THE RURAL SPEED LIMIT AND TRAFFIC ACCIDENTS

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A dissertation submitted to the Faculty of Engineering, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of *Master of Science* in Engineering

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DECLARATION

I declare that this dissertation is my own work, unaided except for the computer runs done by Miss E de Beer for Chapter 8. It is being submitted for the Degree of Master of Science in Engineering in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

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(Signature of candidate)

..... day of 1986

ABSTRACT

This investigation is a comprehensive examination of the relationship between rural speed limits and accidents. South Africa's road fatality rate is very high when compared to those of Western countries, and its urban and rural speed limits are above average. South African drivers are in favour of higher speed limits than are drivers from New Zealand, Finland and the USA. An analysis of twelve industrialized Western countries showed that their fatality rate could largely be explained in terms of their speed limits. Forty-eight speed limit changes in twelve countries are described, and three models relating the change in fatal, injury and total accidents with the change in mean speed have been developed. South Africa's accidents between 1972 and 1985 are analysed against a number of factors by multiple linear regression. The mean speed of rural traffic affects all categories of rural and urban accident; the urban speed limit affects all categories of urban accident and rural fatal and injury accidents. It is concluded that a change of speed on part of the road network affects accidents elsewhere on the network. It is estimated that the lower rural speed limits introduced between November 1973 and August 1984 saved 12 500 lives and 140 000 accidents. It is recommended that the urban and rural speed limits be reduced to 50 and 90 km/h respectively.

ACKNOWLEDGEMENTS

My grateful thanks are tendered to Miss E de Beer who did all the SAS computer regression runs, Mr R J Wixley for his valuable statistical guidance, Mr J O'Day for extracting the National Crash Severity Study data from the University of Michigan's computer for me, Professor R J Brown for his many helpful suggestions, and to Dr S H Kühn, Chief Director of the National *Institute for Transport and Road Research, for permission* to submit this dissertation.

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NOMENCLATURE

accident : in this context, a collision on the road that has been reported to the police.

all accidents : accidents of all degrees of severity, including damage-only accidents (q.v.).

autobahn : a German freeway (q.v.).

casualty : one who is injured or killed in an accident.

damage-only accident : an accident without casualties.

E-days : South African public holidays and certain days associated with them during which the traffic flow is abnormal.

expressway : normally a dual-carriageway road with at-grade intersections and no frontage access, used by all classes of road user. In Europe the term is used for non-freeways indicated by the E17 sign "Roads for motor vehicles" and on which the traffic rules are the same as on a freeway (q.v.).

fatal accident : an accident involving a fatality (q.v.).

fatality : one who is killed in an accident, usually within a period of 30 days. In South Africa the period was 3 months until December 1974 and 6 days from January 1975. In order to make valid comparisons between the pre-January 1975 and the post-January 1975 periods, the numbers of South African fatal accidents occurring before January 1975 have been reduced by 16 per cent.

freeway : a road, usually a dual-carriageway, with grade-separated interchanges, no frontage access, and prohibited to certain classes of road user such as pedestrians, cyclists and riders of mopeds. South Africa has some single-carriageway freeways.

injury accident : an accident involving personal injury.

motorway : a British term for a freeway.

OPEC : Organization of Petroleum Exporting Countries.

the Reef : previously applied specifically to the gold mining area to the east and west of Johannesburg; now applies generally to Johannesburg and environs.

serious injury : in South Africa an injury requiring hospitalization or confinement to bed. Other countries may define a serious injury differently.

slight injury : in South Africa an injury not requiring hospitalization or confinement to bed. Other countries may define a slight injury differently.

vehicle spot speed : the speed of a vehicle at a given point on the road.

CHAPTER 1

INTRODUCTION

The imposition of a maximum rural speed limit and the determination of its level are contentious issues. In this investigation the safety benefits of rural speed limits are examined, drawing upon South African and overseas data. The following topics are covered:

* Speed limits and fatality rates in a number of countries.

* Attitudes to rural speed limits.

* Investigations into the safety effects of speed limit changes, both South African and international.

* The relationship between collision speed and the probability of a fatality.

* The effects of the many changes in speed limits on road accidents in South Africa between 1972 and 1985.

1.1 Structure of the dissertation

The background to the investigation is described in Chapter 2. This chapter comprises the problem, the history of South African speed limits from 1970 and the fuel conservation measures introduced by the government in response to the OPEC oil crisis.

In Chapter 3 the urban and rural speed limits of a number of countries are compared and a relationship between the fatality rate and speed limits of the more industrialized nations is derived. Attitudes to rural speed limits, both South African and international, are described in Chapter 4.

Chapter 5 reviews the results of a number of overseas studies of the effects on accidents of changes in the rural speed limit. Included in this chapter is an examination of the relationship between collision speed and the probability of a fatality occurring. Vehicle speeds on South African roads and South African studies into the relationship between speed limit changes and accidents are discussed in Chapter 6. These results are summarized in Chapter 7 and a general relationship is established; the shortcomings of this approach are then discussed.

Chapter 8 is the most important in the report. The relationships between South Africa's accidents and a number of other factors between 1972 and 1985 are examined and the role of speed and speed limits is investigated. The effects on safety of the government's introduction of lower rural speed limits between 1973 and 1984 is estimated.

Chapter 9 draws conclusions from the findings of the previous chapters, lower urban and rural speed limit are recommended and areas for further research are identified.

CHAPTER 2

BACKGROUND

The application of a maximum speed limit is a traffic control technique that has been used by road and traffic authorities for many years. It has normally been introduced as a road safety measure, although lower speed limits were imposed in some countries as a fuel conservation measure during the oil crises of 1956, 1973 and 1979.

Usually, speed limits have been applied to urban areas initially and extended to rural areas later. In 1936, for example, 30 mph (48 km/h) speed limits were in force in urban areas in the Cape Province and 20 mph (32 km/h) in urban areas in the Transvaal. Not until 1966 was a general rural speed limit of 70 mph (113 km/h) introduced in South Africa.

In this chapter the problem of rural speed limits and the history of South African speed limits from 1970 on both urban and rural roads are discussed. The measures introduced by the government to combat the oil crisis between 1973 and 1984 - with particular reference to fuel selling hours - and the changes to the price of fuel between 1970 and 1986 are also described.

2.1 The problem

The speed limits most commonly applied in urban areas throughout the world range between 48 and 60 km/h. In some countries, lower urban limits of 30 km/h or even 15 km/h have been used in

certain residential areas. There is general consensus among the authorities and the public that urban limits are necessary and there is little pressure to have them raised. They are recognized as an effective traffic safety measure.

However, the situation is quite different when we look at the rural speed limit. There is little agreement about what constitutes an appropriate speed limit, whether the speed limit should vary on different classes of road or whether, indeed, the rural speed limit is an effective road safety measure. This last point is illustrated by the following extract from the 1984 annual report of the National Road Safety Council[1]:

> "There is no direct evidence that speed itself causes accidents. What does, however, contribute to traffic accidents is when the wrong speed for a specific situation is applied."

In a similar vein the Automobile Association of South Africa (AA) stated recently[2]:

> "In South Africa the lower (rural) speed limits were initially given major credit for the subsequent reduction in road accidents but this was at least partly due to a marked change in driver attitudes arising from the prominence given to the fuel crises by the media. However experience has shown that this was only of a temporary nature."

Without doubt the rural speed limit is one of the less popular traffic control measures, both with the public and with many road and traffic organizations and officials. South Africa is

a large co[illegible] with its White, and largely motorized, population concentrated in a few widely separated cities. These cities are linked by an excellent system of high standard roads carrying low volumes of traffic. It is quite understandable that drivers wish to travel at high speed on this network.

On the other hand, South Africa has an extremely high road fatality rate when compared with first world countries - in terms of distance travelled, more than eleven times that of the USA, for example. Nor is there any sign that this fatality rate is decreasing: on the contrary, between 1979 and 1984 the rate rose by 36 per cent from 13,3 to 18,1 fatalities/10^8 veh km^3. When compared with third world countries, however, South Africa's fatality rate compares well. For example, South Africa had a fatality rate of 22 fatalities per 10 000 motor vehicles in 1984. The rates of some randomly chosen African countries were: Tunisia 30; Egypt 72; Kenya 95; Nigeria 264[4].

2.2 South African speed limits since 1970

During 1970 and early 1971 the speed limits on urban and rural roads were 35 mph (56,3 km/h) and 70 mph (112,7 km/h) respectively. On 1 April 1971 the speed limits were metricated and adjusted upwards to 60 and 120 km/h. These limits were regulated by the provinces by means of the Provincial Road Traffic Ordinances.

In late 1973 OPEC countries reduced oil production, applied embargoes against certain countries, including South Africa, and increased the price of oil substantially. The Government reacted by introducing a number of fuel conservation measures which included reducing the urban and rural speed limits to 50 and 80 km/h respectively. These restrictions were imposed by

means of regulations under the National Supplies Procurement Act, which took precedence over the Provincial Ordinances; they came into force on 14 November 1973.

It was soon found that fuel consumption was increased as a consequence of the lower urban limit and on 25 January 1974 the speed limit was restored to 60 km/h; it has remained at this value since.

On 16 May 1975 the rural limit was raised to 90 km/h. It stayed at this level until 1979 when the Iranian civil war threatened the nation's oil supply again. On 8 June 1979 the Government imposed a 70 km/h speed limit on rural roads in designated magisterial districts surrounding the seven largest metropolitan areas. This restriction was very unpopular and the number of metropolitan areas to which the 70 km/h limit applied was reduced to three on 31 August 1979. On 28 September 1979 the 90 km/h speed limit was reinstated on all rural roads.

The rural speed limit was raised on 1 April 1981 to 100 km/h on rural freeways and the national road network; this limit was extended to the remainder of the rural system on 6 November 1981.

During the 1970s the provinces had reduced the maximum speed limit on non-freeway rural roads from 120 to 100 km/h - freeways remained at 120 km/h. These limits did not apply, of course, in view of the Government's fuel conservation legislation. However, on 1 August 1984 the Government was sufficiently confident that the country's fuel supplies were secure and removed speed limits from the regulations. The responsibility for speed limits reverted to the provinces, with the result

that the limit on rural freeways increased from 100 to 120 km/h. During 1985 the speed limit was raised to 120 km/h on certain non-freeway rural roads. These various changes are illustrated in Figure 2.1.

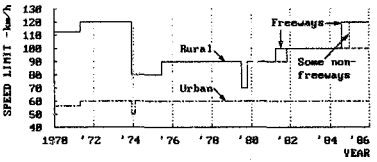

Figure 2.1: History of urban and rural speed limits between January 1970 and December 1985

2.3 Fuel conservation measures during the OPEC oil crisis

The Government introduced a number of measures to conserve fuel in November 1973 in response to the OPEC fuel crisis. These were gradually relaxed during the following years as the security of the country's oil supplies became increasingly assured. In mid-1979 the Iranian civil war threatened the country's oil supplies again and stringent conservation measures were reimposed for three months. The fuel conservation measures were lifted in August 1984.

The introduction of lower rural speed limit has already been described. Other important measures included restricted

selling hours for fuel, greatly increased fines for speed limit violations, constraints on the amount of fuel that could be stored or carried in containers and the introduction of an 80 km/h maximum speed limit for trucks exceeding nine tons in gross vehicle mass; this limit has since been made permanent.

2.3.1 Restrictions on fuel selling hours between 1973 and 1982

It is postulated that restrictions on the selling hours of fuel affect travel, and hence accidents. Restrictions on when fuel could be sold were introduced in November 1973 and lasted until June 1982. Details of these restrictions are listed in Table 2.1.

Table 2.1: *Details of fuel selling hours*

Date	Restriction	No. of h/week
Pre-Nov. 73	No restriction	168
14 Nov. 73	No service Sat. 18h00 - Mon. 08h00	130
10 Dec. 73	No service 18h00 - 06h00 on weekdays No service Fri. 18h00 - Mon. 08h00	58
16 May 75	No service 18h00 - 07h00 on weekdays No service Sat. 13h00 - Mon. 07h00	61
22 Oct. 76	No service 18h00 - 07h00 on weekdays No service Sat. 12h00 - Mon. 07h00	60
3 Mar. 78	No service 18h00 - 08h00 on weekdays No service Sat. 18h00 - Mon. 08h00	60
26 Mar. 79	No service 18h00 - 07h00 on weekdays No service Wed. 12h00 - Thur. 07h00 No service Sat. 18h00 - Mon. 07h00	60
8 June 79	No service 18h00 - 07h00 on weekdays No service Fri. 18h00 - Mon. 07h00	55
28 Sep. 79	No service 18h00 - 07h00 on weekdays No service Sat. 12h00 - Mon. 07h00	60
11 July 81	No service 18h00 - 07h00 on weekdays No service Sat. 18h00 - Mon. 07h00	66
18 June 82	No restriction - R5 levy for sales after 18h15 and on Sundays	168

Note: This table is based on information supplied by the Department of Mineral and Energy Affairs

2.4 Changes to the fuel price between 1970 and 1986

It is also believed that the fuel price affects the amount of travel and therefore the number of accidents; details of the change in price of fuel are given in Table 2.2. The fuel price shown is the retail price at the pump of 93 octane petrol on the Reef (Johannesburg area); two sets of prices are given, the actual price and the real price with a base year of 1975. This same information is also shown in Figure 2.2.

Table 2.2: Retail price of petrol between 1970 and 1986

Date	Price - c/l		Date	Price - c/l	
	Actual price	1975 cents		Actual price	1975 cents
1 Jan. 70	9,2	14,7	1 Apr. 80	54,4	32,0
1 Apr. 71	9,9	14,8	1 Apr. 81	55,0	28,0
1 July 72	10,2	14,2	6 July 81	61,0	29,8
1 Dec. 72	10,4	13,7	1 Mar. 82	64,6	27,3
1 Jan. 73	10,9	14,4	1 Sep. 82	65,2	27,1
25 Oct. 73	12,4	15,2	28 Feb. 83	63,6	24,9
1 Feb. 74	15,1	18,1	22 Aug. 83	59,6	22,3
2 Dec. 74	16,0	17,1	1 Feb. 84	60,2	21,6
27 Mar. 75	18,0	18,4	1 Apr. 84	61,8	21,6
24 Oct. 75	21,1	20,2	1 Sep. 84	63,5	21,2
1 Apr. 76	23,8	21,9	24 Jan. 85	88,5	27,4
1 Sep. 76	24,1	21,1	25 Mar. 85	90,1	27,2
10 Jan. 77	28,1	24,0	9 Sep. 85	94,6	27,1
1 Apr. 77	28,6	23,6	11 Nov. 85	100,0	27,8
3 Apr. 78	28,9	21,5	1 Jan. 86	102,0	26,8
3 July 78	30,1	21,5	3 Mar. 86	92,0	23,9
1 Jan. 79	33,3	22,9	14 Apr. 86	83,0	21,2
23 Feb. 79	39,3	26,4			
8 June 79	54,2	35,6			

Note: This table is based on information supplied by the Department of Mineral and Energy Affairs

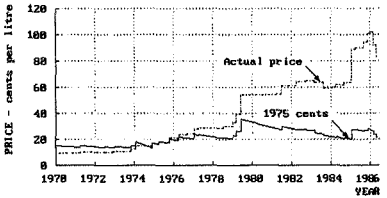

Figure 2.2: Actual and real (1975) price of 93 octane petrol on the Reef between January 1970 and April 1986

Although the petrol price at the beginning of 1986 was more than 11 times what it was in 1970, in real terms it was less than twice as much. The decline in world oil prices at the end of 1985 has resulted in a reduction of the actual price of petrol; the real price is less than 50 per cent higher than it was in January 1970. Petrol reached its highest price in real terms during the Iranian civil war in mid-1979, when South Africa had to purchase its oil supplies on the spot market.

2.5 Concluding remarks

Despite a high road fatality rate in South Africa, there is doubt in official quarters of whether speed and accidents are related. The many changes in the rural speed limit during the OPEC oil crisis offers an excellent opportunity of examining the relationship between these two factors. The fuel conservation measures and the changes in fuel price are also factors which are likely to have had an effect on the number of accidents.

CHAPTER 3

SPEED LIMITS AND FATALITY RATES IN DIFFERENT COUNTRIES

The general urban and rural speed limits for 27 countries are listed in Table 3.1. Where the information was available, the fatality rate is shown as well. The speed limits are those that applied on 1 April 1985 and the fatality rates are for either 1983 or 1982.

The rural speed limits of the Eastern bloc countries, the USA and Scandinavia tend to be lower than those of the other West European nations. South Africa has speed limits that are higher than the average on all categories of road - note also South Africa's formidable fatality rate. Portugal and Spain have the highest fatality rates among the European countries. As these two countries, and South Africa, have fatality rates that are quite different from those of the other countries, the three are excluded from the following analysis.

For Table 3.1 the category of rural road described as "Expressway" is defined in reference 5 as roads indicated by the E17 sign "Roads for motor vehicles" of the 1968 Convention on Road Signs and Signals. This sign is used on non-motorways on which the traffic rules are the same as on a motorway.

Footnote: There is some doubt regarding the fatality rate for Austria. In reference 6 the 1982 fatality rate calculates as 4,9 fatalities/10^8 veh km (1 681 fatalities; 341,5 x 10^8 veh km travelled). In Table 5 of reference 6 the 1982 travel is *estimated as* 392,4 x 10^8 veh km; this gives a fatality rate of 4,3 fatalities/ 10^8 veh km. However, Table 7 of reference 4 gives a fatality rate of 3,6 fatalities/10^8 veh km. In view of these discrepancies, Austria's fatality rate is ignored in the subsequent discussion.

The values of the speed limits given in Table 3.1 for West German freeways and expressways are recommended values only; there are no mandatory speed limits on these classes of road.

Table 3.1: Speed limits and fatality rates in various countries (references 3,5 and 6)

Country	Speed limits - km/h				Fatality rate per 10^8 veh km
	Urban	Rural			
		Free-way	Express-way	Other	
Austria	50	130	100	100	5,0
Belgium	60	120	120	90	5,1
Bulgaria	60	120	80	80	-
Cyprus	48	-	-	97	-
Czechoslovakia	60	110	90	90	-
Denmark	60	100	80	80	-
Finland	50	120	80	80	2,0
France	60	130	110	90	4,4
Germany (East)	50	100	80	80	-
Germany (West)	50	130	130	100	3,4
Hungary	60	100	80	80	-
Ireland	48	97	97	97	-
Italy	50	140	110	110	2,8
Luxembourg	60	120	90	90	3,4
Netherlands	50	100	100	80	2,3
Norway	50	80	80	80	2,2
Poland	60	110	110	90	-
Portugal	60	120	90	90	10,3
Romania	60	90	90	90	-
Spain	60	100	90	80	6,7
Sweden	50	110	110	70	-
Switzerland	50	120	80	80	2,7
USSR	60	90	90	90	-
UK	48	112	112	97	2,1
USA	48	88	88	88	1,6
Yugoslavia	60	120	100	80	-
South Africa	60	120	120	100	18,6
Mean	55	115	96	88	4,7

Figure 3.1 shows the fatality rate plotted against the urban speed limit and the rural expressway speed limit. The fatality

rate is strongly correlated with the speed limits, particularly the urban limit, to which it is very sensitive.

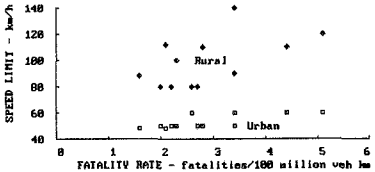

Figure 3.1: Scattergram showing the relationship between the urban and rural speed limits and the fatality rates of twelve Western countries

A multiple linear regression was done on the data and the following relationship was derived:

$$FR = 0{,}14321\ U + 0{,}02788\ RE - 7{,}47185$$
$$(5{,}2) \qquad (3{,}8) \qquad (-4{,}6)$$

$$R^2 = 0{,}823; \quad n = 12$$

where FR = fatality rate - fatalities/10^8 veh km
U = urban speed limit - km/h
RE = rural expressway speed limit - km/h

The t values of the regression coefficients are given in brackets and are all highly significant.

This relationship explains 82 per cent of the variation of the fatality rate of this group of countries. A reduction of the urban speed limit from 60 to 50 km/h (16,7 per cent) reduces the fatality rate by 36,6 per cent. A reduction of the rural expressway limit from 100 to 90 km/h (10 per cent) reduces the fatality rate by 7,1 per cent. The three rural speed limits (freeway, expressway and other) are all highly correlated and this latter reduction in the fatality rate should be construed as a consequence of a ten per cent reduction in the overall rural speed limit. A comparison between the observed and predicted fatality rates of the twelve countries is shown in Figure 3.2.

It might be argued that there is no cause and effect relationship between speed limits and fatality rates, that countries with low fatality rates have achieved them by employing a number of road safety measures, which include lower speed limits. However, for this to hold, there should be strong multicollinearity between the urban and the rural speed limit - countries that set low urban speed limits will also set low rural speed limits. In fact this has not happened; the urban and rural speed limits are almost independent of one another.

We can summarize by saying the following:

* It seems that the fatality rate is strongly influenced by the speed limit, particularly the urban limit. For this group of twelve industrialized nations, the variation in fatality rates is largely attributable to their different speed limits.

* Although South Africa's speed limits are comparable with the countries listed in Table 2.1, they are above average in all four road classes.

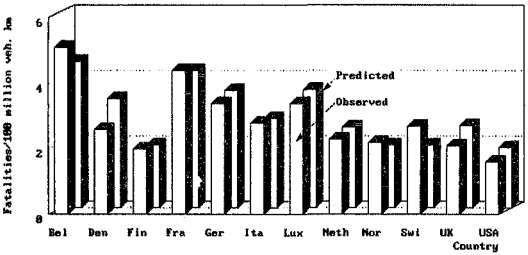

Figure 3.2: Histogram showing the observed fatality rates of 12 Western developed countries and the predicted rates based on their urban and rural speed limits

CHAPTER 4

ATTITUDES TO SPEED LIMITS

In this chapter two recent South African surveys of drivers' attitudes to speed limits are compared and contrasted with the findings of surveys done in New Zealand, the United States of America and Finland.

4.1 South Africa

Two surveys of drivers' attitudes towards speed limits were done in 1983, one by the Automobile Association of South Africa and the other by the market research firm Markinor.

4.1.1 The Automobile Association survey

The AA conducted a speed limit survey in April 1983 through the medium of its journal The Motorist[7]. Readers were asked whether they were satisfied with the current maximum speed limits on *urban and rural roads (then 60 and 100 km/h respectively)* or whether they would like to see the existing limits changed in any way; there then followed a table consisting of a matrix of six types of road and eleven values of speed limit. Further questions dealt with the age, sex, residence and so on of the reader.

The survey was biased in so far as it was addressed to members of the AA only, who are mainly car drivers and are drawn predominantly from the White sector of the population. The

respondents were mainly males (88 per cent), the largest age group was the 60 plus group, followed by the 31 to 40 age group.

Two-thirds wished the urban speed limit to remain at 60 km/h. On two-way rural roads half were satisfied with 100 km/h or less and one-third supported 120 km/h or more. Higher speed limits were favoured on urban and rural expressways. On rural freeways three-quarters were in favour of an increase in the speed limit to 100 km/h or more[8].

4.1.2 The Markinor survey

At about the same time the market research firm Markinor conducted a Gallup poll of a representative sample of 831 white motorists in metropolitan areas, quota controlled by sex, age, language and income[9]. The participants were asked what the speed limit should be on an urban road, a non-freeway rural road and a rural freeway.

Three-quarters of the sample were satisfied with an urban speed limit of 60 km/h, slightly more than half were content with a 100 km/h speed limit on non-freeway rural roads and 60 per cent wished for a 120 km/h speed limit on rural freeways.

It was also found that men prefer to drive faster than women, young people prefer to drive faster than older people, and people from the inland cities (particularly Pretoria) prefer to drive faster than people from the coastal cities.

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4.1.3 The two surveys compared

The results of the two surveys are compared in Table 4.1; they agree quite well, although the percentage of respondents who support the nominated speed limit on each category of road is lower in the case of the AA survey than the Markinor survey.

Table 4.1: Comparison between the AA and Markinor speed limit surveys (references 8 and 9)

Survey	Percentage of respondents in favour of a speed limit as stated		
	Urban roads 60 km/h	Rural non-freeways 100 km/h	Rural freeways 120 km/h
AA	70	49	74
Markinor	73	56	89

The current speed limits - 60 km/h on urban roads, 100 km/h on rural non-freeway roads and 120 km/h on rural freeways - correspond with the desires of the majority of White drivers.

4.2 *The United States of America*

Between 1974 and 1982 the question "Do you favour or oppose keeping the 55 mph (88,5 km/h) speed limit on the nation's highways?" was posed on six occasions in Gallup polls. The responses are given in Table 4.2. The percentages changed little during the eight years and about three-quarters of the population supports the 55 mph speed limit.

A demographic breakdown of the 1982 responses showed that young high-income White males from the southern or western states were the most likely group to oppose the 55 mph speed limit.

Table 4.2: Public opinion of the 55 mph (88,5 km/h) speed limit in the USA (references 10 and 11)

Response	Percentage					
	1974	1977	1979	1980	1981	1982
In favour	73	76	71	81	75	76
Oppose	24	22	26	17	23	21
No opinion	3	2	3	2	2	3

In another survey carried out in 1979 1 323 drivers were asked about their preference for a speed limit on major highways. Only 4,3 per cent preferred a speed limit above 65 mph (105 km/h)[12].

In 1980, in a survey of public perceptions of highway safety, drivers were asked their opinion on the level of enforcement of the 55 mph speed limit. Nearly half thought that the level was about right whereas 44 per cent thought that enforcement was not strict enough[13]. In this same survey it was found that support for the speed limit was related to the amount of driving done by the respondent. The greatest support came from those who had driven less than 2 000 miles (3 200 km) the previous year - 89 per cent in favour - and the least from those who had driven more than 30 000 miles (48 000 km) the previous year - 54 per cent in favour.

4.3 New Zealand

Surveys to gauge the New Zealand public's attitude to road safety measures have been done from time to time. In two of these surveys, in 1975 and 1981, respondents were asked whether they wished the 80 km/h speed limits on open roads to be raised, lowered or left unchanged. The results are given in Table 4.3 and indicate considerable support for the speed limit; the support was slightly higher in 1981 than it was in 1975.

Table 4.3: Public opinion of the 80 km/h speed limit in New Zealand (reference 14)

Response	Percentage endorsing	
	1975	1981
Raised	34	29
Lowered	2	3
Kept as is	63	66
Don't know	0	1

The results were considered surprising by the survey's designers because New Zealand's rural speed limit is low by international standards and is widely flouted.

4.4 Finland

A very interesting review by Peltoniemi describes public opinion regarding speed limits in Finland during 1973 and 1974[15]. A speed limit experiment was initiated in southern Finland in August 1973 for a planned period of three years.

Differentiated speed limits of 60, 80, 100 and 120 km/h were applied; elsewhere in Finland there were no speed limits except those of local communities.

However, the energy crisis intervened and a general speed limit of 80 km/h was applied to the whole country during the period 12 December 1973 to 30 June 1974. Thereafter, the original plan of the experiment was continued.

There was a marked reduction in the number of traffic accidents and fatalities during the experimental period and a state research committee concluded that the effect of speed limits on the decreasing number of accidents was greater than the combined effects of other possible factors. Despite the original experiment having been affected by the nationwide imposition of the 80 km/h speed limit, it was nevertheless possible to study the changes in opinion before and after the setting of speed limits.

The study of the population's opinion consisted of a questionnaire survey of licensed drivers from five centres, three within the experimental area and two outside it. The same drivers were polled in the summers of 1973 and 1974 and 1 531 and 1 374 returns were received. Support for the speed limits was determined by the general question "Do you support speed limits or do you oppose them?". A number of other questions were asked as well.

Articles written on speed limits in 19 newspapers and four automobile journals during 1973 were collected and analyzed. The following emerged from the 1973 questionnaire survey:

* 84 per cent of the respondents supported general speed limits.

* Women supported speed limits slightly more often than did men.

* Younger drivers supported speed limits less than did older drivers.

* People living in cities supported speed limits less than did people living in rural areas.

* Low income earners supported speed limits more than did high income earners.

* Private licence holders supported speed limits more than did professional licence holders.

* Members of automobile clubs were less supportive of speed limits than were non-members.

* Owners of small cars supported speed limits more than did owners of larger cars.

* Those identifying with right-wing parties had the lowest proportion of supporters of speed limits - 67 per cent. Those identifying with centre parties had 90 per cent supporters and those with left-wing identification 94 per cent.

* Opponents of speed limits drove at a higher average speed (106 km/h) than did those supporting speed limits (94 km/h).

Findings concerning attitudes towards speed limits in the press were as follows:

* Articles were evenly distributed among positive (34 per cent), neutral (33 per cent) and negative (33 per cent) groups.

* Automobile journals were quite negative whereas newspapers were generally neutral or positive in their attitudes.

* Right-wing newspapers were more negative in their attitudes, centre party newspapers were generally positive and left-wing newspapers were the most positive.

* The official (editorial) stand of newspapers and journals towards speed limits was most often negative. The most negative editorials appeared in automobile journals and the most positive in left-wing newspapers.

* The articles written by automobile journalists differed quite markedly from other writers' texts. Only 38 per cent of their articles were supportive of speed limits and 58 per cent were negative in their attitude.

In the second opinion survey, in the summer of 1974, the support for speed limits increased from 84 per cent in 1973 to 91 per cent in 1974. Support increased in all political groups, on the left from 84 per cent to 96 per cent and on the right from 67 to 78 per cent. The lowest proportion of support (76 per cent) was found among those belonging to automobile clubs.

The author suggests that the magnitude of the change in opinion in one year is unusual and was brought about largely by the marked decline in traffic accidents and the energy crisis. These created an atmosphere where changing one's attitude could be readily related to the crisis and to the common good.

The author also makes the point that those most hostile to speed limits - the automobile writers - were also presumably those who were in the best position to be aware of the benefits of speed

limits. Facts alone do not necessarily change attitudes.

The press tended to be more negative towards speed limits than was the general public. Similar situations were found in Austrian and West German studies.

4.5 Summary and discussion

White South African drivers are in favour of much higher speed limits than drivers from the three other countries, despite their much higher fatality rate.

Certain findings were common to South Africa, the United States of America and Finland. Younger drivers and male drivers were less supportive of speed limits than older drivers and female drivers. In both Finland and the USA, high income drivers and those who had driven a long distance in the preceding year were more negative towards speed limits than low income drivers and those who drove only a short distance in a year.

If the remainder of the findings in the Finnish study are applicable to other countries then this might help to explain the desire of the White South African to have a high speed limit. He is right-wing and enjoys a high income. The press is also right-wing. In Finland, these factors are associated with negative attitudes towards speed limits. The difference between the AA and the Markinor surveys might be explained by the AA survey being confined to the Association's members. In Finland, automobile club members were more negative towards speed limits than were non-members.

Relatively low speed limits were in force at the times of the surveys in New Zealand, the USA and Finland, and the populations were aware of the safety benefits. In South Africa, the various rural speed limits that have been applied since 1974 were fuel conservation measures and the safety benefits were little known or publicized.

All the public opinion surveys, apart from the Gallup polls in the USA, were aimed at drivers. South Africa, with its population of about 27 million and vehicle population of about 4,8 million, is less motorized than the other countries. Approximately half of the fatalities are pedestrians and it is quite likely that non-drivers would have a very different view from that of drivers of what constitutes a desirable rural speed limit.

CHAPTER 5

FOREIGN EXPERIENCE OF SPEED LIMIT CHANGES AND ROAD SAFETY

This chapter reviews some speed limit changes reported in countries other than South Africa. Although it is comprehensive, this review is not exhaustive.

There have been many experiments and studies related to the effects of changes of speed limit on road safety. A number of experiments involved speed limit changes during school and public holidays and summer weekends. These experiments were an attempt to reduce the number of road accidents and injuries during those periods regarded as most dangerous. Other studies have examined the results of speed limits being applied to short lengths of road.

Most of these experimental results have been excluded from this analysis because they are not thought to be representative of typical traffic conditions. In general, only the results of speed limit studies in which the speed limit was applied continuously for minimum period of about one month - preferably much longer - to a substantial length of road have been included.

Some of these studies have been previously reviewed[15]. They are repeated here and considerably more detail is given; many further results are also included.

5.1 Belgium

The Belgian government imposed a 70 km/h speed limit on previously unrestricted roads as a fuel conservation measure during the Suez crisis. This limit was instituted on 8 December 1956, raised to 80 km/h on 17 February 1957 and abolished on 16 March 1957. Very cold weather was experienced in February 1957 and the analysis of the effect of the change in speed limits on accidents was restricted to a comparison between a 27-day period in January 1957 and the same period in January 1956. After correcting for the change in traffic in the two periods, fatalities and injuries had both decreased by 15 per cent and accidents by 6,5 per cent (2 589 and 2 420 accidents, 47 and 40 fatalities, 372 and 316 injuries for January 1956 and adjusted January 1957 respectively)[17,18].

5.2 Finland

Finland has done extensive speed limit experiments over a 16-year period between 1962 and 1978; these have been described comprehensively by Salusjärvi[19].

5.2.1 Speed limit experiments in the 1960s

During the 1960s four speed limit experiments were done, two of which were short-term experiments applied countrywide during public holidays. The remaining two involved experimental periods lasting several months and are described below.

Speed limit experiment in 1962

On 1 June 1962 a general speed limit of 90 km/h was applied in three provinces for a four-month period on previously uncontrolled roads. Approximately half of the total vehicular travel was done on these roads. On 30 September the speed limit was removed. The mean speed of vehicles prior to the imposition of the speed limit was 69 km/h and the 85-percentile speed was about 90 km/h. After the imposition of the limit the speeds dropped by 2 and 8 km/h respectively.

The recorded number of accidents during the experimental period was compared with the estimated number, had no speed limit been in force. The total number of accidents decreased by 6 per cent, injury accidents by 8 per cent and fatal accidents by 10 per cent.

Speed limit experiment in 1966

During October and November 1966, a general speed limit of 90 km/h was again imposed, this time throughout the country. Compared with 1962 the mean speed had increased by 7 km/h to 76 km/h and about 25 per cent of drivers were exceeding 90 km/h; in 1962 the proportion was 15 per cent. The mean speed fell 3 km/h and the 85-percentile speed 11 km/h. The estimated reduction in total accidents was 7 per cent, injuries 10 per cent and fatalities 24 per cent.

5.2.2 Speed limit experiments between 1973 and 1976

During the early 1970s it was decided to do further speed limit experiments over a three-year period. The first phase applied to the southern provinces only, the second phase covered the whole country and the third incorporated some changes in the levels of the speed limits. The experiment involved the selective application of differential speed limits.

During Phase I there was no speed limit on the rural network except in the southern provinces. The speed limit on the remainder of the network was 80 km/h during the application of the general speed limit and during Phases II and III. The first phase lasted just under five months and was interrupted by the imposition of a general speed limit as a consequence of the 1973 oil crisis. This unplanned speed limit lasted just over six months and the experiment resumed with Phases II and III, each of which lasted twelve months. The speed limits and the lengths of road to which they applied are shown in Table 5.1.

Table 5.1: Finland, speed limits and experimental road length during the various phases of the experiment (ref. 19)

Speed limit km/h	Length of road to which speed limit applied							
	Phase I		General 80 km/h limit		Phase II		Phase III	
	km	%	km	%	km	%	km	%
120	991	19	-	-	817	5	807	5
100	2 947	56	-	-	1 073	65	9 899	60
80	948	18	948	72	3 418	22	3 755	23
60	220	4	220	17	845	6	1 687	10
50	143	3	143	11	321	2	396	2
Total	5 249	100	1 311	100	15 474	100	16 544	100

Table 5.2 compares accidents by severity in the three-year period before the experiment with the thee-year experimental period and it will be seen that the experiments were highly successful in reducing the numbers of accidents and their severity. The highest proportionate reduction was in fatal accidents and the lowest in all accidents.

Table 5.2: Finland, average annual accidents before and during the experimental period (reference 19)

Accident severity	Average number of accidents per year		Percentage change
	Before: 1970-73	During: 1973-76	
Fatal	734	550	-25
Injury	5 038	4 615	-18
All	12 043	10 320	-14

Table 5.3 shows the percentage change in the number of accidents *during each phase of the experiment*, compared with the before period, on weekdays and weekends. During Phase 1 the change in the number of accidents was greatest over weekends, but during the other phases the changes on weekdays and at weekends were approximately the same.

Table 5.3: Finland, percentage change in accidents during different phases of the experiment compared with the before period (reference 19)

	Percentage change in all accidents			
	Phase I	General limit	Phase II	Phase III
Weekdays	+5	-28	-12	-15
Weekends	-18	-29	-9	-19
Average	-7	-28	-11	-17
Injury accs only	-16	-28	-15	-24

Table 5.4 lists the change in speed and the percentage change in the number of accidents during each phase of the experiment and on each speed limit category of road.

Table 5.4: Finland, the change in speeds and accidents on roads with different speed limits during the experimental period (reference 19)

Phase	Group	Speed limit km/h	Change in speed km/h			Percentage change in accidents		
			Mean	85 %-ile	Std dev.	Fatal	Injury	All
I	1	60	-2	-6	-1,8	(+12)	-5	-15
	2	80	-6	-13	-5,5	-40	-34	-48
	3	100	-2	-9	-4,5	-17	-11	-7
	4	120	-1	-1	-1,4	(-44)	-26	-20
General speed limit	1	60	-2	-5	-1,7	(+33)	-35	-10
	2	80	-6	-17	-6,1	-13	-39	-39
	3	80	-7	-19	-7,6	-47	-45	-42
	4	80	-9	-20	-7,4	(-20)	-42	-33
II	1	60	0	-4	-0,9	(+64)	-8	+1
	2	80	-3,5	-11	-5,4	-37	-33	-28
	3	100	-2	-7	-4,5	-48	-9	+2
	4	120	+2	0	-1,7	(+5)	+31	+17
III	1	60	-4	-6	0,0	(-45)	-23	-23
	2	80	-3	-10	-5	-48	-40	-32
	3	100	0	-6	-5	-46	-20	-10
	4	120	+2	0	-3	(-51)	-6	0

Notes: The column headed "Group" refers to those roads with speed limits of 60, 80, 100 or 120 km/h during Phases I, II and/or III. During the period of the general speed limit, Group 3 and 4 roads were restricted to 80 km/h.
Percentages in parentheses are based on small samples and are not statistically significant.

The changes in the mean speeds are generally quite modest and the application of an 80 km/h speed limit on the roads previously controlled by a 120 km/h speed limit reduced the mean speed by only 9 km/h. In Phase II the imposition of a 120 km/h speed limit actually increased the mean speed by 2 km/h, which

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	3	100	-2	-9	-4,5	-17	-11	-7
	4	120	-1	-1	-1,4	(-44)	-26	-20
General speed limit	1	60	-2	-5	-1,7	(+33)	-35	-10
	2	80	-6	-17	-6,1	-13	-39	-39
	3	80	-7	-19	-7,6	-47	-45	-42
	4	80	-9	-20	-7,4	(-20)	-42	-33
II	1	60	0	-4	-0,9	(+64)	-8	+1
	2	80	-3,5	-11	-5,4	-37	-33	-28
	3	100	-2	-7	-4,5	-48	-9	+2
	4	120	+2	0	-1,7	(+5)	+31	+17
III	1	60	-4	-6	0,0	(-45)	-23	-23
	2	80	-3	-10	-5	-48	-40	-32
	3	100	0	-6	-5	-46	-20	-10
	4	120	+2	0	-3	(-51)	-6	0

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led to an increase in injury- and all accidents and a non-significant increase in fatal accidents.

5.2.3 Main conclusions from the Finnish experiments

Salusjärvi drew the following conclusions from the study:

* Speed limits have a decreasing effect on all accidents only when the average speeds have decreased.

* The larger the decrease in speeds, the greater the effect on accident numbers.

* Small reductions in speeds result in proportionately greater reductions in fatal and injury accidents than in all accidents.

* If the average speed decreases by more than 5 km/h, injury accidents and all accidents decrease in equal measure.

Based upon the study results, he suggests the following will apply:

* If the speed limit is set higher than the 85-percentile speed then drivers travelling slower than the speed limit will increase their speeds, leading to a reduction in the standard deviation of the speed but an increase in the mean speed. The number of accidents will increase but fatal and injury accidents will remain the same.

* If the speed limit is set at the 85-percentile speed the mean speed will be unaffected because the effect of faster drivers driving more slowly will be counteracted by slower

drivers driving more quickly. The standard deviation of the speed will decrease, leading to fatal and injury accidents decreasing but the overall number of accidents remaining unchanged.

* If the speed limit is set lower than the 85-percentile then both the mean speed and the standard deviation of the speed will decrease. Fatal, injury and all accidents will decrease.

5.3 France

Speed limit experiments had been done on some rural roads during selected weekends between 1958 and 1961. A decline in the number of accidents was ascribed to the speed limits. Further experiments were done in 1969 and 1970 and are described below[18,20,21,22].

5.3.1 Speed restrictions on major roads in 1969

Speed limits were applied from 24 March 1969 on five major roads with a total length of 1 570 km. It was not stated but was implied that these roads were previously unrestricted and that the experiment lasted for nine months. The roads affected were the RN 2, 7, 13, 23 and 113. The limit was 100 km/h except on a short length of the RN 113, where it was set at 120 km/h, and certain dangerous sections, where an 80 km/h limit was applied.

Effect on speeds

The speed limits reduced both the average speed of vehicles and the percentage of vehicles exceeding 100 km/h; this is illustrated in Table 5.5.

Table 5.5: France, mean speed of vehicles and percentage exceeding 100 km/h before and after the application of the 100 km/h speed limit (reference 18)

	Weighted mean speed km/h			Percentage exceeding 100 km/h		
	Before	After	Diff.	Before	After	Diff.
Fast vehicles:						
RN 2	84,4	88,0	+3,6	21,0	21,9	+0,9
RN 7	97,5	85,8	-11,7	42,7	18,1	-24,6
RN 13	104,8	94,8	-10,0	74,2	38,8	-35,4
RN 23	110,1	93,3	-16,8	72,1	31,0	-41,1
RN 113	100,4	86,6	-13,8	48,7	16,2	-32,5
Slow vehicles:						
RN 2	79,6	84,5	+4,9	13,7	14,1	+0,4
RN 7	86,8	81,3	-5,5	22,1	9,0	-12,1
RN 13	94,1	88,4	-5,7	35,4	22,8	-12,6
RN 23	100,7	89,5	-11,2	51,3	21,4	-29,9
RN 113	89,9	83,3	-6,3	31,1	9,5	-21,6

Note: The speeds of fast and slow vehicles were measured. Fast vehicles comprised the following models: Renault R16, Peugeot 404 and 504, Citroen ID and DS.

There was a very significant decline in both the percentage of vehicles exceeding 100 km/h and the average speed of vehicles on all roads other than the RN 2. The apparent speed increase on this road was ascribed to the bad weather that traditionally affects this road during January and February, the period when the before speeds were measured. The greatest changes were observed on the RN 23; this road had the highest mean before speed. The standard deviation of speeds was lower on all five roads after the introduction of speed limits.

Effect on accidents and casualties

Table 5.6 shows the number of injury accidents recorded on each road in the last nine months of each of the years 1964 to 1969. Also shown is the predicted number of accidents for the last nine months of 1969, had no change in the speed limit taken place. On each road the recorded number of accidents in 1969 is lower than the 1968 or 1967 accidents and similar to or lower than the 1964 accidents.

Table 5.6: R.. ded injury accidents in the last three-q.. the year, 1964 to 1969, and the predicted numba.. ..cidents in 1969 (reference 18)

Road	Number of injury accidents during the last three-quarters of the year							% diff. 1969 recorded compared with predicted
	'64	'65	'66	'67	'68	'69 rec.	'69 pred.	
RN 2	146	155	149	177	245	152	240	-37
RN 7	712	744	670	759	898	528	873	-40
RN 13	273	269	258	332	441	264	434	-39
RN 23	322	333	332	425	414	257	448	-43
RN 113	405	405	421	521	678	420	685	-39
All	1 858	1 906	1 830	2 214	2 676	1 621	2 680	-40

The predicted number of accidents was obtained by linear regression of the number of accidents against the year, based on the years 1964 to 1968 and extrapolating the trend for 1969. This method was found to give a higher correlation coefficient than a regression on the number of accidents against traffic flow.

In South Africa it has been demonstrated that, although there is a general upward trend in accidents with time, there are

exogenous factors that affect the year to year trends[23]. One such factor is the level of the economy, which can have a considerable influence on the number of accidents. An examination of Table 5.6 suggests that the economy in 1966 was at a low point in view of the decline in accidents in that year. The sharp rise in the number of accidents in 1967 and 1968 is indicative of strong economic growth. A far better approach would have been to select a control group of roads and to do an analysis of the before-and-after accidents on the control and experimental groups.

The predicted values were not given in reference 18 and the values in Table 5.6 have been recomputed. The 1969 predicted values are similar to the 1968 recorded values. Had no change in the speed limit taken place, the percentage reduction of the 1969 recorded injury accidents compared with the predicted number of accidents is remarkably consistent on the individual roads and on all the roads considered together. The average reduction is 40 per cent.

Table 5.7 shows the history of injury accidents and casualties on the experimental roads between 1964 and 1969. Once again, the predicted 1969 figures are extrapolations of the 1964-68 trend lines and have also been recomputed. The recorded 1969 figures in each category are lower than any of the previous five years' figures.

The percentage reductions of the 1969 recorded injury accidents and casualties compared with the predicted values are again a very consistent set of data; the average reduction is 40 per cent. The percentage reduction of accidents and casualties is the same, irrespective of the severity of the accident.

Table 5.7: *France, injury accidents and casualties during the last three-quarters of the year, 1964 to 1969 (reference 18)*

Type	Number of accidents and casualties during the last three-quarters of the year							% diff. 1969 recorded compared with predicted
	'64	'65	'66	'67	'68	'69 rec.	'69 pred.	
Accidents:								
Non-fatal	1 616	1 668	1 605	1 946	2 340	1 406	2 353	-40
Fatal	242	237	225	268	336	215	327	-34
Total	1 858	1 906	1 830	2 214	2 676	1 621	2 680	-40
Casualties:								
Slight	2 180	2 371	2 236	2 593	3 148	1 840	2 823	-35
Serious	1 289	1 236	1 150	1 405	1 760	1 034	1 701	-39
Fatal	304	298	276	334	444	270	426	-37
Total	3 773	3 905	3 662	4 332	5 352	3 144	5 280	-40

5.3.2 Speed restrictions on major roads in 1970

The speed limit experiments of 1969 were resumed in 1970 and were extended to cover 13 070 km of the most heavily trafficked roads. The speed limit was set at 110 km/h (130 km/h when overtaking) and was introduced on 25 April on some roads and 15 May on the remainder. It is not known how long this experiment lasted but it was still in operation during August 1970. It is assumed that these roads were unrestricted prior to the introduction of the speed limit.

Effect on speeds

Speed measurements, before and during the trial, were done in April and August and the weighted results are shown in Table 5.8.

Table 5.8: France, speed measurements of vehicles before (April) and during (August) the application of the 110 km/h speed limit (reference 18)

Measure	Weekends and public holidays		Other weekdays	
	Before	During	Before	During
Free speed of vehicles - km/h:				
Mean speed	93,5	90,0	90,2	87,5
85-%ile speed	110	106	108	104
15-%ile speed	75	73	71	71
% exceeding speed limit	14,5	8,7	12,5	5,9
Overtaking speed of vehicles - km/h:				
Mean speed	99,2	101,3	101,3	96,3
85-%ile speed	116	116	116	113
15-%ile speed	83	86	85	81

Note: The free speed of a vehicle is the vehicle spot speed when unaffected by other traffic.

The introduction of the 110 km/h speed limit was successful in reducing the mean speed and the 85-percentile speeds of vehicles by 3 and 4 km/h respectively. Although Tables 5.5 and 5.8 are not directly comparable, the application of the 100 km/h speed limit had a considerably greater effect on vehicle speeds than did the 110 km/h speed limit. The proportion of vehicles exceeding the 100 km/h speed limit was, however, much larger than the proportion exceeding the 110 km/h speed limit. Intuitively, these are results we should expect.

Effect on accidents and casualties

Accident and casualty data were collected for the roads affected by the speed limit and for other rural roads located in the same Departments that were unaffected by the speed limit. These data were collected for the months May to August 1970 - during the period the speed limit experiment was in operation - and for the

same period one year earlier. The results are shown in Tables 5.9 and 5.10.

Table 5.9: France, monthly injury accidents on the experimental and control groups of roads before and during the speed limit experiments (reference 18)

Group of roads	Before: 1969				During: 1970			
	May	June	July	Aug.	May	June	July	Aug.
Experimental	884	817	1 062	1 158	530	724	942	1 052
Control	6 946	7 568	8 677	9 246	6 841	7 521	8 685	9 136
Percentage	12,7	10,8	12,2	12,5	7,7	9,6	10,8	11,5

Table 5.9 shows that there was a slight drop in the number of accidents on the control group of roads in 1970 compared with 1969. On the experimental group of roads there was a substantial drop in the number of accidents. The largest fall occurred in May, the first month of the experiment; thereafter the fall was much less.

Table 5.10: France, injury accidents and casualties by severity before and during the speed limit experiment (reference 18)

Severity	Before May-Aug. 1969	During May-Aug. 1970	Percentage change
Accidents:			
Fatal	567	435	-23,3
Other injury	3 354	2 813	-16,1
Total	3 921	3 248	-17,2
Casualties:			
Slight	4 588	4 002	-12,8
Serious	2 644	2 329	-11,9
Fatal	716	582	-18,7
Total	8 148	6 913	-15,2

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The increase in traffic from 1969 to 1970, during June and August, was about four per cent on the experimental roads and about seven per cent on the French network as a whole. The decline in accidents on the control group of roads, despite an increase in the volume of traffic, suggests that the effect of the speed limit might have carried over from the experimental group to the control group of roads. A decline in the economy is likely to have had a similar effect.

Table 5.10 shows that the number of accidents in 1970 on the roads affected by the speed limit dropped by 17 per cent compared with the same period a year earlier; casualties dropped 15 per cent. Fatal accidents and casualties were reduced the most.

5.4 Denmark

Rural speed limits were reduced following the oil crises of 1973 and 1979 and the effect of the limits on speeds and accidents has been described by Christensen[24].

5.4.1 Speed limit change in 1973

In the autumn of 1973 the Danish government introduced general speed limits of 60 km/h on urban roads and 80 km/h on all rural roads. It was not stated but it is assumed that there was no rural speed limit on rural roads prior to 1973. On urban roads there were a number of local speed limits on individual streets. The rural limit was raised in March 1974 to 90 km/h on non-freeway roads and 110 km/h on freeways. The safety benefits were such that a year later the limits were made permanent.

Effect on speeds

Table 5.11 shows the average and the standard deviation of vehicle speeds measured before and after the imposition of the speed limits. Measurements were taken between June and October 1973 and during the trial year, April 1974 to March 1975. Four freeway locations and ten non-freeway locations were surveyed.

Table 5.11: Denmark, rural speeds before and during the application of speed limits (*reference* 24)

Class of road	Speed limit km/h	Speed - km/h					
		Before		During		Change	
		Mean	Std dev.	Mean	Std dev.	Mean	Std dev.
Freeway	110	98	18	89	14	-9	-4
Non-freeway	90	83	16	79	11	-4	-5

The change in the mean speed was modest, particularly on non-freeway roads, but there was a substantial percentage reduction in the standard deviation of the speed.

Effect on accidents

The numbers of recorded rural injury accidents for the 12-month periods 1 April 1972 to 31 March 1973 and 1 April 1974 to 31 March 1975 are shown in Table 5.12. The 30 per cent reduction in accidents following the imposition of the speed limit is considerable. Despite the higher speed limit, the greatest reduction was recorded on freeways (nearly 40 per cent).

Table 5.12: Denmark, injury accidents on rural roads before and during the application of speed limits (reference 24)

Class of road	Speed limit km/h	Number of injury accidents			% diff.
		Before Apr.72 to Mar.73	During Apr.74 to Mar.75	Diff.	
Freeway	110	221	136	-85	-38,4
Non-freeway	90	7 563	5 341	-2 222	-29,4
Total		7 784	5 477	-2 307	-29,6

The accident rate had been declining steadily during the years preceding 1972 and an extrapolation of this trend to the experimental year would account for 3,4 per cent of the reduction. Traffic declined by 7,7 per cent during the experimental period and the remaining 11,2 per cent reduction in the number of accidents was ascribed to the speed limits. Similarly, the effect of the speed limits on the reduction in fatal accidents was estimated to be 20 per cent. The calculation of fatal accidents was based upon total (urban plus rural) accidents. As the percentage change in injury accidents in rural areas was greater than for the country as a whole, it is likely that the percentage reduction in fatal accidents would also be higher in rural areas. The 20 per cent estimate is therefore probably conservative.

Total injury accidents (urban plus rural) declined by 22,3 per cent and fatalities by 34 per cent. Urban injury accidents declined by 2 071 accidents from the 11 838 in the control year (a drop of 17,5 per cent). It was estimated that less than five per cent of this could be ascribed to the speed limits.

The above analyses take no account of any change in economic conditions between the before and experimental periods. Any such change can have a substantial effect on the number of accidents. As many Western countries' economies suffered after the OPEC oil crisis in 1973, it is possible that the foregoing analysis overestimates the effect of the speed limits.

5.4.2 Speed limit change in 1979

A threat to the country's fuel supplies caused the Danish government to introduce further speed limits on 15 May 1979. Rural speed limits were reduced to 100 km/h and limits on non-freeway rural roads were reduced to 80 km/h; urban speed limits remained at 60 km/h.

A 30 per cent increase in the price of fuel was introduced on 1 July 1979 (just three and a half months after the introduction of the speed limits) and this led to a substantial and long-term decline in the volume of traffic.

Effect on speeds

Speed measurements were taken immediately before and after the introduction of the speed limit at four sites on freeways and six rural non-freeway sites. Details for each site are given in Table 5.13. There was a small reduction in the mean speed at most sites and a reduction in the standard deviation of the speed at all sites. The speed limit was widely flouted by drivers.

Table 5.13: Denmark, speed parameters on rural roads before and after the imposition of the 1979 speed limits (reference 24)

Speed limit km/h	Speed - km/h						Percentage exceeding new speed limit	
	Before		During		Change			
	Mean	Std dev.	Mean	Std dev.	Mean	Std dev.	Before	During
Freeways:								
100	84,0	11,9	80,4	10,0	-3,6	-1,9	8,4	2,9
100	89,7	11,9	88,7	11,6	-1,0	-0,3	16,6	13,8
100	99,1	13,3	95,4	12,3	-3,7	-1,0	45,4	31,6
100	94,9	14,6	95,0	12,4	+0,1	-2,2	35,4	35,2
National highways:								
80	85,5	11,4	80,6	9,4	-4,9	-2,0	64,5	48,7
80	82,5	12,5	81,7	10,6	-0,8	-1,9	53,4	44,1
80	75,3	10,0	73,9	8,3	-1,4	-1,7	25,9	15,2
80	82,9	10,1	77,0	9,6	-5,9	-0,5	57,1	27,4
Secondary highways:								
80	77,8	12,7	77,9	11,6	+0,1	-1,1	39,5	39,7
80	69,7	15,2	72,5	9,7	+2,8	-5,5	26,8	23,5

Effect of the 1979 speed limits on accidents

The evaluation of the effect of the speed limit change is based on the period 15 March 1979 to 30 September 1979 compared with the same period during the preceding three years. Although there was a fuel price rise in the middle of this period in 1979, the total traffic was about the same as during 1978.

It was estimated that there would have been 2 793 injury accidents on the rural network subject to the 80 km/h speed limit (freeways not included) in the analysis period in 1979 had there been no change in the speed limit. A total of 2 306 accidents were recorded, which suggested that the imposition of the speed limit was responsible for the 17,4 per cent reduction in accidents.

Although urban speed limits were not affected, a reduction in the number of accidents within urban areas during the analysis period in 1979 compared with similar periods in the years 1976 to 1978 was recorded. The figures are given in Table 5.14.

Table 5.14: Denmark, urban injury accidents in the period 15 March to 30 September for the years 1976 to 1979 (reference 24)

Year	No. of injury accidents
1976	4 730
1977	4 944
1978	4 746
1979	4 270

The total vehicle kilometres travelled in urban areas in Denmark is unknown but, if the percentage reduction in travel during the analysis period from 1978 to 1979 was the same as in rural areas, then this would not explain the 10,0 per cent reduction in urban injury accidents that occurred. A change in the economy may well have contributed to the reduction, but the possibility of the effects of the rural speed limit influencing driver behaviour in urban areas, thereby reducing accidents, should not be discounted.

5.5 Sweden

Sweden has carried out a number of speed limit experiments over the years. Prior to 1967 a number of trials were done involving the imposition of speed limits on rural roads over weekends and during holiday periods. In the intervening periods, no speed limit applied. The results of these experiments have been fully reported by Jönrup and Svensson[18] but only the trials of differentiated speed limits that took place between 1968 and 1972 are described here[18,25].

The speed limits tested on freeways were 110 and 130 km/h; on non-freeway rural roads they were 70, 90 and 110 km/h. The differentiation was done on the basis of the standard of the road; the speed limit set on high standard roads was higher than that on lower standard roads. The experiments are described in Table 5.15.

Table 5.15: Sweden, speed limit experiments between 1968 and 1972 on rural roads (reference 25)

Experiment No. C = control E = experimental	Speed limit - km/h (NSL = no speed limit)	
	From	To
Non-freeway roads:		
1	NSL	90
2	NSL	110
3E	90	110
3C	90	90
4E	110	90
4C	90	90
5E	90	70
5C	90	90
6E	90	110
6C	90	90
7E	90	110
7C	90	90
Freeways:		
8	130	110

5.5.1 Effect on speeds

Unfortunately, reference 25 does not give many details of the speed changes that occurred during the various experiments. When the speed limit changed from 90 km/h to 70 km/h (experiment 5E) the mean speed decreased by 6 km/h; when the speed limit changed from 90 to 110 km/h the mean speed increased by 6 km/h. A general comment was made that a reduction of 20 km/h in the speed limit led to an average reduction of 6 to 8 km/h in the mean speed.

5.5.2 Effect on accidents

The before-and-after accidents by severity for the various speed limit changes are shown in Table 5.16.

Except in the case of experiment 2, lowering the speed limit reduced accidents and raising the speed limit increased accidents. It is presumed that either the mean speed or the standard deviation of the vehicle speeds, or both, were increased when the speed limit was set at 110 km/h in experiment 2.

The results were not always consistent: reducing the speed limit from no speed limit to 90 km/h reduced accidents by about 10 per cent (experiment 1) whereas reducing the speed limit from 110 to 90 km/h reduced accidents by one-quarter (experiment 4). Increasing the speed limit from 90 to 110 km/h increased accidents by 50 per cent in the case of experiments 3E and 7E but by only 10 per cent in the case of experiment 6E. The criteria for selecting a speed limit for a particular road changed from experiment to experiment and this may have contributed to the inconsistencies.

Table 5.16: Sweden, accidents by severity before and after the change in speed limits (reference 25)

Period	Number of accidents			
	Fatal	[illegible]	Damage only	Total
Experiment 1: NSL - [illegible]				
Before	6	[illegible]	948	1 423
After	4	[illegible]	878	1 291
% diff.	-30,2	[illegible]	-7,4	-9,3
Experiment 2: NSL - 110 km/h:				
Before	40	277	652	969
After	44	303	695	1 042
% diff.	+10,0	+9,4	+6,6	+7,5

Table 5.16 cont.: Sweden, accidents by severity before and after the change in speed limits

Period	Number of accidents			
	Fatal (or fatalities)	Injury	Damage only	Total
Experiment 3B: 90 - 110 km/h:				
Before	8	90	165	263
After	22	122	256	400
% diff.	+175,0	+35,6	+55,2	+52,1
Experiment 3C: 90 - 90 km/h:				
Before	14	161	294	459
After	12	161	326	489
% diff.	-14,0	0,0	+10,9	+6,3
Experiment 4B: 110 - 90 km/h:				
Before	14	75	183	272
After	11	56	134	201
% diff.	-21,4	-25,3	-26,8	-26,1
Experiment 4C: 90 - 90 km/h:				
Before	8	85	180	273
After	10	90	194	294
% diff.	+25,0	+5,9	+7,9	+7,7
Experiment 5B: 90 - 70 km/h:				
Before	(80)	606	1 250	1 856
After	(46)	462	1 059	1 521
% diff.	(-42,5)	-23,8	-15,3	-18,0
Experiment 5C: 90 - 90 km/h:				
Before	(61)	505	1 077	1 582
After	(60)	534	1 117	1 651
% diff.	(-1,6)	+5,7	+3,7	+4,4
Experiment 6B: 90 - 110 km/h:				
Before	(16)	79	86	165
After	(13)	85	96	181
% diff.	(-18,7)	+7,6	+11,6	+9,7
Experiment 6C: 90 - 90 km/h:				
Before				1 078
After				1 081
% diff.				+0,2
Experiment 7B: 90 - 110 km/h:				
Before	(7)	71	114	185
After	(14)	104	169	273
% diff.	(+100,0)	+46,5	+48,2	+47,6

Table 5.16 cont.: Sweden, accidents by severity before and after the change in speed limits

Period	Number of accidents			
	Fatal (or fatalities)	Injury	Damage only	Total
Experiment 7C: 90 - 90 km/h:				
Before	(19)	99	206	305
After	(14)	94	197	291
% diff.	(-26,3)	-5,1	-4,4	-4,6
Experiment 8: 130 - 110 km/h (on freeways):				
Before	(32)	385	751	1 136
After	(28)	321	631	952
% diff.	(-12,5)	-16,6	-16,0	-16,2

5.6 Australia

In 1972 a 70 mph (113 km/h) maximum speed limit was introduced in the state of Victoria. At the beginning of 1973 this limit was raised to 60 mph (97 km/h); in mid-1974 it was metricated to 100 km/h. The effects of the reduction of the speed limit from 70 mph on both vehicle speeds and accidents have been investigated[26].

5.6.1 Effect on speeds

The free speed of vehicles was measured at twelve rural sites in each year from 1972 to 1976. The weighted values of mean speed, standard deviation and 85-percentile speed are shown in Table 5.17.

The mean speed in 1974 dropped by 3,7 km/h compared with the previous year; the standard deviation dropped by 1,4 km/h and

the 85-percentile speed by 5,8 km/h. This substantial decline in the faster speeds is responsible for the reduction in the mean speed and the standard deviation. By 1976 the mean and the 85-percentile speeds had both increased to within 2 km/h of the 1973 speeds. This gradual increase in speed with time has also been observed in South Africa.

Table 5.17: Australia, the weighted mean parameters of speed on rural roads in Victoria, 1972 to 1976 (reference 26)

Measurement period	Mean speed km/h	Std dev. km/h	85 %-ile speed	Number of measurements
Nov./Dec. 1972	101,2	12,2	113,0	3 400
June/July 1973	99,4	12,1	111,7	3 400
Aug./Sep. 1974	95,7	10,7	105,9	3 178
Aug./Sep. 1975	95,2	11,4	106,7	4 412
Aug./Sep. 1976	97,6	11,8	109,4	4 118

5.6.2 Effect on accidents

Fatal and injury accidents for Victoria for the years 1973 to 1976 were divided into two categories - state highways and the rest of the state - and further divided into high speed zones (70 mph/60 mph/100 km/h speed limits) and low speed zones (speed limits lower than the above). It is not clear whether these zones equate with rural and urban areas. Possibly low speed zones would include some rural roads. These accidents are shown in Table 5.18.

Injury accidents declined on State highways and on other roads in both high and low speed zones. The reason for the introduction of the lower speed limit was not given. The OPEC oil crisis, which started in November 1973, occurred during the

Table 5.18: Australia, fatal and injury accidents in Victoria, 1973 to 1976 (reference 26)

Year	No. of accidents		% change from 1973		No. of accidents		% change from 1973	
	Fatal	Inj.	Fatal	Inj.	Fatal	Inj.	Fatal	Inj.
State roads: high speed zones					Other roads: high speed zones			
1973	188	1 431			176	1 791		
1974	155	1 212	-;8	-15	165	1 519	-6	-15
1975	183	1 242	-3	-13	186	1 684	+6	-6
1976	191	1 247	+2	-13	191	1 674	+9	-6
State roads: low speed zones					Other roads: low speed zones			
1973	82	1 794			360	9 469		
1974	76	1 609	-7	-10	343	8 204	-5	-13
1975	88	1 559	+7	-13	327	8 140	+6	-14
1976	88	1 504	+7	-16	360	8 255	+1	-13

study period. The reduction in the number of accidents might have been affected by factors associated with the crisis, such as a downturn in the economy, an increased fuel price, reduced travel and so forth.

The percentage reduction in injury accidents was similar in the four areas and the number of accidents in 1974, 1975 and 1976 was in all cases lower than the accidents recorded in 1973. If the reduction in speed was a factor in reducing the number of accidents - and from other countries' experiences there is no reason to doubt that it was - the similarity in the percentage reductions suggests that the effects of the lower speed limit were not confined to the roads to which it was applied.

The percentage reduction in the number of *fatal accidents* was lower than that of injury accidents. This is surprising because a reduction in speed would be expected to have a greater effect on the more severe accident. The numbers of fatal accidents are

rather small and we may just be observing a spurious result. Nevertheless, it is odd that the results should be so consistent in the four areas each year.

5.7 New Zealand

In December 1973 a 50 mph (80,5 km/h) maximum speed limit was introduced on New Zealand's roads as a fuel conservation measure. Prior to December 1973 the speed limit was 55 mph (88,6 km/h) or 60 mph (96,6 km/h). In 1975 the speed limit was metricated to 80 km/h and was still in force in 1980; it is therefore one of the lowest rural speed limits in the world. The effects of the speed limit one year before and after implementation have been described by Frith and Toomath[27].

5.7.1 Effect on speeds

Speeds on rural roads showed a dramatic drop immediately after the speed limit was introduced. The mean speed declined by between 8 and 10 mph (13 to 16 km/h) initially, then stabilized at about 3 to 5 mph (5 to 8 km/h) below previous levels. By 1980 vehicle speeds were still generally below 1973 levels. The 85-percentile speed declined most markedly, initially by 22 to 23 km/h, and by October 1979 the decreases ranged between 4 and 13 km/h.

5.7.2 Effect on casualties

Table 5.19 shows the changes in the numbers of fatalities and serious and slight casualties on urban and paved rural roads one year before and after the change in speed limit. There was

a substantial reduction in the number of casualties on rural roads; fatalities were affected the most and slight injuries the least. There was also a reduction in casualties in urban areas. Once again, economic conditions, reduced urban travel, abnormal driver behaviour following the oil crisis, or the carry-over effect of the rural speed limit into the urban areas - all or any combination of these factors could be responsible.

Table 5.19: New Zealand, casualties by severity before and after the imposition of the 50 mph maximum speed limit (reference 27)

Period	Casualties					
	Fatal		Serious		Slight	
	Urban	Rural	Urban	Rural	Urban	Rural
Before: Dec. 72 - Nov. 73	347	368	4 923	2 300	10 331	2 652
After: Dec. 73 - Nov. 74	294	231	4 480	1 743	9 909	2 070
Percentage diff.	-15,3	-37,2	-9,0	-24,2	-4,1	-21,9

5.8 Ireland

A maximum speed limit of 60 mph (96,6 km/h) was introduced on all rural roads on 1 April 1969. The effects were investigated by means of before-and-after speed measurements and accident comparisons[28].

5.8.1 Effect on speeds

Speed measurements were made on 69 high-speed sections of road during the period March to June in both 1968 and 1969, before and during the imposition of the speed limit; further measure-

ments were taken in October 1969. The results are shown in Table 5.20.

The effect of the speed limit was to increase the mean speed of vehicles slightly but to reduce the standard deviation of the speed and the 85-percentile speed. This suggests that the slower vehicles in the traffic stream travelled faster after the speed limit was introduced. By October 1969 the benefits of the speed limit were much diminished.

Table 5.20: *Ireland*, speed parameters before and during the introduction of the general 60 mph (96,6 km/h) speed limit (reference 28)

Measure of speed mph	Before	During	
	May-July 1968	May-July 1969	October 1969
Mean	50,0	50,3	51,0
Standard deviation	9,8	8,9	9,2
85-percentile	60,6	59,6	60,4
% vehs > 60 mph	16,4	13,8	15 9
% vehs > 70 mph	2,7	1,9	? ?

5.8.2 Effect on accidents

A new accident recording system had been introduced on 1 January 1968 and it was only possible to use 1968 accidents in the before study. The results are shown in Table 5.21.

The numbers of accidents in 1969 were similar to those of 1968 although there was an increase in rural traffic of between three and ten per cent. A comparison of accidents in urban areas showed that there the 1969 figures were about the same as those in 1968. No change in the number of accidents could be ascribed to the lower rural speed limit.

Table 5.21: Ireland, rural accidents by severity for the period April to October, 1968 and 1969 (reference 28)

Apr. to Oct.:	Accidents			
	Fatal	Injury	Damage only	Total
1968	169	2 059	3 156	5 584
1969	174	2 025	3 281	5 480
% diff.	+3,0	-1,7	-4,0	-1,9

This study supports, at least in part, the generalization made by Salusjärvi[19] that -

"if the speed limit is set to the 85th percentile speed the mean speed will be unaffected because the effect of faster drivers driving more slowly will be counteracted by the slower drivers driving more quickly. The standard deviation of the speed will decrease, leading to fatal and injury accidents decreasing but the overall number of accidents being unchanged."

5.9 Great Britain

Since 1956 there have been a number of speed limit trials outside built-up areas in Great Britain. The first large-scale trial involved the experimental introduction of a 40 mph (64,4 km/h) speed limit on 120 miles (193 km) of main road in the suburbs of London. Between 1959 and 1964 a 50 mph (80,5 km/h) limit was applied to certain heavily trafficked rural routes during summer weekends. In 1965 the 50 mph speed limit was applied permanently to 400 miles (650 km) of main road. At the end of 1965 a general maximum speed limit of 70 mph (112,7 km/h) was introduced.

The effects of these different speed limits have been investigated and the results have been well summarized by Newby[29,30]. The Road Research Laboratory has issued a Special Report on the 70 mph trial[31].

The OPEC oil crisis caused the British government to introduce a general 50 mph (80,5 km/h) maximum speed limit in December 1973. In March 1974 the 70 mph (112,7 km/h) speed limit was restored on motorways (freeways) and this was extended to other rural roads in May. In December 1974 speed limits were again reduced - to 60 mph (96,6 km/h) on dual-carriageway roads and 50 mph (80,5 km/h) on single-carriageway roads. The results of these speed limit changes have been reported by Scott and Barton[32].

5.9.1 The 1956 trials of the 40 mph (64,4 km/h) speed limit

Effect on speeds

The imposition of the 40 mph limit on previously unrestricted roads reduced vehicle speeds. The mean speed of cars on dual-carriageway roads decreased from 40,7 to 37,0 mph (65,5 to 59,6 km/h) and on single-carriageway roads from 36,4 to 33,6 mph (58,6 to 54,1 km/h). There was also a corresponding decrease in the speed of commercial vehicles. The proportion of vehicles exceeding 40 mph fell by half.

On roads where the speed limit had increased from 30 to 40 mph, a small increase in vehicle speeds was observed.

Effect on injury accidents

After six months' operation following the introduction of this speed limit, injury accidents were 20 per cent fewer than expected and fatal and serious injury accidents were 30 per cent fewer on the 72 miles (116 km) of road that was previously unrestricted.

On the 46 miles (74 km) of road that was previously subject to a 30 mph (48,3 km/h) speed limit, injury accidents increased by two per cent more than expected and fatal and serious injury accidents by eight per cent. Although these results were not significant, they were consistent with raising the speed limit.

A subsequent investigation confirmed that the initial results continued almost unchanged for the next 17 months[30]. A summary of the results is shown in Table 5.22.

5.9.2 The trials of the 50 mph (80,5 km/h) speed limit

Between 1959 and 1964 temporary 50 mph speed limits had been applied on certain rural roads during summer weekends (June, July and August). The results were encouraging and in 1965 the speed limit was applied permanently to 400 miles (650 km) of heavily trafficked road that had a high accident record. This mileage of road included sections that had previously been subject to the weekend speed limits.

Table 5.22: Great Britain, expected and observed injury accidents on roads after the introduction of the 40 mph speed limit (reference 30)

Period	No. of injury accidents				Percentage change	
	All injuries		Serious & fatal		All injuries	Serious & fatal
	Obs.	Exp.	Obs.	Exp.		
Roads formerly unrestricted:						
First 6 months	594	740	129	184	-19,7	-29,9
Next 17 months	1 869	2 297	432	589	-18,6	-26,7
Total 23 months	2 463	3 034	561	772	-18,8	-27,3
Roads formerly subject to a 30 mph speed limit:						
First 6 months	142	143	33	31	-0,7	+6,5
Next 17 months	390	376	88	81	+3,7	+8,6
Total 23 months	532	521	121	112	+2,1	+8,0

Effect on speeds

The speed of vehicles was measured before and after the introduction of the experimental 50 mph speed limits on summer weekends. Some results for the years 1960 to 1962, measured at one site west of London when the speed limit was operational and when it was not operational, are shown in Table 5.23.

The results were quite consistent and in every case the vehicle mean speed and the percentage of vehicles exceeding 50 mph was lower when the speed limit was in operation. The speed limit had only a small effect on the average speed of vehicles - a reduction of 2,7 km/h. The major benefit was the halving of the percentage of vehicles exceeding 50 mph.

In 1962 speeds were measured on road A24; this road was unrestricted. It was found that the vehicle mean speed was eight

per cent lower when the 50 mph speed limit was in operation, even though this particular road was unaffected by the limit[33]. It was suggested that the imposition of a speed limit on some roads might affect the speeds of vehicles at similar but unrestricted sites. The reduction of accidents at the unrestricted sites could have resulted from this reduction in vehicle speeds.

Table 5.23: Great Britain, mean speed of vehicles and percentage exceeding 50 mph on road A40, 1960 to 1962 (ref. 33)

Year	Day	50 mph SL.		Unrestricted		Percent. diff.	
		Mean spd. mph	% > 50 mph	Mean spd. mph	% > 50 mph	Mean spd.	> 50 mph
1960	Fri.	42,4	14	45,6	33	-7,0	-58
1960	Sun.	40,0	6	44,5	29	-10,1	-79
1960	Sun.	43,1	17	44,6	29	-3,4	-41
1961	Fri.	46,3	35	49,0	48	-5,5	-27
1961	Sun.	43,5	20	46,8	37	-7,1	-30
1962	Sun.	44,6	16	45,9	29	-2,8	-45
Mean		43,2	17	45,9	32	-5,9	-45

Effect on accidents and casualties

The percentage changes in the number of injury accidents and casualties during weekends in June to August, 1961 to 1964, compared with the corresponding period in 1959, are shown in Table 5.24. Three categories of road are shown in the table: (a) experimental roads, restricted to 50 mph at weekends; (b) control roads, similar to the experimental roads but unrestricted; (c) other unrestricted rural roads.

There were substantial reductions in the number of injury accidents and casualties on the roads subject to the weekend 50

km/h speed limit for each year between 1961 and 1964 when compared with 1959. This reduction did not decline with time, despite a considerable increase in traffic during this period.

There was also a substantial, though smaller, decrease in accidents and casualties on the control roads, both in comparison with 1959 and in comparison with other rural roads without speed limits. During the period 1960 to 1963 casualties on these other roads were lower than they were in 1959 but in 1964 they were nine per cent higher. The proportionately greater reduction in accidents on the control roads suggests that either there was a sudden change in travel patterns on these roads, or - which is perhaps more likely - the effect of the speed limit on the experimental roads carried over onto the unrestricted control roads.

Table 5.24: Great Britain, changes in injury accidents and casualties during weekends in June to August for the years 1961 to 1964 compared with 1959 (reference 29)

Year	Percentage reduction compared with 1959				
	Experimental roads		Control roads		Other roads
	Accs.	Cas.	Accs.	Cas.	Cas.
1961	-26	-21	-21	-18	-5
1962	-30	-30	-31	-28	-8
1963	-29	-26	-16	-15	-9
1964	-26	-20	-16	-10	+9
Average 1961-1964	-27	-24	-21	-18	-3

A permanent 50 mph speed limit was introduced in July 1965 and the fatal and serious accidents on approximately 100 miles (160 km) of road before and after the application of the speed limit were compared. As some of these 100 miles included sections

that were subject to the 50 mph weekend speed limit, the accidents for June to August were excluded from the analysis. In addition, similar accident data were collected for Class 1 and trunk roads within the same police area; these roads had no speed limit. The results are shown in Table 5.25.

The safety record on these rural roads is quite remarkable; between 1960 and 1967 traffic on rural main roads in Britain increased on average by 60 per cent and a substantial increase in the number of accidents would have been expected. Instead, we see that the number of serious and fatal accidents on the unrestricted roads was virtually constant over the seven-year period. On the roads subject to the 50 mph speed limit fatal and serious accidents dropped by 19 per cent during the two years after the introduction of the speed limit compared with the previous five years.

5.9.3 The 70 mph (112,7 km/h) speed limit trial

This speed limit was introduced just before Christmas 1965 on all previously unrestricted roads. In October 1967 the Road Safety Act was introduced, which included legislation on drivers' maximum permissible blood alcohol content. To avoid the effect of this legislation on safety, the speed limit after-study was ended in September 1967.

Effect on speeds

Speed measurements were made before and after the speed limit was introduced at three sites on motorways and at two sites on all-purpose roads - one a dual-carriageway road and the other a single-carriageway road.

Table 5.25: G.. Britain, a comparison of fatal and serious injury accidents on roads before and during the application of the permanent 50 mph speed limit and on similar unrestricted roads (reference 29)

Nine month period Sep.-May	No. of fatal and ser. inj. accidents	
	Experimental roads	Other unrestricted Class 1 & trunk roads
Before:		
1960-61	111	2 240
1961-62	108	2 005
1962-63	134	2 037
1963-64	150	2 187
1964-65	116	2 098
Average 1960-65	124	2 113
During:		
1965-66	100	2 157
1966-67	100	2 087
Average 1965-67	100	2 122

Motorways: Table 5.26 shows speed trends of cars at the three sites between December 1965 and April 1967. There was an immediate drop in the various speed parameters after the introduction of the speed limit and they remained fairly constant over the next 15 months. The mean speed dropped on average by 3,2 mph (5,2 km/h), the standard deviation by 2 mph (3,2 km/h) and the percentage of cars exceeding 70 mph by half.

All-purpose roads: Table 5.27 shows the speed trends of cars just before and nine months after the introduction of the speed limit. On the dual-carriageway A1 the mean speed of cars was lower than on the motorways, both before and after the introduction of the speed limit. The effect of the speed limit was also smaller than it was on the motorways: the mean speed dropped by 2,4 mph (3,8 km/h), the standard deviation of the speed by 0,2 mph (0,3 km/h) and the percentage exceeding 70 mph by about 30 per cent.

Table 5.26: Great Br.tain, combined speed parameters of cars at three motorway sites (reference 31)

Measurement period	Speed - mph		Percentage exceeding	
	Mean	Std dev.	70 mph	80 mph
Before: Mid-December 1965	64,2	11,3	29	8
During:				
Jan./Feb. 1966	60,3	8,5	10	1
Apr./May. 1966	61,2	9,4	15	2
September 1966	61,0	9,8	16	3
Dec. 1966/Jan. 1967	61,8	9,2	16	2
Mar./Apr. 1967 (two s es only)	60,7	9,7	14	1
Arithmetic mean Jan. 1966/Apr. 1967	61,0	9,3	14	2

Table 5.27: Great Britain, speed parameters of cars on all-purpose roads shortly before and nine months after the introduction of the 70 mph speed limit (ref. 31)

Road	Speed - mph		Percentage exceeding	
	Mean	Std dev.	70 mph	80 mph
A1 (dual-c/way):				
Before	59,2	10,0	14	2,5
After	56,8	9,8	10	1,5
A412 (single-c/way):				
Before	49,9	8,8	3	0
After	48,3	9,8	2,5	0,5

On the A412 single-carriageway road the effects of the speed limit were smaller still. Although the mean speed dropped by 1,6 mph (2,6 km/h), the standard deviation of the speed increased by 1 mph (1,6 km/h). The speed limit had virtually no effect on the percentages of vehicles exceeding 70 and 80 mph. This indicates that the cars originally travelling slower than the mean speed drove faster after the introduction of the speed limit.

Effect on accidents and casualties

Motorways: Table 5.28 shows the actual and expected numbers of casualties on motorways in 1966. Fatalities declined by nearly 40 per cent and all casualties by 20 per cent. This reduction was ascribed to the speed limit.

Table 5.28: Great Britain, predicted and observed numbers of casualties by severity on motorways in 1966 (*reference* 31)

Severity of casualty	Number		Percentage change
	Predicted	Observed	
Fatal	150	92	-38,7
Serious	752	667	-11,3
Slight	1 606	1 266	-21,2
All casualties	2 508	2 025	-19,3

All-purpose roads: An estimate of the number of accidents on different classes of road was done using regression analysis. The predicted number of accidents in 1966 was compared with the number observed and it was concluded that on rural main roads the 3,5 per cent lower accident rate could be ascribed to the 70 mph speed limit.

On a sample of approximately 100 miles (160 km) of dual-carriageway rural road, where a greater than average proportion of drivers exceeded 70 mph before the introduction of the speed limit, it was found that fatal and serious injury accidents in 1966 were 13 per cent lower than in 1965. On all other Class 1 and trunk roads the decline was only one per cent. Similarly, fatal and serious casualties declined by 21 per cent on these dual-carriageway roads and were unchanged on the remainder of the Class 1 and trunk road network.

It was also found that the injury accident rate on roads subject to 30 and 40 mph limits was also lower than predicted in 1966. The following statement is made in reference 31:

"Although the reasons for these differences are not at present understood they can hardly be associated with the 70 mph speed limit."

South African experience, however, strongly suggests that the application of a speed limit on part of the network can, and does, affect accidents elsewhere on the network.

5.9.4 The initial speed limit changes during the OPEC oil crisis

On 8 December 1973 oil supply problems caused the British government to impose a general maximum 50 mph (80,5 km/h) speed limit as one of several fuel conservation measures. On 29 March 1974 the 70 mph (112,7 km/h) speed limit on motorways was restored and on 8 May this limit was extended to all-purpose roads. During this period, a number of other factors occurred which were likely to have affected driver behaviour. These included the introduction of a three day working week, a 50 per cent reduction in street lighting, industrial action by the train drivers' union and fuel price rises.

Scott and Barton attempted to take some of these factors into account[32]. Their analysis was based upon changes in injury accident rates rather than changes in the number of accidents. This, it was felt, would overcome the problem of the change in traffic flow resulting from the factors mentioned above. They also divided accidents into daytime and night-time accidents, thereby separating the effects of the changes to the street lighting.

Effect on speeds

There is a lack of information on vehicle speeds. Some limited speed data for the M3 and M4 motorways are summarized in Table 5.29. The imposition of the speed limit had a sharp effect on the mean speed of cars and the percentage exceeding 70 mph. During the next few months both the mean speed and the percentage exceeding 70 mph crept upwards. The speed limit reduced the car mean speed by 13 mph (21 km/h) on average and the percentage of cars exceeding 70 mph from 49 to 6 per cent. When the speed limit was repealed, the speed of cars quickly returned to their original levels.

Table 5.29: Great Britain, speed of cars on the M3 and M4 motorways (reference 32)

Date of measurement	Mean speed mph	Percentage > 70 mph
Before:		
August/October 1973	70	49
During:		
December 1973	54	1
January 1974	57	3
February 1974	60	13
Mean	57	6
After:		
April 1974	66	34
September 1974	70	50

Effect on the injury accident rate

An estimate of the injury accident rate was made for each month from November 1973 to October 1974, assuming that there had been no change in the speed limit. This was based on the accident history from January 1969 to October 1973, using multiple linear

regression. The accident rate was calculated for different classes of road by daytime and by night-time.

Motorways: The daytime injury accident rates while and after the 50 mph speed limit was in operation are shown in Table 5.30. These observed values are compared with the predicted injury accident rates for each month. The 50 mph speed limit had a very considerable effect on the injury accident rate - a more than 40 per cent reduction. On the speed limit being restored to 70 mph, the accident rate returned to its previous level. For the seven-month period April to October 1974 the predicted and observed accident rates were within 2,5 per cent of one another.

Table 5.30: Great Britain, predicted and observed daytime injury accident rates on motorways, December 1973 to October 1974 (reference 32)

Month and year	Injury accident rate (accs/10^8 veh. km)		
	Predicted	Observed	Percentage change
During:			
Dec. 73	0,114	0,085	-25,4
Jan. 74	0,138	0,075	-45,7
Feb. 74	0,115	0,057	-50,4
Mar. 74	0,115	0,075	-34,8
Mean	0,127	0,073	-42,5
After:			
Apr. 74	0,106	0,115	+8,5
May 74	0,121	0,139	+14,9
June 74	0,121	0,110	-9,1
July 74	0,138	0,111	-19,6
Aug. 74	0,118	0,127	+7,6
Sep. 74	0,112	0,132	+17,8
Oct. 74	0,109	0,114	+4,6
Mean	0,118	0,121	+2,5

All-purpose rural roads: Table 5.31 shows the daytime injury accident rates for roads previously subject to a 50 or 70 mph speed limit during the period the 50 mph speed limit was in operation and for six months after. The observed values were consistently below the predicted values during the currency of the speed limit - on average by 16 per cent. After the speed restriction was lifted, the injury accident rate quickly increased to its former value.

Table 5.31. Great Britain, predicted and observed daytime injury accident rates on all-purpose rural roads (ref. 32)

Month and year	Injury accident rate (accs/10^8 veh. km)		
	Predicted	Observed	Percentage change
During:			
Dec. 73	0,553	0,520	-6,0
Jan. 74	0,498	0,398	-20,1
Feb. 74	0,508	0,385	-24,2
Mar. 74	0,413	0,343	-16,9
Apr. 74	0,391	0,328	-16,1
Mean	0,473	0,395	-16,5
After:			
May 74	0,416	0,392	-5,8
June 74	0,419	0,416	-0,7
July 74	0,438	0,409	-6,6
Aug. 74	0,404	0,387	-4,2
Sep. 74	0,407	0,457	+12,3
Oct. 74	0,453	0,445	-1,8
Mean	0,423	0,418	-1,2

There was a much smaller percentage reduction in the accident rate on all-purpose roads than there was on motorways. However, in the period November 1973 to July 1974 there were 2 100 injury accidents on motorways compared with 36 500 injury accidents on all-purpose rural roads. In absolute terms, the speed limit had the greatest effect on the latter.

All-purpose rural roads: Table 5.31 shows the daytime injury accident rates for roads previously subject to a 50 or 70 mph speed limit during the period the 50 mph speed limit was in operation and for six months after. The observed values were consistently below the predicted values during the currency of the speed limit - on average by 16 per cent. After the speed restriction was lifted, the injury accident rate quickly increased to its former value.

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All-purpose urban roads: An analysis similar to that undertaken for motorways and all-purpose rural roads was also done for roads subject to a 30 or 40 mph (48,3 or 64,4 km/h) speed limit. Although these roads are not directly affected by the 50 mph speed limit, it is quite feasible that a change in driver behaviour on rural roads brought about by the lower speed limit might well affect driver behaviour, and hence safety, in urban areas. The results are shown in Table 5.32.

Table 5.32: Great Britain, predicted and observed daytime injury accident rates on all-purpose urban roads (ref. 32)

Month and year	Injury accident rate (accs/10^8 veh. km)		
	Predicted	*Observed*	Percentage change
During:			
Dec. 73	2,063	2,225	+7,9
Jan. 74	1,905	1,975	+3,7
Feb. 74	2,010	1,941	-3,4
Mar. 74	1,936	1,894	-2,2
Apr. 74	1,850	1,808	-2,3
Mean	1,953	1,969	+0,8
After:			
May 74	1,933	1,970	+1,9
June 74	1,899	1,917	+0,9
July 74	1,821	1,842	+1,2
Aug. 74	1,751	1,819	+3,9
Sep. 74	1,956	2,202	+12,6
Oct. 74	2,123	2,116	-0,3
Mean	1,914	1,978	+3,3

The observed injury accident rate showed a nearly one per cent increase compared with the predicted rate during the period of the 50 mph speed limit. After the speed limit was restored to 70 mph, the predicted injury accident rate showed a 3,3 per cent increase over the observed rate. These results do not differ significantly and we cannot say that the lower rural speed limit had any effect on the urban injury accident rate.

However, if we look at the urban accidents from another viewpoint, we get a quite different result. Daytime injury accidents and estimated total traffic flow on roads with a 30 or 40 mph speed limit for the period December 1973 to March 1974, and the mean values for the same period in the years 1969/70, 1970/71 and 1972/73, are shown in Table 5.33.

Table 5.33: Great Britain, daytime injury accidents and estimated traffic flow for the period December to March on urban roads (reference 32)

Period	No. of daytime injury accs (1)	Total traffic flow (million veh. km) (2)	(1)/(2)
Before: Dec.-Mar. 69/70 70/71 72/73 (mean value)	37 951	16 887	2,247
During: Dec.-Mar. 73/74	33 863	16 991	1,993
Percentage diff.	-10,8	+0,6	-11,3

During the period the 50 mph speed limit was in operation, daytime urban accidents decreased by ten per cent compared with an earlier three-year average for the same period, when the 70 mph speed limit prevailed. This was despite a slight increase in the total (daytime plus night-time) traffic volume in 1973/74 compared with the earlier years. If the ratio of the daytime traffic flow to total traffic flow remained constant during the analysis period, then the urban accident rate dropped by 11 per cent in 1973/74. This approach suggests that the urban accident rate fell following the reduction in the rural speed limit.

5.9.5 The later speed limit changes during the OPEC oil crisis

On 14 December 1974 general speed limits of 50 mph (80,5 km/h) on single-carriageway roads and 60 mph (96,6 km/h) on dual-carriageway roads were introduced; motorways were unaffected. The reason for the speed limit change was not given in reference 32, nor was the date when the speed limit was lifted.

Effect on speeds: There was again little information about vehicle speeds. Table 5.34 gives details before and after the introduction of the 50 mph speed limit on three single-carriageway main roads. The reduction in the mean speed and the standard deviation of the speed just after the imposition of the speed limit was 2 mph (3,2 km/h) but two to three months later this reduction had halved. The effect of the speed limit was to reduce the speed of the faster drivers but, again, the reduction in the percentage of drivers exceeding 50 mph (80,5 km/h) after three months was only half of the initial reduction.

Table 5.34: Great Britain, vehicle speed parameters on single carriageway A-class rural roads before and during the introduction of the 50 mph (80,5 km/h) speed limit (reference 32)

Period of measurement	Speed - mph		Percentage > 50 mph
	Mean	Std dev.	
Before: Dec. 1974	46,6	8,0	26
During: Dec. 1974	44,6	6,0	3
Feb./Mar. 1975	45,7	7,4	20

Effect on the accident rate

The effect of the speed limit was analysed in the same fashion as was done in subsection 5.9.4, i.e. the observed accident rate was compared with a predicted rate based on past trends.

Motorways: Although the speed limit did not affect motorways, reference to Table 5.35 shows that the motorway accident rate during the period the lower speed limit was in force on all-purpose rural roads was lower than predicted six months out of seven.

Table 5.35: Great Britain, predicted and observed daytime injury accident rates on motorways, April 1974 to July 1975 (reference 32)

Month and year	Injury accident rate (accs/10^8 veh. km)		
	Predicted	Observed	Percentage change
Before:			
Apr. 74	0,106	0,115	+8,5
May 74	0,121	0,139	+14,9
June 74	0,121	0,110	-9,1
July 74	0.138	0,111	-19,6
Aug. 74	0,118	0,127	+7,6
Sep. 74	0,112	0,132	+17,8
Oct. 74	0,109	0,114	+4,6
Nov. 74	0,188	0,163	-13,3
Mean	0,128	0,126	-1,6
During:			
Jan. 75	0,188	0,138	-26,6
Feb. 75	0,165	0,152	-7,8
Mar. 75	0,145	0,173	+19,3
Apr. 75	0,132	0,118	-10,6
May 75	0,135	0,134	-0,7
June 75	0,131	0,130	-0,8
July 75	0.149	0,128	-14,1
Mean	0,156	0,145	-7,1

Prior to the introduction of this speed limit, the mean values of the predicted and observed accident rates were almost the same. Nevertheless, the variability between the predicted and observed rates from month to month means that these findings are not statistically significant.

All-purpose rural roads: Monthly predicted and observed accident rates for these roads, before and during the period of the lower speed limit are shown in Table 5.36. Immediately after the introduction of the speed limit, the accident rate was well below the predicted value but the difference between the

Table 5.36: Great Britain, predicted and observed daytime injury accident rates on all-purpose rural roads, May 1974 to July 1975 (reference 32)

Month and year	Injury accident rate (accs/10^8 veh. km)		
	Predicted*	Observed*	Percentage change
Before:			
May 74	0,416	0,392	-5,8
June 74	0,419	0,416	-0,7
July 74	0.438	0,409	-6,6
Aug. 74	0,404	0,387	-4,2
Sep. 74	0,407	0,457	+12,3
Oct. 74	0,453	0,445	-1,8
Mean	0,423	0,418	-1,2
During:			
Jan. 75	0,650	0,532	-18,2
Feb. 75	0,649	0,499	-23,1
Mar. 75	0,530	0,494	-6,8
Apr. 75	0,479	0,456	-4,8
May 75	0,489	0,482	-1,4
June 75	0,478	0,480	+0,4
July 75	0.520	0,489	-6,0
Mean	0,542	0,490	-9,6

* Predicted and observed accident rates for May to October 1974 are daytime accident rates, whereas for the period January to July 1975 they are 24-hour accident rates.

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* Predicted and observed accident rates for May to October 1974 are daytime accident rates, whereas for the period January to July 1975 they are 24-hour accident rates.

observed and predicted values was much smaller after two months.

All-purpose urban roads: Table 5.37 shows that the effect of the speed limit on all-purpose rural roads probably had little, if any, effect on the accident rate on urban roads. The observed accident rate before the speed limit was applied was just over three per cent higher than the predicted value; after, it was just over one per cent higher. Unfortunately, reference 32 did not include the information to enable an analysis to be done such as was done in Table 5.34.

Table 5.37: Great Britain, predicted and observed daytime injury accident rates on all-purpose urban roads, May 1974 to July 1975 (reference 32)

Month and year	Injury accident rate (accs/10^8 veh. km)		
	Predicted*	Observed*	Percentage change
Before:			
May 74	1,933	1,970	+1,9
June 74	1,899	1,917	+0,9
July 74	1,821	1,842	+1,2
Aug. 74	1,751	1,819	+3,9
Sep. 74	1,956	2,202	+12,6
Oct. 74	2,123	2,116	-0,3
Mean	1,914	1,978	+3,3
During:			
Jan. 75	2,311	2,270	-1,8
Feb. 75	2,191	2,095	-4,5
Mar. 75	2,114	2,175	+2,9
Apr. 75	2,012	2,075	+3,1
May 75	2,030	2,025	-0,2
June 75	1,932	2,053	+6,3
July 75	1,934	2,037	+5,3
Mean	2,075	2,104	+1,4

* Predicted and observed accident rates for May to October 1974 are daytime accident rates, whereas for the period January to July 1975 they are 24-hour accident rates.

Summary of the effects of the lower speed limits as a result of the OPEC oil crisis

There was a substantial drop in the accident rate on motorways and rural all-purpose roads during the first period of the lower speed limits (December 1973 to March/May 1974). After the speed limits were restored, the accident rates and car speeds quickly returned to their original levels. There was some indication of a drop in accident rates in urban areas, even though there was no change in the speed limit on these roads. The reduction in vehicle speeds and accident rate was greatest just after the introduction of the speed limit. As time passed, these effects diminished.

The accident rate was much less affected by the second period of the lower speed limit (introduced in mid-December 1974). This speed limit was applied to all-purpose rural roads only, but the accident rate on motorways showed a fall after the introduction of the limit; there was also a possibility that the urban rate showed a small change.

5.10 West Germany

5.10.1 The 100 km/h speed limit trial[34]

On 1 October 1972 a trial 100 km/h speed limit was introduced on two-lane rural roads in Germany. The experiment was designed to find out whether the speed limit reduced vehicle speeds, improved safety and adversely affected traffic operations. The experiment was planned to last for several years and a special team was appointed to evaluate the effects of the speed limit. The OPEC oil crisis at the end of 1973 seriously

affected the results of the experiment. From the end of November 1973 until mid-March 1974 an 80 km/h speed limit was imposed on rural roads and a 100 km/h limit on autobahns (freeways). In addition, the project team reported that seat belt wearing-rates increased and vehicle design improved during the course of the experiment.

Effect on speeds

The introduction of the speed limit had an immediate and pronounced effect on the speed of vehicles but after a few months the speed crept upwards and stabilised at a level lower than previously. The greatest effect was observed on the higher speeds and the effect on the percentage of vehicles exceeding 120 km/h on different categories of rural road, before and after the introduction of the speed limit, is shown in Table 5.38. These figures are unaffected by the OPEC oil crisis. The speed limit had its greatest effect, as might be expected, on the high speed roads.

Table 5.38: West Germany, percentage of vehicles exceeding 120 km/h on different categories of rural road before and after the introduction of the 100 km/h speed limit (reference 34)

Category of road	% of vehicles exceeding 120 km/h	
	Before	After
High speed/high volume	11,2	4,9
Lower speed/high volume	4,6	2,5
High speed/ low volume	10,1	3,9
Lower speed/ low volume	5,4	3,1

The lower speed limits during the OPEC oil crisis (80 km/h on rural roads, 100 km/h on autobahns) further reduced vehicle

speeds. The percentage of vehicles exceeding 100 km/h on two-lane rural roads dropped from 24 per cent to 8 per cent. The 100 km/h speed limit was restored in mid-March 1974 and the percentage of vehicles exceeding 100 km/h immediately increased. For the next six months at least, the percentage exceeding 100 km/h was consistently three per cent lower than the same month one year earlier. A similar phenomenon was observed in South Africa in 1979 when the rural speed limit was restored to 90 km/h after three months at 70 km/h. The mean speed and the 85-percentile and 20-percentile speeds of cars were all lower during the five months after the 90 km/h limit was restored than before it had been reduced[35].

Effect on accidents

Injury accidents two years before and after the introduction of the speed limit on urban and rural roads are shown in Table 5.39. There were substantial percentage reductions in the rural accidents, particularly on the Federal rural roads. It was reported that there was a drop in the number of accidents on the rural roads in 1972/73 after the introduction of the 100 km/h speed limit and this was followed by a further fall in 1973/74

Table 5.39: West Germany, injury accidents two years before and after the introduction of the 100 km/h speed limit (reference 34)

Type of road	No. of inj. accs for 2 years:		Percentage change
	Before (70-72)	After (72-74)	
Urban	479 560	453 504	-5,4
Federal rural	91 070	70 662	-22,4
Other rural	122 864	109 897	-10,6
Autobahns	31 833	29 259	-8,1
Total	725 327	663 392	-8,5

owing to the oil crisis. Urban injury accidents were also reduced by 26 000 during the two-year period, despite the speed limit on these roads remaining unchanged.

Accidents and casualties are compared on four categories of rural road one year before and one year after the imposition of the 100 km/h limit in Table 5.40. The OPEC oil crisis did not affect these results. The more severe casualties on roads designed for high speeds carrying high volumes showed the greatest reductions. The only category of road to show an increase in accidents and casualties after the introduction of the speed limit was the lower design speed road with little traffic.

Table 5.40: West Germany, accidents by severity on different categories of rural road (excluding autobahns) before and after the introduction of the 100 km/h speed limit (reference 34)

Category of road	Accident and casualty severity	12-month period:		Percentage change
		Before (71/72)	After (72/73)	
High speed/high volume	Injury accs	533	466	-12,6
	Fatal & ser. inj. cas.	474	296	-37,6
Lower speed/high volume	Injury accs	390	374	-4,1
	Fatal & ser. inj. cas.	276	247	-10,5
High speed/ low volume	Injury accs	603	506	-16,1
	Fatal & ser. inj. cas,	452	349	-22,8
Lower speed/low volume	Injury accs	414	418	+1,0
	Fatal & ser. inj. cas.	261	276	+5,8
All roads	Injury accs	1 940	1 760	-9,3
	Fatal & ser. inj. cas.	1 403	1 168	-16,8

5.11 United States of America

In March 1974 the OPEC oil embargo caused the US government to reduce the maximum speed limit to 55 mph (88,6 km/h) as a fuel conservation measure. In the following year, the number of fatalities declined by 17 per cent and Congress made the speed limit permanent. The measure has proved to be very contentious and the National Research Council was requested to investigate the benefits of the speed limit. A committee was set up and it reported in 1984[11]. The major findings of the study were as follows:

* The 55 mph speed limit led to slower speeds and more uniform travel which, was in turn responsible for between 3 000 and 5 000 of the 9 100 fewer fatalities recorded in 1974.

* The reduction in fatalities that occurred in 1974 was not a temporary phenomenon. It is estimated that in 1983, for example, between 2 000 and 4 000 fatalities, 2 500 and 4 500 serious injuries and 34 000 and 61 000 slight injuries were a direct consequence of the 55 mph speed limit.

* The speed of vehicles is still well below that prevailing before the 55 mph limit was introduced. For example, the mean car speed on the rural Interstates increased from 57,6 mph in 1974 to 59,1 mph in 1983 (92,7 km/h to 95,2 km/h). This is much lower than the 65 mph (105 km/h) recorded in 1973.

* Each highway user spends on average seven hours more per year driving at 55 mph than driving at 1973 speeds. (If 1973 speeds were re-introduced, some of the time saved by drivers would be used to make additional trips and it is

not clear whether this has been taken into account in estimating the seven hours.)

The recommendations of the committee were as follows:

* The 55 mph speed limit should be retained on most of the highways now posted at 55 mph. The members of the committee disagreed on whether the speed limit should be retained on all roads, particularly the Interstate system.

* The federal government should continue its overseeing role of withholding funds from states that do not enforce driving speeds adequately. However, it was proposed that the federal government measure state compliance by means of a points system that attaches more significance to high speed violations than to violations just above the speed limit (this implies that the standard deviation of the speed has a greater effect on accidents than does the mean speed).

5.11.1 Effect on speeds

Reference 11 does not give a great deal of information about vehicle speeds before and after the introduction of the speed limit in 1974. Table 5.41 lists details of mean speeds on rural and urban Interstates and rural primary roads in the years 1973, 1974 and 1983.

The introduction of the speed limit had the greatest effect on speeds on the rural Interstates; after nine years most of the benefits had been retained. On urban Interstates the fall in mean speed was smaller and the speed had increased by 1983 to close to the 1973 level. The reduction in the mean speed was

Table 5.41: USA, mean speeds on selected roads before and during the period of the 55 mph speed limit (reference 11)

Category of road	Speed - mph					Retained benefit %
	Mean 1973	*Mean* 1974	*Change* 73-74	*Mean* 1983	*Change* 74-83	
Rural Interstate	65,0	57,6	-7,4	59,1	+1,5	79,7
Urban Interstate	57,0	53,1	-3,9	56,8	+3,7	5,1
Rural primary	57,1	53,5	-3,6	54,6	+1,1	69,4

Note: The retained benefit of the speed limit =
[(1973 speed - 1983 speed)/(1973 speed - 1974 speed)] x 100

least on the rural primary roads but most of the benefit accruing to these roads had been retained in 1983.

5.11.2 Effect on accidents and casualties

In 1974 the fatality rate per 100 million vehicle miles was 3,59 compared with 4,24 in 1973 (2,23 compared with $1,39/10^8$ veh km), a 15,3 per cent reduction. This was the greatest reduction in any one year since the Second World War. A number of states have undertaken studies into the effects of the introduction of the 55 mph speed limit on their accidents. In most cases the investigations concentrated on the change in the numbers of fatal accidents or fatalities or in the fatal accident or fatality rates.

Since the war the fatality rate in the United States had been steadily declining. The introduction of the 55 mph speed limit was accompanied by a fuel shortage, increased fuel cost and reduced travel. In determining the effect of the speed limit on safety, many of the studies attempted to separate the effects of these other factors. Some results are summarized in Table 5.42.

Table 5.42: USA, proportion of the change in safety in individual states attributed to the 55 mph (88,6 km/h) speed limit in 1974 (reference 11)

State	Study period	Effect
Arizona	1973/74	34% of the reduction in fatal accident rate on Interstate, US and state highways
California	1969/74	46% of the reduction in fatalities on roads with changed speed limits
California	1964/74	39% of the reduction in fatalities on roads with changed speed limits
Illinois	1971/77	60% of the reduction in fatal accidents in 1974 compared with 1971/73 on affected roads compared with unaffected roads
Maryland	1970/76	21 to 24% of the reduction in fatalities on affected roads
Michigan	1972/74	38% of the reduction in fatal accidents on major state roads and 8% on Interstate roads
Texas	1972/74	57% of the reduction in fatalities on affected roads compared with unaffected roads

Despite methodological differences between the various studies, the results are broadly consistent.

In Arizona fatalities declined on all highways but most (92 per cent) took place on high-speed roads. In North Carolina and Michigan, on the other hand, fatalities fell equally on roads posted at or below 55 mph and on the Interstate roads. Mean speeds and speed variance declined on all types of roads and it was postulated that either drivers slowed down on all roads to save fuel or there was a carry-over effect from the high-speed roads onto the lower-speed roads.

In Texas the fatality rate, fatal accident rate, injury rate and injury accident rate declined significantly, well below historic

trends, when the 55 mph speed limit was introduced and remained below projections when the fuel shortage abated. The effects of the speed limits appeared to diminish in later years.

5.11.3 The National Crash Severity Study

In this subsection some results from American data are presented that shed further light on the distribution of collision speeds and their effect on the probability of a fatal accident.

Between 1977 and 1979 a National Crash Severity Study (NCSS) was undertaken in seven regions in the United States of America. This project involved teams of trained investigators examining a stratified sample of accidents that involved one or more passenger cars having to be towed away from the scene of the accident.

Within each designated area:

* all reported accidents were investigated where a car occupant was hospitalized overnight or fatally injured.

* half of the reported accidents were investigated where at least one casualty was hospitalized, but not overnight.

* one-tenth of the remaining reported accidents were investigated, whether or not any car occupant was injured.

Estimates of the total number of injury accidents in the survey areas involving a towed-away car were obtained by multiplying the sum of each accident category by the reciprocal of its weighting and summing the totals.

Included in the data collected were details of the vehicle damage, vehicle mass and vehicle model, an estimate of the direction of travel and an estimate of vehicle speed. These data are used to calculate a parameter known as Delta-V. This is a measure of the change in velocity in the collision but takes the angle of impact, the crushability of the vehicles involved in the collision, their mass and so on into account as well. For example, two identical cars, each travelling at the same speed in opposite directions and colliding head on, could each have a Delta-V of 50 km/h. A large heavily laden truck colliding head on with a small car, each vehicle travelling at an identical speed, might result in a Delta-V of 10 km/h for the truck and, say, 90 km/h for the car.

Results

It was possible to access the NCSS data file at the University of Michigan and the numbers and percentages of fatalities and non-fatalities involving car occupants for different values of Delta-V were extracted. These data are shown in Table 5.43.

One per cent of car occupants died in tow-away accidents. Only 10 per cent of occupants were in accidents with a Delta-V greater than 20 mph (32 km/h) but this 10 per cent included 80 per cent of the fatalities. Figure 5.1 shows the distribution of the percentages of occupants involved in accidents against Delta-V. Most of the accidents (40 per cent) occurred with a Delta-V of between 6 and 10 mph (10 and 16 km/h).

Figure 5.2 shows the percentages of fatal and non-fatal car occupants involved in accidents for different values of Delta-V. Below 30 mph (48 km/h) the chance of survival is high but above this value one's chances diminish rapidly. Approximately half

Table 5.43: USA, Delta-V and car occupant fatalities and non-fatalities, extracted from the NCSS data files

Delta-V mph	Injuries to car occupants in tow-away accidents				
	Fatal		Non-fatal		Total
	No.	%	No.	%	No.
1 - 5	6	0,1	5 907	99,9	5 913
6 - 10	18	0,1	20 260	99,9	20 278
11 - 15	27	0,2	13 406	99,8	13 433
16 - 20	59	1,0	5 999	99,0	6 058
21 - 25	56	2,3	2 420	97,7	2 476
26 - 30	73	6,4	1 075	93,6	1 148
31 - 35	67	1,5	515	88,5	582
36 - 40	47	22,0	167	78,0	214
41 - 45	33	23,2	109	76,8	142
46 - 50	35	46,1	41	53,9	76
51 - 55	22	46,8	25	53,2	47
56 - 60	19	33,9	37	66,1	56
61 - 65	13	41,9	18	58,1	31
66 - 70	5	45,5	6	54,5	11
71 - 75	6	100,0	0	0,0	6
81 - 85	1	100,0	0	0,0	1
86 - 90	1	25,0	3	75,0	4
91 - 95	1	100,0	0	0,0	1
96 -100	1	100,0	0	0,0	1
Total	490		49 749		50 478

of car occupants will die in accidents with a Delta-V of between 60 and 70 mph (97 and 113 km/h). Above 70 mph (113 km/h) the probability of survival is very small.

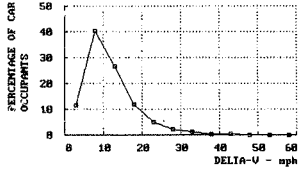

Figure S.1: Distribution of the percentage of car occupants involved in tow-away accidents for different values of Delta-V

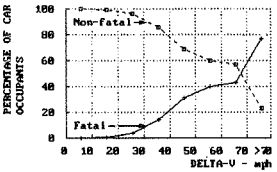

Figure S.2: Percentages of fatal and non-fatal car occupants involved in tow-away accidents for different values of Delta-V

5.12 Summary of foreign experience

In this chapter speed limit changes on the rural roads of 11 countries have been reviewed. The effects of 46 changes of speed limit have been described. Of these, 39 changes were downwards and resulted in a reduction in accidents or casualties, two changes were downwards and resulted in a slight increase in accidents or casualties, and five changes were upwards and resulted in an increase in accidents or casualties. Some of the decreases in accidents and casualties reported have been very considerable - of the order of 50 per cent.

Of the two downward changes in rural speed limit that resulted in an increase in accidents, in one of them (Ireland 1969) the speed limit actually caused the mean speed to increase by a small amount, which resulted in fatal accidents increasing. In the other case (Swaden 1968-1972 - Experiment 2) a speed limit of 110 km/h was applied to previously unrestricted roads but no details were given of the change in mean speed.

Mention has been made of the role played by the economy in the number of accidents and of the fact that some of the before-and-after results of the analyses might have been affected by this factor. Nevertheless, the experiences of these countries have been very consistent and, when considered together, they present a persuasive argument that the rural speed limit is an important variable that has a significant effect on the accident rate.

The accident data reviewed in this chapter has provided some evidence that the effect of a speed limit is not confined to that portion of the network to which the speed limit applies, but that it can carry over into other parts of the network.

This implies that the effects of a change in speed limit on safety have been understated; this is an aspect that requires further investigation.

The nature of the relationship between a change in speed limit and the corresponding change in safety is investigated in Chapter 7.

The analysis of the American National Crash Severity Study results in subsection 5.11.3 has shown that most accidents involve a small change in speed and that the probability of survival is high. Accidents involving a Delta-V of more than 100 km/h are extremely dangerous and the probability of survival is 50 per cent or less. The rural speed limit at the time of writing is 120 km/h on freeways and the same speed limit has recently been introduced on many major non-freeway routes, including two-lane two-way roads. A crash involving a Delta-V of 120 km/h will result in almost certain death to the car occupants.

CHAPTER 6

SPEEDS, SPEED LIMIT CHANGES AND ROAD SAFETY IN SOUTH AFRICA

This chapter describes the results of speed measurements done on Transvaal rural roads and three investigations into the effects of speed limit changes.

6.1 Vehicle speeds on Transvaal rural roads, 1970 to 1985

The National Institute for Transport and Road Research has been measuring vehicle speeds regularly since the 1960s at six sites on Transvaal rural roads. Until the OPEC oil crisis in 1973 the vehicle speeds were measured annually; since then the period has been reduced to approximately six-weekly intervals. The speed measurements are done on weekdays during off-peak periods. Three of the sites are on freeways and the other three sites are on two-lane two-way roads; all the sites are on straight and level sections. The mean speeds of all vehicles during this period, together with the speed limits, are shown in Figure 6.1.

It is clear from the figure that the mean speed is influenced by the speed limit. The oil shortages of 1973 and 1979 and the accompanying publicity undoubtedly also had an effect. The level of speed limit enforcement and the fuel price possibly contributed as well.

Until 1974 the vehicle mean speed on freeways was up to 20 km/h

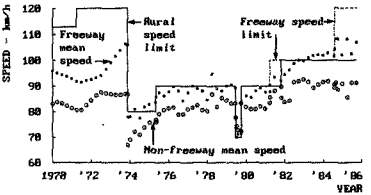

Figure 6.1: Maximum rural speed limits and mean speed of all vehicles on freeways and non-freeway rural roads - 1970 to 1985

higher on freeways than on non-freeway roads. Between 1974 and 1983 the difference reduced to between 6 and 8 km/h. This did not apply during the three-month period in 1979 when a 70 km/h speed limit was in force; then the mean speeds were the same. In 1983 the difference increased to 10 km/h and in 1984, when the rural freeway speed limit was raised to 120 km/h, the gap widened to nearly 20 km/h.

The weighted mean speed of all vehicles on the six sites in Transvaal at the end of 1985 is about 15 km/h higher than it was at the beginning of 1970.

Two reductions in the speed limit are shown in the figure (November 1973 and June 1979). On these occasions, the speed of vehicles dropped sharply and immediately. When the speed limit was increased, on the other hand, a small initial increase in mean speed was followed by a slow growth in speed

that took place over a period of years. This suggests that the mean speed would be a much better variable than the speed limit for predicting accidents. When the mean speed exceeds the speed limit, and assuming the speeds are normally distributed, more than 50 per cent of vehicles are exceeding the limit. Figure 6.1 shows that this happened on several occasions on freeways during the 10 years, which confirms the view expressed by other researchers that the speed limit is a measure that is widely flouted.

6.2 The effect of speed limit changes

There have been three investigations into the effects of speed limit changes in South Africa[23,35,36] and the results are summarized below.

6.2.1 The 80 km/h speed limit in 1973

The OPEC oil crisis caused the South African government to introduce certain fuel conservation measures. On 14 November 1973 the maximum speed limit on rural roads was reduced from 120 km/h to 80 km/h and the urban limit was reduced from 60 km/h to 50 km/h; on 25 January 1974 the latter was restored to 60 km/h. On 7 December 1973 the sale of petrol was restricted to the hours between 06h00 and 18h00. The first six months' operation at the lower speed limits were investigated[35].

Effect on speeds

Spot speed measurements of light vehicles on rural roads in three provinces, before and after the reduction of the speed limit, are summarized in Table 6.1. The speeds in the Trans-

vaal are much higher than in the other two provinces, both before and after the reduction in the speed limit. The Transvaal is an inland province and the measured speeds tend to confirm the finding of the Markinor survey - which was done ten years later - that drivers from the inland cities prefer to drive faster than do drivers from the coastal cities (see subsection 4.1.2). The greatest changes in speed, both absolute and percentage, were also recorded in the Transvaal.

Table 6.1: Rural speed measurements before and after the introduction of the 80 km/h speed limit (reference 35)

Me-	Province		
	Transvaal	Cape	Natal
Mean speed - km/h:			
Before	108	94	-
After	73	69	-
Change	-35	-25	-
Percentage change	-32%	-27%	-
85-percentile speeds - km/h:			
Before	128	110	97
After	83	78,5	79
Change	-45	-21,5	-18
Percentage change	-35%	-23%	-19%

The changes in both the mean and the 85-percentile speed in Table 6.1 are very large. Unfortunately, no speed measurements were taken in urban areas.

The effect of time on light vehicle speeds on Transvaal rural roads is illustrated in Table 6.2. Although the mean speed dropped on average by 30 km/h in the week after the introduction of the 80 km/h speed limit, the mean speed continued to fall slowly during the following few weeks. Thereafter, the mean speed rose slightly. The greatest speed reductions were recorded on the freeways.

Table 6.2: The *mean* speed of light vehicles on six Transvaal rural roads before and after the introduction of the 80 km/h speed limit (reference 35)

Period	Road number					
	General purpose rural road				Rural freeway	
	T122-1	P1-3	P1-3	P27-1	N1	N4
Before:						
June 1972	95,2	88,0	109,2	113,1	114,7	110,6
June 1973	94,9	89,9	106,7	112,5	124,5	118,4
During: Week No. from 14 Nov. 1973						
1	67,7	70,9	77,8	82,2	82,9	82,8
2	-	63,8	74,5	76,6	76,5	81,5
3	63,1	59,8	72,2	74,5	-	77,3
4	61,5	70,2	85,8	-	70,6	-
5	62,9	65,4	69,4	74,1	69,2	-
8	-	68,1	72,3	70,9	78,2	79,0
15	71,5	67,9	71,9	75,4	-	79,9
19	72,2	67,1	75,0	74,4	82,1	80,6
23	71,7	69,0	76,4	76,1	80,0	79,4
26	69,5	69,9	73,9	72,7	75,4	75,1

Effect on accidents and *casualties*

Predicted monthly accidents and casualties from November 1973 to April 1974 were calculated and compared with the numbers recorded. The predictions were based on the assumption that the trends during the previous three or four years would have continued. The numbers were estimated by linear regression, extrapolating the monthly data from 1970. The results are shown in Table 6.3.

The South African economy was growing steadily during the whole of 1973 and strongly during the first half of 1974. It has previously been demonstrated that accidents and casualties increase during periods of economic growth[23]. The predicted

Table 6.3: Predicted and recorded numbers of accidents and casualties, November 1973 to April 1974 (ref. 35)

Month	Urban			Rural		
	Predicted No.	Actual No.	% diff.	Predicted No.	Actual No.	% diff.
All accidents:						
Nov. 73	16 485	14 577	-11,6	2 444	2 110	-13,7
Dec. 73	15 288	11 514	-24,7	3 212	1 749	-45,5
Jan. 74	15 304	11 398	-25,5	2 776	1 606	-42,1
Feb. 74	16 128	13 052	-19,1	2 595	1 521	-41,4
Mar. 74	18 943	15 589	-17,7	3 029	1 937	-36,1
Apr. 74	16 128	14 898	-7,6	3 183	2 078	-34,7
Casualties:						
Nov. 73	4 426	3 683	-16,8	1 790	1 503	-13,8
Dec. 73	4 771	2 735	-42,7	2 770	1 291	-53,4
Jan. 74	3 786	2 427	-35,9	2 109	1 171	-55,5
Feb. 74	4 084	3 273	-19,9	2 021	1 106	-45,3
Mar. 74	4 972	3 658	-26,4	2 527	1 424	-43,7
Apr. 74	4 157	3 518	-15,4	2 463	1 543	-37,4
Fatalities:						
Nov. 73	335	304	-16,8	290	286	-1,4
Dec. 73	405	182	-55,1	385	221	-42,6
Jan. 74	311	192	-38,3	314	176	-43,9
Feb. 74	329	229	-30,4	352	190	-46,0
Mar. 74	478	243	-49,2	414	250	-39,6
Apr. 74	415	280	-32,5	401	251	-37,4

figures - and therefore the percentage changes - are probably underestimated. Nevertheless, the results are quite remarkable and suggest that the speed limit is a very powerful safety tool. A measure that can halve the number of fatalities is worthy of consideration.

Table 6.3 contains some interesting results. Although no speed measurements were taken in urban areas, the change in the urban speed limit - 60 to 50 km/h -almost certainly resulted in a downward change in the urban mean speed. A 25 per cent reduction in accidents, a 35 per cent reduction in casualties and a 40 per cent reduction in fatalities were recorded in urban

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areas. In rural areas, where the reduction in mean speed was very large, the average reduction of accidents, casualties and fatalities was about the same - about 45 per cent. This supports Salusjärvi's view (see subsection 5.2.3) that:

* small reductions in speeds result in proportionately greater reductions in fatal and injury accidents than in all accidents;

* if the average speed decreases by more than 5 km/h, injury accidents and all accidents decrease in equal measure.

The large improvement in urban safety that followed a small change in the urban speed limit supports the general expression derived in Chapter 3, in which the fatality rate is most sensitive to the urban speed limit.

In March and April 1974 the percentage reduction between predicted and observed numbers of accidents, casualties and fatalities on rural roads was lower than during the preceding months. As mentioned earlier, this was almost certainly due to the effect of economic growth.

After allowing for the fact that the speed limits were introduced on 14 November 1973, there was a proportionately smaller drop in accidents, casualties and fatalities in that month compared with later months in both urban and rural areas. This was probably because speeds were still dropping on rural roads one month and more after the lower speed limit had been introduced.

It is difficult to say what factors were responsible for what changes in the numbers of accidents. Not only were there

changes in the urban and rural speed limits but restricted fuel selling hours were introduced and the fuel price was increased. Despite the urban speed limit being restored to 60 km/h on 25 January 1974, urban accidents, casualties and fatalities were substantially below predicted values during February, March and April. Two important questions are "To what extent does the rural speed limit affect urban accidents?" and its converse "To what extent does the urban speed limit affect rural accidents?" These and other questions are examined in Chapter 8.

6.2.2 The 70 km/h speed limit in 1979

The internal revolution in Iran during 1978 and 1979 resulted in a temporary shortage of oil on world markets and caused the government to reduce the 90 km/h rural speed limit to 70 km/h in 41 magisterial districts surrounding the major conurbations. The lower speed limit was introduced on 8 June 1979 and proved to be very unpopular. On 31 August the area to which the limit applied was reduced to 24 magistarial districts and on 28 September 1979 the limit was restored to 90 km/h.

Simultaneously with the introduction of the 70 km/h speed limit, the price of petrol was increased by 30 per cent and filling stations were closed over weekends. Filling stations were permitted to open on Saturday mornings between 07h00 and 12h00 when the speed limit reverted to 90 km/h on 28 September.

The combined affect of these measures, particularly the fuel price rise, was sharp and immediate. There was a move back to public transport, car pooling became fashionable, large cars were no longer popular, sales of motor cycles surged, and so on. Because of this change in behaviour, the normal analysis of comparing the change in accidents with the speed limit

change from 90 to 70 km/h was not considered appropriate. Instead, the change in accidents and casualties following the increase in the speed limit from 70 to 90 km/h was studied; the effect on driver behaviour of the fuel price rise was thus common to both periods[36].

Effect on speeds

Of the six sites on Transvaal rural roads used for regular speed measurements, four fell within the area subject to the 70 km/h speed limit (three freeway sites and one non-freeway site) and the other two (both non-freeways) were located about 30 km outside the boundary and were thus unaffected by the lower speed limit. Previously unpublished data on light vehicle and truck speeds inside and outside the 70 km/h zone are shown in Table 6.4.

The table shows that the means of the 50-percentile speeds of heavy and light vehicles within the 70 km/h speed limit zone fell by 8 and 17 km/h respectively. The 85-percentile speeds fell slightly more and the 20-percentile speeds slightly less. The range in speeds between the 20- and the 85-percentile speeds of heavy and light vehicles dropped by 7 and 4 km/h respectively. Thus, within the 70 km/h zone, the mean speed and the standard deviation of the speed of vehicles declined.

After the speed limit was restored to 90 km/h the speeds increased but to a lower level than before. Even six months later, the 50-percentile speed of cars was about 3 km/h lower than before the 70 km/h speed limit was introduced.

Table 6.4: Speed parameters of light vehicles and trucks within and outside the 70 km/h zone

Period	Speed - km/h							
	Cars and LDVs				Trucks			
	Within zone			Outside	Within zone			Outside
	20%-ile	50%-ile	85%-ile	50%-ile	20%-ile	50%-ile	85%-ile	50%-ile
Before (90 km/h speed limit):								
Feb. 79	75,9	85,3	95,1	87,7	64,4	74,1	88,3	78,0
Mar. 79	79,7	89,9	101,7	87,0	59,8	73,7	87,6	80,7
May 79	79,0	88,4	99,2	94,0	58,3	69,9	83,7	77,6
Mean	78,2	87,9	98,7	89,6	60,8	72,6	86,5	78,8
During (70 km/h speed limit):								
June 79	63,5	70,2	80,4	79,2	55,2	62,6	73,3	72,2
July 79	63,0	69,7	79,9	82,3	56,0	64,7	74,9	67,5
Aug. 79	64,1	70,9	80,7	78,4	56,7	64,8	74,1	71,2
Sep. 79	63,6	71,2	80,2	80,7	55,4	64,9	75,7	73,7
Mean	63,6	70,5	80,3	80,2	55,8	64,3	74,5	71,2
After (90 km/h speed limit):								
Oct. 79	75,6	83,1	92,9	84,5	62,6	73,1	81,7	74,2
Oct. 79	74,5	83,2	92,8	80,5	60,2	70,9	80,7	73,8
Dec. 79	74,4	84,2	95,0	87,6	57,7	68,8	81,0	78,1
Jan. 80	79,7	86,6	96,0	86,7	65,9	75,2	85,9	76,7
Mar. 80	76,2	85,3	96,5	87,4	60,8	70,1	80,1	75,0
Mean	76,1	84,5	94,6	85,3	61,4	71,4	81,9	75,6

Note: LDV = light delivery vehicle

Speed reductions were observed at the two sites outside the 70 km/h zone that were theoretically unaffected by the speed limit change. These reductions were quite large; the 50-percentile speeds of light vehicles fell by 9 km/h and of trucks by 7 km/h. Upon restoration of the 90 km/h limit within the 70 km/h zone, the mean speed at these two sites increased out, again, to a lower level than was observed before June 1979. How far outside the 70 km/h zones this reduction in vehicle speed extended, whether it occurred elsewhere in the country, and to

what extent the increase in the price of fuel contributed to the reduction are all unknown. These observations provide further strong support to the hypothesis that the effects of a speed limit are not necessarily confined to that portion of the network to which the speed limit applies.

Effect on accidents and casualties

A total of 6 310 rural accidents was recorded in 1978 in the magisterial districts later to be affected by the 70 km/h speed limit. This represents 18 per cent of the 34 905 accidents that occurred on the rural network in that year. The 70 km/h speed limit applied for only 84 days in 17 magisterial districts and 112 days in the remaining 24. In an analysis of the effect of the lower limit on accidents and casualties by severity, therefore, one is dealing with rather small numbers.

As stated earlier, the analysis was done by comparing the effects of the 70 km/h limit with the effects of raising the speed limit to 90 km/h. The after period chosen was 28 September 1979 to 31 December 1979 - a short after period was used in the hope that the traffic speed would remain reasonably constant and that the petrol price would still be exercising an effect on vehicle trips similar to that during the 70 km/h period. Results are summarized in Table 6.5.

Raising the speed limit from 70 to 90 km/h increased accidents by a significant 30 per cent but the only class that could be shown to contribute to this rise was damage-only accidents (39 per cent increase). Injury accidents increased by a non-significant 15 per cent. From experience of other speed limit changes, one would have expected a larger change in injury accidents than in damage-only accidents.

Table 6.5: Summary of the change in accidents and casualties on raising the speed limit from 70 to 90 km/h (ref.36)

Severity	Percentage change		Significant change?
	Best estimate	Upper and lower limits at 10 % probability	
Accidents:			
Fatal	+12	-44 and +124	No
Serious	+48	-22 and +179	No
Slight	+2	-34 and +53	No
All injury	+15	-15 and +56	No
Damage only	+39	+11 and +74	Yes
All	+30	+8 and +56	Yes
Casualties:			
Fatal	+3	-48 and +101	No
Serious	-12	-44 and +38	No
Slight	-12	-35 and +19	No
All	-11	-30 and +12	No

A proportion of the increase in Table 6.5 is attributable to the slight improvement in the economy that occurred between October and December compared with the period June to September. On the other hand vehicle speeds during the after period had not reached their previous values; the analysis therefore underestimates the effect of the speed limit change because traffic speeds during the after period had not stabilized.

6.2.3 The analysis of the effect of the rural speed limit on accidents, 1974 to 1981

The accident pattern between January 1974 and December 1981 was analyzed, using multiple linear regression[23], with the objective of identifying the factors contributing to the number and severity of accidents. The weekly number of accidents in seven categories - fatal, injury and all accidents divided into urban and rural, and total all accidents - was abstracted from

accident tapes supplied by Central Statistical Services. A total of 415 observations was obtained for each category of accident.

During this period there was a general increase in the number of accidents but the increase was not uniform. Some years showed a rapid increase in the number of accidents, other years showed no increase or even a fall in the number of accidents. These yearly trends were perturbed by the scatter caused by the week-to-week variations in the number of accidents.

Factors identified as having a significant effect on the year to year trend of the number of accidents were the vehicle population, the level of economic activity, the rural speed limit and the period elapsed since a change in the speed limit. Public holidays and the week of the month affected the week-to-week variations.

The coefficients of the speed variables for different categories of accident are shown in Table 6.6. The variable "Period elapsed since a change in the rural speed limit" is a surrogate measure of the increase of rural vehicle speed with time.

During the analysis period, other fuel conservation measures were introduced, such as restricted fuel selling hours and fuel price increases; they may well have affected accidents but they were not taken into account in the analysis.

The coefficients of the rural speed limit in the table are significant for all categories of accident. The fact that they appear in the urban equations indicates that the rural speed limit affects driver behaviour in urban areas. Furthermore, because more injury and damage-only accidents occur in urban

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Table 6.6: Coefficients of speed-related variables affecting the weekly numbers of accidents

Category of accident	Speed-related variable	
	Rural speed limit km/h	*No.* of weeks elapsed since rural speed limit last changed
Rural:		
Fatal	0,808	0,040
Injury	2,589	0,139
All	4,999	0,451
Urban:		
Fatal	0,716	-
Injury	5,518	0,336
All	27,600	2,166
Total:		
All	33,811	2,958

areas, the rural speed limit has a greater effect in absolute terms in urban areas than it does in rural areas. This is illustrated by the fact that the coefficients of the speed limit are larger for urban injury and urban all accidents than for the corresponding rural accidents. The size of the coefficients of the *rural speed limit confirms* the importance of the rural limit's effect on accidents.

The variable "the number of weeks elapsed since a change in the speed limit" appeared in all the equations except urban fatal accidents. The size of the coefficient was small in each equation; *total all accidents increased* only by three per week as a result of this factor.

Table 6.7 shows the estimated effect of reducing the rural speed limit from 100 to 90 km/h. The speed limit has the greatest proportionate change on the most severe accidents; *this supports the findings* of other researchers.

Table 6.7: Estimated percentage reduction in the number of accidents if the rural speed limit were reduced from 100 to 90 km/h

Category of accident	Percentage reduction in number of accidents
Rural:	
Fatal	10,8
Injury	8,2
All	5,8
Urban:	
Fatal	9,2
Injury	5,0
All	4,3
Total:	
All	4,6

The predictive equations, which were based upon 1974 to 1981 data, were used to estimate the numbers of the different categories of accidents in 1982; the seven equations performed satisfactorily and were accurate within the range -5,3 to +2,5 per cent.

6.3 Summary of South African experience

The results from the South African studies are consistent with those of the other countries described in the previous chapter. The 1973 study gives details of the effects of a large change in the rural speed limit and the 1979 study is one of the few that reports on the effects of an increase in the rural speed limit. They are therefore a valuable contribution to the body of literature. The results of these two studies are included in the analysis of the relationship between speed and accidents that is described in the next chapter.

The analysis of the effect of the rural speed limit on accidents described in section 6.3 offers a different approach to the problem. The findings that urban accidents are affected by changes in the rural speed limit and that the level of the economy affects accidents suggests that some of the results of earlier studies do not accurately portray the relationship between speed and safety.

CHAPTER 7

A GENERAL RELATIONSHIP BETWEEN RURAL SPEED AND ACCIDENTS

In this chapter the results from the studies described in Chapters 5 and 6 are combined and analyzed with a view to establishing:

* whether a general relationship exists between speed and accidents;
* which variables best describe such a relationship;
* the form of the relationship; and
* the conclusions that can be drawn.

7.1 *The choice of variables*

Most of the changes in safety described in Chapters 5 and 6 are given in terms of the percentage change in accidents or casualties, subdivided by severity into all accidents, injury accidents or injuries and fatal accidents or fatalities. For the purposes of this analysis no differentiation has been made between accidents and casualties. Where both classifications were given, the accident data were used in preference.

The most common measure of speed given in the previous two chapters is the difference in mean speed before and after the change in speed limit; in only a few cases were the absolute values of the mean speeds given. The difference in the 85-percentile speeds was given in a number of cases, as was the

difference in the standard deviations of the speed. Another parameter that was often given was the percentage of vehicles exceeding a given speed before and after the speed limit change. The independent variables available for selection in the analysis were the change in mean speed, the change in the 85-percentile speed and the change in the standard deviation of the speed, expressed in km/h.

It is known from a few investigations into speed distributions on South African rural roads that the speed distribution is approximately normally distributed. In cases where information about either the standard deviation of the speed or the 85-percentile speed was not given, it was a relatively simple matter to estimate the missing parameter, knowing the mean speed and one other parameter and assuming the speed to be normally distributed. This was done before and after the change in speed limit and the difference was obtained by subtraction. In those cases where neither the 85-percentile nor the standard deviation was given, but details of the percentage of vehicles exceeding a given speed were supplied, it was again possible to estimate the missing parameters.

In a few instances the speeds were given for specific classes of vehicles rather than for the whole traffic stream or the speeds were given for different time periods (for example at weekends and for weekdays). In such cases the figures were modified so that they were representative of all traffic.

The resulting data set is shown in Table 7.1. The table contains 35 results from seven countries, with half of them from Finland.

Table 7.1: Changes in speed and accidents and casualties in different countries

Percentage change in accidents or casualties			Change in speed km/h			Country and year
All	Injury	Fatal	Mean	85-%ile	Std dev.	
-6	-8	-10	-2	-8	-5,8*	Finland 1962
-7	-10	-24	-3	-11	-	Finland 1966
-15	-5	-	-2	-6	-1,8	Finland 73/76
-48	-34	-40	-6	-13	-5,5	"
-7	-11	-17	-2	-9	-4,5	"
-20	-26	-	-1	-1	-1,4	"
-10	-35	-	-2	-5	-1,7	"
-39	-39	-13	-6	-17	-6,1	"
-42	-45	-47	-7	-19	-7,6	"
-33	-42	-	-9	-20	-7,4	"
+1	-8	-	0	-4	-0,9	"
-28	-33	-37	-3,5	-11	-5,4	"
+2	-9	-	-2	-7	-4,5	"
+17	+31	-	+2	0	-1,7	"
-23	-23	-	-4	-6	0	"
-32	-40	-48	-3	-10	-5	"
-10	-20	-46	0	-6	-5	"
0	-6	-	+2	0	-3*	"
-	-40	-	-5,5	-8,8*	-3,2*	France 1969
-	-39	-	-5,7	-5,9*	-0,2*	"
-	-43	-	-11,2	-19,5*	-8,0*	"
-	-39	-	-6,3	-14,7*	-7,8*	"
-	-40	-34	-7,3	-11,6	-4,1*	"
-	-16	-19	-2,9	-4*	-1,1	France 1970
-	-11	-20	-4	-9	-5	Denmark 1973
-	-17,4	-	-2	-3,8*	-2,1	Denmark 1979
-	-	-37,2	-6,5	-8,5	-	N Zealand 73
-1,9	-1,7	+3,0	+0,7	-0,6*	-0,7	Ireland 1969
-	-18,0	-38,7	-5,1	-8,5*	-3,2	UK 1965
-	-	-13	-3,9	-4,2*	-0,3	"
-	-3,5	-	-2,6	-1,0	+1,6	"
-	-42,5	-	-21	-	-	UK 1973
-	-9,6	-	-2,3	-4,5	-2,1	UK 1974
-39,9	-	-41,6	-30	-38	-7,7*	S. Africa 73
-	+30	-	+14	+14,3	+0,2	S. Africa 79

Note: estimated values are shown thus: -11,6*

7.2 Analysis

The first stage of the analysis was a multiple linear regression of the form

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \qquad .....(7.1)$$

where Y_i = the percentage change in accidents or casualties
i = severity (all, injury or fatal)
X_1, X_2 and X_3 are the three measures of speed
ε = error term

The results showed considerable multicollinearity between the predictor variables, particularly between the difference in mean speed and the difference in 85-percentile speed. Of the three predictor variables, the change in mean speed was correlated most strongly with the dependent variable in the case of the change in all accidents and injury accidents; the change in the standard deviation of the speed was correlated the least strongly. The opposite applied in the case of the change in fatal accidents or casualties - the change in the standard deviation was correlated more strongly and the change in mean speed a little less so.

A best subsets approach was tried and it was found that, no matter whether one used one, two or three predictor variables, the fit of the equation as measured by the coefficient R^2 changed little. This simplified the subsequent anlysis and the change in safety was investigated in terms of a single variable - the change in mean speed. Although, as mentioned in the previous paragraph, this variable was found to be correlated least strongly with the change in fatal accidents, it was a measured variable in all the observations, whereas in the case of the change in standard deviation more than one-quarter of the values were estimated.

An examination of the residuals strongly suggested that a simple linear regression of the form

$$Y_i = \beta_0 + \beta_1 X + \varepsilon \qquad .....(7.2)$$

was not appropriate and that the relationship between Y and X followed an ogee curve. Transformation of Y or X or both was therefore required.

Various transformations were tried and the best results were given by a power transformation of X:

$$Y_i = \beta_0 + \beta_1 (X)^n + \varepsilon \quad \text{where } 0 < n < 1 \qquad .....(7.3)$$

The value of n was established by setting n to different values and repeating the regression. The resultant values of R^2 were plotted against n and the value of n that gave the highest R^2 was determined. The equations are

$$Y_{all} = 8,767\{(sign)|X|^{0,5}\} - 4,9 \qquad .....(7.4)$$

$R^2 = 0,62$: F value = 29,49: N = 20

$$Y_{injury} = 10,158\{(sign)|X|^{0,5}\} - 5,6 \qquad .....(7.5)$$

$R^2 = 0,67$: F value = 62,01: N = 32

$$Y_{fatal} = 12,915\{(sign)|X|^{0,333}\} - 7,4 \qquad .....(7.6)$$

$R^2 = 0,44$: F value = 10,99: N = 16

where Y_{all} = percentage change in all rural accidents

Y_{injury} = percentage change in rural injury accidents and casualties

Y_{fatal} = percentage change in rural fatal accidents and fatalities

X = change in mean speed in km/h

Figures 7.1, 7.2 and 7.3 show the regressions.

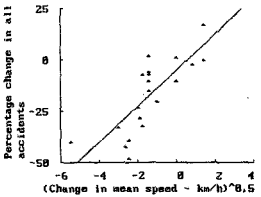

Figure 7.1: Regression of change in all accidents on the square root of the change in mean speed

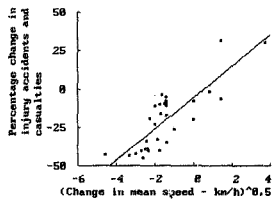

Figure 7.2: Regression of change in injury accidents and casualties on the square root of the change in mean speed

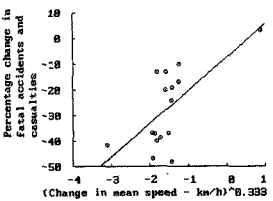

Figure 7.3: Regression of change in fatal accidents and casualties on the cube root of change in mean speed

In all three cases the regression equations are significant at the one per cent level. In Figures 7.1 (all accidents) and 7.2 (injury accidents and casualties) the regression lines fit the data very well. In Figure 7.3 (fatal accidents and fatalities), however, the regression line is influenced by the extreme left-hand data point (South Africa 1973) and particularly strongly by the extreme right-hand point (Ireland 1969). The central cluster of points suggests that the slope of the regression line might be considerably steeper than calculated. If in fact one or both of these extreme points is not a typical value, then the regression line is conservative. Moreover, the cube root of the change in mean speed may not necessarily be the best transformation.

The inclusion of the absolute value of the mean speed as well as of the difference in mean speed in the regression equation

may have given better results. Unfortunately, as mentioned earlier, the absolute values of the mean speed were only given in a few cases.

Figure 7.4 shows a comparison between the three regression lines, with the horizontal axis drawn to a natural scale. A quite modest change in mean speed gives rise to a substantial change in the number of accidents and casualties. The figure indicates that a 5 km/h reduction in the mean speed, for example, will yield a 25 to 30 per cent reduction in accidents and casualties. The largest proportional change in safety is achieved with a small change in mean speed of between ±2 km/h. Within this range, fatal accidents and fatalities show the greatest percentage change and all accidents are the least affected. For changes in the mean speed of more than 2 km/h the slopes of the three regression lines are similar.

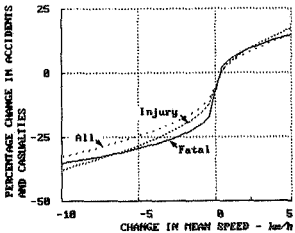

Figure 7.4: Comparison of the change in accidents and casualties by severity and the change in mean speed

An analysis of the relationship between the change in severity and the change in speed was also done. The change in severity was measured in two ways

$$S_{f/i} = Y_{fatal}/Y_{injury}$$

$$S_{f/a} = Y_{fatal}/Y_{all}$$

where Y_{fatal} = percentage change in rural fatal accidents and fatalities

Y_{injury} = percentage change in rural injury accidents and casualties

Y_{all} = percentage change in all rural accidents

The relationships were as follows:

$$S_{f/i} = 0,149X + 2,0 \qquad .....(7.7)$$

$$R^2 = 0,29; \quad N = 13$$

$$S_{f/a} = 0,472X + 3,6 \qquad .....(7.8)$$

$$R^2 = 0,64; \quad N = 9$$

where X = change in mean speed between 0 and -10 km/h

Although equation 7.7 is not significant, both equations 7.7 and 7.8 confirm that small changes of mean speed have a proportionately greater effect on fatal accidents than on injury or all accidents, i.e.

$$S_{f/i} \text{ and } S_{f/a} > 1$$

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Y_{injury} = percentage change in rural injury accidents and casualties

Y_{all} = percentage change in all rural accidents

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$$S_{f/i} \text{ and } S_{f/a} > 1$$

When the mean speed falls by about 8 km/h then the percentage changes in fatal accidents and all accidents are similar.

7.3 Comparison with other studies

In 1983 Godwin did a similar exercise to that described above, in which he examined the relationship between the change in the fatality rate and the change in the posted speed limits in countries outside the United States[37]. He used the results of 26 changes of speed limit in 10 countries. Of these observations, only seven related specifically to fatalities or fatal accidents; the remaining 19 described changes to accidents or injury accidents. The relationship he derived was

$$F = 7{,}07 + 0{,}716\ P \qquad R^2 = 0{,}52 \qquad .....(7.9)$$

where F = change in the fatality rate
P = change in posted speed limit

Although Godwin used equation 7.9 to estimate the change in the fatality rate on American roads that was directly attributable to the imposition of the 55 mph speed limit, the expression more nearly describes the change in the injury accident rate or the all accident rate. (Godwin recognized this but argued that the change in the fatality rate would be higher than this relationship would indicate because a change in speed affects the more serious accidents more than the less serious. The results would therefore be conservative.)

If we use equation 7.9 as a measure of change in the injury accident rate and assume an initial posted speed limit of 100 km/h that is reduced by 20 per cent to 80 km/h, then

Percentage change in the injury accident rate =

$$7{,}07 + 0{,}716 \times 20 = 21 \text{ per cent}$$

Now, in Sweden it was reported that a 20 km/h reduction in the speed limit led to a 6 to 8 km/h reduction in the mean speed. If this finding has general applicability then we can compare the percentage reduction in the injury accident rate calculated above with the percentage change in injury accidents and casualties calculated using equation 7.5.

Percentage change in injury accidents and casualties lies between

$$10{,}158\{-(6)^{0{,}5}\} - 5{,}6 \text{ and } 10{,}158\{-(8)^{0{,}5}\} - 5{,}6$$

$$= 30 \text{ and } 34 \text{ per cent}$$

At an OECD symposium held in 1981 it was reported that a reduction in the mean speed of traffic resulted in a reduction in the accident rate and a reduction in accident severity. Based on Swedish research, the change in safety could be approximated by the expression given below[38].

$$P = V \times N \qquad \text{.....(7.10)}$$

Where P = percentage drop in accident rate in rural areas
V = percentage change in mean speed in km/h
N = 4 for fatal accidents
= 3 for injury accidents
= 2 for damage-only accidents

If we assume an initial mean speed of 100 km/h and a 6 to 8 km/h reduction, then equation 7.10 gives the following reductions in the accident rate:

Fatal = 24 to 32 per cent
Injury = 18 to 24 per cent
Damage-only = 12 to 18 per cent

For the same initial speed and speed change, equations 7.4, 7.5 and 7.6 predict the changes in accidents and casualties as follows:

Fatal = 31 to 33 per cent
Injury = 30 to 34 per cent
All accidents = 26 to 30 per cent

7.4 Summary and discussion

Based on the experience of a number of countries, a general relationship between the change in mean speed and accidents and casualties has been established and three predictive equations have been derived. These equations are all significant at the one per cent level and are consistent with one another - all accidents are least affected by small changes in mean speed and fatal accidents and fatalities are most affected. The equations indicate that small changes in the speed of the traffic have a great effect on safety.

In this set of data, the change in mean speed was shown to be the best predictor variable in two of the three equations and this is an interesting finding because it is commonly believed that it is the variability of the speed that is the most important factor. This variability is usually expressed as the standard deviation of the speed.

Predictions based on equations 7.4, 7.5 and 7.6 were compared with predictions based on equation 7.9, developed by Godwin, and equation 7.10, developed from Swedish data. Although these expressions do not measure the same things, assumptions were made regarding the relationship between change in speed limit and change in mean speed. Although the predictions of the equations did not agree particularly closely, they supported the importance of the relationship between speed and accidents and confirmed that relatively small changes in the mean speed give rise to large changes in accidents and casualties.

7.5 Shortcomings of this approach

In any cross-national study of this nature there are deficiencies in the data and several aspects are discussed below.

a) A downward change in the speed limit is usually accompanied by considerable publicity and increased surveillance and enforcement by the police, especially during the period immediately following the the introduction of the lower limit. If the lower speed limit is applied for a short period only, vehicle speeds will tend to be lower than if the limit were permanent. Consequently, the reduction in accidents will be greater in the short term than in the longer term. The converse will apply if the speed limit is raised, but the difference should be less because increased police surveillance is unlikely to accompany an increased speed limit.

   This problem is largely overcome by relating the change in safety to the change in mean speed rather than to the change in the speed limit. Nevertheless, the increased publicity and enforcement that accompany the introduction

of a lower speed limit may well create a climate that influences driver behaviour abnormally.

b) It has been demonstrated that small changes in mean speed affect the average severity of an accident. Different countries, however, have different criteria for classifying the four categories of accident severity. For example, in most countries a casualty is classified as a fatality if death occurs within 30 days of accident. In France the period is only six days and in Italy it is seven days; prior to 1975 in South Africa the period was three months and since then it is six days. In addition, the proportion of non-injury accidents reported to the police varies considerably from country to country.

c) The results of the studies on which this analysis has been based have been reported in a variety of units. In the analysis there has been no differentiation between results reported in the units of, say, the change in the number of casualties, the change in the number of injury accidents, the change in the casualty rate or the change in the injury accident rate. I believe that one effect of a change of speed limit is a change in the amount of travel - a reduction in the limit leads to reduced travel, an increase in the limit leads to increased travel. A change in the speed limit will therefore have a greater proportionate effect on the number of accidents than on the accident rate.

d) Several studies have shown that the change in accidents brought about by a change in speed limit varies, depending on the class of road. For the same change in speed limit the greatest changes were recorded on heavily trafficked high speed roads and the smallest changes on lightly

trafficked low speed roads. In this analysis no differentiation has been made between classes of road.

It may well be that the change in speed limit changed the mean speed of traffic most on the heavily trafficked high speed roads and that it was this that was responsible for the greater change in accidents. If so, the use of the change in mean speed in the analysis may have overcome this problem. Nevertheless, this factor should be borne in mind as a further potential source of error.

e) The effect of a change in speed limit on safety may be affected by climate. It is quite conceivable that a given change in mean speed will have a quite different effect on accidents in Finland or Sweden, with their difficult winter driving conditions, from that in South Africa, with its kinder climate.

f) Economic and cultural differences between countries may also affect the relationship between speed and accidents. A considerable proportion of South Africa's population is less educated and has had less road user training and experience than the sophisticated populations of Europe and North America. South Africa also has a large rural pedestrian population. The same change in rural traffic speed here and in, say, the United States might affect safety quite differently.

g) Many of the changes to speed limits were introduced at the end of 1973 during the OPEC oil crisis. This particular event had a considerable effect on the economies of countries, which, if the South African experience applies elsewhere, affects the numbers of accidents. A number of

countries reduced their speed limits and also experienced a fall in economic activity. A before-and-after study in these circumstances would lead to an overestimation of the effects of the lower speed limit if the effect of the depressed economy were not taken into account. A review of the studies showed that this factor was not recognized.

In view of the deficiencies listed above, the relationships between change in safety and change in mean speed described in equations 7.4, 7.5 and 7.6 are probably stronger than their R^2s might suggest.

CHAPTER 8

AN ANALYSIS OF FACTORS AFFECTING SOUTH AFRICA'S ACCIDENTS AND CASUALTIES

The accidents and casualties during the seventies and the first half of the eighties are analysed in this chapter with a view to determining the factors that influence safety - particularly the effect of speed. The effect on safety of the government's speed limit reductions between 1973 and 1984 is also examined.

8.1 The accident pattern between 1972 and 1985

A scattergram of fatal and all accidents (which include non-injury accidents) for each month of the 14-year period 1972 to 1985 is shown in Figure 8.1. For the purposes of illustration, the values of the fatal accidents have been multiplied by 25.

The general trend of both all accidents and fatal accidents during the period is upwards - the monthly number of all accidents during 1985 was more than 50 per cent higher than it was in 1972 and the number of fatal accidents was about 20 per cent higher. During the period 1974-1980 the number of fatal accidents was less than during the periods 1971-1973 and 1981-1985. The rural speed limit between 1974 and 1980 varied between 70 and 90 km/h.

Superimposed on these long-term trends are the year-to-year trends and these are quite varied. The years 1974 and 1975 and mid-1979 to mid-1981 suffered large increases in the number of accidents - both periods were associated with high economic

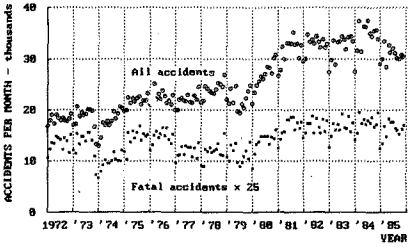

Figure 8.1: All accidents and fatal accidents - 1972 to 1985

activity. The periods 1976 to 1977 and 1984 to 1985 saw reductions in accidents and fatalities when the economy was in recession.

Superimposed on the long-term and the year-to-year trends is the month-to-month trend. It will be seen, for example, that January and February consistently exhibit a lower-than-average number of accidents.

Figure 8.2 shows the ratio between all accidents and fatal accidents by month during the period 1972 to 1985. Between 1972 and 1978 there was a marked increase in the ratio; this was a time of extensive improvements to the road network, particularly in rural areas. This, and the development of safer cars, probably contributed to the increase in safety. Since 1978 the ratio has remained constant at approximately one fatal accident per 50 all accidents.

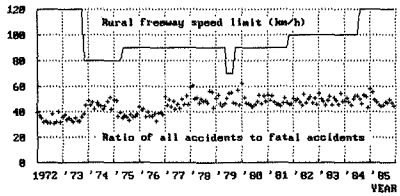

Figure 8.2: The rural freeway speed limit and the ratio between all accidents and fatal accidents - 1972 to 1985

The rural freeway speed limit is also shown in Figure 8.2. There was a sharp increase in the ratio of all accidents to fatal accidents at the end of 1973 and this coincided with the reduction of the rural speed limit from 120 to 80 km/h. There is a hint that the ratio was decreasing in 1985 and this may be associated with the increase of the rural speed limit to 120 km/h in August 1984 and a similar increase on a number of other rural roads during 1985. The ratio seems to be unaffected by any other changes in the rural speed limit.

Figure 8.3 shows the average numbers of fatal and all accidents by month between 1972 and 1985 and confirms that January and February are the safest months of the year. April and November also exhibit slightly fewer accidents than average. The mean of the ratios of all accidents to fatal accidents between 1972 and 1985 is plotted against month in Figure 8.4. During

January, February, March and November the ratio is above average; these are the months with the lower-than-average numbers of accidents. No explanations are proffered why these monthly variations should arise.

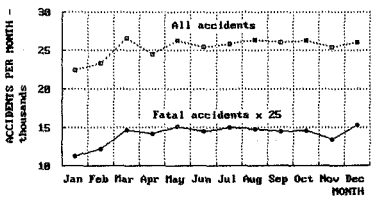

Figure 8.3: Average number of fatal and all accidents each month during the period 1972 to 1985

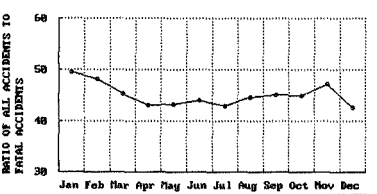

Figure 8.4: The arithmetic mean ratio of all accidents to fatal accidents by month for the period 1972 to 1985

8.2 The data base

A data set of monthly data from January 1972 to December 1985 was created. The dependent variables consisted of fatal, serious injury, slight injury, damage-only and total accidents, subdivided into urban and rural. The independent variables are listed in Table 8.1.

Table 8.1: The independent variables included in the data base

Population	The mean speed of heavy vehicles on all rural roads
The vehicle population	The mean speed of light vehicles on all rural roads
The percentage of motorcycles	The mean speed of all vehicles on all rural roads
Real fuel price, 1975 c/ℓ	The standard deviation of the speed of heavy vehicles on rural freeways
Fuel selling hours/week	The standard deviation of the speed of light vehicles on rural freeways
Whether the petrol pumps were closed on Sunday	The standard deviation of the speed of all vehicles on rural freeways
The number of days/month	The standard deviation of the speed of heavy vehicles on rural non-freeways
The number of Saturdays/month	The standard deviation of the speed of light vehicles on rural non-freeways
The number of Sundays/month	The standard deviation of the speed of all vehicles on rural non-freeways
The Business Coinciding Index	The 85-percentile speed of heavy vehicles on rural freeways
The number of kilometres of rural freeway completed the previous year	
The percentage increase in the rural freeway network	
The urban speed limit	
Months elapsed since the urban speed limit changed	
E-days associated with New Year	
E-days associated with Founder's Day	
E-days associated with Easter	
E-days associated with Ascension Day	
E-days associated with Republic Day	
E-days associated with Settler's Day	
E-days associated with Kruger Day	
E-days associated with the Day of the Vow	
E-days associated with Van Riebeeck Day	

Table 8.1 cont: The independent variables included in the data base

E-days associated with Family Day	The 85-percentile speed of all vehicles on rural freeways
E-days associated with Christmas	The 85-percentile speed of all vehicles on rural freeways
E-days associated with all other public holidays	The 85-percentile speed of heavy vehicles on rural non-freeways
Cape school holidays	The 85-percentile speed of light vehicles on rural non-freeways
Natal and OFS school holidays	The 85-percentile speed of all vehicles on rural non-freeways
All school holidays	The 85-percentile speed of heavy vehicles on all rural roads
The months of the year	The 85-percentile speed of light vehicles on all rural roads
The mean speed of heavy vehicles on rural freeways	
The mean speed of light vehicles on rural freeways	
The mean speed of all vehicles on rural freeways	
The mean speed of heavy vehicles on rural non-freeways	
The mean speed of light vehicles on rural non-freeways	
The mean speed of all vehicles on rural non-freeways	

8.3 Discussion of the variables

8.3.1 Accidents

The Central Statistical Services publishes road traffic accident statistics annually, and the latest available published figures are for 1984[39]; provisional figures for 1985 have been obtained from the CSS. Prior to 1975 a fatality was defined as a death occurring within three months of an accident: from January 1975 the period was reduced to six days. Smeed has published results that show that a considerable number of additional deaths can occur in the period six days to three months after an accident[40]. To bring the numbers to a common base, fatal accidents prior to 1975 have been reduced by 16 per

cent. This change, naturally, affects the number of serious accidents as well.

8.3.2 Vehicle kilometres travelled

The number of vehicle kilometres travelled is an obvious variable affecting the number of accidents. Unfortunately, we do not have a national traffic counting system operating in South Africa and estimates of total annual vehicle kilometres travelled are based on fuel sales and the number of registered vehicles. In a previous study of factors affecting accidents[23], an attempt was made to derive weekly estimates from the annual estimates. The weekly number of accidents and the estimated weekly travel did not correlate very well.

8.3.3 Population

These data are also available from the Central Statistical Services in the form of mid-year estimates. The monthly figures were obtained by simple linear interpolation of the yearly figures. The latest published figures available were for June 1984[41], and the June to December 1984 values were extrapolations of the previous year. The population has increased from 21,7 million at the beginning of 1970 to 27,1 million at the end of 1984.

8.3.4 The vehicle population

The number of licensed motor vehicles at 30 June is published annually by the Central Statistical Services[42]. The numbers for 1971,1973 and 1975 were not published and have therefore

been estimated. The vehicle population for 1980 onwards excluded dealers' stock, and published figures before that date have been reduced by 2,72 per cent (the dealers' stock in 1980). The monthly figures are estimates based on the linear interpolations from the published June figures. Provisional figures for 1984 and 1985 were obtained from the CSS.

8.3.5 Percentage of motorcycles

In 1979 the large increase in the petrol price caused a surge in motorcycle sales and by 1984 the motorcycle population had increased by 120 per cent. It was therefore thought that motorcycles, expressed as a percentage of the vehicle population, might well be an explanatory variable in an accident model.

As in the case of licensed vehicles, the numbers for 1971, 1973 and 1975 were not published and have also been estimated. The population for 1980 onwards excluded dealers' stock, and published figures before that date have been reduced by 1,95 per cent (the dealers' stock in 1980). Provisional figures for 1984 and 1985 were similarly obtained from the CSS.

8.3.6 Fuel price

It is quite possible that the cost of fuel affects the amount of vehicle travel and hence the number of accidents. It is also possible that the cost of fuel may affect the speed at which drivers travel, which in turn will also affect the number of accidents. The real price of fuel, measured in terms of 1975 cents/litre, has been used.

8.3.7 Fuel selling hours and Sunday closure

Fuel selling hours are another factor which may well affect the amount of travel and therefore the number of accidents. We have seen in subsection 2.3.1 that restrictions on selling hours were a measure used by the government to conserve fuel. One of the variables used in this analysis is the number of selling hours per week, but this by itself is not the only measure. The success of regulations restricting fuel selling hours depends upon their nuisance value - if the pumps were closed overnight between 18h00 and 06h00, this would be far less irksome than if the pumps were closed through the day between 06h00 and 18h00. Similarly, pump closures at weekends can seriously affect recreational travel. Whether the pumps were closed on Sunday has been used as an additional variable.

8.3.8 Saturdays, Sundays and the number of days per month

Travel patterns on Saturdays and Sundays are quite different from one another and both are quite different from travel patterns during the week - the number of Saturdays per month and the number of Sundays per month have been included as variables. The number of days per month has been included as a further variable.

8.3.9 The composite index of coinciding indices

Van Coller has developed a system of business cycle leading and coinciding indices and it has previously been shown that the number of accidents is closely related to the coinciding index[23]. The coinciding index is a composite of five other indices: total imports, registered unemployment, the physical

volume of manufacturing production, wholesale sales and retail sales, the last two at 1975 prices. These indices are computed and published monthly by the Bureau of Economic Research[43].

8.3.10 Freeway construction

During the past 15 years there has been a rapid increase in the freeway network - from 371 km in 1970[44] to 1 692 km in March 1984[45] (the latest figure available at the time of writing). These roads have a much lower accident rate than have non-freeway roads and should be included in the accident model. Two measures have been used, the annual change in the length of freeways, expressed in kilometres, and the annual percentage increase in the freeway network.

8.3.11 Urban speed limits

The urban speed limit was increased from 35 mph (56,4 km/h) to 60 km/h in April 1971 and reduced from 60 km/h to 50 km/h for a period of two-and-a-half months between November 1973 and January 1974. It was restored to 60 km/h and has remained at this level since. It has been noted that after a change in speed limit, vehicle speeds tend to increase slowly with time. The number of months that have elapsed since a change in the urban speed limit has been introduced as a variable to take account of this increase in speed.

The changes in the urban speed limit were quite small and it has been assumed that because vehicle speeds in urban areas would have stabilized after 12 months, a maximum value of 12 has been given to this variable.

8.3.12 Holidays

Sweet and Lockwood have shown that traffic flow does not exhibit seasonality in South Africa as it does in other countries, but that it is strongly influenced by public holidays[46]. Depending upon the day of the week on which the public holiday falls, other days may also manifest abnormal traffic flow; the first two weeks in January, which are school holidays, also display abnormal traffic. These days are termed E-days (exceptional days). The July school holidays cause the traffic pattern to change on certain recreational routes.

The variables used in this analysis were the New Year period, the number of E-days associated with the different public holidays, and the school holidays of the different provinces.

8.3.13 Month

Despite Sweet and Lockwood's findings that traffic flow is not seasonally affected, this does not apply to accidents. During the analysis it was found that the E-days and school holidays did not explain all the month-to-month variations in the number of accidents; a monthly effect was present as well. This effect was displayed most strongly in the rural areas. Indicator variables (see section 8.4 below) were introduced for 11 of the 12 months.

8.3.14 Speed of rural traffic

The rural speed limit has changed on a number of occasions and the details have been given in Section 2.2. The rural speed limit has not, however, been used as a variable; measures of rural vehicle speed have been used instead.

A description of the speed measurements made on Transvaal rural roads has been given in section 6.1. These measurements, which were taken annually before 1974 and at approximately six-weekly intervals since then, have been converted to monthly data by linear interpolation. The measures used in the analysis are the mean, the 85-percentile and the standard deviations of the speeds of heavy, light and all vehicles, on rural freeways, non-freeways and all rural roads.

8.4 Analysis

The procedure used in this analysis is multiple linear regression, in which it is assumed that a dependent variable Y (in this case one or other measure of safety) is a linear function of two or more independent variables $X_1, X_2, \ldots X_k$. Independent variables are also called explanatory or predictor variables. We describe the model as

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_k X_k + \varepsilon$$

where β_0 is the intercept term

β_0, β_1 etc. are the regression coefficients of the corresponding X variables

ε is an error term. The error of any observation is *the difference between* the observed and predicted values of that observation.

Use has been made in this analysis of dummy or indicator variables, where a predictor variable takes the value of one or zero. An example of its use is whether petrol filling stations were closed on Sunday - a value of zero indicates they were not and a value of one indicates they were.

The goodness of fit of the model to the data is the coefficient of multiple determination, R^2, which can take a value of between zero and one. A value of zero indicates no relationship and a value of one shows a perfect fit between the model and the data.

Multiple linear regression is a well proven, widely used and robust technique that, if used with circumspection, can give valuable insight into the nature of the relationship between the dependent and the predictor variables. In this analysis we are particularly interested in the relationship between speed and speed limits and safety.

8.4.1 Speed variables

The first stage of the analysis was to find out whether speed was a significant variable. A regression of total rural accidents on all the variables, including one of the measures of speed, confirmed that speed was significant. The next stage was to choose the best measure of speed. The correlation matrix showed that all the measures of speed were highly correlated with one another. The inclusion of correlated predictor variables into the equation violates one of the underlying assumptions of linear regression, i.e. that the predictor variables are independent of one another. A high degree of association between the predictor variables can give rise to distorted values of the regression coefficients; this association is known as multicollinearity. Although the resulting model may well give good results, interpretation of the contribution of the multicollinear variables to the predictions may be impossible. The correlation matrix was examined to see which of the speed variables was most highly correlated with the dependent variables, i.e. the various categories of accident. It was found that the mean of the speeds of all vehicles on all roads was the most consistent.

A principal component analysis of the speed variables was also done. In this method of analysis, a set of new variables which uses information from the 27 speed variables is created. The regression was run with the best of these new variables replacing the mean speed of all vehicles on all roads and there was a small improvement in the fit of the equation to the data. However, this improvement in performance was not considered to outweigh the difficulty of interpreting the new variable, and the mean speed of all vehicles on all roads was retained.

8.4.2 Seasonal variables

The regressions were run first of all without any of the month variables, but it was found that there was a seasonal effect in the number of accidents; for example, the number of accidents in February was consistently being overpredicted. Furthermore, some of the E-day variables were not significant. The introduction of indicator variables depicting months introduced multicollinearity between certain pairs of E-days and months - for example, December and Christmas. To overcome this, and also to retain the information contained in some of the non-significant variables, the regression between rural total accidents and all variables excluding months was run. From the resulting regression equation, the coefficients of the E-days were grouped into four categories - large negative, medium negative, small negative and positive. Four new E-day variables were created and these replaced the individual E-days. For example

EDAY3 = ASCENS + 1,5(DOFVOW) + 2(EASTER) + 3(VANRIE) ....(8.1)

where

ASCENS = number of E-days associated with Ascension Day
DOFVOW = number of E-days associated with The Day of the Vow
EASTER = number of E-days associated with Easter
VANRIE = number of E-days associated with Van Riebeeck Day

The regression equation was then rerun with the new E-day variables but this time including the months. The coefficients of the month variables were grouped into four categories - large negative, medium negative, medium positive and large positive - and four new month variables were created.

These new variables were used in the other rural regression equations on the assumption that the E-days and the months would have the same proportionate effect on the other severities of rural accident as they did on rural total accidents. The procedure was repeated for urban accidents.

Because the individual E-days and the individual months are associated and because the coefficients of the individual E-days were estimated without months appearing in the regression equation, these coefficients contain month information as well. This means that one cannot conclude from equation 8.1 that Van Rieteeck Day is three times more dangerous than Ascension Day. Similarly, because some of the month information is contained in the E-day variables, one cannot directly compare the safety of the individual months from their coefficients - the E-days and months must be looked at together.

8.4.3 Multicollinearity

Multicollinearity, or association between the independent

variables, is frequently a problem in an investigation of this nature - very often the variables are linked in some way. If the predictor variables are independent they are said to be orthogonal. In such circumstances, the interpretation of a regression equation by examining the change in the response variable corresponding to a unit change in one of the predictor variables, at the same time holding the other predictor variables constant, can be done with confidence. Usually the lack of orthogonality is not serious enough to affect the analysis, but cases can arise where it is conceptually impossible to change one predictor variable without changing one or more of the other predictor variables[47].

Multicollinearity is present among the variables used in this analysis. The most important is between the vehicle population, the mean speed of vehicles on all rural roads and the percentage of motorcycles. Fortunately, this is a spurious multicollinearity - during the selected analysis period these three variables had increased independently. Although the vehicle population is likely to increase in the future, there is no reason why the percentage of motorcycles or the vehicle mean speed should not fall. Negative multicollinearity occurred between the vehicle mean speed and the Sunday closure of petrol pumps.

When multicollinearity is serious, the estimated values of the coefficients are very sensitive to slight changes in the data and to the addition or deletion of variables in the equation. The regression coefficients would have large sampling errors[47]. In this analysis the regression coefficients of all the variables were stable during the addition or deletion of variables or during changes to the number of observations. The smallest ratio between the regression coefficient and its standard deviation was 1,7 (mean speed of all vehicles in the equation for estimating urban damage-only accidents). In most cases the ratio was 4 or more.

8.4.4 Procedure

The analysis was done on the CSIR's Amdahl computer using the statistical analysis package SAS[48]. A multiple regression containing all the independent variables was carried out for the response variables total rural accidents and total urban accidents. This gave an immediate feel for the adequacy of the model, which variables were significant and which could be discarded. An eigenvector analysis, which identifies multicollinearity between pairs or sets of variables, was very useful for determining which variables could be omitted from the model. The residuals were examined for model misfit, misspecification, missing variables, non-constant variance of the error terms (heteroscedasticity) and stuctural change in the model over time. Once the reduced list of variables had been decided upon, the seasonal variables were constructed as described in subsection 8.4.2 above.

The next stage was to build up the model using the STEPWISE procedure and the Maximum R^2 improvement (MAXR) option. The procedure is described on page 765 of reference 49 as follows.

"The MAXR method begins by finding the one-variable model producing the highest R^2. Then another variable, the one that yields the greatest increase in R^2, is added. Once the two-variable model is obtained, each of the variables in the model is compared with each variable not in the model. For each comparison, MAXR determines if removing one variable and replacing it with the other variable increases R^2. After comparing all possible switches, MAXR makes the switch that produces the largest increase in R^2. Comparisons begin again, and the process continues until MAXR finds that no switch could increase R^2. Thus, the two-variable model achieved is considered the "best" two-variable model the technique can find. Another variable is then added to the model, and the comparing-

and-switching process is repeated to find the "best" three-variable model, and so forth."

The Mallows C_p statistic was used as a guide for selecting the appropriate size of the model.

$$p \approx C_p$$

where p = the number of terms in the regression equation including the intercept term.

The selected equations were rerun using the REG procedure, a residual analysis was done and potential outliers were examined. The Cook's D influence statistic was also requested; this statistic measures the change to the estimates that results from deleting each observation. Observations with residuals with a standardized value greater than 2,5 and with a large Cook's D statistic were dropped and the regressions were rerun. The new regression coefficients were compared with the previous values to see whether there was a significant change.

The analysis took two months to complete, and well over 100 separate runs were done.

8.5 Results

A large number of variables were found to affect the number of accidents significantly. To simplify the presentation, the results have been separated into the rural and urban areas.

8.5.1 Rural areas

Altogether, 12 variables were identified as influencing the five categories of rural accident. These were the closure of pumps on Sunday, the level of the economy, the vehicle population, the percentage of motorcycles in the vehicle population, the rural vehicle mean speed, the urban speed limit, the numbers of Saturdays per month, three variables related to public holidays, and two variables related to season. The details of the regression equations are given in Table 8.2, and the coefficient matrix is given in Table 8.3.

Table 8.2: The coefficients of the variables (β), their F values (F) and probabilities (P), and other parameters of the regression equations of the different severities of rural accidents

Variable and measure		Severity of rural accident				
		Fatal	Serious	Slight	Damage only	Total
SUNDAY						
If pumps	β	27,705	-	-	-	-
closed on	F	24,10	-	-	-	-
Sunday	P	0,0001	-	-	-	-
BCI						
Business	β	1,372	1,954	-	7,736	12,923
Coinciding	F	14,78	26,38	-	7,22	12,85
Index	P	0,0002	0,0001	-	0,0080	0,0005
VPOP						
Vehicle	β	-	17,04	-	311,69	396,93
population	F	-	15,97	-	27,66	28,63
millions	P	-	0,0001	-	0,0001	0,0001
MCPERC						
Percentage	β	7,107	-	37,449	123,647	135,137
of motor-	F	8,75	-	111,33	13,48	10,28
cycles	P	0,0036	-	0,0001	0,0003	0,0016
MNTOPO						
Vehicle	β	6,298	5,818	7,794	30,782	51,049
rural mean	F	121,76	213,64	111,33	83,02	145,76
speed km/h	P	0,0001	0,0001	0,0001	0,0001	0,0001

Table 8.2 cont.: The coefficients of the variables (β), their F values (F) and probabilities (P), and other parameters of the regression equations of the different severities of rural accidents

Variable and measure		Severity of rural accident				
		Fatal	Serious	Slight	Damage only	Total
URB_SL						
Urban	β	3,325	3,953	7,263	-	-
speed	F	5,00	5,44	8,63	-	-
limit km/h	P	0.0267	0,0209	0,0038	-	-
SATS						
No. of	β	10,742	20,251	30,485	83,113	151,849
Saturdays	F	6,98	18,42	19,50	6,96	14,77
per month	P	0,0090	0,0001	0,0001	0,0092	0,0002
EDAY_1	β	-	-	-	104,271	138,160
	F	-	-	-	6,53	7,32
	P	-	-	-	0,0116	0,0076
EDAY_2	β	2,518	3,548	8,524	24,141	40,666
	F	23,52	36,73	99,11	38,16	65,77
	P	0,0001	0,0001	0,0001	0,0001	0,0001
MNTH_1	β	5,703	7,007	13,978	-	95,023
	F	2,63	3,36	6,26	-	7,79
	P	0,1071	0,0684	0,0133	-	0,0059
MNTH_3	β	-4,269	-	-	-51,381	-45,433
	F	5,61	-	-	15,67	6,80
	P	0,0190	-	-	0,0001	0,0100
MNTH_4	β	-33,273	-19,751	-34,142	-267,014	-328,697
	F	52,65	16,30	22,77	64,92	55,78
	P	0,0001	0,0001	0,0001	0,0001	0,0001
Intercept	β	-729,35	-779,16	-904,88	-3570,96	-5440,28
No. of obs.		175	175	175	163	163
R^2		0,830	0,803	0,883	0,918	0,932

Where: EDAY_1 = FOUNDR

EDAY_2 = ASCENS + EASTER + VANRIE + KRUGER + XMAS

MNTH_1 = MAY + 2(JUL)

MNTH_3 = 2(MAR + APR) + OCT + 4(NOV)

MNTH_4 = JAN + 1,5(FEB)

and where: FOUNDR, ASCENS, EASTER, VANRIE, KRUGER, and XMAS are the number of E-days associated with Founders' Day, Ascension Day, Easter, Van Riebeeck Day, Kruger Day and Christmas respectively. MAY, JUL, MAR and so on are dummy variables which take the value one if the month is May, July, March, ..., otherwise zero.

Table 8.3: Rural accidents - correlation matrix of the independent variables

	SUNDAY	BCI	VPOP	MCPERC	MNTOTO	URB_SL
SUNDAY	1,000	0,208	-0,007	-0,352	-0,653	0,102
BCI	0,208	1,000	0,041	0,218	-0,155	-0,024
VPOP	-0,007	0,041	1,000	0,874	0,631	0,374
MCPERC	-0,352	0,218	0,874	1,000	0,764	0,162
MNTOTO	-0,653	-0,155	0,631	0,764	1,000	0,217
URB_SL	0,102	-0,024	0,374	0,162	0,217	1,000
SATS	0,013	-0,014	0,019	-0,004	-0.015	0,032
EDAY_1	-0,011	0,115	0,169	0,217	0,139	0,042
EDAY_2	0,015	-0,014	0,002	-0,025	-0,008	-0,054
MNTH_1	-0,013	-0,005	-0,001	0,013	-0,014	0,058
MNTH_3	0,023	0,002	0,011	-0,002	0,032	-0,045
MNTH_4	0,023	0,010	-0,038	0,002	-0.030	-0,074

	SATS	EDAY_1	EDAY_2	MNTH_1	MNTH_3	MNTH_4
SUNDAY	0,013	-0,011	0,015	-0,013	0,023	0,023
BCI	-0,014	0,115	-0,014	-0,005	0,002	0,010
VPOP	0,019	0,169	0,002	-0,001	0,011	-0,038
MCPERC	-0,004	0,217	-0,025	0,013	-0,002	0,002
MNTOTO	-0,015	0,139	-0,008	-0,014	0,032	-0,030
URB_SL	0,032	0,042	-0,054	0,058	-0,045	-0,074
SATS	1,000	-0,076	0,039	0,009	-0,049	-0,098
EDAY_1	-0,076	1,000	0,038	-0,063	0,151	-0,065
EDAY_2	0,039	0,038	1,000	-0,105	-0,119	-0,213
MNTH_1	0,009	-0,063	-0,105	1,000	-0,255	-0,184
MNTH_3	-0,049	0,151	-0,119	-0,255	1,000	-0,266
MNTH_4	-0,098	-0.065	-0,213	-0,184	-0,266	1,000

The models for each severity of accident fit the data quite satisfactorily; the value of R^2 varies from 0,80 for serious accidents to 0,93 for total accidents The coefficients of the variables behave predictably - they are smallest for the fatal

accidents and increase as the severity of the accidents decreases. Furthermore, of those variables that occur in all five categories of accident, the coefficient of a variable in the total accident category is approximately equal to the sum of the coefficients of the same variable in the fatal, serious, slight and damage-only categories.

An examination of the residuals showed that the models were correctly specified and that the variances of the residuals were independent of the predicted values - the models were homoscedastic. However, the residuals were not independent of one another; if the residual from an observation was positive, say, residuals from the preceding and the succeeding observations were both likely to be positive as well. It is quite probable that this association is due to a missing variable in the models. The inclusion of the variable ANFWPC - the annual percentage increase in the freeway network - helped to reduce this association between the residuals but, unfortunately, details of freeway constructed were only available up to March 1984. The inclusion of this variable in the data set would have decreased the number of observations by 21. Its exclusion had little effect on the coefficients of the remaining variables.

Outliers were present in all five categories but their deletion caused little change to the variable coefficients. The models described in Table 8.2 are based on the data without the outliers being deleted.

8.5.2 Urban areas

Fifteen variables were associated with the five categories of urban accident. These were the real price of petrol, the

closure of pumps on Sunday, the level of the economy, the vehicle population, the percentage of motorcycles in the vehicle population, the rural vehicle mean speed, the urban speed limit, the number of months elapsed since the urban limit changed, the number of days per month, the number of Saturdays per month, three variables related to public holidays, December school holidays, and one variable related to season. The details of the regression equations are given in Table 8.4, and the coefficient matrix is given in Table 8.5.

Table 8.4: The coefficients of the variables (β), their F values (F) and probabilities (P), and other parameters of the regression equations of the different severities of urban accidents

Variable and measure		Severity of urban accident				
		Fatal	Serious	Slight	Damage only	Total
RL_PRC						
Real price	β	-	-3,828	-11,934	-157,363	-182,168
of petrol	F	-	6,13	14,40	38,27	39,86
1975 c/l	P	-	0,0143	0,0002	0,0001	0,0001
SUNDAY						
If pumps	β	-	206,878	373,367	3565,957	4211,827
closed on	F	-	107,72	109,60	129,15	140,10
Sunday	P	-	0,0001	0,0001	0,0001	0,0001
BCI						
Business	β	2,297	-	-	-	-
Coinciding	F	22,39	-	-	-	-
Index	P	0,0001	-	-	-	-
VPOP						
Vehicle	β	-44,24	-128,51	-	1783,29	1681,24
population	F	22,02	37,51	-	27,21	18,79
millions	P	0,0001	0,0001	-	0,0001	0,0001
MCPERC						
Percentage	β	29,272	153,545	356,642	2595,882	3155,590
of motor-	F	25,75	193,06	473,21	214,55	246,40
cycles	P	0,0001	0,0001	0,0001	0,0001	0,0001
MNTOTO						
Vehicle	β	2,668	7,696	17,684	49,933	72,370
rural mean	F	16,99	19,24	25,93	2,91	4,74
speed km/h	P	0,0001	0,0001	0,0001	0,0903	0,0310
URB_SL						
Urban speed	β	3,811	15,754	37,364	143,364	186,725
limit	F	3,61	17,21	22,49	4,27	5,63
km/h	P	0,0590	0,0001	0,0001	0,0405	0,0189

Table 8.4 cont.: The coefficients of the variables (β), their F values (F) and probabilities (P), and other parameters of the regression equations of the different severities of urban accidents

Variable and measure		Severity of urban accident				
		Fatal	Serious	Slight	Damage only	Total
U_MNTH						
Mnths since	β	3,455	14,086	17,906	325,508	383,483
urban S.L.	F	8,62	32,70	12,65	35,87	38,68
changed	P	0,0038	0,0001	0,0005	0,0001	0,0001
DY_MTH						
No. of	β	-	28,237	130,943	715,850	851,333
days per	F	-	22,47	37,10	53,92	61,01
month	P	-	0,0001	0,0001	0,0001	0,0001
SATS						
No. of	β	13,971	41,173	72,824	-	-
Saturdays	F	7,02	17,22	12,67	-	-
per month	P	0,0089	0,0001	0,0005	-	-
ALL						
Dec. school	β	-	-	-	-145,811	-168,032
holidays	F	-	-	-	5,19	5,36
	P	-	-	-	0,0241	0,0220
EDAY2	β	-4,988	-13,943	-28,603	-187,412	-236,279
	F	58,91	124,88	118,81	86,20	106,95
	P	0,0001	0,0001	0,0001	0,0001	0,0001
EDAY3	β	-	-	-	-59,491	-67,574
	F	-	-	-	4,57	4,58
	P	-	-	-	0,0342	0,0340
EDAY4	β	-	-15,560	-40,286	-379,632	-452,627
	F	-	10,45	16,24	23,94	26,45
	P	-	0,0015	0.0001	0,0001	0,0001
MNTH1	β	-21,197	-	90,642	-	-
	F	25,03	-	9,98	-	-
	P	0,0001	-	0,0019	-	-
Intercept	β	-505,76	-2291,62	-7554,22	-38727,9	-46675,3
No. of obs.		175	175	175	163	163
R^2		0,715	0,898	0,956	0,961	0,963

Where: EDAY2 = NEWYR + REPUBL + SETTLR + PUBLIC

EDAY3 = ASCENS + 1,5(DOFVOW) + 2(EASTER) + 3(VANRIE)

EDAY4 = KRUGER + 1,5(FAMILY) + 2(FOUNDR)

MNTH1 = 2(FEB) + NOV

and where: NEWYR, REPUBL, SETTLR, PUBLIC, ASCENS, DOFVOW, EASTER, VANRIE, KRUGER, FAMILY and FOUNDR are the number of E-days associated with New Year (the first 14 days), Republic Day, Settlers' Day, all other public holidays, Ascension Day, the Day of the Vow, Easter, Van Riebeeck Day, Kruger Day, Family Day and Founders' Day respect'vely. FEB and NOV are dummy variables which take the value one if the month is February or November, otherwise zero.

ALL is the number of days during December before the Day of the Vow (December 16) when the schools in the four provinces are on holiday.

The models for each severity of accident again fit the data very satisfactorily, the value of R^2 varying between 0,71 for fatal accidents to 0,96 for total accidents. The coefficients of the variables also behave predictably, as in the rural models.

With regard to the structure of the model, the same comments that applied to the rural analysis apply to the urban analysis as well. The models were correctly specified and they were homoscedastic. The residuals were similarly related to one another, again probably due to a missing variable. Outliers were present in all five categories of accidents but, again, their deletion caused little change to the variable coefficients. The models are based on the full data set.

Table 8.5: Urban accidents - correlation matrix of the independent variables

	RL_PRC	SUNDAY	BCI	VPOP	MCPERC
RL_PRC	1,000	0,394	-0,039	0,720	0,522
SUNDAY	0,394	1,000	0,208	-0,007	-0,352
BCI	-0,039	0,208	1,000	0,041	0,218
VPOP	0,720	-0,007	0,041	1,000	0,874
MCPERC	0,522	-0,352	0,218	0,874	1,000
MNTOTO	0,162	-0,653	-0,155	0,631	0,764
URB_SL	0,337	0,102	-0,024	0,374	0,162
U_MNTH	0,349	-0,038	-0,226	0,365	0,281
DY_MTH	-0,002	-0,014	0,002	0,018	-0,004
SATS	0,027	0,013	-0,014	0,019	-0,004
ALL	-0,005	0,015	-0,010	0,030	0,000
EDAY2	-0,037	0,027	0,004	-0,044	-0,020
EDAY3	-0,060	-0,029	-0,013	-0,082	-0,017
EDAY4	0,049	-0,023	0,055	0,043	0,075
MNTH1	-0,006	0,022	0,004	-0,011	0,013

	MNTOTO	URB_SL	U_MNTH	DY_MTH	SATS
RL_PRC	0,162	0,337	0,349	-0,002	0,027
SUNDAY	-0,653	0,102	-0,038	-0,014	0,013
BCI	-0,155	-0,024	-0,226	0,002	-0,014
VPOP	0,631	0,374	0,365	0,018	0,019
MCPERC	0,764	0,162	0,281	-0,004	-0,004
MNTOTO	1,000	0,217	0,447	0,012	-0,015
URB_SL	0,217	1,000	0,303	-0,005	0,032
U_MNTH	0,447	0,303	1,000	0,012	-0,013
DY_MTH	0,012	-0,005	0,012	1,000	0,217
SATS	-0,015	0,032	-0,013	0,217	1,000
ALL	-0,008	-0,095	-0,011	0,206	0,068
EDAY2	-0,047	-0,116	0,003	0,225	0,113
EDAY3	-0,001	0,015	-0,093	0,043	-0,042
EDAY4	0,107	0,047	0,022	0,104	0,027
MNTH1	-0,008	-0,040	-0,003	-0,828	-0,193

	ALL	EDAY2	EDAY3	EDAY4	MNTH1
RL_PRC	-0,005	-0,037	-0,060	-0,023	-0,006
SUNDAY	0,015	0,027	-0,029	-0,067	0,022
BCI	-0,010	0,004	-0,013	0,055	0,004
VPOP	0,030	-0,044	-0,082	0,043	-0,011
MCPERC	0,000	-0,020	-0,033	0,075	-0,001
MNTOTO	-0,008	-0,047	-0,001	0,107	-0,008
URB_SL	-0,095	-0,116	0,015	0,047	-0,040
U_MNTH	-0,011	0,003	-0,093	0,022	-0,003
DY_MTH	0,206	0,225	0,043	0,104	-0,828
SATS	0,068	0,113	-0,042	0,027	-0,193
ALL	1,000	-0,114	0,181	-0,101	-0,125
EDAY2	-0,114	1,000	-0,127	-0,129	-0,160
EDAY3	0,181	-0,072	1,000	-0,186	-0,190
EDAY4	-0,101	-0,129	-0,186	1,000	0,022
MNTH1	-0,125	-0,181	-0,190	0,022	1,000

8.5.3 *The role of speed*

The variable MNTOTO - the mean speed of all vehicles at the three freeway sites and the three non-freeway sites in the Transvaal - occurs in all five severities of accident in both urban and rural areas. The significance of this variable as measured by its F value is very high in all categories of rural accident and in fatal and injury accidents in urban areas. The coefficient of MNTOTO in the rural fatal accident model (6,298) is more than twice that of the urban fatal model (2,668). In the other categories of accident the coefficients of MNTOTO in the urban models are larger than the corresponding coefficients in the rural models. At first sight this may appear illogical, but it should be remembered that most accidents occur in urban areas - in 1984 only 13 per cent of accidents occurred on rural roads[3]. A unit change in speed has the greatest proportional effect on non-fatal accidents on rural roads, but the greatest absolute effect on urban roads.

It is instructive to examine the coefficients of MNTOTO whilst the models are being built up using the MAXR procedure. (It will be recalled that this procedure starts by constructing the model with a single variable and then adding variables one at a time, each time seeking to maximize R^2.) The coefficients of MNTOTO in the urban and rural fatal accident models are shown in Table 8.6. The coefficients corresponding to the models used in Tables 8.2 and 8.4 are shown underlined.

The values of the coefficient of MNTOTO vary between 6,0 and 7,8 in the rural fatal accident model - this is quite satisfactory. In the case of the urban fatal model things are not quite as good - the coefficient varies between 2,7 and 5,2. It will be seen that the largest changes to the coefficient occur when the variables HRS_WK, SUNDAY, MCPERC and, to a lesser

Table 8.6: The coefficients of MNTOTO in the rural and urban fatal accident models using the MAXR procedure

No. of vars. in model	Fatal rural accidents			Fatal urban accidents		
	Variable added or swapped	Coeff of MNTOTO	R^2	Variable added or swapped	Coeff. of MNTOTO	R^2
1	MNTOTO in	6,103	0,588	MNTOTO in	5,024	0,403
2	MNTH_4 added	6,072	0,683	BCI added	5,248	0,510
3	HRS_WK added	7,751	0,733	EDAY2 added	5,172	0,592
4	BCI added	7,741	0,764	MNTH1 added	5,152	0,648
5	EDAY2 added	7,759	0,792	SATS added	5,174	0,662
5	HRS_WK out RL_PRC in	6,076	0,793			
6	MNTH_3 added	6,091	0,804	URB_SL added	5,027	0,66[illegible]
6	RL_PRC out HRS_WK in	7,815	0,807			
7	MCPERC added	6,623	0,814	MCPERC added	4,105	0,676
7	HRS_WK out SUNDAY in	6,566	0,815	SATS out VPOP in	3,364	0,688
7				URB_SL out U_MNTH in	2,711	0,697
8	SATS added	6,620	0,822	SATS added	2,780	0,709
9	URB_SL added	6,286	0,827	URB_SL added	2,668	0,715
10	MNTH_1 added	6,298	0,830	EDAY4 added	2,729	0,722
11	VPOP added	6,360	0,832	DY_MTH added	2,703	0,725
12	DY_MTH added	6,610	0,834	EDA[illegible] added	2,669	0,728
13	EDAY_3 added	6,591	0,836	SUNDAY added	3,251	0,729
14	U_MNTH added	6,320	0,837	MNTH3 added	3,328	0,731

Where: HRS_WK = the number of hours per week that petrol could be purchased.
All other variables are as previously defined.

extent, VPOP and *U_MNTH enter* or leave the equation. These variables are all correlated with MNTOTO. There is not much one can do with the deficiencies in the data we are dealing with, and interpretations of the effects on safety in urban areas of a change in the mean rural traffic speed must be treated with care. Fortunately, the coefficient used in the analysis (2,668) is at the lower range and is therefore probably conservative.

Table 8.6: The coefficients of MNTOTO in the rural and urban fatal accident models using the MAXR procedure

No. of vars. in model	Fatal rural accidents			Fatal urban accidents		
	Variable added or swapped	Coeff of MNTOTO	R^2	Variable added or swapped	Coeff. of MNTOTO	R^2
1	MNTOTO in	6,103	0,588	MNTOTO in	5,024	0,403
2	MNTH_4 added	6,072	0,683	BCI added	5,248	0,510
3	HRS_WK added	7,751	0,733	EDAY2 added	5,172	0,592
4	BCI added	7,741	0,764	MNTH1 added	5,152	0,648
5	EDAY2 added	7,759	0,79[illegible]	SATS added	5,174	0,662
5	HRS_WK out RU_PRO in		0,793			
6	[illegible] added	6,091	0,804	URB_SL added	5,027	0,669
6	[illegible]ut [illegible]i	7,815	0,807			
7	[illegible]dded	6,623	0,814	MCPERC added	4,105	0,676
7	hrs[illegible] out SUNDAY in	6,566	0,815	SATS out VPOP in	3,364	0,688
7				URB_SL out U_MNTH in	2,711	0,697
8	SATS added	6,620	0,822	SATS added	2,780	0,709
9	URB_SL added	6,286	0,827	URB_SL added	2,668	0,715
10	MNTH_1 added	6,298	0,830	EDAY4 added	2,729	0,722
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Where: HRS_WK = the number of hours per week that petrol could be purchased.
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extent, VPOP and U_MNTH enter or leave the equation. These variables are all correlated with MNTOTO. There is not much one can do with the deficiencies in the data we are dealing with, and interpretations of the effects on safety in urban areas of a change in the mean rural traffic speed must be treated with care. Fortunately, the coefficient used in the analysis (2,668) is at the lower range and is therefore probably conservative.

It is interesting to note that MNTOTO is the first variable to enter both the rural and urban equations, which underlines the importance of this factor in fatal accidents. MNTOTO was also the first variable to enter the rural serious and slight accident models.

The urban speed limit, as might be expected, is positively correlated with accidents and appears in all five of the urban accident models. Perhaps more surprisingly, it appears as a significant variable in the three rural injury-accident models as well, thereby adding further support to the hypothesis that the effects of a speed limit applied to a portion of the network are felt elsewhere on the network. The coefficients of the urban speed limit URB_SL in the urban accident models are larger than the coefficients of MNTOTO in the same models: the converse applies in the rural areas. These are, of course, what one would expect.

We can interpret the models as follows. A 1 km/h increase in MNTOTO, at the same time holding all the other variables constant, is associated with an increase of 9 fatal accidents per month, of which 6 occur on rural roads and 3 on urban roads. Total accidents would increase by 120 per month - 50 in rural areas and 70 in urban areas. Similarly, a 1 km/h increase in URB_SL is associated with an increase of 4 fatal accidents per month in urban areas and 3 in rural areas. Non-fatal injury accidents would increase by 53 per month on urban roads and 11 per month on rural roads.

The economic consequences of these changes are very considerable. The estimated 1984 unit costs of fatal, serious injury, slight injury and damage-only accidents are R111 478, R21 670, R4 752 and R1 996 respectively[49]. The calculated annual accident costs of a 1 km/h increase of the rural mean speed is just

under R19 million. A 1 km/h increase in the urban speed limit would cost R20 million per annum.

Although it is outside the scope of this investigation, the strong *positive correlation* between accidents and the percentage of motorcycles in the vehicle population (MCPERC) should be noted. The model predicts that a unit increase in MCPERC would result in an increase of nearly 3 300 accidents per month, mostly in the urban areas. Once again, this prediction should be viewed cautiously *because of* multicollinearity between MCPERC, MNTOTO, SUNDAY and VPOP.

8.6 The effect on safety of the lower rural speed limits between November 1973 and July 1984

The government applied lower *maximum rural speed* limits between November 1973 and July 1984 for the purpose of fuel conservation. The foregoing analysis allows us to estimate the effect of *these lower speed* limits on safety. In October 1973 and in August 1984, immediately before and after the lower speed limits, the variable MNTOTO (the average speed of *all* traffic at the six sites on Transvaal rural roads) had the values of 92,8 and 99,2 km/h respectively. The assumption is made that the speed would have *increased linearly* with time from 92,8 to 99,2 km/h during this period had the rural speed limit not been lowered. It is further assumed that all the other variables would have behaved as they did.

A comparison between the estimated and recorded numbers of fatal and total accidents is shown in Table 8.7. The table clearly shows that the lower speed limits had a very pronounced affect on accidents, particularly on fatal accidents. During this period there were on average 1,14 fatalities per fatal accident; applying this ratio to the difference of 10 958 fatal accidents gives an estimated 12 500 lives saved. At 1984 costs this represents a saving of R1,2 billion.

Table 8.7: The estimated effect of the lower rural speed limits on accidents between November 1973 and July 1984

Category of accident	Predicted number	Recorded number	Difference	Percentage change
Fatal accidents:				
Rural	41 255	33 507	7 748	-18,8
Urban	40 134	36 924	3 210	-8,0
All	81 389	70 431	10 958	-13,5
Total accidents:				
Rural	461 038	396 871	64 167	-13,9
Urban	2 989 090	2 910 146	78 944	-2,6
All	3 450 128	3 307 017	143 111	-4,1

8.7 *Summary*

Ten models have been constructed, consisting of fatal, serious injury, slight injury, damage-only and total accidents, subdivided into urban and rural areas. The models fit the data quite well - the coefficients of multiple determination, R^2, vary between 0,715 (urban fatal accidents) and 0,963 (urban total accidents.

The best measure of speed was found to be the mean speed of all vehicles on rural roads (MNTOTO). This variable occurred in all ten models and has a large influence on accidents. Its effect is greatest on fatal accidents and least on damage-only accidents. The coefficients of MNTOTO for the non-fatal accidents are larger in the urban models than in the corresponding rural models.

The urban speed limit (URB_SL) appeared as a significant variable in all the urban models and in the three injury accident models in rural areas as well. The presence of MNTOTO in the urban accident models and URB_SL in the rural injury

accident models strongly suggests that the effect of speed changes on part of the road network carries over onto other parts of the network.

The importance of speed is highlighted by the analysis of the effects of the lower speed limits between 1973 and 1984 where it was estimated that accidents were reduced by 143 000 and 12 500 lives were saved.

CHAPTER 9

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

9.1 Summary

South Africa has a very much higher fatality rate than other Western countries (Chapter 3), although it it was shown to be lower than the fatality rates of some African countries for which statistics were available (Chapter 1). The speed limits on South African roads are not out of line with those of countries elsewhere but, when compared with those of 27 Western countries, they were found to be above average on all four categories of road - urban; rural non-freeway; rural expressway; rural freeway (Chapter 3).

South African drivers are in favour of much higher speed limits than are drivers from New Zealand, Finland and the United States (Chapter 4). Drivers' opinions of speed limits were solicited in two opinion polls held in 1983. One of these was directed exclusively at White drivers and the other at members of a motoring organization. At the time of the survey the rural speed limit was 100 km/h. The current speed limits of 60 km/h on urban roads, 100 km/h on rural non-freeway roads and 120 km/h on rural freeways correspond with the desires of the majority of White drivers (Chapter 4).

A policy of increasing the speed limit to 120 km/h on selected non-freeway roads was introduced in 1935 and has become widespread in certain provinces since. If public opinion has remained unchanged since 1983, this policy is a response to a desire held only by a minority of drivers. Other road users' views have not been sought.

The effects of speed limit changes in twelve countries, including South Africa, have been reviewed. Altogether, the change in safety resulting from 48 changes in speed limit have been described (Chapters 5 and 6). Of these, 42 were downward changes and resulted in reductions in accidents and casualties in 40 of the cases. All six increases in the speed limit resulted in increases in accidents and casualties.

Some of the evidence reviewed suggested that changes to the speed limit on part of the network affected accidents elsewhere on the network. This corroborates the South African experience.

An analysis of American crash data involving tow-away cars has been done, using Delta-V as a measure of speed (Chapter 5). Most accidents occur at low speed and the probability of survival is high. When Delta-V exceeds 100 km/h the probability of survival is less than 50 per cent.

Three numerical analyses have been done to link a change in speed or speed limit with a change in safety.

i) The fatality rates of twelve industrialized Western countries were examined and more than 80 per cent of their variability could be explained in terms of their urban and rural speed limits (Chapter 3).

ii) Three predictive equations have been derived, relating a change in fatal, injury and all accidents with the change in mean speed following a change in the rural speed limit (Chapter 7). Fatal accidents were shown to be affected most by a given change in the mean speed and all accidents

the least. The equations indicated that small changes in speed resulted in large changes in accidents; this is consistent with other research findings. Shortcomings of this approach were described.

iii) Models of the monthly number of accidents between 1972 and 1985, subdivided into five urban and five rural categories, have been constructed (Chapter 8). Included in the models was a measure of the mean speed of vehicles on rural roads and this variable appeared and was significant in all ten models. Nearly 60 per cent of the variance of the rural fatal accidents between 1972 and 1985, and 40 per cent of the variance of urban fatal accidents, could be explained in terms of the changes in the rural mean speed during this period.

A 1 km/h increase in the mean vehicle speed in rural areas was shown to result in an increase of 9 fatal accidents and 120 total accidents per month. The greatest increase in serious injury, slight injury and damage-only accidents occurred in urban areas.

During the period November 1973 to August 1984 the government applied lower speed limits as fuel conservation measures and it was estimated that 12 500 lives and 140 000 accidents were saved in consequence.

The urban speed limit was also shown to contribute significantly to all categories of accident in urban areas and to fatal and injury accidents in rural areas.

9.2 Conclusions

i) South Africa has a road accident fatality rate many times that of the United States of America and Western European countries.

ii) South Africa's speed limits are above average when compared with those of the USA and Eastern and Western European countries.

iii) The evidence that lowering the speed of traffic on rural roads reduces accidents is overwhelming. Similarly, increasing the speed increases accidents.

iv) The mean speed on rural roads, the 85-percentile speed, and the standard deviation of the speed are highly correlated. The mean speed was found to be the best descriptor of speed.

v) Changes in the mean speed have the greatest effect on the most severe accidents and the smallest effect on the least severe accidents.

vi) Changes in the speed limit affect the mean speed of traffic. The application of a high speed limit on a previously unrestricted road can result in an increase in mean speed.

vii) Speed limit changes on part of the South African road network affect accidents elsewhere on the network. There is some evidence that the same phenomenon has occurred in other countries.

viii) During the past year or so, a number of non-freeway rural roads have had their speed limits raised from 100 to 120 km/h, based on whether their geometric design is adequate for the higher limit. Such a policy does not take into

account the fact that increasing the speed on part of the network increases accidents elsewhere.

ix) In 1983 the majority of White drivers were content with a speed limit of 100 km/h on non-freeway rural roads. It is difficult to understand why the provinces have raised the speed limit to 120 km/h on some non-freeway roads, particularly in view of this country's poor fatality rate.

x) In South Africa, the change in the number of accidents brought about by a change in the rural speed limit is felt most in the urban areas. This suggests that urban authorities should be consulted when changes to the rural speed limit are being considered.

xi) The estimated accident costs of a 1 km/h change in the rural mean speed considerable - of the order of R19 million per annum.

xii) The urban speed limit was not under investigation in this study, but the analysis has nevertheless shown that considerable safety benefits could accrue if the urban speed limit were to be reduced to 50 km/h. Such a speed limit would still be in line with those of other countries - but at the lower end of the range instead of the upper end as it is today.

xiii) There are many factors that influence the number and severity of accidents. An upward or downward change in one of the factors which is, say, positively correlated with accidents does not necessarily mean that the number of accidents will increase or decrease correspondingly; other factors may be exerting a more powerful influence in the opposite direction.

xiv) There is some evidence from Finland and Ireland that

setting the speed limit at the 85-percentile speed has little effect on the number of accidents.

xv) The models described in Chapter 8 should be viewed as descriptive models - the values of the coefficients of the different variables are not fixed and incapable of change. For instance, were the road authorities to address with vigour and determination the problems of single-vehicle and pedestrian accidents, which together comprise three-quarters of the fatal accidents, then there will have been a change in structure and the models will no longer be appropriate.

9.3 Recommendations

i) Although speed limits have been used for fuel conservation measures, their most important function is road safety and it has been shown that both the rural speed and the urban speed limits have a great influence on the number of accidents. In view of this country's high fatality rate compared with developed countries, it is recommended that there should be a national maximum speed limit of 90 km/h and an urban speed limit of 50 km/h. The United States of America, which has the lowest road accident fatality rate in the world, has a national maximum speed limit of 55 mph (88 km/h); many Western countries have 50 km/h urban speed limits.

ii) It is hoped that the evidence presented in this report is sufficiently persuasive to convince the National Road Safety Council and the Automobile Association that there is direct evidence that speed itself causes accidents (see page 4). When viewed against the accident record of this country over the past decade, during which time a number of other countries have achieved a raduction in accidents, the performance of the authorities responsible

for road safety cannot be considered to have been particularly successful. I believe that the active support of the National Road Safety Council for a 90 km/h maximum rural speed limit and a 50 km/h urban speed limit, unpopular though these restrictions might be, is essential for their adoption. The introduction of these two measures will bring about an immediate improvement in road safety and can only enhance the image of the Council.

iii) The current policy of using the 85-percentile speed as one of the factors for setting speed limits should be reviewed.

iv) During the preparation of the data set on which the analysis in Chapter 8 was based, accident and casualty data by province and by class of road user were also collected. It was expected that these accidents and casualties would be highly correlated. For instance, one would expect that serious rural accidents in Natal and the Cape or rural pedestrian fatalities in the Cape and the Orange Free State would exhibit similar patterns. Instead we find that the correlations are very close to zero. This strongly suggests that there are regional factors affecting safety; these require further investigation.

iv) The percentage of motorcycles in the vehicle population is an important factor in the accident models. The sudden growth in the number of motorcycles that ensued following the oil crisis in 1979, and the slight reduction that has taken place since then, are probably linked to the price of fuel and the purchase price of a motorcycle. The authorities may wish sometime to impose controls on the use of motorcycles, or certain categories of motorcycle, on public roads. They may wish to review the minimum age a person may ride a motorcycle. A study of motorcycle ownership and accident characteristics would provide valuable input.

v) The relationship between the economy and road safety is poorly understood. Is the level of the economy purely a surrogate measure of vehicle kilometres travelled, or are there other factors that are affected by the level of the economy such as alcohol consumption, or the incidence of new (high risk) drivers entering the driver population? This is a further area that requires study.

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