	1,873	11,480	2,000	1,631.5	10.7
15. Italy	5,734	49,642	9,764	1,155.1	17.0
16. Germany (W)	7,797	53,224	14,540	1,464.9	18.6
17. Portugal	218	8,826	738	247.0	33.8
18. Spain	842	30,303	1,809	277.9	21.5
19. Switzerland	865	5,362	1,385	1,613.2	16.0

APPENDIX TABLE 4.9
VEHICLE OWNERSHIP AND FATALITY RATES FOR DIFFERENT DEVELOPED COUNTRIES 1970

Country	Vehicles (000's)	Population (000's)	Fatalities	Vehicles per 10,000 persons	Fatalities per 10,000 vehicles
1. Gt. Britain	14,135	53,880.	7,501	2,623.4	5.3
2. N. Ireland		NOT AVAILABLE			
3. Eire	443	2,944	460	1,504.8	10.4
4. United States	107,412	204,800	52,060	5,244.7	4.8
5. Australia	4,997	12,552	3,798	3,981.0	7.6
6. Canada	7,877	21,406	5,080	3,679.8	6.4
7. New Zealand	1,096	2,816	655	3,892.0	6.0
8. Denmark	1,360	4,921	1,208	2,763.7	8.9
9. Finland	860	4,695	1,055	1,831.7	12.3
10. Norway	1,022	3,879	560	2,634.7	5.5
11. Sweden	2,392	8,040	1,307	2,932.0	5.5
12. Belgium	2,658	9,683	3,088	2,745.0	11.6
13. France	19,740	50,775	18,072	3,887.7	9.2
14. Netherlands	4,991	13,019	3,181	3,833.6	6.4
15. Italy	13,734	53,667	11,229	2,559.1	8.0
16. Germany (W)	15,822	61,560	19,123	2,570.2	12.1
17. Portugal	763	9,635	1,417	791.9	18.6
18. Spain	4,403	33,645	4,197	1,308.7	9.5
19. Switzerland	2,187	6,281	1,694	3,481.9	7.7

APPENDIX TABLE 4.10
VEHICLE OWNERSHIP AND INJURY RATES FOR DIFFERENT DEVELOPING COUNTRIES 1968

Country	Vehicles	Injuries (serious and slight)	Injuries per 10,000 vehicles	Vehicles per 10,000 persons
1. Botswana	4,685	209	446	77
2. Cameroon	53,547	2,157	403	99
3. Ceylon	142,260	7,739	544	118
4. Chile	283,240	24,037	849	303
5. Cyprus	67,789	3,031	447	1,090
6. Dahomey	17,626	452	256	68
7. Ethiopia	53,200	3,015	567	22
8. Gambia, The	3,326	290	872	95
9. Guyana	32,495	1,955	602	452
10. India*	1,153,586	51,377	445	23
11. Indonesia	623,174	11,010	177	54
12. Iraq	138,406	1,580	114	157
13. Ivory Coast	83,462	4,326	518	204
14. Jordan	26,290	2,070	787	123
15. Kenya	101,972	4,929	483	100
16. Kuwait	134,188	2,623	195	1,917
17. Madagascar	79,960	2,630	329	111
18. Malawi	17,005	1,547	910	40
19. Malaysia (W)	526,485	7,834	149	591
20. Mauritius	20,405	1,848	906	257
21. Morocco	277,360	20,470	738	187
22. Niger	5,852	437	747	16
23. Pakistan	203,165	5,129	252	18
24. Portugal	738,229	23,533	319	830
25. Rhodesia	151,153	5,653	374	603
26. Singapore	246,798	9,264	375	1,241
27. South Africa	1,929,000	54,511	283	1,006
28. Swaziland	10,395	476	458	263
29. Syria	50,747	1,665	328	93
30. Tunisia	101,826	3,473	341	212
31. Yugoslavia	893,555	38,724	433	443
32. Zambia	74,000	5,043	681	178

* Figures for 1967

APPENDIX TABLE 4.11
VEHICLE OWNERSHIP AND INJURY RATES FOR BRITAIN 1909-1938

Year	Injuries (serious and slight)	Injuries per 10,000 vehicles	Vehicles per 10,000 persons
1909	30,573	2,265	33
1910	33,924	2,189	38
1911	38,293	1,877	50
1912	41,881	1,630	63
1913	48,384	1,522	77
1914	67,526	1,680	96
1915	68,500	1,635	104
1916	58,567	1,328	112
1917	48,933	1,382	91
1918	40,534	1,675	62
1919	55,382	1,615	85
1920	62,966	950	157
1921	70,241	817	201
1922	79,013	818	224
1923	93,887	839	258
1924	110,833	843	301
1925	130,658	858	348
1926	133,888	774	393
1927	148,575	782	430
1928	164,838	803	463
1929	170,917	778	494
1930	177,895	778	512
1931	202,119	913	494
1932	206,450	922	497
1933	226,328	985	507
1934	231,603	958	532
1935	221,726	859	566
1936	227,813	823	605
1937	226,402	771	639
1938	226,711	733	670

APPENDIX TABLE 4.12
VEHICLES FOR 10km OF ROAD AND INJURY RATES FOR DIFFERENT
DEVELOPING COUNTRIES

Country	Vehicles	Km total road	Vehicles/10km of road	Injuries per 10,000 vehicles
1. Botswana	4,685	7,780	6.0	446
2. Cameroon	53,547	13,755	38.9	403
3. Ceylon	142,260	39,292	36.2	544
4. Chile	283,240	54,400	52.1	849
5. Cyprus	67,789	8,862	76.5	447
6. Dahomey	17,626	6,500	27.1	256
7. Ethiopia	53,200	23,000	23.0	567
8. Gambia, The	3,326	1,175	28.3	872
10. India	1,153,586	949,000	14.1	445
11. Indonesia	623,174	80,000	78.0	177
12. Iraq	138,406	20,800	66.5	114
13. Ivory Coast	83,462	35,149	23.7	518
14. Jordan	26,290	5,600	47.0	787
15. Kenya	101,972	42,294	24.1	483
16. Kuwait	134,188	1,523	881.0	195
17. Madagascar	79,960	8,363	95.6	329
18. Malawi	17,005	10,740	15.8	910
19. Malaysia (W)	526,485	15,425	341.0	149
20. Mauritius	20,405	1,897	107.0	906
21. Morocco	277,360	51,800	53.5	738
22. Niger	5,852	7,450	7.8	747
23. Pakistan	203,165	250,373	8.1	252
24. Portugal	738,229	17,800	414.7	319
25. Rhodesia	151,153	78,428	37.4	374
26. Singapore	246,798	1,912	1,292.0	375
27. South Africa	1,929,000	332,813	58.0	283
28. Swaziland	10,395	2,670	38.9	458
29. Syria	50,747	10,500	48.3	328
30. Tunisia	101,826	16,728	60.9	341
31. Yugoslavia	893,555	78,750	113.5	433
32. Zambia	74,000	33,500	22.1	681

APPENDIX TABLE 4.13

THE SEVERITY INDEX AND MEDICAL FACILITIES FOR DIFFERENT
DEVELOPING COUNTRIES

Country	Severity index	Population per available hospital bed	Population per physician
1. Botswana	8.73	400	21,960
2. Cameroon	4.01	480	26,050
3. Ceylon	7.17	320	4,060
4. Chile	5.68	250	2,320
5. Cyprus	3.72	210	1,360
6. Dahomey	18.41	930	31,300
7. Ethiopia	16.20	2,490	65,380
8. Gambia, The	8.52	690	18,670
9. Guyana	6.01	210	4,450
10. India	15.93	1,670	4,830
11. Indonesia	17.45	1,470	27,560
12. Iraq	34.36	540	3,830
13. Ivory Coast	7.72	510	17,980
14. Jordan	8.69	580	3,880
15. Kenya	11.97	730	10,240
16. Kuwait	7.28	150	9,640
17. Madagascar	5.33	360	9,640
18. Malawi	8.95	800	45,110
19. Malaysia (W)	8.41	250	4,750
20. Mauritius	4.15	250	4,120
21. Morocco	5.99	660	12,930
22. Niger	15.31	140	56,140
23. Pakistan	24.34	3,560	9,890
24. Portugal	4.79	170	1,200
25. Rhodesia	7.83	300	5,280
26. Singapore	3.26	280	1,780
27. South Africa	9.63	190	1,500
28. Swaziland	13.14	290	7,280
29. Syria	16.83	900	3,970
30. Tunisia	5.80	390	8,320
31. Yugoslavia	6.52	170	1,130
32. Zambia	10.90	380	16,100

APPENDIX TABLE 9.1
KINGSTON JAMAICA 1962 CENTRAL AREA STREETS

No.	Road	Total Inj. Acc./ KM/P.A.	Av. Veh. flow/hr
1.	Parade	52	1100
2.	W Queen St., Spanish Town Rd.	29	684
3.	E Queen St., Victoria Av., Windward Rd.	24	790
4.	Elletson Rd., Mountain View Rd.	30	900
5.	Orange St., Slipe Rd., Half Way Tree Rd.	17	773
6.	King St.	30	549
7.	South Camp Rd.	27	643
8.	Orange St.	37	750
9.	North St.	43	1070

APPENDIX TABLE 9.2

KINGSTON JAMAICA 1962 'A' AND 'B' ROADS

No.	Road	Total Inj. Acc./ KM/P.A.	Av. Veh. flow/hr
1.	Retirement/Rosseau	15	264
2.	Brentford/Lyndhurst	9	457
3.	East Street	21	789
4.	South Camp Rd.	10	714
5.	Merrion Rd.	7	477
6.	Mountain View Av.	4	187
7.	Shortwood Rd.	5	230
8.	Waltham Park Rd.	17	335
9.	Molynes Rd.	5	282
10.	Dunrobin Av.	7	344
11.	Hagley Park Rd.	18	488
12.	Old Hope Rd.	11	657
13.	Hope Rd.	9	663
14.	Mona Rd.	2	486
15.	Lady Musgrave Rd.	3	326
16.	Trafalgar Rd.	5	498
17.	Wellington Drive	4	340
18.	Red Hills Rd.	4	136
19.	Mannings Hill Rd.	1	66

APPENDIX TABLE 9.3

MOMBASA KENYA 1972/73 CENTRAL AREA STREET

No.	Road	Total Inj. Acc./ KM/P.A.	Av. Veh. flow/hr
1.	Kilindini Rd.	20.5	1011
2.	Jomo Kenyatta	28.0	1122
3.	Tom Mboya	3.14	357
4.	Digo Rd.	9.11	900
5.	Nkrumah	5.0	714
6.	Haile Selassie	10.5	625
7.	Mbaraki	4.8	536

APPENDIX TABLE 9.4

NAIROBI KENYA 1972 CENTRAL AREA STREETS

No.	Road	Total Inj. Acc./ KM/P.A.	Av. Veh. flow/hr
1.	Ronald Ngala	52	1040
2.	Government Road	19	1157
3.	Haile Selassie Avenue	50	2064
4.	Harambee Avenue	6	1214
5.	Kenyatta Avenue	64	2310
6.	Kimathi Street	9	973
7.	Koinange Street	7	799
8.	Muindi Mbingo Street	9	755
9.	New Pumwani Road	69	1637
10.	Mama Ngina	7	1174
11.	Racecourse Road	86	1610
12.	River Road	23	603
13.	Tom Mboya Street	20	1206
14.	Kaunda Street	10	326

APPENDIX TABLE 9.5

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CENTRAL AREA STREETS

No.	Road	Pedestrian relative risk rate ($\frac{2 \text{ yr. ped. acc.}}{\text{ped. flow/hr.}}$)	Av. Veh. flow/hr
1.	Ronald Ngala	0.0036	967
2.	Government Road	0.0037	1110
3.	Haile Selassie Avenue	0.025	1973
4.	Harambee	0.0009	1082
5.	Kenyatta Avenue	0.0069	2148
6.	Kimathi Street	0.0005	875
7.	Koinange Street	0.0008	637
8.	Muindi Mbingo Street	0.0011	364
9.	New Pumwani Road	0.0090	1522
10.	Mama Ngina	0.0007	960
11.	Racecourse Road	0.0108	1489
12.	River Road	0.0058	585
13.	Tom Mboya Street	0.0025	1223
14.	Uhuru Highway	0.0249	2917
15.	Kaunda Street	0.0014	297

APPENDIX TABLE 9.6
NAIROBI KENYA AVENUE FOR YEARS 1969,70,72 'A' AND 'B' ROADS

No.	Road	Total Inj. Acc./ KM/P.A.	Av. Veh. flow/hr
1.	Sclaters Road	4.90	773
2.	Fort Hall Road	7.79	779
3.	Ngong Road(-Dagoretti)	8.00	619
4.	Naivasha Road	3.60	206
5.	Valley Road	7.00	1100
6.	Haile Selassie Avenue	10.80	1306
7.	Lower Kabete Road	2.10	550
8.	Mombasa Road	1.50	435
9.	Marlborough Road	1.10	206
10.	Limuru Road	5.25	825
11.	Forest Road	3.45	619
12.	Ngara Road	8.80	688
13.	Ainsworth Hill Road	8.25	894
14.	Park Road	11.60	619
15.	Jogoo Road	13.30	1123
16.	Outer Ring Road	4.70	206
17.	Liverpool Road	7.25	550
18.	St. Austins Road	1.75	413
19.	Juja Road	16.50	619
20.	Landhies Road	15.00	1581
21.	Argwings Kodhek Road	5.50	619
22.	Kiambu Road	1.50	275
23.	Racecourse Road	28.00	1100
24.	Watkins Street	13.60	481
25.	Ring Road Ngara	8.10	894
26.	Ngong Road (After Dagoretti)	1.90	172

APPENDIX TABLE 9.7

SURBAYA INDONESIA 1974

CENTRAL AREA STREETS

No.	Road	Total Inj. Acc./ KM/P.A.	Av. Veh. flow/hr
1.	Ambengan	97.6	1621
2.	Bubutan	36.8	1509
3.	Panglima Sudirman	161.6	2674
4.	Pemuda	65.6	2485
5.	Tunjungan	155.2	2405
6.	Pasar Besar Wetan	19.2	1175
7.	Undaan Wetan	22.4	523
8.	Praban	80.0	1644
9.	Blauran	113.6	1379
10.	Kedungdoro	43.2	1291
11.	Genteng Kali	67.2	1889
12.	Embong Malang	49.6	983

APPENDIX TABLE 9.8

No.	Road	Pedestrian relative risk rate ($\frac{2 \text{ yr. ped. acc.}}{\text{ped. flow/hr.}}$)	Av. Veh. flow/hr.
1.	Ambengan	0.01776	1621
2.	Bubutan	0.00672	1509
3.	Panglima Sudirman	0.02960	2674
4.	Pemuda	0.01200	2485
5.	Tunjungan	0.02832	2405
6.	Pasar Besar Wetan	0.00352	1172
7.	Undaan Wetan	0.00400	523
8.	Praban	0.01456	1644
9.	Blauran	0.02080	1379
10.	Kedungdoro	0.00784	1291
11.	Genteng Kau	0.01216	1889
12.	Embong Malang	0.00896	983

APPENDIX TABLE 9.9
GREAT BRITAIN CENTRAL AREA STREETS

No.	Area		Total Inj. Acc./ KM/P.A.	Pedestrian relative risk rate (2 yr. ped. acc.) (ped. flow/hr.)	Av. Veh. -flow/hr.
1.	Hammersmith Rd.	1961	31	0.0090	2050
2.	Goldhawk Rd.	1961	17	0.0087	1519
3.	Uxbridge Rd. Hammersmith	1961	28	0.0070	1289
4.	Kensington High St.	1961	53	0.0034	2202
5.	Ladbroke Grove	1961	6	0.0025	718
6.	Kings Rd. Chelsea	1961	22	0.0057	1202
7.	Kensington High St.	1967	64	0.0054	2366
8.	Kensington Rd.	1967	36	0.0059	2549
9.	Brompton Rd.	1967	66	0.0025	2468
10.	Uxbridge Rd. Ealing	1964-66	30	0.0049	990
11.	Green Lanes Harringay	1964-66	23	0.0070	1170
12.	Slough High St.	1967	25	0.0020	1180
13.	Kensington High St.	1968	68	0.0072	2628
14.	Kensington Rd.	1968	26	0.0100	2604
15.	Kensington High St.	1969-70	98	0.0084	3070
16.	London Rd/High St Cheltenham	1965	6	0.0023	729
17.	Lawford/Clifton Rds Rugby	1965	4	0.0013	572
18.	Southgate/London Rd. Bath	1965	10	0.0069	1160
19.	Hammersmith Rd.	1949	27	0.0040	1242
20.	Goldhawk Rd.	1949	12	0.0038	696
21.	Uxbridge Rd. Hammersmith	1949	22	0.0046	1476
22.	King St. Hammersmith	1949	23	0.0024	870
23.	Kings Rd. Chelsea	1949	18	0.0023	894
24.	Christchurch Rd. Boscombe	1960	22	0.0020	1290