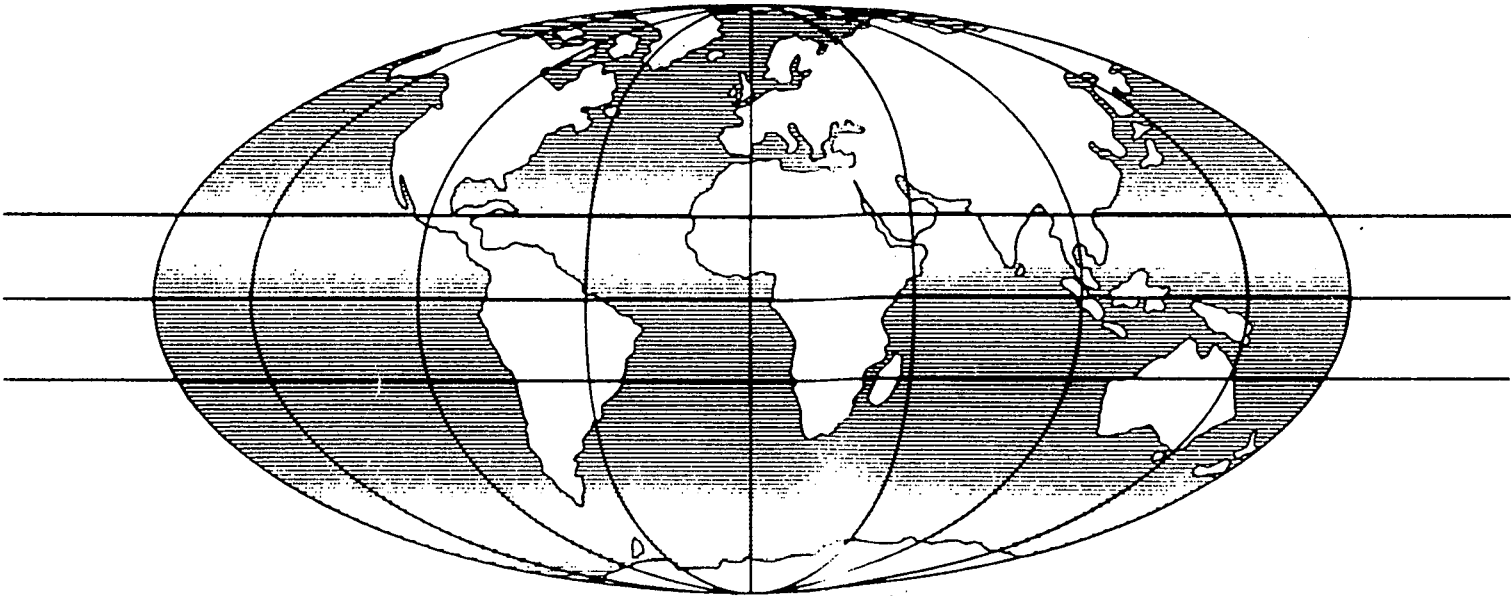


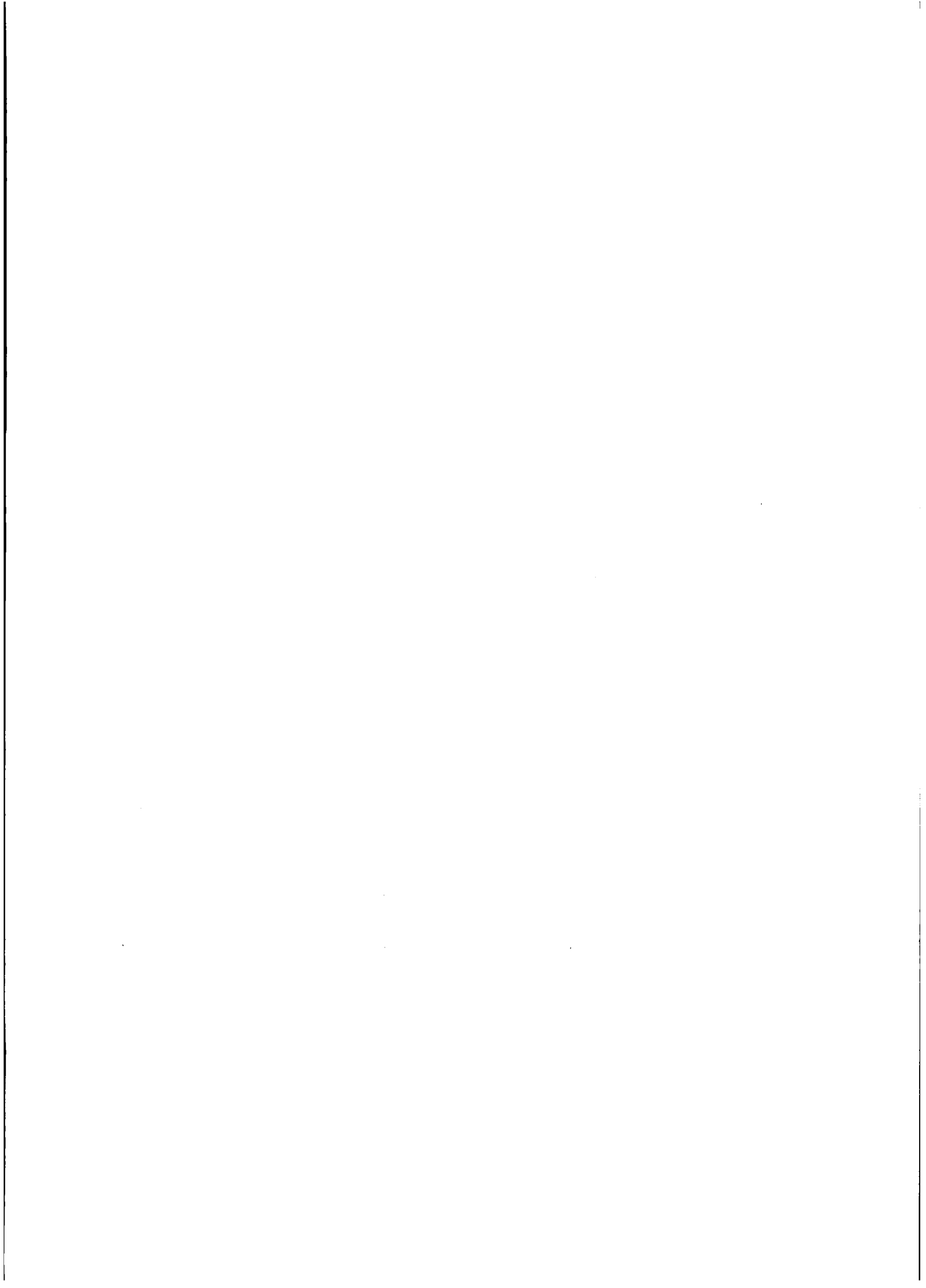
Reprint

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Road accident fatality rates



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ROAD ACCIDENT FATALITY RATES IN DEVELOPING COUNTRIES - A REAPPRAISAL

1. Introduction

For at least the last forty years or so the countries of Western Europe and North America have had to acknowledge the fact that road accidents are a major cause of death and injury. Over this period substantial sums of money have been spent on trying to contain the road safety problem. In Great Britain for example over £1000 million is spent each year on a wide range of road safety measures. 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 a small team was formed within the Overseas Unit at TRRL to undertake research on road safety in Third World countries in order to establish the nature and extent of the problem and, in the longer term to assess the effectiveness of remedial measures.

Numerous studies (1,2,3) carried out by its Overseas Unit have attempted to identify the magnitude of the road accident problem in different developing countries and to rank countries in order of 'seriousness'. Comparisons have also been made between developed and developing countries in order to show that the safety problem is particularly severe in the Third World.

In order to compare the safety problem in different countries it is obviously meaningless to use total number of fatalities or casualties because of the vastly different population sizes and degrees of motorisation in the various countries. Ideally comparisons should be made as though both their human and vehicle populations were the same. In the past, fatality rates (defined as road accident deaths per 10,000 vehicles licenced) have been used in order to compare the accident situation in developed and developing countries. The number of fatalities as opposed to casualties or injury accidents have been used because the poor accident recording systems in most Third World countries means that only fatalities are recorded to any reasonable degree of accuracy. In addition, numbers of vehicles licenced have been used, as opposed to millions of vehicle kilometres travelled per annum because very rarely are accurate n-point or trend censuses carried out in developing countries to provide such data.

In a recent paper (4) on accident rates however, Andreassen raises objections to the use of deaths per vehicles licenced in order to make international comparisons. In examining the relationship between deaths and vehicle ownership for three different developed countries, he identifies that the two parameters are not linearly related over time. For the periods chosen there is an apparent difference between each country in the sensitivity of deaths to changes in the number of vehicles. Thus to double the number of road deaths in each country would require an eight-fold increase in the number of vehicles in the USA, a four-fold increase in Australia and a two-fold increase in New Zealand. This was found to be so even though the three (developed) countries all had fairly similar levels of motorisation. This he suggests makes the level of vehicle ownership unsuitable as a measure of exposure.

Another argument against the use of 'deaths per 10,000 vehicles' was made by Preston (5) who makes the point that a comparison based on deaths per 10,000 vehicles implies that a person is more likely to be killed on the roads in Nigeria for example than in Great Britain or the USA. This she suggests is not so and from the point of view of the victim she suggests that deaths per persons resident might be more appropriate. If so then someone would be safer in Nigeria than in the USA. However the same

criticism by Andreassen on the use of fatalities per vehicles licensed could also be levelled against the use of fatalities per persons, namely that changes in vehicle or population levels do not produce linearly-proportional changes in accidents or casualties. There is ample evidence that an increase in motorisation produces a less than proportional increase in casualties, presumably because the change necessarily induces (possibly subtle) behavioural changes. The argument that the change in accidents would be linearly proportional "all else being equal" is unsound if "all else" is not equal.

What is needed therefore is a more appropriate relationship between fatalities, population and motorisation (subject to the availability of the data) in order to make allowances for these influences. A model of the form

$$\frac{\text{Fatalities}}{(\text{vehicles licenced})^a \cdot (\text{population})^b}$$

would appear to be a more satisfactory way of defining the death rate in a group of countries rather than simply deaths per 10,000 vehicles licenced or per 10,000 persons resident. Deaths divided by vehicles is in fact a measure of the death rate associated with each vehicle licenced in a country. Deaths divided by people is a measure of the risk of death in a road accident experienced by the population as a whole. What is really needed is a measure of the risk experienced by by all road users be they pedestrians, drivers or users of public transport.

This paper examines a number of alternative ways of attempting to use some combination of vehicles and people in order to obtain a more appropriate road accident death rate in developed and developing countries. The effect that the different ways of defining death rate have on ranking countries in order of 'seriousness' of the problem is also examined.

2. Alternative ways of determining fatality rate

Figure 1 shows the ranking of countries in order of 'seriousness' of the road accident problem when deaths per 10,000 vehicles licenced are used. This may not be a particularly good measures of exposure since it does not take into account the extreme overcrowding of vehicles in Third World countries or the very heavy pedestrian movements in the major cities. It does have the advantages of being both easy to understand and easy to calculate.

An alternative approach might, as suggested by Preston be to use road accident deaths per 10,000 persons as a measure of the death rate. Values for the same developed and developing countries for 1980 used earlier are given in figure 2. Using this measure of death rate a completely different order of ranking is obtained. Oil-rich Middle Eastern countries now head the list followed by a number of developed countries. Particularly poor countries such as Ethiopia, India, Niger and Pakistan now appear at the bottom of the order of ranking.

In order to determine the combined effects of vehicles licenced and population on road accident fatalities, two approaches have been used, the first involving multiple regression analysis. Using 1980 data for

the same group of countries given in figures 1 and 2 stepwise regression analysis was carried out using number of deaths as the dependent variable and total population and vehicles licenced as the two independent variables. An equation significant at the 5 per cent level was obtained of the form.

$$\log (\text{Fatalities}) = -0.994 + 0.299 \log (\text{Vehicles}) + 0.594 \log (\text{Population}) \quad (1)$$

which can be approximated to

$$\text{Fatalities} = 0.1 (\text{Vehicles})^{0.3} (\text{Population in thousands})^{0.6} \quad (2)$$

The R^2 value which indicates the amount of variation in deaths explained by the two independent variables, population and vehicles was over 80 per cent.

Having derived a relationship it can be appreciated that an equation of the form

$$\frac{\text{Fatalities}}{(\text{Vehicles}^{0.3} (\text{Population in thousands})^{0.6})} = \text{constant} \quad (3)$$

is less easy to use or interpret than expressions of the form (F/V) or (F/P). The relationship was used however to determine the 'predicted' number of deaths using for each country the appropriate number of vehicles (V) and people (P). The percentage difference was then obtained between the actual number of road accident deaths taking place in 1980 and that predicted by the above equation using

$$\frac{F_{\text{actual}} - F_{\text{predicted}}}{F_{\text{actual}}} \times 100 \% \quad (4)$$

A positive value means that actual deaths recorded are greater than might be 'expected' from the equation. These countries therefore appear to have a safety problem greater than might be 'expected' from their levels of vehicle ownership and population. Conversely, a negative value suggests that actual deaths are less than that predicted, the safety problem in these countries being less than might be 'expected'.

Countries were then ranked in order of percentage difference between actual and predicted death and results are given in figure 3. It can be seen that this gives a different order of ranking from that in figure 1 but fairly similar to that in figure 2 with oil rich Middle Eastern countries heading the list together with a number of African countries such as South Africa, Kenya and Nigeria. Countries at the bottom of the list are mainly those of Northern Europe together with the relatively poorer countries of Africa such as Niger, Sierra Leone and Ethiopia.

If the appropriate values (for 1980) of F, V and P for each country are used in equation 3 a value is derived of the constant C. This can be used as a measure of risk in the different countries with the number of road accident fatalities divided by some function of both vehicles and people. These values of C multiplied by 1000 have been plotted in order of magnitude and results are given in figure 4. (The order of countries in figure 4 is of course exactly the same as that given in figure 3).

Using this 'fatality index' it can be seen that Libya and Saudi Arabia have the highest values followed as before by a range of Middle Eastern and African countries. The countries with the lowest index are those of Northern Europe with Niger and Sierra Leone also having low values. As stated earlier this gives a different order of ranking from the use of fatalities per 10,000 vehicles.

It is noticeable that using this index, differences between countries are much less than when fatalities per 10,000 vehicles was used. For example, from figure 4 it can be seen that the value for Kenya, at 180 is just over three times greater than the value for Great Britain, at 56. Conversely from figure 1 it can be seen that the value for Kenya (141) is over forty times greater than that for Great Britain (3.3).

The second method of using a combination of vehicles and people in order to rank countries in some order of 'death rate' was to make use of the 'Smeed' relationship. Using data for road fatalities, vehicles and population for the year 1938 for 20 mainly European countries, Smeed (6) derived a relationship expressed by the formula

$$\frac{F}{V} = 0.0003 \quad V/P \quad -0.66 \quad (5)$$

where F, V and P are as used above. Using the same method as Smeed, the author has carried out numerous analyses (1,2,3) of fatality rates in developing countries for a number of different years ranging from 1965 to 1978. The analysis was now repeated for those developed and developing countries listed in figures 1 to 3 and an equation (significant at the 0.1 per cent level) derived of the form

$$F/V = 0.000204 \quad V/P \quad -0.84 \quad (6)$$

Using this expression it should be possible to identify these countries having particularly high or low death rates (in relation to the level of vehicle ownership). Figure 5 shows the values for the different countries for the year 1980 together with the regression equation derived. Using equation (6), with appropriate values of V and P for each country the predicted number of deaths can be determined.

The percentage difference between actual and predicted death was then obtained using the relationship (4) above. These were then ranked in order of increasing percentage difference and the results are given in figure 6. It can be seen that the ranking obtained is similar to that given in figures 3 and 4 with Middle Eastern countries at the top of the list and with Northern European countries at the bottom together with poor countries such as India, Niger and Ethiopia.

3. The effects of different ranking procedures

In order to determine whether or not the order of ranking of the different countries as given in figures 1 to 6 are similar or differ significantly one from another, Spearman's Rank Correlation Coefficients were calculated. This test has been designed so that when two rankings are identical the rank correlation has the value plus 1. (such as Qatar top of the list in both figures 1 and 5). When the rankings are as greatly in disagreement as possible (such as Ethiopia in figures 1 and 2), the rank correlation coefficient is equal to minus 1. The Student

t-test is then used to test the significance of the rank correlation coefficient ie. to be sure that the measure of agreement did not arise by chance.

TABLE 1
RESULTS OF RANKING TESTS

	F/V		
F/P	Sig 1% level but inversely so	F/P	
'Mult Regression' Equn	Not sig	Sig 0.1% level	'Multiple Regn' Equn
'Smeed-Type' Equn	Not sig	Sig 0.1% level	Sig 0.1% level

Using this test (see table 1) it was found that the rankings given in figures 2, 3 and 6 was very closely correlated indeed (at the 0.1 significance level). In other words rankings based on fatalities per 10,000 persons, or fatalities related to some function of vehicles and persons produced very similar rankings in order of increasing fatality rate. The order of ranking based on fatalities per 10,000 vehicles (see figure 1) was not related to that based on the 'Smeed type' equation; showed a degree of correlation to that based on equation 3 (but was not statistically significant); and was significantly related (at the 1 per cent level) with that based on fatalities per 10,000 persons (see figure 2) but with a negative correlation. In other words its order of ranking given in figure 1 was almost the complete reverse of that given in figure 2.

The interesting result from the analysis is that the order of ranking based in deaths per 10,000 vehicles which has been most frequently used to date differs markedly from the alternative methods used.

4. Discussion

As noted above, when death rates are expressed in terms of deaths per 10,000 vehicles, difference between countries are considerable. For example fatality rates in Kenya and Great Britain using this measure are 141 and 3.3 respectively. Conversely, differences are much less if the fatality index (based on the multiple regression equation relating fatalities to both vehicles and people) is used. For example Kenya at 180 is just over three-times greater than Great Britain, at 56. It is worth comparing these alternative methods of determining fatality rates with actual measures of exposure or risk obtained from safety studies carried out in different developing countries.

Over the period 1975-80 the Overseas Unit was involved in road safety studies in Kenya which determined factors affecting accident rates on busy inter-urban roads and also factors affecting accident rates for pedestrians crossing busy roads in central shopping areas of Nairobi (7).

These results enabled direct comparison to be made with similar relationships derived in Great Britain.

In the study of pedestrian risk, numbers of pedestrian accidents on each street were divided by the average hourly flow of pedestrians across the road thus obtaining a 'pedestrian relative risk rate' for each street. These values were then correlated with average hourly vehicle flows along the streets. The method used was similar to that used by the author to measure pedestrian risk in four towns in Great Britain in the early 1970's (8). A comparison of the equations derived showed that with vehicle flows of between 3,000 to 4,000 vehicles per hour pedestrian risk in Nairobi was about 3.5 times greater than in the towns in Great Britain.

In a study (9) of the factors affecting accident rates on busy inter-urban roads a relationship was established between personal-injury accident rates and vehicle flow for sections of road between Nairobi and Mombasa the main port of Kenya. A similar relationship for developed countries was established by Silyanov (10) using combined data from a number of European countries. At flow levels of about 200 vehicles per hour, the Kenya equation gave a rate about five times greater than that derived by Silyanov for developed countries.

Although the above comparison only relates to one country they suggest that differences in risk and exposure between Kenya and Great Britain may well be of the order of that suggested by the 'fatality index' used above and are considerably less than that suggested by the use of a death rate expressed as deaths per 10,000 licenced vehicles.

Before this index can be used with any degree of certainty more work needs to be carried out. For example the relationship may not be stable over time and may vary between groups of countries. Nevertheless there may well be merit in using a relationship that relates road accident fatalities to both vehicles licenced and population in order to compare accident rates in different countries rather than merely using the number of fatalities per 10,000 vehicles licenced.

5. References

1. JACOBS, G D and P R FOURACRE. Further research on road accident rates in developing countries. Department of the Environment Department of Transport. TRRL Report SR 270. Crowthorne 1977 (Transport and Road Research Laboratory)
2. JACOBS, C D and W A HARDS. Further research on road accident rates in developing countries (second report). Department of the Environment Department of Transport. TRRL Report SR 434. Crowthorne 1978 (Transport and Road Research Laboratory).
3. JACOBS, G D. The potential for road accident reduction in developing countries. Transport Rev. 2, 213-224, 1982..
4. ANDREASSEN, D C. Linking deaths with vehicles and population. Traffic Engineering and Control, November 1985.
5. Care on the Road - July 1984 (Royal Society for the Prevention of Accidents)
6. SMEED, R J. Variations in the pattern of accident rates in different countries and their causes. Traffic Engineering Control 10(7), 364-371, 1968.
7. JACOBS, G D and I A SAYER. A study of road accidents in selected urban areas in developing countries. Department of the Environment Department of Transport. TRRL Report LR 775. Crowthorne, 1977 (Transport and Road Research Laboratory).
8. JACOBS, G D and G D WILSON. A study of pedestrian risk in crossing busy roads in four towns. Ministry of Transport. RRL Report LR 106. Crowthorne 1967 (Road Research Laboratory).
9. JACOBS, G D. A study of accident rates of rural roads in developing countries. Department of the Environment TRRL Report LR 732. Crowthorne 1976. (Transport and Road Research Laboratory).
10. SILYANOV, V. Comparison of the pattern of accident rates on roads in different countries. Traffic Engineering and Control. January 1973.

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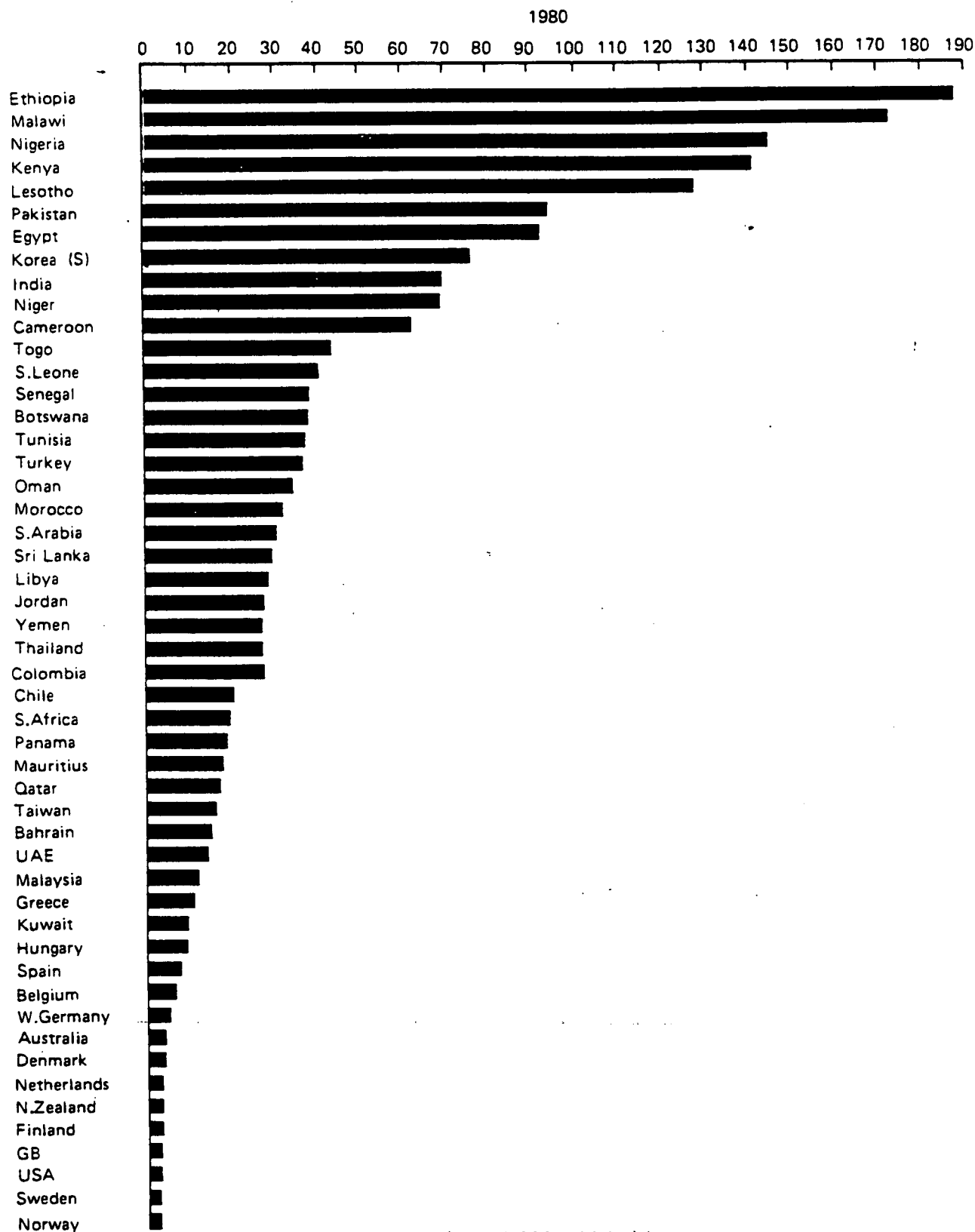


Fig. 1 Fatality rates (per 10 000 vehicles) in developed and developing countries

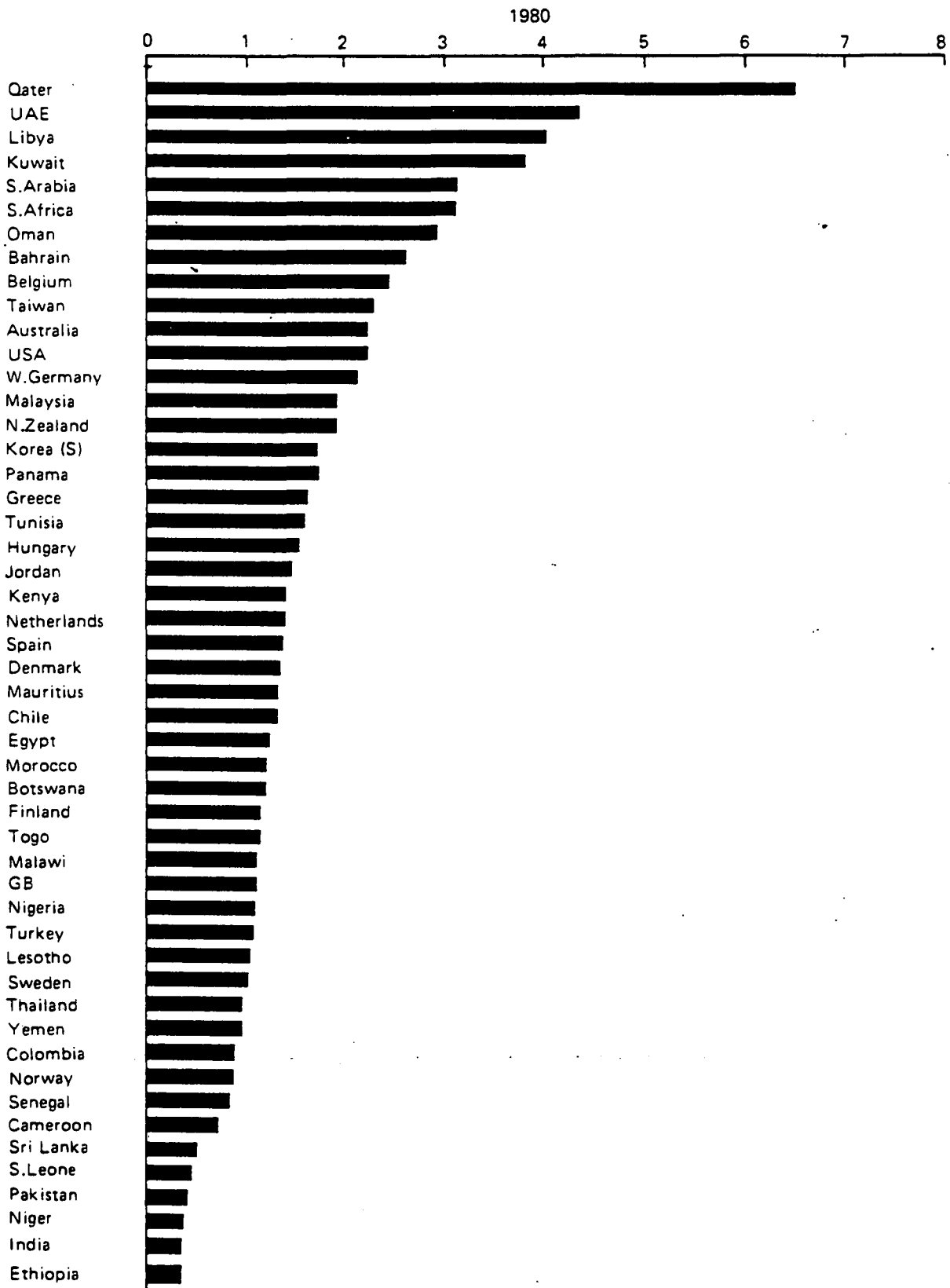


Fig. 2 Fatality rates (per 10 000 persons) in developed and developing countries

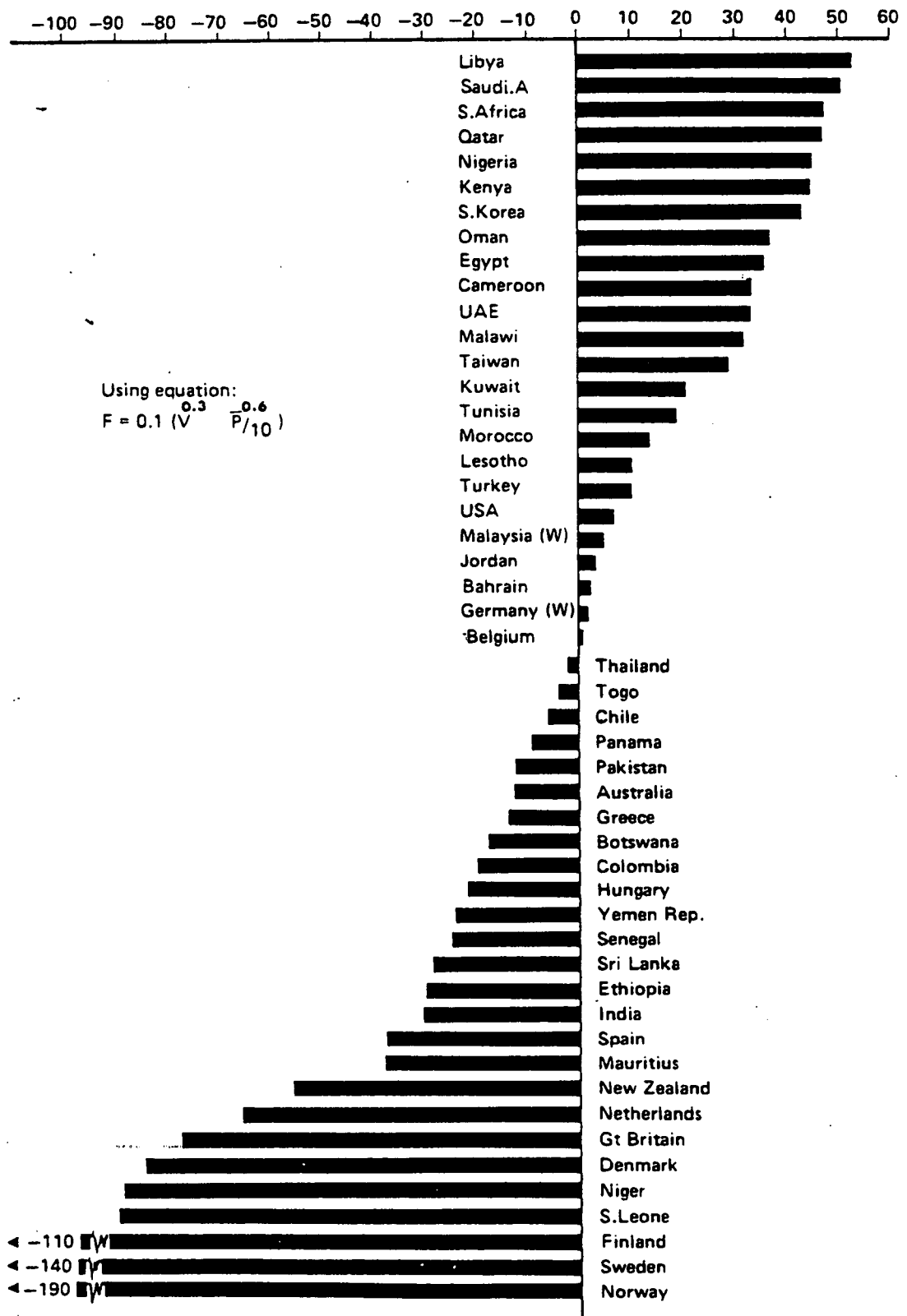


Fig.3 Percentage difference between actual and predicted number of road accident fatalities 1980.

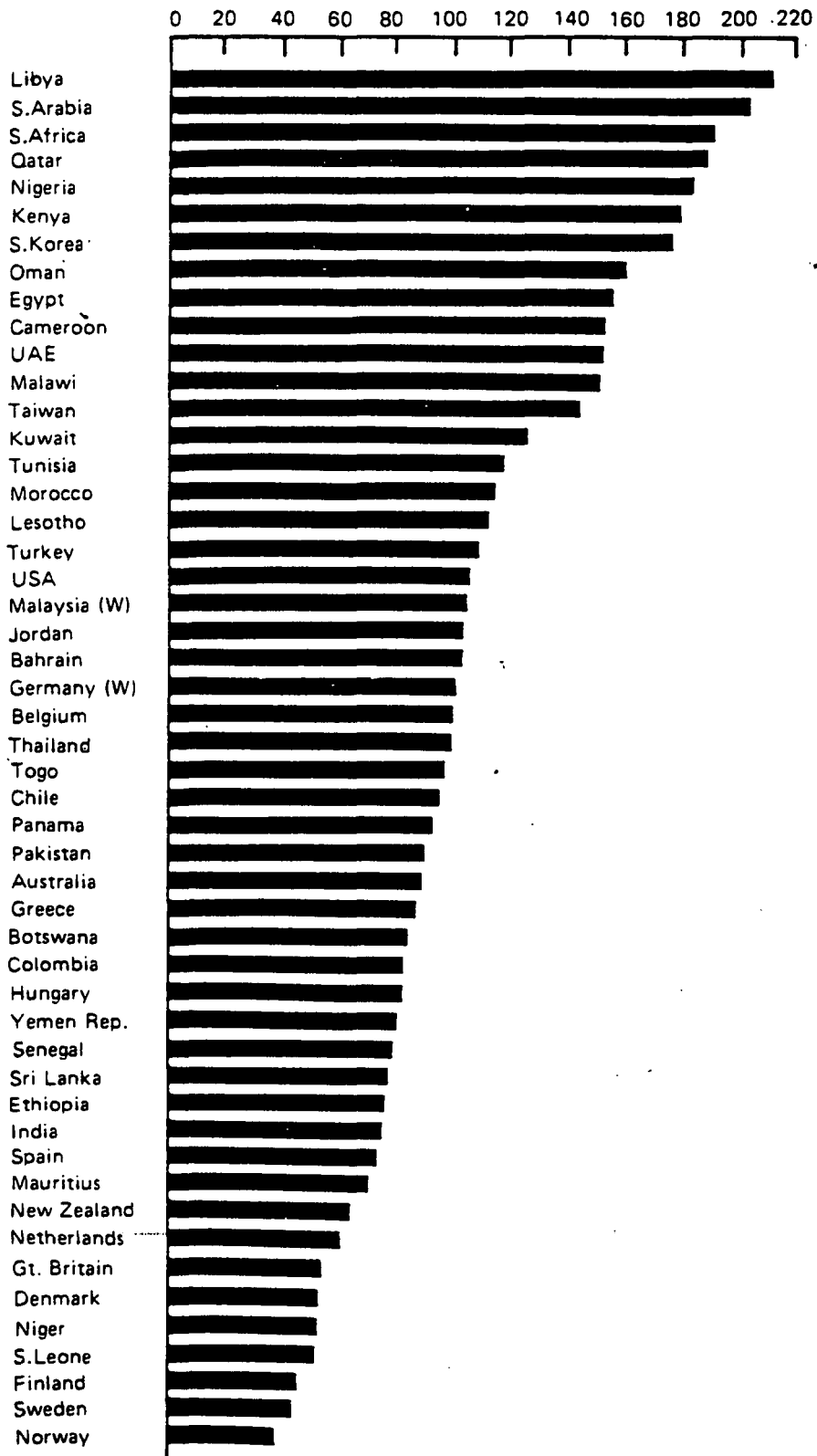


Fig. 4 Fatality rates based on $C = \left(\frac{F}{V^{0.3} \frac{P}{10^3}^{0.6}} \right) \times 1000$

1980

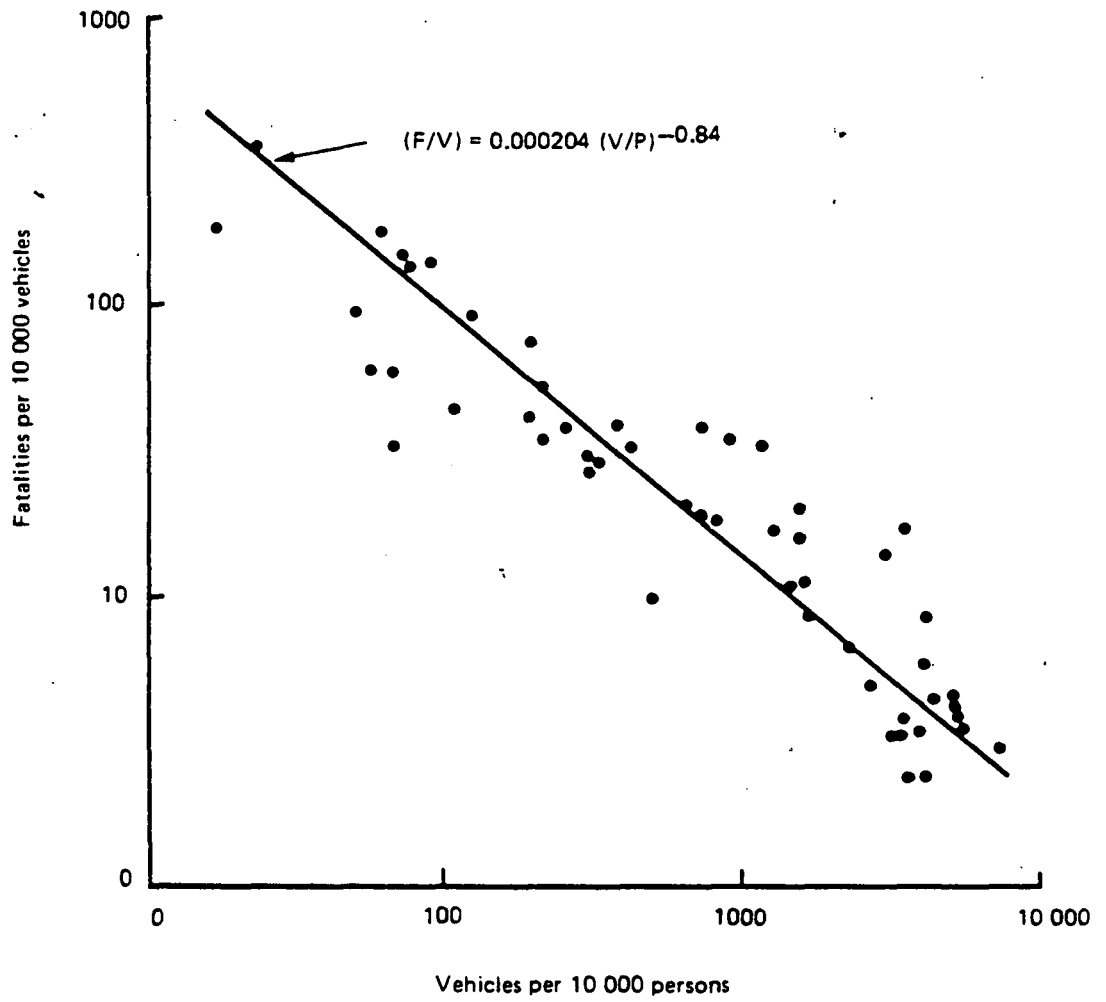


Fig. 5 The relationship between fatality rate (per 10 000 vehicles) and vehicle ownership in developed and developing countries

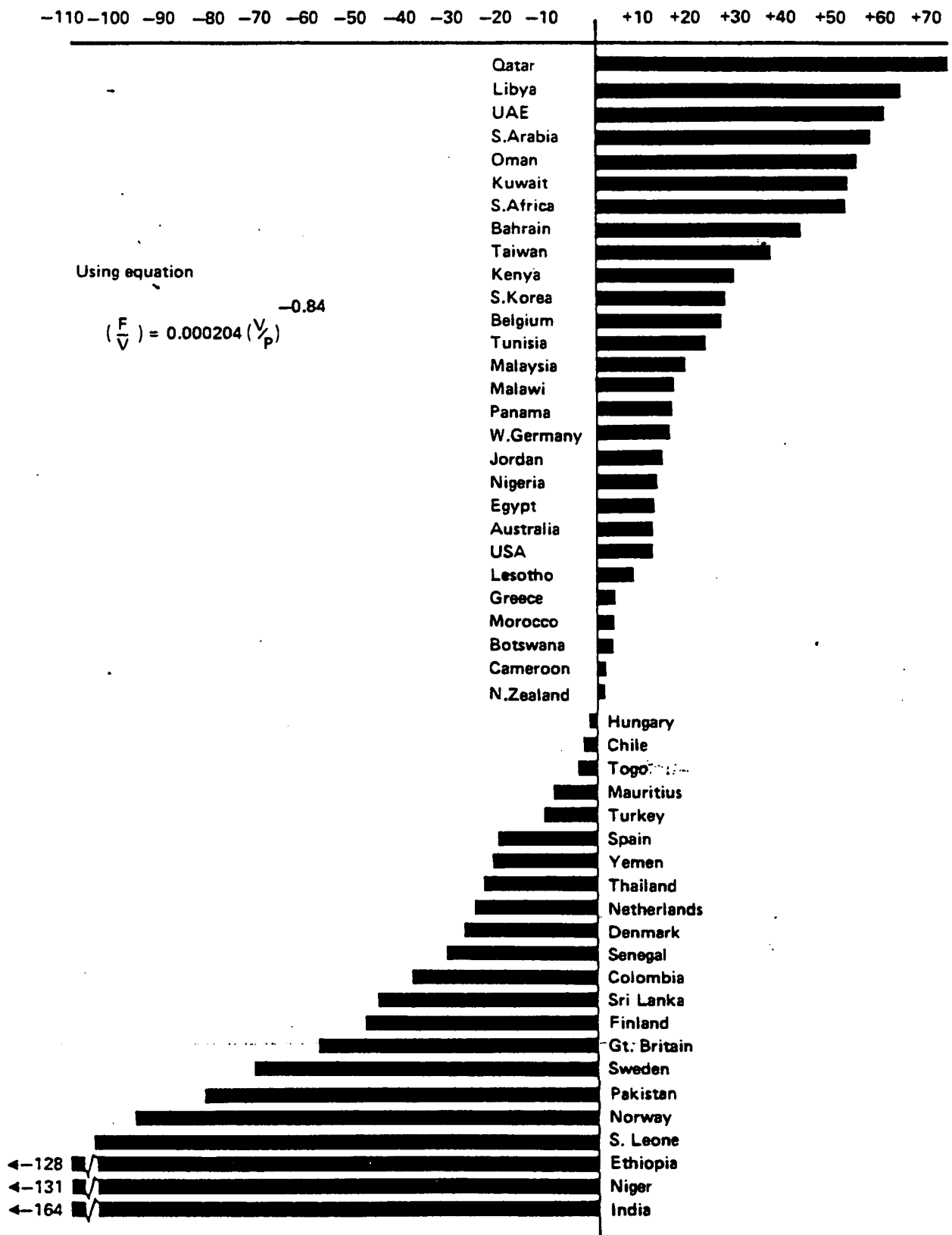


Fig. 6 Percentage difference between actual and predicted number of road accident fatalities 1980