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DEPARTMENT of the ENVIRONMENT DEPARTMENT of TRANSPORT

Road accidents in developing countries

by

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ABSTRACT

By the early 1970's countries of the Third World were becoming increasingly aware that they faced a growing road safety problem. In 1972, following numerous requests made by developing countries for aid and guidance in the road safety field, a small research team was formed within the Overseas Unit of the Transport and Road Research Laboratory. The aim of this team was to undertake research in Third World countries with a view to establishing the nature and extent of their traffic accident problems and, in the longer term to assess the effectiveness of remedial measures. This paper describes some of the major findings of this research team.

1. INTRODUCTION

For at least the last forty years the countries of Western Europe and North America have had to acknowledge the fact that road accidents are a prime cause of death and injury. Over this period substantial sums of money have been spent on trying to contain what is clearly a serious health problem. In a number of these countries, Great Britain for example, the successful application of a wide range of safety measures can be judged by the fact that not only has there been a decrease in the accident rate (in terms of vehicle kilometers travelled) but the number of people killed and injured has also decreased.

By the early 1970's countries of the Third World were becoming increasingly aware that they too faced a growing road safety problem. In 1972, following numerous requests made by developing countries for aid and guidance in the road safety field, a small research team was formed within the Overseas Unit of the Transport and Road Research Laboratory. The aim of this team was to undertake research in Third World countries with a view to establishing the nature and extent of their traffic accident problems and, in the longer term to assess the effectiveness of remedial measures. This paper describes some of the major findings of this research team.

2. MAGNITUDE OF THE PROBLEM

2.1 *The cost of road accidents*

No clear cut definition of a "developing country" exists but in a recent analysis of accident rates carried out by the Unit, a developing country was taken as one with a gross national product (GNP) per capita of less than $ 1400 per annum (1978 prices). A preliminary study of accident costs[1] indicated that in those developing countries for which data were available, the total cost of road accidents was almost 1 per cent of these gross national products – a sum that these countries can ill afford to lose. If the above definition is taken of a developing country, then 1 per cent of the total GNP's of all countries below $ 1400 GNP/capita per annum combined is approximately $ 14,000 million – a very crude estimate of the total annual cost of accidents in these countries. Most of the countries for which data were available in the above study used a "gross output" approach in costing road accidents with no additional sum added to reflect "pain, grief and suffering". This additional sum now represents over 30 per cent of the assumed cost of a fatal accident in Great Britain. Further, alternative ways[2] of costing road accidents such as the "value of risk change" approach are likely to produce accident cost estimates considerably greater than the "gross output" method, particularly if, in the

latter, no component for "pain, grief and suffering" is included. Thus the cost of accidents to developing countries could possibly be higher than that stated above.

2.2 *Road accidents compared with other causes of death*

Another way of illustrating the extent of the road accident problem is to compare road accident fatalities with the number of deaths resulting from diseases and other known causes in developing countries. Using statistics published by the World Health Organisation and the United Nations, data were obtained from 19 Third World countries using the most up-to-date classification of causes of death used by these two organisations. It was found that road accidents accounted for almost 2.5 per cent of all deaths recorded in these countries, making road accidents the tenth most important cause of death. The analysis was repeated for the age groups 5–64 years thus removing the very young and the elderly; in this analysis, data were available on only eleven countries. In this case, road accidents accounted for over 6 per cent of all deaths, a value exceeded by only five other causes. When repeated for the 5–44 years age group (again with data available on eleven countries), road accidents accounted for almost 10 per cent of the total number of deaths reported and ranked second to the "multiple" cause of "all other accidents, homicide and suicide". A similar analysis was carried out on a computer file of mortality statistics provided by the WHO. The analysis of data on this file gave similar results to that described above but again the number of countries for which data were available was small (14 in this case). Although the countries for which data were available are unlikely to be representative of the entire Third World, it is clear that road accidents represent a growing social problem particularly for juveniles, young adults and those in early middle age.

2.3 *Comparative accident rates*

Research work carried out by the Overseas Unit TRRL has shown that road accident fatality rates (ie deaths per 10,000 vehicles licenced) are high in developing countries[3,4], very often 20 times greater than for those countries of Western Europe and North America (see Fig. 1). Perhaps even more worrying is the fact that whereas fatality rates in developed countries have decreased steadily over the last twenty years, those in a considerable number of developing countries have increased.

Using data for road fatalities, vehicles and population for the year 1938 from 20 mainly European countries, Smeed (1968)[5] derived a relationship expressed by the formula.

$$F/V = 0.0003\ (V/P)^{-0.66}$$

where F is the road fatalities, V is the number of vehicles and P is the population.

Using the same method as Smeed, the authors carried out analyses of fatality rates on developing countries for a number of different years ranging from 1965 to 1978. Relationships derived for these two years, which were statistically significant at the 1 per cent level are shown in Fig. 2 (on a logarithmic scale). Two aspects are of particular interest. Firstly it can be seen that as vehicle ownership increases, the fatality decreases; that is countries with the lower levels of vehicle ownership were those with higher fatality rates. Secondly, it can be seen that over the given time period, the slope of the regression line has increased. In other words, for the same level of vehicle ownership, the fatality rate in 1978 was higher than in 1965.

In an earlier analysis[3] the same group of countries used by Smeed in 1938 were taken and the analysis repeated for the years 1950, 1960 and 1970. The relationships derived were very similar indeed to those

derived by Smeed. In other words, the relationship between fatality rate and vehicle ownership would appear to be fairly stable in developed countries, whereas in developing countries the fatality rates increased markedly for similar levels of vehicle ownership over the period 1965–78.

2.4 *Possible savings*

If the equation had remained stable in the group of 35 developing countries with, say, the relationship for 1965 still applying in 1978 there would have been far fewer deaths in 1978 than was the case. In a study of the potential that exists for accident reduction in developing countries[6], the actual number of vehicles and people that existed in 40 developing countries in 1978 were substituted into the 1965 equation and the estimated (total) number of deaths given by the 1965 equation was obtained. This was estimated to be 45,000, in comparison with the 75,000 that actually occurred, ie 40 per cent less. Thus it can be argued that if fatality rates had not increased in the Third World between 1965 and 1978, then the number of deaths might have been, say, 60 per cent the actual number occurring in 1978. If this reduction is applied to all developing countries with a GNP per capita below $ 1400 then instead of the 130,000 estimated deaths from road accidents in 1978 in all developing countries below the above income level, there may have been say 80,000 deaths. Further, since the collection of road accident data is not very thorough in the large majority of developing countries (see later) then the actual number of people killed is likely to be even greater than the data available suggests. In addition, a number of developing countries use "killed on the spot" as a definition of a road accident fatality. Almost all developed countries use "died within 30 days" as a definition and on this basis the number of people who eventually die from road accidents in developing countries may be greater than that reported. These two points suggest that the potential for reduction in deaths taking place is likely to be greater than the figures above indicate.

3. THE NATURE OF THE PROBLEM

Broad classifications of accidents and casualty types occurring in a country are important indications of the general strategy required in dealing with the country's road safety problem. In Great Britain for example, three-quarters of all accidents occur in built-up areas, and of these accidents, two thirds occur at or within 20 yards of a junction[7]. Also, almost 60 per cent of those killed on all types of road in Great Britain are either pedestrians or riders of two-wheeled vehicles.

3.1 *The class of road users involved*

The pattern of accidents taking place will clearly vary from country to country and Table 1 shows that for classes of road users killed, these differences can be considerable. Thus in Hong King 70 per cent of all persons killed are pedestrians whilst in Indonesia the proportion is only 20 per cent. In Indonesia however 34 per cent of those killed are riders of motor cycles and scooters. Important differences also exist between the age groups of those killed and injured in road accidents. More often than not these reflect the age distribution of the population of the different countries. This in turn means that there are proportionately more children killed and injured in road accidents in developing countries than is the case in Europe and North America. This suggests that the education of children on road safety matters is even more important in the developing world than in developed countries.

Wide differences between countries can also exist in the urban/rural split: for example, whereas 44 per cent of fatalities in Great Britain occurred on roads in non built-up areas in 1977, the equivalent figure for West Malaysia was 61 per cent with a further 26 per cent occurring in villages and only 12 per cent occurring on towns.

TABLE 1

Percentage of fatalities by road-user class

Country	Year	Pedestrians	Cyclists	Motorcyclists and scooterists	Drivers and passengers	Total
Ethiopia	1976	84	1	1	13	100
Guyana	1977	45	13	10	28	100
Hong Kong	1976	70	4	7	19	100
Indonesia	1977	20	2	34	44	100
Jamaica	1978	41	5	17	37	100
Jordan	1979	47	1	2	50	100
Kenya	1972	45	9	2	40	100
Kuwait	1978	55	2	2	41	100
Nigeria	–	35	3	20	42	100
Sri Lanka	1980	51	10	10	28	100
Swaziland	1978	55	5	0	40	100
West Malaysia	1979	22	13	33	32	100
Zambia	1977	40	8	3	49	100
Zimbabwe	1979	36	9	2	47	100
(United Kingdom	1980	32	5	19	44	100)

With this situation, it would appear appropriate to devote more resources to rural accidents in West Malaysia than would be the case in Great Britain.

An analysis of one complete year's accident records from Kenya[8] showed that 16 per cent of all road casualties were occupants of commercial vehicles. The equivalent value in most developed countries is under 5 per cent. In many developing countries, commercial vehicles are used to transport people to and from places of work (see Plate 1) and greater attention than in developed countries to accidents involving commercial vehicles might be needed.

3.2 *Urban accidents*

A comparison of accidents taking place in selected cities in developed and developing countries showed interesting differences[9]. In the towns and cities studied in Great Britain, 20 per cent of all accidents occurred within the central area of each town. In Nairobi and Mombasa (Kenya), Surabaya (Indonesia) and Kingston (Jamaica), the equivalent values ranged from 24 to almost 60 per cent, the differences probably reflecting the differences in land use and social activity.

The proportions of casualties occurring in urban areas to the various classes of road user also revealed important differences. In most of the Third World cities studied, the proportion of pedestrian casualties was considerably higher than in European countries. Greater efforts should perhaps be devoted in Third World cities to dealing with pedestrian accidents than is the case in Europe. Indeed, in the authors' opinion the pedestrian is often the most neglected road user in many Third World cities.

In many Third World countries a major road safety problem may be present that does not exist at all in Western Europe and North America – accidents involving paratransit forms of public transport. Thus in Surabaya, the second city of Indonesia, 17 per cent of all casualties were drivers or passengers of betjaks (cycle rickshaws, see Plate 2). According to surveys carried out in Surabaya there were, in 1974 an estimated 70,000 of these vehicles operating in the city. The drivers and passengers of these vehicles are often placed in a vulnerable position, not only because the vehicles provide little protection but also because the drivers frequently ignore all traffic rules and regulations. Other types of public transport common in the developing world are the shared taxi such as the Dolmus of Turkey and the Service taxi of the Middle East. In Jordon, Service taxis are involved in almost a quarter of all accidents yet represent only 10 per cent of the total vehicles registered in that country. This type of problem is rarely encountered in the developed world and remedial measures adapted from developed countries may do little to deal with this situation.

An analysis of the vehicles involved in urban road accidents again illustrates important differences between towns and cities in Great Britain and six major Third World cities. In Britain, 60 per cent of all vehicles involved were cars and taxis. Not surprisingly, in the Third World cities where car ownership levels are much lower, the proportion of accidents involving cars was much less. In Surabaya (Indonesia) and Bangalore (India) for example, the proportion was little over 10 per cent. Correspondingly, the proportions of accidents involving commercial vehicles and buses, which are often overloaded (see Plate 3), were much greater than in Great Britain. Thus in eight major cities of India, for example, buses are involved in about 25 per cent of all personal injury accidents, the equivalent figure for Britain being under 5 per cent.

The above examples show that major differences exist in the accident patterns of developed and developing countries. These differences have been used to emphasise the point that the order of priorities in road safety programmes in developing countries could, more often than not, be very different from that in developed countries.

4. DATA COLLECTION AND ANALYSIS

Little progress can be made on improving the road accident situation in a country until the problem itself has been clearly defined. Accident statistics must be collected over a period of time so that an understanding is obtained of where accidents are occurring, to what classes of road user, at what time of day and in what type of accident. Most of the accident patterns described in the previous section could not have been identified without there being some sort of accident data collection system in operation.

Road accident data need to be collected over a wide range of levels from the broad perspective of the national scene to the detail of the individual accident. Although analysis of national accident statistics show the source of problems (as seen above), they do not indicate specific remedial measures. In order to do this, data need to be collected at the "regional" level. In such studies measurements of vehicular and possibly pedestrian flows are obtained as well as accident statistics. Examples of studies of this type given earlier would include work carried out by the Unit in Nairobi and Surabaya. Finally, a detailed understanding of factors involved in road accidents can be obtained only by "local" in-depth studies of road layout, vehicle design and road-user behaviour. At the present time the Overseas Unit safety team are carrying out such analysis on two major roads in Egypt (see below).

A survey was carried out[10] which showed that in over 40 developing countries, the data collection and analysis procedures varied greatly. Most of them were found to operate a fairly comprehensive accident data

collection system, which is perhaps not surprising because the information collected by the police is used mainly for legal purposes. At the time of the survey (1973) few countries analysed the data collected in great detail, or in such a way as to obtain a clear understanding of the road accident situation. Since this survey was carried out, the situation has undoubtedly improved but the police forms or booklets used are still inadequate being either too complex or not detailed enough, or deficient in design. (The most common fault is to ask the police to provide subjective answers to questions that cannot be completed with any degree of certainty). Similarly, relatively few countries carry out detailed analysis so that "black spots" can be identified and the factors contributing to these black spots assessed.

As stated, it is essential in dealing with the road safety problems that a good accident data collection and analysis system be established. With this goal in mind, the Overseas Unit, TRRL and the Egyptian Ministries of the Interior and Transport have begun a programme of cooperative road safety research involving the following components.

(a) Police Accident Booklet Design. An experiment was conducted in which four different designs of police booklet were compared, including one heavily dependent upon symbols and pictograms. From the results, two compromise designs were drawn up and tested in field trials leading eventually to one preferred design. This final booklet is soon to be tested by the police throughout Egypt and its performance will be carefully monitored. In this research, the aim has been to optimise the ease, speed and accuracy with which the booklet can be completed, whilst at the same time ensuring that sufficient details are recorded for the purposes of accident analysis.

(b) Microcomputer Analysis. An experimental low-cost microcomputer system is being developed and tested, again with the emphasis on ease of use.

The rapid developments in microcomputers in recent years is opening new possibilities in accident analysis. Their low cost and general robustness in difficult environments make them well suited for use in developing countries. Micros also have the benefit of being readily accessible and available for immediate use; since computer facilities are fewer and more centralised in developing countries, this is probably a greater advantage than in more industrialised countries.

In view of these various potential benefits the development of an experimental low-cost microcomputer system was included in the programme of cooperative research in Egypt. Early prototypes of the package have already been tested in Egypt and it is planned to be given an extended trial in 1983. The system is designed for use at the "Local Authority" level (county, large city, etc). Particular emphasis has been placed on ease-of-use, with the operator merely having to select one of a number of options at most stages of the programmes. Accident and casualty cross tabulations, accident record retrieval, histograms of accidents along a route and "stick diagrams" analyses are among the features under development. In the field, the major hurdle to be overcome is that of maintenance in the event of breakdown.

(c) Accident Investigation. This work follows broadly the British "Local Authority" approach to accident investigation as described in the British Department of Transport Accident Investigation Manual[11] and in the Guidelines for Accident Reduction and Prevention in Highway Engineering[12] produced by the British Institution of Highway Engineers. Analysis has been carried out on the two Cairo-Alexandria roads, one having a particularly high accident rate. A simple accident code numbering system was adapted and tables of accidents by kilometerage from Cairo drawn up, thus enabling accident black spots to be identified (similar work is now being undertaken by the Overseas Unit on the Great Trunk Road Pakistan).

Accidents at the most critical black spots have been analysed in detail using the "stick diagram" technique. In this way common factors such as overtaking or nose-to-tail accidents can be identified. Not unexpectedly, marked differences in the nature of the accidents taking place were found with the different sites. Following these analyses appropriate low-cost remedial measures are being introduced and their effectiveness evaluated (see next section).

5. THE APPLICATION OF REMEDIAL MEASURES

Over the past 40 years, developed countries have built up considerable experience in road safety theory and practice, which includes a fairly substantial body of research data. Potentially, this experience should be of value to developing countries in assessing priorities in their own road safety programmes. However, before attempting to apply research findings from, say, Great Britain or the US to Third World countries, a number of general reservations should be made:

(1) As shown earlier, the nature of the problem in developing countries may be considerably different from that in Europe or North America.

(2) Countermeasures that are effective in developed countries may be ineffective in developing countries, (and possibly vice versa).

(3) Although there has been extensive research into the effectiveness of countermeasures in developed countries, the results of this research may be less definitive than might be desired.

(4) Countermeasures that are appropriate in developed countries may, for financial or other reasons, be inappropriate in Third World countries.

As described in Section 3, the road safety problem in developing countries is often markedly different from that in the UK or the USA. Therefore, although research findings from developed countries can provide some guidance, the inevitable uncertainties surrounding their transfer to developing countries emphasises the need for caution in their application. As a direct consequence, there is a need to evaluate any counter-measures that are undertaken, thus emphasising the value of mounting local or regional trails of any counter-measures and carefully monitoring their effectiveness before using them nationally.

As stated by Sabey[13] "The final step towards identifying vehicle features relevant to preventing accidents or reducing injury, establishing human factors susceptible to treatment and investigating all the interacting factors between the driver, the vehicle and the road, can only be achieved by investigations in depth. These essentially include detailed examination of vehicles, interviews and examination of people involved as well as consideration of road features, and in the extreme they involve attendance at the scene of accidents". Unfortunately, information on the factors involved in road accidents rarely exists in Third World countries.

As stated earlier, however, the Overseas Unit is presently working with a number of developing countries on the improvement of data collection and analysis systems and also on the effectiveness of low-cost highway engineering improvements. Results from these studies should be forthcoming over the next year or so. Mean-while some insight can be obtained of the factors involved in road accidents both from the results of research carried out in Great Britain and from the developing countries themselves.

A four year "on-the-spot" accident investigation[13] was carried out by the Accident Investigation Division of the TRRL in an area of South East England between 1970 and 1974. Results to date indicate that human factors contributed to nearly 95 per cent of accidents and were the sole contributor in 65 per cent. Those factors playing the largest part in accidents were errors of perception, lack of skill, errors in executing manoeuvres, and impairment. An important link was established between the road-user and the road environment. In over 25 per cent of the accidents studied, a deficiency in the road environment was identified in association with some driver error. Vehicle defects were found in over 8 per cent of the accidents studied and contributed less to accident occurrence than did human factors or adverse road layout and condition. However, the importance of properly maintained tyres and brakes was clearly evident from the study.

Over the last few years the Overseas Unit has collected annual police reports from a number of developing countries. Most of these reports provide a basic summary of the road accident situation in each country, together with a list of the major "causes" of accidents. These data have clearly not been collected as accurately as those in the on-the-spot study carried out by the Laboratory and present a completely different data base. Furthermore, in the records collected, the police have ascribed a single "main cause" to each accident as opposed to listing the "factors involved". Nevertheless, this information does provide some insight into what the police regard as the major factors involved in the road accidents in developing countries. (Note: If the police have little road engineering expertise it is likely that they will underestimate the part played by the road environment.)

The results from the police data of 5 developing countries (see Table 2) show that road-user error was identified as the main cause in at least 70 per cent of the road accidents. The percentage of accidents attributed to the three main causes varied considerably from one country to another. However it is dangerous to draw conclusions about variations between these countries as there are likely to be differences in the types of accident reported to the police and in the way in which the police analyse the accidents for causes.

Also it is likely that the percentages are underestimates of the true contribution of these factors because in many of the accidents there are probably several factors involved and not just one. Thus the percentage of accidents due to adverse road conditions and environment may in reality be much higher because many of the road user errors could have been due to inadequate road singing or marking. Nevertheless the results do indicate the importance of road user error as a contributory factor in the road accidents of developing countries.

5.1 *Studies of behaviour in developing countries*

Two measures commonly used for controlling road users and improving their safety are traffic signals and pedestrian crossings. Preliminary studies[14] have observed the behaviour of drivers at traffic signals and pedestrian crossings in selected cities in developing countries and comparisons made with results from Great Britain. For example, driver behaviour at "Zebra-type" crossings was observed in five Third World cities and compared with behaviour at selected Zebra crossings in Reading and London. It was mandatory for drivers to stop for pedestrians on the crossing in all cities studied. It was found that the average proportion of drivers stopping in four of the Third World cities ranged from 10 to 17 per cent, whilst in Surabaya the percentage was well under 1 per cent. The equivalent values in Reading and London were 72 and 40 per cent respectively.

Observations were also made at signal-controlled junctions in the same cities and the proportions of drivers (presented with a free choice) stopping at the red signal were recorded. Results are given in Table 3. It can be seen that the percentage of drivers choosing not to stop at the red signal in the Third World cities was greater than in Reading and London. Studies were carried out in Nairobi in 1975 and 1977; the results

TABLE 2

The main causes of road accidents as determined by police, in developing countries

	Jamaica 1977		Ghana 1974		Botswana 1976		Malaysia 1976		Hong-Kong July–Sept 1977	
Main cause of accident	Number of accidents (including damage only)	%	Number of accidents (Not known if damage only included)	%	Number of accidents (including damage only)	%	Number of accidents (including damage only)	%	Number of accidents (injury accidents only)	%
Road-user error	7,027	95	8,164	77	844	71	41,997	87	3,309	92
Vehicle defect	108	1	1,679	16	137	12	656	1	*	*
Adverse road conditions or environment	72	1	551	5	19	2	3,675	8	*	*
Other	225	3	262	2	176	15	1,963	4	303	8
TOTAL	7,432	100	10,456	100	1,176	100	52,191	100	3,612	100

* grouped with 'other'

for 1977 showed a marked improvement over the 1975 value. This surprising result may be due to the fact that the number of signals in the city increased from 3 to over 20 between 1975 and 1977. Having more signals (and having them set correctly) may have brought about the observed improvement in driver behaviour. It should be noted, however, that in Bangkok, Ankara and Surabaya many junctions were signal-controlled, but behaviour was still poor.

This, in at least the cases of traffic signals and pedestrian crossings, there is evidence of road safety countermeasures being less effective in developing countries compared with developed countries (although increased enforcement could perhaps have improved the performance of these measures). This also implies that the use of computer controlled traffic signal systems may be less effective in reducing traffic congestion in Third World cities than is the case in Europe and North America.

5.2 *Road-user knowledge in developing countries*

The poor road-user behaviour by drivers in developing countries described above may have been due to a lack of knowledge of road safety rules and regulations or possibly to a general attitude towards road safety matters.

In order to gain an understanding of drivers' knowledge of road safety matters in developing countries, drivers in Jamaica, Pakistan and Thailand were interviewed at roadside and asked questions about traffic rules and recommended driver procedures. The study[15] found that there were gaps in drivers' knowledge but in only a few topics was there a widespread lack of knowledge. For example, most of the drivers interviewed knew that they should give way to pedestrians using pedestrian crossings and the replies from respondents in Jamaica and

TABLE 3

Non-observance of the red signal in selected Third World cities

City		Number of drivers who had a free choice of stopping or not stopping at red signal	Number of drivers choosing not to stop at red signal	Percentage of drivers choosing not to stop at red signal
Ankara (2 sites)	1974	101	36	35.6
Bangkok (9 sites)	1975	754	391	52.0
Nairobi (2 sites)	1975	203	101	50.0
Nairobi (10 sites)	1977	3045	210	7.0
Surabaya (6 sites)	1975	253	92	36.0
Surabaya (6 sites)	1976	396	130	48.8
Central London (11 sites)	1977	364	22	6.0
Reading Area (19 sites)	1977	726	30	4.1

Pakistan suggested that pedestrians would be given high priority over motor vehicles. However, as stated earlier, studies of road-user behaviour carried out in these countries showed that few drivers were prepared to stop for pedestrians using crossing facilities.

Questions were asked about traffic signals and in Thailand and Jamaica, 80 and 90 per cent respectively, knew what phase followed the amber signal, but in Pakistan only 53 per cent of drivers gave the correct answer. In Jamaica and Pakistan many drivers did not know the give-away rules at roundabouts, the correct observation procedures to adopt at junctions or the meaning of flashing headlights. In Pakistan the Highway Code instructions for behaviour at roundabouts is explicit yet only 33 per cent of drivers interviewed knew that they should give way to vehicles already using the roundabout.

Drivers in the three countries were asked to estimate the shortest distance they could stop their vehicles in when making an emergency stop on a dry road when travelling at 30 mile/h (45 km/h). Almost all drivers underestimated to a considerable degree their stopping distances with less than 13 per cent of all drivers giving an answer of "over 10 metres". The UK Ministry of Transport's Manual[16] "Driving" gives 75 feet (approximately 23 m) as the minimum stopping distance of a car under the conditions given in the question.

As stated earlier, children under the age of 15 represent a significantly higher proportion of road accident casualties than is the case in the UK or USA, reflecting the higher proportion of the population aged between 5 and 14 years in developing countries. Children in the Third World may be more exposed to dangers of traffic because of fewer pedestrian facilities or because they have not been taught the basic rules for crossing busy roads.

Children between the ages of 5 and 11 years from schools in Jamaica, Pakistan and Thailand were interviewed[17] to determine what they knew about crossing roads safely. In addition, the children were asked to demonstrate how they crossed roads by using a simulated road laid out in the playgrounds of the schools where the interviews took place. Replies from children in developing countries were compared with replies given by children from the UK to the same type of questions.

When asked what they should do to cross roads safely the majority of children from developing countries failed to mention some of the important items usually associated with safe crossing. For example, only 1 per cent

of the Jamaican children said "stop before crossing" but only 38 per cent of the Pakistan children mentioned this. On the practical tests however the children did much better than they did on the knowledge questions. Although very few children in Jamaica and Thailand mentioned stopping before crossing, the majority did stop in the playground tests. The one aspect of behaviour that was least performed was "looking to the side while crossing". In Thailand 64 per cent of the children simply looked straight ahead while crossing the road.

In Pakistan and Thailand (but not in Jamaica), the research showed that children who had received guidance from parents, teachers or policemen had a better knowledge how to cross busy roads safely than did children who had not had the benefit to such advice. Unfortunately significantly fewer children in developing countries received advice on road safety (53 per cent in Thailand for example) than in the UK where 95 per cent of those interviewed said they had discussed road safety with the parents.

Clearly the level of knowledge on road safety matters is not high in those developing countries where investigations have taken place. Whether this poor knowledge and behaviour result in more accidents in developing countries is not yet established and more research is needed to establish whether such links exist. However it would appear that remedial measures such as road-user education or propaganda, whose benefits have been found difficult to identify and quantify in Europe and the UK, could be far more effective in developing countries where the existing standard of road-user knowledge is much lower.

5.3 *Traffic law enforcement*

With the generally low standard of road-user behaviour that exists in many Third World countries – which may in turn be due either to a lack of awareness of traffic regulations or to a general "attitude" towards road safety – it is important that adequate traffic law enforcement is provided by the police. Because little research has been carried out in this field it is difficult to assess the potential of police enforcement for accident reduction in developing countries. There is however likely to be considerable potential in these countries, for in many of them the traffic police are not so well trained or equipped as they are in developed countries. Further, in many developing countries the police are obliged to spend much of their time controlling traffic, with little time available for traffic law enforcement.

The most promising evidence for the road safety benefits of enforcement in developing countries comes from Singapore and Egypt. In Singapore, a combined publicity and enforcement campaign appears to have lead to a drop in fatalities of 19 and 50 per cent in serious injuries, although there was a rise of 20 per cent in slight injuries. In Egypt a combined package of police enforcement measures including radar, increased patrols and heavier penalties for traffic offences has had a significant effect on accidents on two major inter-urban roads. On one of these roads there has been an overall reduction in the number of accidents of over 50 per cent. (Comparing a six-month period after the introduction of the improvements with a comparable six-month period before their introduction.)

5.4 *Vehicle safety*

Vehicle safety measures can be both "primary" and "secondary" in nature; the former aim at preventing an accident occurring whilst the latter attempt to protect the road-user during the course of an accident. The extent to which a Third World country can affect road safety through vehicle engineering will depend to a considerable degree upon local circumstances. The majority of developing countries rely entirely upon imported vehicles and the use of import controls would appear to be their main method of influencing the types of vehicles used in these countries. Where vehicles are imported but assembled locally, more direct involvement is possible. In some developing countries such as India, local manufacturers exist and the potential for improved

road safety through better vehicle engineering may be possible. In many Third World countries the standard of vehicle maintenance is poor and in recent years efforts have been made to improve periodic vehicle inspection. Periodic inspection, of both private and commercial vehicles is common in most developed countries but its cost-effectiveness has yet to be clearly established.

As stated in Section 3, commercial and public service vehicles are involved in proportionately more accidents in Third World countries than is the case in Europe and North America. The way in which these vehicles are used leads to potentially dangerous situations with open lorries often carrying large numbers of workers (see Plate 1) and buses carrying people hanging on the outside of the vehicles (see Plate 3). Paratransit forms of public transport, cycle rickshaws, shared taxis etc – (see Section 3) – also have a reputation of being dangerous vehicles in which to travel. The accident record of these vehicles could be considerably improved by legislation prohibiting lorries, buses and minibuses from carrying passengers in a dangerous manner.

A study[18] of accident records of a number of transport undertakings in India showed that buses were involved in about five times more accidents than might be expected from their numbers on the road or the annual vehicle kilometrage travelled by different classes of vehicle. Fatality rates per million bus kilometres travelled were about six times greater than for public transport in London and over ten times greater than for other cities in Great Britain. This study examined one complete year's accident records of the Delhi Transport Corporation (DTC). In addition, about 10 per cent of all bus drivers (580) were interviewed to obtain information on their background, experience, knowledge of the highway code and working conditions. Surveys were made of the condition of 237 buses operated by DTC from five of the main depots so that a general assessment of the condition of vehicles could be made. From 1973 to 1980 the number of accidents involving DTC buses trebled and the accident rate increased by 17 per cent.

The survey of 10 per cent of DTC drivers showed that almost all received some form of training from the DTC but relatively little time was spent actually behind the wheel of a vehicle. Each driver interviewed was asked a number of questions on the highway code and it was found that the question on emergency stopping distances was particularly poorly answered. The survey of the condition of 234 buses (over 10 per cent of the total) in five depots operated by the DTC showed that over 90 per cent had no rear lights, stop lights or side lights in working order and over 47 per cent had no front or rear indicators in working order. Over half the buses examined had either extreme or uneven tyre pressures. Clearly the accident record of the DTC could be improved by improving vehicle condition and driver training. Since the survey was undertaken in 1979/80 the DTC has taken charge of several hundred new buses and efforts have been made to improve the safety of DTC buses. A Central Accident Cell has also been set up which will attempt to analyse accident records, attend the scene of accidents and to establish a greater understanding of the factors leading to accidents involving the DTC fleet.

Perhaps the two most important measures that can be adapted to protect the road user during the course of an accident are the use of seat belts for vehicle occupants, and crash helmets for motorcyclists. There has been growing evidence, particularly from Australia, that the compulsory wearing of seat belts results in a significant reduction in injuries, particularly those of a more severe nature. The benefits of wearing a seat belt in any particular accident situation should be similar in both developed and developing countries. In view of the often poorer medical facilities, the benefits could in fact be greater in developing countries in the case of the more serious injuries. Regrettably, few Third World countries have, as yet, introduced compulsory wearing of seat belts.

Motorcycling has been shown to be a particularly dangerous activity. In Great Britain for example the fatality rate (per million vehicle miles travelled) of motor cyclists in 1977 was almost 30 times greater than that

for car drivers, despite the introduction of the compulsory wearing of helmets in 1973. In many developing countries, motor cyclists are a major casualty group particularly in the countries of South East Asia where motor cycles form a high proportion of the traffic mix.

Table 4 presents the results of what is perhaps the first published "before-and-after" study of a road accident countermeasure to have been reported from a developing country. The study is an investigation by Asogwa[19] into the effectiveness of the motorcycle helmet legislation introduced in Anambra State, Nigeria, in 1976. Table 4 appears to show that there was a sharp rise in motorcyclist injuries and fatalities in the "after" period. There were apparently no changes in the accident recording procedure in the "after" period. Ideally, a number of "control" comparisons could have been made to confirm this rather surprising result; for example, a comparison with the "before" and "after" accident frequencies for other road user groups in Anambra State and a comparison with motorcycle accidents in both periods in a neighbouring State that had not introduced the legislation. The International Road Federation's World Road Statistics suggest that for all Nigeria there were the following increases for the period 1976–77 compared with 1974–75; all road accident fatalities, 41 per cent; all injuries, 50 per cent; injury accidents, 30 per cent; and "four-plus" wheeled vehicles, 25 per cent. If these figures are representative of Anambra State, it would suggest that there remains an increase in motorcycle accidents over and above the expected increase. Asogwa attributes this to the large percentage of riders and passengers (40 per cent in a roadside sample of 220) who wore the helmet incorrectly, ie either loosely secured or not secured at all. He also argues that the helmets could have given the riders a false sense of security, leading to greater risk-taking. It would appear that the discomfort caused by wearing the helmet in a high temperature and humidity was a major reason for the chinstraps not being fastened properly.

TABLE 4(a)

A "before-and-after" analysis of the introduction of crash-helmet legislation in Anambra State, Nigeria (from Asogwa)

Period	No. registered motorcycles	No injured	No. death
Before edict (June 1974–May 1976)	5303	70	5
After edict (June 1976–May 1978)	7071	145	18

TABLE 4(b)

Results of a roadside survey

Wear of helmet	Number	Percentage
Worn correctly	134	60.9
Worn incorrectly	86	39.1
Total	220	100

Cultural differences must also be considered when assessing the potential for road accident reduction in developed and developing countries. Thus in many Asian countries three or more people can frequently be observed riding a motor cycle or scooter (see Plate 4). The relative risk of such overloading has not been

investigated but new legislation and/or stronger enforcement of existing laws would be required if this problem is to be dealt with effectively. Thus in Delhi legislation exists for the compulsory wearing of crash helmets (with members of the Sikh religion being exempt) but the law applies only to the driver of the vehicle; consequently passengers rarely wear crash helmets. As it is common in Delhi to find up to five people (usually the father, mother and children of one family) using a motor cycle or scooter, at one time the law is far less effective than in Great Britain for example.

Thailand presents another interesting example of cultural or social differences making it difficult to introduce a safety measure effectively. In that country, compulsory wearing of crash helmets was introduced but the users of these vehicles felt that the law was introduced so that certain influential members of the community could make money by selling crash helmets. In the ensuing debate the law was eventually rescinded.

5.5 *Highway engineering*

There has been increasing evidence from the UK[20,21] and the US that relatively detailed local accident investigation, combined with low-cost engineering remedial measures, can be highly cost-effective. The experience being gained from following this approach in these two countries is of particular relevance to the Third World. In developed countries, a growing emphasis has been placed in recent years on obtaining value for money from money spent on road safety. With their lower gross national product, this must also be an important consideration for developing countries.

Work by Jorgensen and Westat[22] in the US indicated clearly the high benefit-cost ratios that could be obtained from "spot" improvements as compared with continuous widening or overall modernisation projects. The limited data available to them strongly suggested that low-cost projects yield the greatest safety benefit per dollar expended. In the UK Duff[23] showed a similar result and his analysis of 29 schemes confirmed that small inexpensive schemes could have a very marked effect on road safety.

Table 5 compares the cost-effectiveness of a limited selection of countermeasures from five studies. The comparison is restricted to those projects where it appears that only one countermeasure was involved. Although the three sets of data from the UK are based on relatively small samples they show similar results to those studies conducted in the US confirming that certain low-cost remedial measures such as road-markings, signing, delineation and improved skid-resistance can be highly cost-effective in reducing accidents.

As far as the authors are aware, no studies similar to those shown in Table 5 have been completed in a developing country. As explained in Section 4 however, the Overseas Unit, TRRL has started work on the effectiveness of low-cost highway engineering countermeasures in Egypt and Pakistan.

In order to investigate the relationship between accident rates and geometric design standards, a different technique was adopted by the authors. Using data collected in Kenya and Jamaica[24], personal injury accident rates on main inter-urban roads were correlated with certain geometric design characteristics.

Step-wise multiple regression analysis, in which the accident rate was expressed as a function of several independent variables was used to correlate the number of personal injury accidents per million vehicle kilometres with geometric design features. The following Equations were derived:

Kenya

$y = 1.45 + 1.02X_5 + 0.017X_3$ (at 5% level)

$y = 1.09 + 0.031X_3 + 0.62X_5 + 0.0003X_4 + 0.062X_2$ (at 10% level)

TABLE 5

A comparison between five studies of the cost-effectiveness/benefit of certain engineering countermeasures

	Duff (UK) Av. benefit/ cost ratio	Wilson (Hertfordshire) Av. 1st year rate of return	Landles (London) 'Typical' 1st year rate of return	Henry (California) Cost ($) per accident saved	Jorgensen (US) Av. benefit/ cost ratios
Road-markings, inc. ghost island	58 (6)	1500% (5)	640% + (60)		26.5 (2000)*
Shoulder widening					28.8 (46)
Road-signs	47 (2)	1600% (2)	3700% (20)	350 (77)	15.0 (775)†
Parking restrictions			2500% (20)		
Traffic management (roundabouts, one-way, etc.)			790% (40)		
Pedestrian facilities			320% (80)		
Road surface treatment	14 (2)	300% (20)	200% (190)	5200 (179)	20.1 (96)
Roundabout installation		350% (6)			
Traffic signals (installed or improved)	0.9 (3)	−3700% (2)	400% (140)	14800 (262)	6.4 (700)
Visability improved	1.1 (2)	290% (2)			3.0 (140)
Channelisation	0.5 (3)		640% + (60)	21000 (166)	3.9 (610)
Reconstruction				33300 (161)	

Number of projects on which each evaluation is based is shown in brackets

* Installation of striping and/or delineators

† In addition 3046 projects 'Signing and/or marking' with average B/C ratio of 14.9

\+ Hatch-marking, ghost islands and physical channelisation are grouped together

Jamaica

$y = 5.77 - 0.755X_1 + 0.275X_5$ (at 5% level. No other factors enter at 10% level)

where Y is the accident rate per million vehicle kilometres;

X_1 is the road width (m);

X_2 is the vertical curvature (m/km);

X_3 is the horizontal curvature (degrees /km);

X_4 is the surface irregularity (mm/km);

X_5 is the junctions per km.

From the foregoing equations it can be seen that the accident rates fall as the standard of the road improves. In the equation derived for Jamaican roads it can be seen that roadwidth and junctions per kilometre were significantly related to the accident rate whereas in Kenya, junctions per kilometre, horizontal curvature and surface irregularity were found to affect the accident rate.

Since this work was carried out by the authors, research workers in other Third World countries, including India and Chile have also managed to correlate accident rates with geometric design. Thus in India for example equations were derived for the Bombay-Pune road that related the accident rate on this road to the horizontal curvature, vertical curvature and number of junctions per km. Using equations of this type, estimates can be derived of the likely changes in accident rate following a specific road improvement. By costing accidents on the road, the economic benefits from reduced accident rates following the road improvement can be estimated. In this way accident savings can be incorporated into feasibility studies on proposed road improvements in developing countries. Clearly much more work needs to be done on the relationships between accident rates and road geometry before equations of this type can be used with any degree of reliability.

Finally on this subject, it is important to bear in mind that safety features such as those involving geometry, signing and delineation, should be introduced at the design stage rather than be added later, almost as an "after-thought". For example, it can often be much more expensive to widen the main roads at a T-junction after an accident problem has built up than to incorporate it at the construction stage; this is because after construction it is often found that utility services have to be moved for any local widening scheme.

6. CONCLUSION

Since 1972 the Overseas Unit of the UK Transport and Road Research Laboratory (TRRL) has been engaged in a programme of research on road accidents in developing countries. Results to date indicate that fatality rates (per licenced vehicle) are high in comparison with those in developed countries, and whereas in Europe and North America the situation is generally improving, many developing countries have experienced a worsening situation, particularly over the last five years. A preliminary study indicated that road accidents cost on average almost 1 per cent of these countries' annual gross national product and it is clear that road accidents are utilising scarce financial sources that the countries can ill afford.

Using statistics published by the World Health Organisation and United Nations, data were obtained from 19 Third World countries using the most up-to-date classification of causes of death used by these two organisations. It was found that road accidents ranked highly as a cause of death in these countries. Although the countries for which data were available may not be representative of the entire Third World, it is clear that road accidents represent a growing social problem, particularly for juveniles, young adults and those in early middle age, and also a growing economic problem for the country as a whole.

Almost all the countries of the Third World suffer from a lack of financial resources and the sums of money available to spend on road safety improvements, road rehabilitation and maintenance, police enforcement, etc. will be severely limited. Consequently it is particularly difficult for these countries to deal effectively with their road safety problems.

Although research findings from developed countries can provide some guidance, the inevitable uncertainties surrounding their transfer to developing countries emphasise the need for caution in their application. As shown in the paper, the problem faced by many countries is often markedly different from that in Western Europe and North America. This, coupled with major differences in road-user behaviour, knowledge and attitude

introduce an element of uncertainty in the potential effectiveness of many countermeasures. Results however suggest that the introduction of improved education, training and enforcement could be highly beneficial in Third World countries and the potential for improved road safety by these methods is greater than in the developed world. It is essential that scarce resources are not wasted and that any measures that are introduced are carefully appraised and an assessment made of their relative effectiveness. The careful monitoring of remedial measures and an assessment of their cost-effectiveness is one of the goals of an ongoing programme of research within the Overseas Unit of TRRL. This points to the further and fundamental need for a good accident data collection and analysis system. This should be sufficient to produce essential information for accident investigation purposes but, at the same time, it should not be too sophisticated either for the needs or capabilities of those who operate it or contribute to it. This again is part of the ongoing programme of research in the Overseas Unit.

The work carried out by the Overseas Unit TRRL over the last ten years has done much to identify the magnitude and nature of the road safety problem in developing countries. Continuing research can play an important role in identifying appropriate remedial measures. Based on these research findings it is hoped that international organisations such as the World Bank, WHO etc, in collaboration with the developing countries themselves, will be able to invest wisely and effectively in road safety programmes to contain this growing problem.

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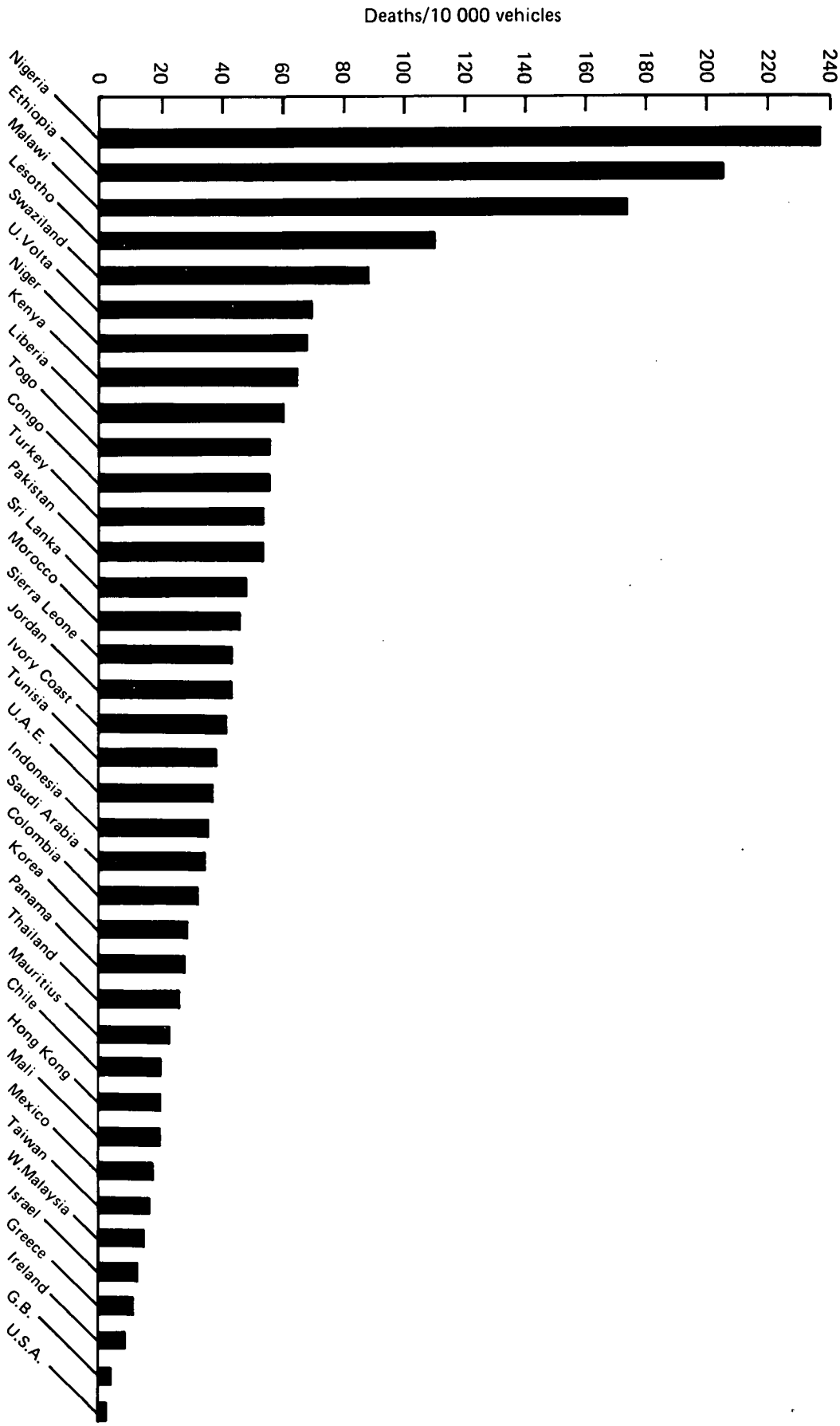


Fig. 1 Fatality rates in various developing countries 1978

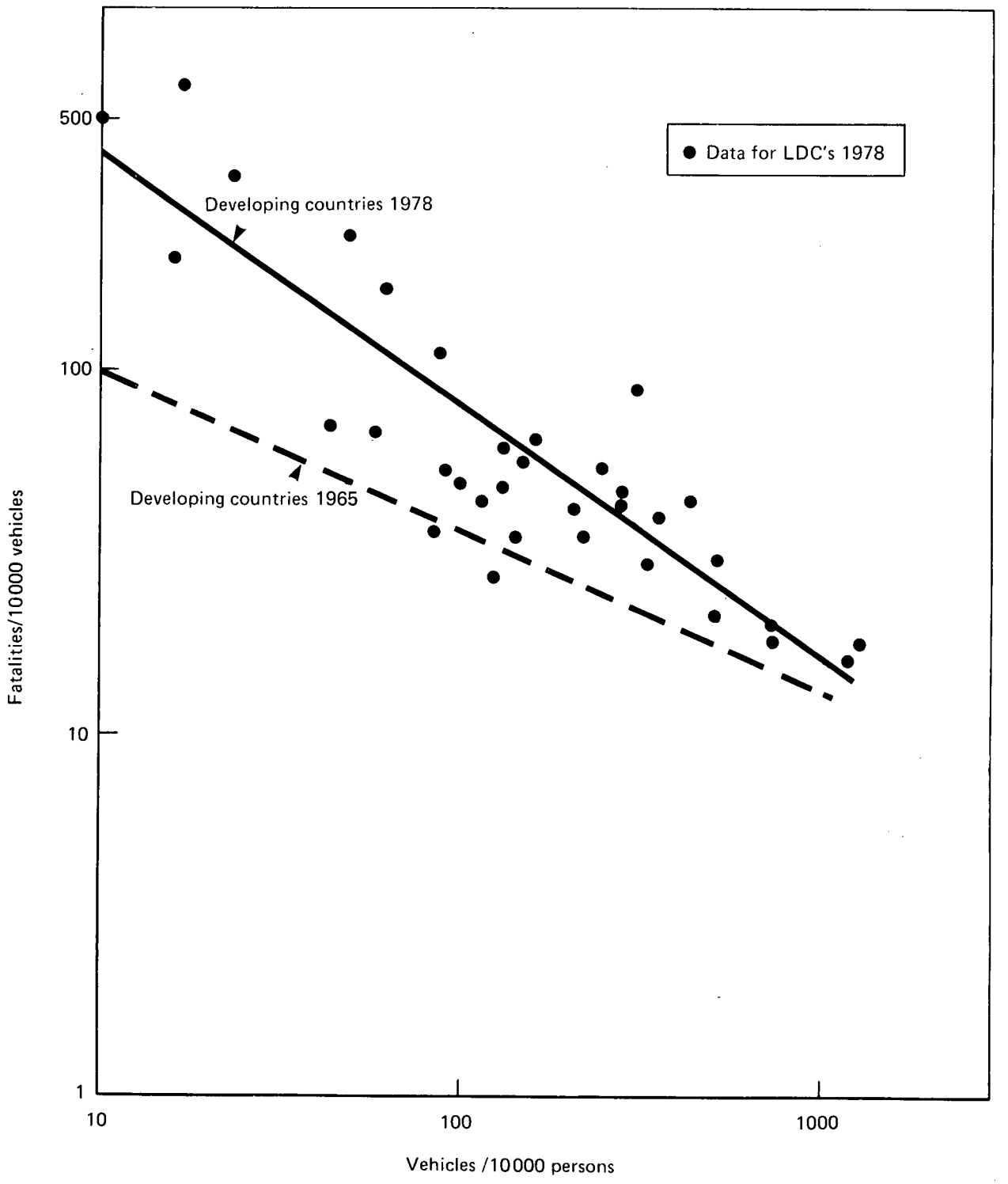
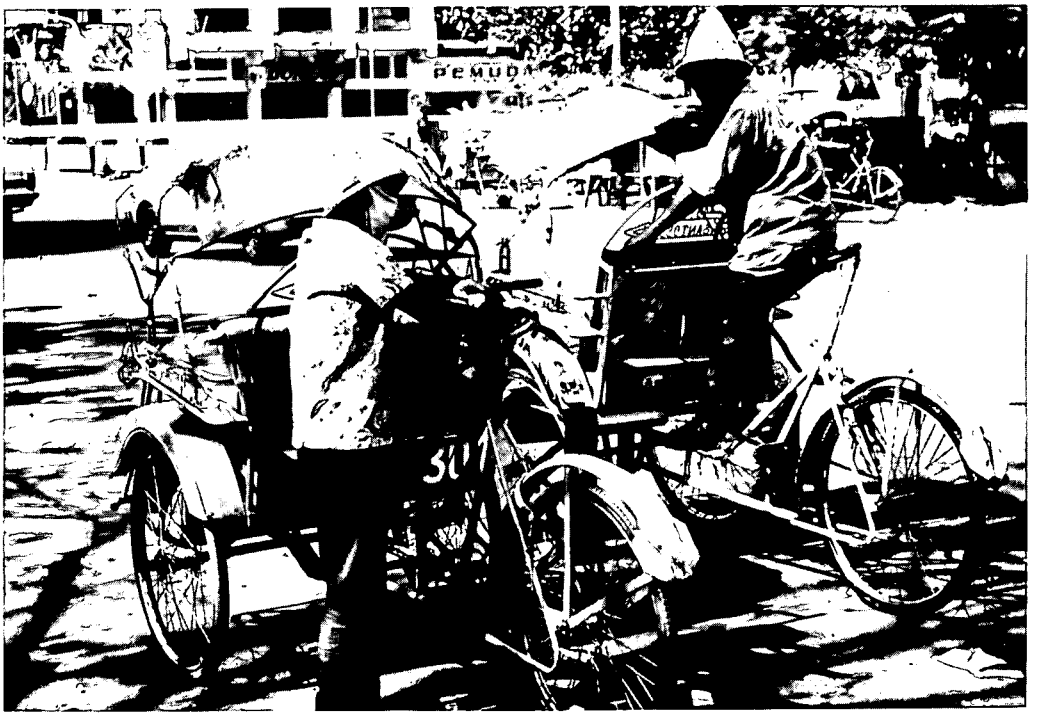


Fig.2 Relationships between fatality rates and levels of vehicle ownership

Plate 1 Commercial vehicles being used to transport men to places of work



Neg. no. B421/77

Plate 2 Cycle rickshaws in Indonesia

Neg. no. R23/81/1

Plate 3 Overloaded bus in India

Neg. no. B1018/82

Plate 4 Motor scooter riders in Delhi

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