DRINKING AND DRIVING

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drinking and driving

A literature study

INSTITUTE FOR ROAD SAFETY RESEARCH SWOV

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The Institute for Road Safety Research SWOV was founded in 1962. Its object is, on the basis of scientific research, to supply the authorities with data for measures aiming at promoting road safety. The information obtained from this scientific research is disseminated by SWOV, either as individual publications, or as articles in periodicals or via other communication media.
SVOV's Council consists of representatives of various Ministries, of industry and of leading social institutions.
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Foreword

Not only the Netherlands, but other countries as well have shown great interest in recent years in the subject of drinking and driving. Very many research projects, symposia, conferences and published articles testify to this. In the Netherlands, SWOV published a study of the literature on this subject (See SWOV, 1969). Furthermore, SWOV has had research carried out by the Institute for Perception TNO, Soesterberg, and by the Criminological Institute of the Groningen State University. In 1970, SWOV started a series of roadside surveys on drinking and driving, four of which have since been completed.
In aid of the Dutch Road Safety Association VVN's publicity campaign when the new legislation on drinking and driving was introduced on 1st November 1974, a review was made of the scientific data available at that moment.

This publication can be considered as a follow-up of the 1969 literature study mentioned above. It is the crystallisation of 'descriptive' research in which a large number of Dutch and other research projects were critically examined. Next, the results of these were arranged so as to review the growth in knowledge concerning drinking and road safety since 1968. This knowledge is needed for a correct explanation of the effect of the 1st November 1974 legislation on drinking and driving and for mapping out a future policy.
This publication has been written by P.C.Noordzij, Research Psychologist, acting head of the Department Applied Research Pre-Crash Projects.

E.Asmussen
Director Institute for Road Safety Research SWOV

1. Introduction

The Netherlands have had new legislation on drinking and driving since 1st November 1974. There have already been greatly different expectations and suppositions about its effectiveness. Soon, however, the SWOV research project on Drinking and driving will have sufficient information available for making a significant comparison of the situation before and after the new legislation.
Proper assessment of the effect of the legislation necessitates a very wide knowledge of the drinking and driving question. This publication has the purpose of contributing to this with reference to Dutch and other literature. Only research will be discussed the subject matter of which relates to actual road users, whether or not based on official records. The results of such research provide much stronger evidence than those of physiological or psychological experiments under controlled conditions. The latter can be used only for supplementing and supporting practical research results. Experimental research is reviewed, for instance, in Levine et al. (1973) and Perrine (1974).
With some exceptions, the research discussed concerns motor-vehicle, especially private-car drivers. Hardly any statistics exist concerning other road users. This is unfortunate, especially in the Netherlands with its high rates of pedestrian, cyclist and moped fatalities.

2. The risk of drinking-driving

The effect of drinking on the risk of road-accident involvement can be investigated by comparing a group of accident-involved drivers with a non-accident group. The blood alcohol concentration is then the most important research variable. There are both psychological and practical reasons for taking the BAC as a variable instead of, say, quantity of alcohol consumed or driving capability.
A limited number of investigations of this type are known. Zylman (1971) gives a short description of some of them. The Grand Rapids research dating from 1964 has the fewest limitations and is therefore the most widely known. It has even been republished recently (Borkenstein et al., 1974).

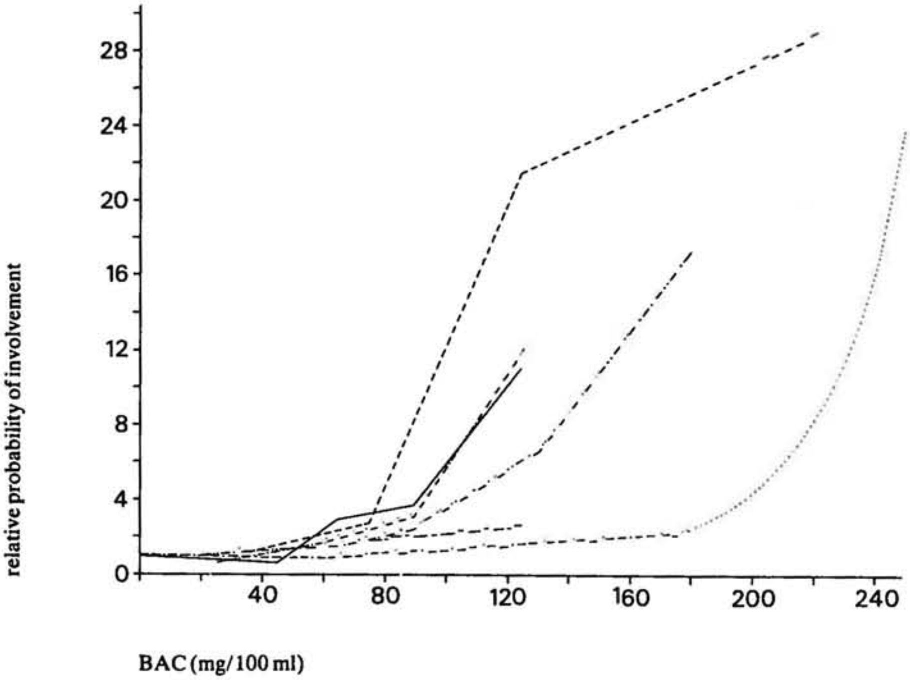
Hurst (1970) made a uniform calculation, for various investigations, of how great the effect of the BAC is on the risk of accident involvement (See Figure 1). He used Bayesian analysis, resulting in the following formula:

$$RP(C/B) = \frac{P(C/B)}{P(C/B_0)} = \frac{P(B_0)\,P(B/C)}{P(B)\,P(B_0/C)}$$

in which:

RP	=	relative probability
P(X/Y)	=	probability of X, given Y
C	=	accident
B	=	a given positive BAC class
B_0	=	negative BAC class

All that this really indicates is that in comparable circumstances the positive-BAC group of drivers run a higher accident risk than the negative-BAC group (between 0.0 and a low limit). The result depends on how the accident-involved group is selected (according to time, place, severity and type of accident etc.), to what extent the control group is comparable (in time and place) and how carefully the BAC is measured. Hurst's calculations show that the general form of the relationship between BAC and accident risk is the same in the various investigations: the accident-involvement risk increases faster as the BAC becomes higher. No opinion is expressed as to the cause of this. Hurst mentions several arguments making it credible that the positive BAC is the main cause of the greater accident risk and not other driver, vehicle or circumstantial characteristics.
Countless psychological experiments have demonstrated reduced performance after drinking. The form of the ratio between reduced performance and drinking, however, is not entirely comparable with that of the BAC/accident-risk ratio (See Levine et al., 1973; Perrine, 1974).
An indirect demonstration of the causal connection between positive BAC and increased accident risk is that research into the effect of other driver characteristics



—·· — ··—	Grand Rapids data,	5985	total accidents
—·—·—·—	Grand Rapids data,	300	fatal or serious accidents
————	Evanston data,	270	crash injuries
—–––– –	Toronto data,	423	total accidents
—–·—–·	Manhattan data,	34	fatal accidents
—— —— —	Vermont data,	106	fatal accidents
....	Estimated approx. extension of Manhattan trace		

Figure 1. Relative probability of accident involvements as a function of BAC (mg/100 ml), where 1 = relative probability at zero alcohol (Hurst, 1974).

on their accident risk (except for age and driving experience) has proved little. In the Grand Rapids research (Borkenstein et al., 1974), drivers were asked about the frequency of drinking. Frequent drinkers with the same BAC (negative or positive) were found to run a lower accident risk than the less frequent, probably because they are more experienced drivers.
Since frequent drinkers on average have a high BAC, the greater accident risk with an increasing BAC proves to be slighter than if only less frequent drinkers were considered. This argument, rather than confirming the causal connection between drinking and increased accident risk, counterbalances the assertion that there is no such connection.

For some researchers, drinking is too ready an explanation of the increased accident risk of positive-BAC drivers. Smart (1969), for example, claims that some of these drivers are alcoholics. He makes it a credible assumption that alcoholics even when sober are more involved in accidents.
Dutch research (Buikhuisen, 1973) compared a group of drivers convicted of driving while intoxicated with a group with similar biographic characteristics. The convicted drivers proved, in a period subsequent to conviction, to have had more accidents and committed more traffic offences than the others. These were solely accidents and traffic offences in which there was no known drinking. But these results cannot be generalised. They do not apply to all positive-BAC drivers, as will be set forth below.

The general form of the BAC/accident-risk ratio is after all still found upon classification by driver characteristics such as age and drinking habits.
The precise form of the ratio may differ however. The risk increases less quickly with an increasing BAC in the case of frequent drinkers than it does for less frequent (Hurst, 1974). There are also indications in the case of youthful drivers that the risk is greatly increased even with a low BAC. Hyman (1968) presents a table with a distribution by motorists' sex, age and BAC class from the Grand Rapids material. If Hurst's calculation method is applied to these figures, the pattern for male motorists is as given in Figures 2 and 3. The risk for sober motorists aged 35 to 54 is put at 1.
Figure 2 shows that with an increasing low BAC, the accident risk for male motorists increases faster for the age group under 20 than for the other age groups. At higher BAC's nothing can be said as regards youthful motorists because there are not enough data.
At BAC's over 100 mg/100 ml, males from 20 on run less and less risk of accident-involvement the older they get. From 55 on, however, the risk increases very rapidly indeed the older they get (See Figure 3).
Hyman (1968) has also calculated accident-vulnerability ratios, which Zylman (1973a) has depicted. The chance of a specific BAC given an accident is divided by the chance of a specific BAC given no accident. Or, with Hurst's notation: $P(B/C)/P(B)$ Although the conclusions from this calculation are comparable with those of Hurst's, the calculating method is not as appropriate as his.
Further indications of the role of age in the relation between alcohol and accidents are given by Carlson (1972). He finds in the first place that the proportion of young people (16-20 age group) is greater in a group of drivers in single-vehicle accidents than in a control group. The proportion of young people proves to be higher still if only positive-BAC drivers in the group of drivers in single-vehicle accidents are consid-

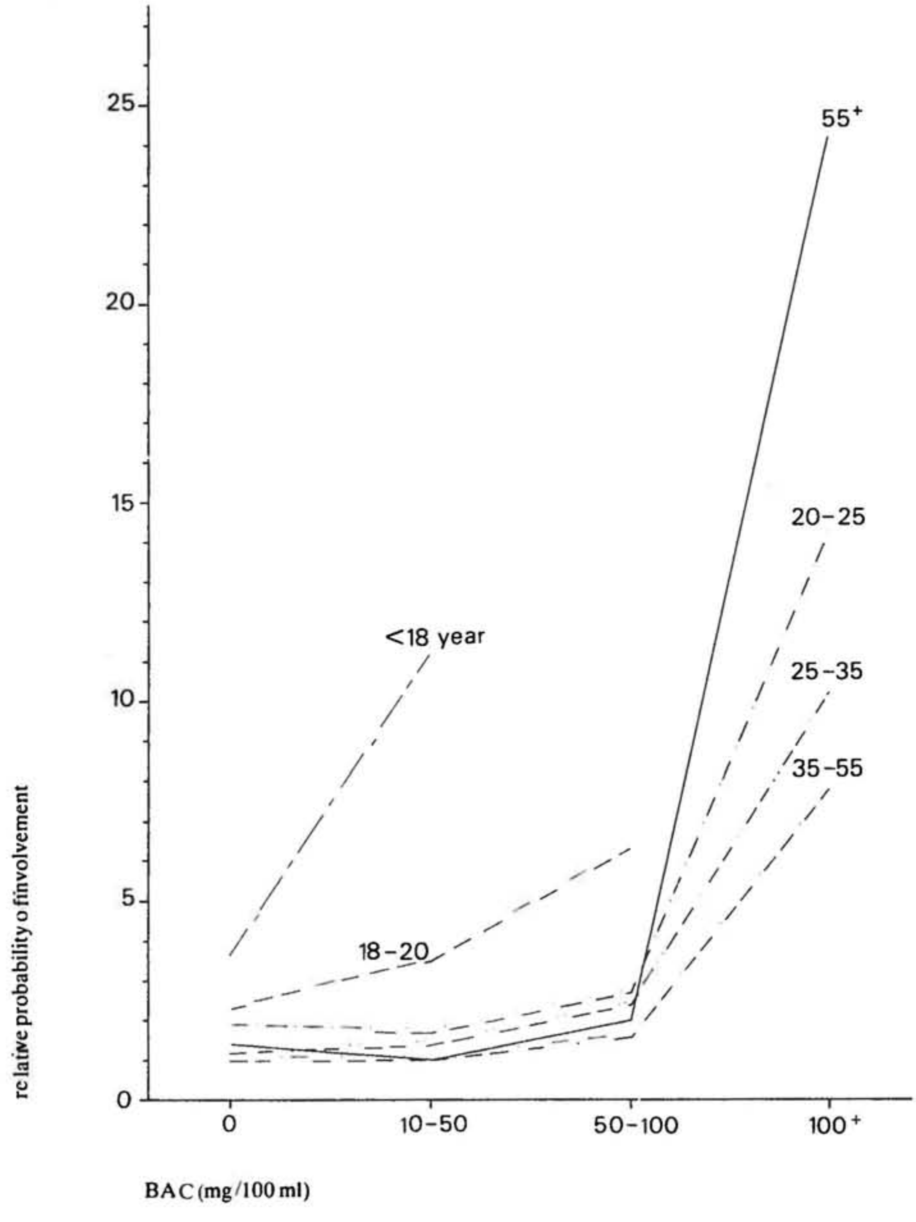


Figure 2. Relative probability of accident involvement as a function of BAC (mg/100 ml) per age group, where 1 = relative probability at zero alcohol for age group 35-55 (Grand Rapids data, men).

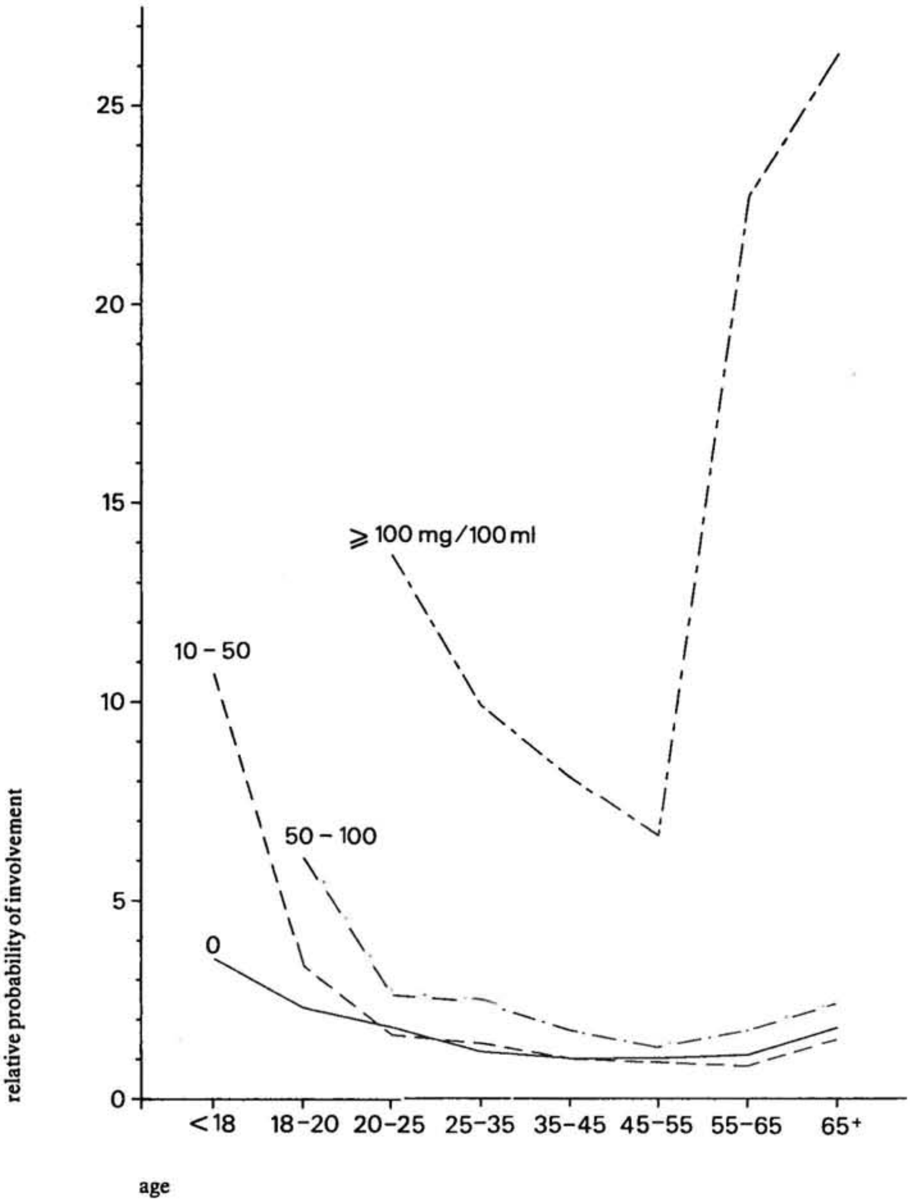


Figure 3. Relative probability of accident involvement as a function of age groups per BAC (mg/100 ml), where 1 = relative probability at zero alcohol for age group 35-55 (Grand Rapids data, men).

ered. It therefore means that a positive BAC has more effect on the 16-20 age group drivers than on older drivers. A later publication by Carlson (1973) splits the category of drivers in single-vehicle accidents into smaller age groups. It is then found that the higher proportion of young people in the accident group applies up to 18 years if only negative BAC's are compared. Comparison of positive-BAC drivers shows this overrepresentation to exist up to the age of 21. A difficulty in evaluating Carlson's results is that in the accident group the BAC was counted as positive because of the impression made on the police, whereas breath analysis was used for the control group. Furthermore, no distinction was made as between positive BAC's and the control group was only comparable in general terms with the accident group as regards time and place.
There are also indications that the effect of drinking on the accident risk is influenced by circumstances such as time and place. Zylman (1973b) says that the effect of a positive BAC is greater in daytime, particularly at rush hours, than at other times. Hurst (1974) assumes that a positive BAC will have more effect on the accident risk in urban areas than elsewhere. He also says that the increased risk owing to a positive BAC seems to be greater in the case of serious accidents as compared with less serious one.

The ultimate conclusion can be that as the BAC rises there is in consequence a more rapid increase in the accident-involvement risk. Yet it is not impossible that this increased accident risk can be explained partly by factors other than the higher BAC. For instance, some of the high-BAC group of motorists may run a higher than average risk even when sober.
On the basis of the research discussed in this chapter, it is not possible to indicate the BAC limit above which it is undesirable to drive for road safety reasons. The BAC/accident-risk ratio is somewhat variable, besides which some inaccuracy is inherent in the results of each of the investigations. Apart from this, the general form of the ratio gives no support either: a slight increase in the accident risk already starts at low BAC's and after these increases faster. There is no BAC above which the accident risk is suddenly much greater than below it. Other forms of research into the relationship between drinking and driving behaviour, such as experimental laboratory, simulator or field research, are in themselves also unsuitable for choosing a limit.

3. The drinking-driver's contribution to road accidents

In The Netherlands, the Central Bureau of Statistics CBS gives both absolute numbers and percentages of accidents in which the police has noted that one or more of those involved had been drinking. This does not mean they are suspected of driving while intoxicated. The police used no aids to establish that a driver has been drinking, and there are no indications, therefore, of the degree of intoxication or the BAC.
The numbers of fatal accidents in which drinking was recorded are set forth as moving twelve-months totals in Figure 4. The numbers of accidents in which drinking was recorded rose from 1972 to mid-1973 and then remained constant until the end of 1974. There are no indications that actual drinking by road users follows such a varying pattern as in Figure 4. This illustrates that the recording of drinking by road users depends on various other factors than the actual consumption of alcohol.

Figure 5 shows the moving twelve-months totals of fatal accidents involving alcohol as a percentage of the total number of fatal accidents. A further breakdown shows that the percentage of fatal accidents involving alcohol varies, inter alia, with the type of road usage, severity of the accident, time and day of the week and road users' ages. Nor can this variation be taken as proof of a real variation in drinking, because the pattern is probably distorted owing to incomplete records. The records are nothing more than indications regarding drinking. In other countries, too, standard police statistics appear to underestimate drinking and in some cases to distort it (Zylman, 1970; Goldberg & Bonnichsen, 1970; Waller, 1971).
Moreover, in presenting data as in Figure 5, a major part is played by another factor apart from incomplete records, viz. the numbers of fatal accidents in which drinking is not established. These numbers may vary independently of drinking. Although the number of fatal accidents involving alcohol remained more or less the same from mid-1973 until the end of 1974, the percentage increased. This is because of a big decrease in the number of other fatal accidents during this period.

In the United States, various investigations have been made establishing the BAC of road user fatalities. The results of these are often degraded to the statement that half the people killed on the roads are caused by drinking-driving.
Zÿlman (1974) combined the results from a number of investigations and gives average percentages for fatally injured persons with BAC's of 100 mg/100 ml or higher. For drivers involved in multi-vehicle accidents, 32.2% had a BAC above 100 mg/100 ml; for those in single-vehicle accidents it is 56.6% and for these drivers combined 44.3%. For adult pedestrians the comparable proportion is 35.7%. Compared together, the investigations show numerous differences in design and presentation of the data. Furthermore, the actual percentages are probably lower. Some reasons for this are: incomplete sampling, underrepresentation of youthful and elderly people in the sample, preclusion of the lowest age

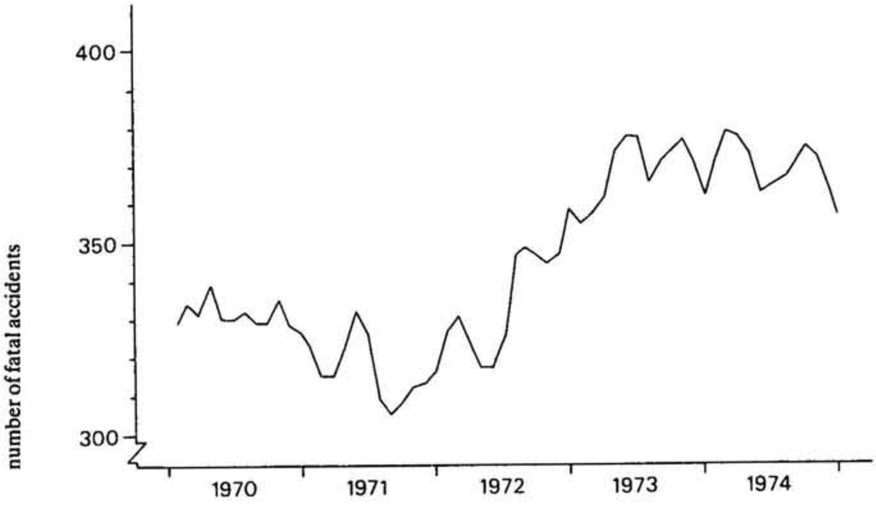


Figure 4. Moving twelve-months total of fatal accidents involving alcohol in The Netherlands.

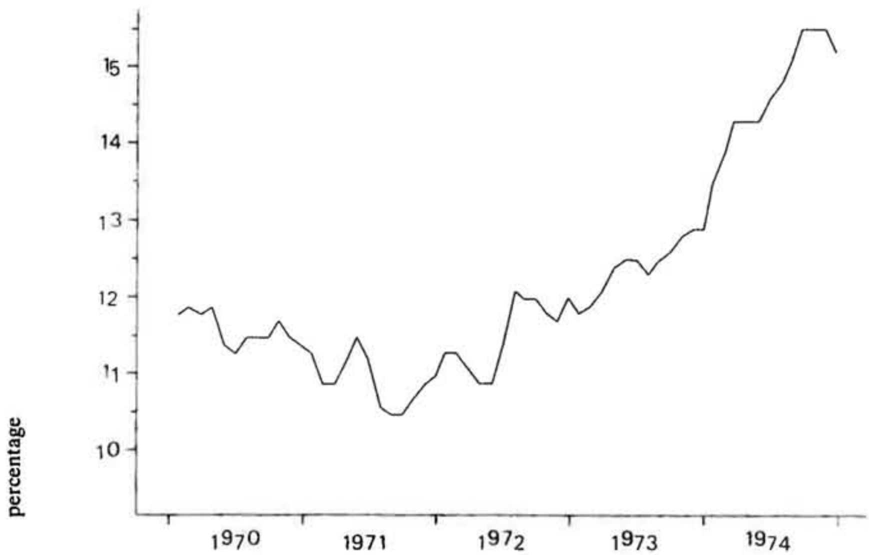


Figure 5. Moving twelve-months percentages of fatal accidents involving alcohol in The Netherlands.

groups, inclusion of fatalities only occurring soon after the accident (say, within six hours). These percentages are not the same as those for fatal accidents or fatalities *caused* by drinking-driving. In the first place, not all casualties with high BAC's are responsible for the accidents. Moreover, drivers not killed include an unknown number with high BAC's and responsible for the accident. Besides, it may be added that the combination of a high BAC and responsibility for the accident does not automatically imply that the responsibility is a consequence of the BAC.
Zylman ultimately draws up a table in which the proportion of motor-vehicle fatalities that may have involved alcohol in some caused fashion, is very carefully estimated (See Table 1). His estimate is 36.4%. Attributing responsibility for an accident to one of those involved, however, is a dubious matter.

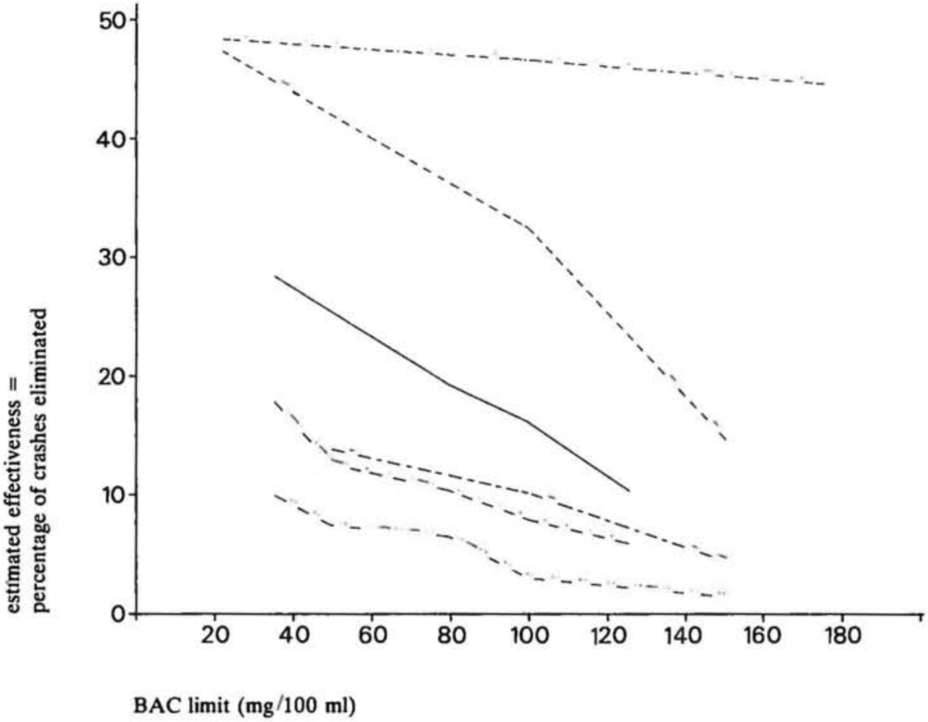
There is also another method of estimating the effect of drinking-driving on road safety. This is conditional upon knowing the BAC's of road users involved in accidents. It must also be known what accident risk there is at these BAC's as compared with a negative BAC. Moreover, it must be assumed that the negative-BAC accident risk remains unchanged when there are more or fewer positive-BAC road users. Hurst (1970) applied Bayesian analysis to the available research material and gives the results in a graph (Figure 6). If the BAC distribution or the BAC-accident-risk ratio differs from these investigations, then the percentage of accidents eliminated will be different as well. Based on the Grand Rapids research, the number of serious accidents would be reduced by 9% if all drivers with a BAC of 100 mg/100 ml or higher were to be replaced by drivers with a BAC not exceeding 100 mg/100 ml. There is a striking difference between this estimated reduction in the number of serious accidents (9%) and Zylman's estimated reduction in the number of fatalities (36.4%).
In a number of European countries road accident casualties' BAC's have been investigated too. Kielholz (quoted by Lutz & Leu, 1975) found positive BAC's for 41.8% of drivers admitted to hospital. Codling & Samson (1974) took a sample of deceased motorvehicle drivers and found a positive BAC for 20-30% of them. Hoffmann et al. (1975) took various samples among vehicle drivers admitted to hospital. They found a positive BAC for 50-60%. Bø et al. (1975) likewise investigated motor-vehicle drivers admitted to hospital; 52.6% had a positive BAC.

Too little information is available, however, regarding the composition of the various samples. For the moment, it is best to take Codling & Samson's data as a basis, because they relate to deceased drivers. These data give the impression that the number of alcohol-related fatalities in Europe is relatively lower than in the USA. Furthermore, traffic conditions in the USA cannot be automatically compared with those in Europe. In The Netherlands, for instance, it is not even approximately known how many accidents and casualties are caused by drinking-driving or could be eliminated by driving at lower BAC's. Nor is it known what the BAC distribution is of accident-involved road users. In order to gain more insight into this in the future, the BAC's of all persons involved in traffic accidents would have to be determined. If need be the investigations could be limited to fatalities and/or nighttime accidents.
Enough has been published on the characteristics of accidents involving alcohol, such as their nature, severity and time, e.g. by SWOV (1969) and Voas (1973). The principal results can be summarised as: accidents involving alcohol are mainly

		Sober not responsible	Alcohol involved	Sober responsible	100mg/ 100ml not responsible	Alcohol involved	100 mg/ 100 ml responsible	Alcohol involved	Total
Driver multivehicle		4245	1275	5860	475	235	4270	4270	14,850
Adult passenger multivehicle		6170	780		2170	1760			8340
Driver-single vehicle				5225			6925	6925	12,150
Adult passenger single vehicle		4115	1030		1445	1300			5560
Child passenger		2800	280						2800
Adult pedestrian		2525	250	2525	855	430	1995	1995	7900
Child pedestrian		700	70	2100					2800
Bicycle		275 adult	40	265 adult			10	10	
		165 child		385 child					1100
Non-traffic	1100								1100
Total	1100	21,230		16,205	5325		12,740		56,600
per cent	1·9	37·5		28·6	9·4		22·5		99·9
Total 'Alc Inv'			3725			3725		13,200	20,650*
per cent			18·0			18·0		63·9	

* Approximately 36·4 per cent of all motor vehicle deaths may involve alcohol in some causal fashion.

Table 1. Categorized estimates of motor vehicle deaths in the United States in 1972 and the portion that may have 'involved alcohol' in some causal fashion (derived from Zylman, 1974).



Grand Rapids data, 5985 total accidents
Grand Rapids data, 300 fatal or serious accidents
Evanston data, 270 crash injuries
Toronto data, 423 total accidents
Manhattan data, 34 fatal accidents
Vermont data, 106 fatal accidents

Figure 6. Effectiveness of BAC limits (mg/100 ml) (derived from Hurst, 1970).

single-vehicle accidents, they are generally serious and occur especially at nighttime and during the week-end. These findings are obviously not unrelated.

If the relationship between positive BAC and accident risk is taken as adequately proved, it is also possible to describe the extent of the problem by reference to the BAC distribution of a random sample of road users. In recent years there has been growing interest in this research. An extensive review of such investigations has been made by Stroh (1974). To some extent, in fact, the control groups in the research by Hurst (1970) can be regarded as random samples of road users. Recent research has been carried out, for instance, in France (Biecheler et al., 1974), Canada (Smith & Wolynetz, 1975), the United States (Wolfe, 1974; Clark, 1973). In The Netherlands similar research has been carried out by SWOV (Noordzij, 1975).
Despite the extensive organisation required for investigating the BAC distribution of a random sample of road users, it has advantages over studying accidents or casualties. Within a comparatively short period, both BAC's and other characteristics can be collected for a large number of drivers. Besides the aggregate BAC distribution, therefore, the correlation between drivers' BAC's and other drivers' characteristics can also be determined. Repetition of the research can provide a picture of any changes in the situation. A drawback is that drivers with very high BAC's hardly occur in such investigations. The BAC distributions found by Clark, Wolfe and Biecheler respectively are given in Tables 2, 3 and 4.

Period	BAC (mg/100 ml)								
	0-20		20-50		50-100		100+		Total
	N	%	N	%	N	%	N	%	N
1971									
Weekday									
7-9pm	112	89%	8	6%	2	2%	4	3%	126
10-12pm	111	84%	11	8%	6	5%	4	3%	132
1-3am	77	75%	11	11%	6	6%	8	8%	102
Weekend									
7-9pm	114	89%	7	5%	5	4%	2	2%	128
10-12pm	114	81%	12	9%	10	7%	4	3%	140
1-3am	78	66%	15	13%	17	14%	8	7%	118
1972									
Weekday									
7-9pm	156	92%	5	3%	7	4%	2	1%	170
10-12pm	157	87%	13	7%	8	4%	2	1%	180
1-3am	92	69%	13	10%	12	9%	16	12%	133
Weekend									
7-9pm	169	91%	9	5%	5	3%	3	1%	186
10-12pm	195	89%	14	6%	8	4%	2	1%	219
1-3am	75	57%	23	17%	15	11%	19	14%	132
1973									
Weekday									
7-9pm	146	94%	4	3%	5	3%	1	1%	156
10-12pm	139	89%	10	6%	5	3%	2	1%	156
1-3am	102	75%	15	11%	12	9%	8	5%	137
Weekend									
7-9pm	130	93%	7	5%	3	2%	0	-	140
10-12pm	121	92%	4	3%	5	4%	2	1%	132
1-3am	83	66%	19	15%	13	10%	11	9%	126

Table 2. Distribution of Drivers by BAC, Weekday or Weekend, and Time of Night (derived from Clark, 1973).

Time Period of Interview	Wtd. N	BAC Reading (mg/100 ml) 0-20	20-50	50-80	80-100	100-150	150+
10-11 pm	1032	85.5	6.4	3.9	1.8	1.5	09
11-12 pm	1210	81.8	8.4	5.5	1 3	2.0	1.1
12-1 am	133	75.1	12.0	7.5	0.0	3 8	1.6
10-1 Subtotal	1685	82.9	7.7	4.8	1 5	2.1	1.1
1-2 am	573	66.0	12.8	8.9	3.8	5.8	2.6
2-3 am	524	64.3	11.2	8.2	5.3	9.3	1.8
3-4 am	46	75.1	4.2	10.4	4 9	4.4	1.0
1-4 Subtotal	1505	66.5	12.4	8.0	4.5	6.7	1.9
Total	3719	77.4	9.2	6.1	2.4	3.6	1.4

Table 3. National Comparison of Percentage of Cases at Various BACs by Time of Night; Using Speed/Traffic, Population, and Drinking Estimate Weights (derived from Wolfe, 1974).

Time of day	Interviewees	BAC (mg/100 ml) 0-10	10-50	50-80	80-110	100+	Total
6.30-9.30 am	293	82.59	15.70	1.37	0.34	0.00	100.00
9.30 am-12.30 pm	330	68.48	27 27	1.52	1.21	1 52	100.00
12.30-3.30 pm	363	57.30	37.19	2.48	1.65	1.38	100.00
3.30-8 pm	901	59.38	32.08	3.88	2 66	2.00	100 00
8-11 pm	357	53.22	38.66	2 24	3.08	2.80	100.00
11 pm-2 am	79	48.10	32.91	12.66	5.06	1.27	100.00
2-6.30 am	35	65.71	14 29	8.57	2 86	8.57	100.00

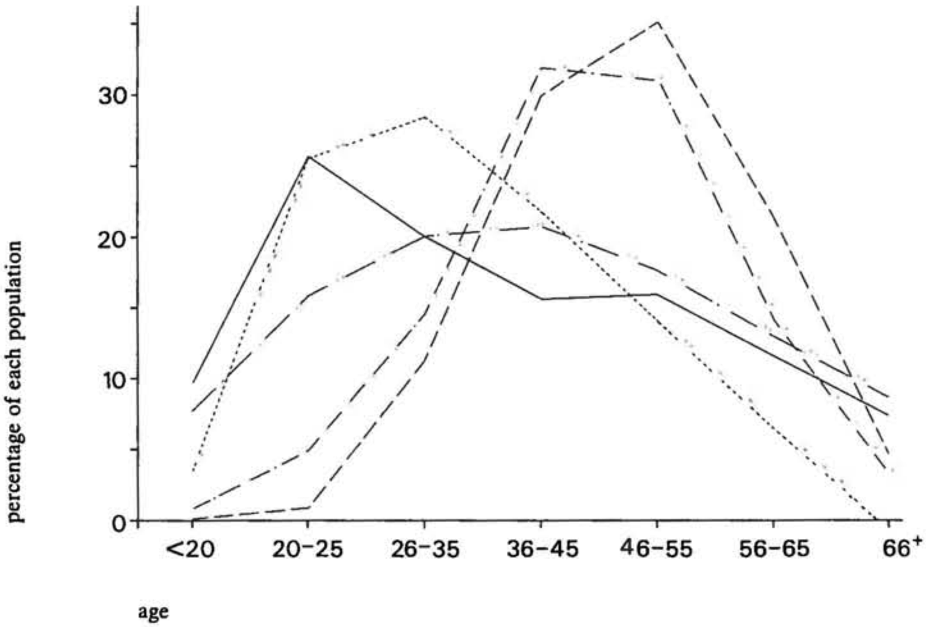
Table 4. BAC distribution of drivers by time of day in 1970 (derived from Biecheler et al., 1974).

4. Drinking-drivers' characteristics

A description of road users driving while intoxicated can start with various groups of drivers. For road safety purposes, an accident-involved group with high BAC's is however the most appropriate. Drivers themselves victims of accidents and having high BAC's could be used instead. But it is easier to select a random sample of drivers with high BAC's. The fact that very few drivers with very high BAC's are found in such a group does impose a limitation for the investigation. A third group of drivers for whom data can be collected without too much difficulty is drivers convicted of driving while intoxicated. A fourth possibility is to start with drivers who can be assumed to drive regularly while intoxicated: problem drinkers or alcoholics. In order to determine what is characteristic of these four groups, their characteristics must be compared with those of non-drinking drivers in comparable circumstances. A less correct approach is to compare their characteristics with those of specific population groups without the circumstances being comparable.

There has been little research covering more than one of these groups of drivers so as to ascertain any difference in the results. Research by Clark (1972) compared four groups: fatalities, drivers convicted of driving under influence (DUIL-sample), alcoholics admitted to hospital, and a random sample taken from all holders of driving licences. The fatalities were next subdivided into three categories: negative BAC, BAC between 10 mg/100 ml and 150 mg/100 ml, and BAC's higher than 150 mg/100 ml.

First of all, considerable differences in age emerged between the groups (See Figure 7). The fatalities included many younger than 25. Fatalities with BAC's exceeding 150 mg/100 ml were largely between 20 and 35. The ages of persons convicted of driving under influence and alcoholics were higher on average. The sample of holders of driving licences has a more uniform age distribution than the other groups.
There are also differences between the groups in average number of traffic offences. The lowest number is in the sample of driving-licence holders, followed by alcoholics, fatalities with negative BAC's, fatalities with BAC's between 10 mg/100 ml and 150 mg/100 ml, fatalities with higher BAC's and lastly persons convicted of driving under influence.
In the average number of convictions for driving under influence, the sequence is from low to high: sample of driving-licence holders and fatalities with a BAC below 150 mg/100 ml, fatalities with a BAC below 150 mg/100 ml, fatalities with a BAC above 150 mg/100 ml, persons convicted of driving under influence, and alcoholics.
The differences between the groups as regards accidents in the past are of primary importance. As to this, the convicted category is an unfavourable exception, while there are only minor differences between the other groups. It is notable that of the fatalities with BAC's exceeding 150 mg/100 ml, only 16% had had two or more accidents during the preceding six and a half years as compared with as many as 31% of the persons convicted of driving under influence.



Population	Mean Age
Michigan Driver Profile	42 years
Hurley Alcoholics	49 years
DUIL Sample	44 years
Fatalities	39 years
Fatalities with BAC ≥ 150 mg/100 ml	35 years

Figure 7. Age distribution for four populations, plus the sub-population of fatalities with BAC ≥150 mg/100 ml (according to Clark, 1972).

Figure 8 comes from research by Waller (published by Haddon, 1970) and shows the percentage of men with previous arrests for driving while intoxicated, for various groups. Here, the percentage is considerably higher for persons with arrests for driving while intoxicated than for all other groups of drivers investigated.

A particularly interesting comparison is that of persons convicted of driving while intoxicated with fatalities with high BAC's. In Clark's research (1972) some of the differences found may be due to the differences in age structure. Thomas (included by Pollack et al., 1970) compared these two categories by separate age groups. So as to make the groups themselves as fully comparable as possible beforehand, the only comparison of fatalities was that of white ('caucasian') drivers responsible for the accident, deceased within six hours of the accident. Of those convicted of driving while intoxicated, only white drivers who had accident records were compared.
The average BAC of drinking-driver fatalities was found to be 180 mg/100 ml. This is even higher than the average at the time of arrest, i.e. 140 mg/100 ml, of persons convicted of driving while intoxicated. Past convictions, for which differences are found between the two groups, differ in the respective age groups, but are all to the disadvantage of the convicted group.
Research by Perrine et al. (1971) included not only deceased drivers and persons convicted of driving while intoxicated, but also roadblock drivers, stopped at times and places where there had been fatal accidents. In this latter group they have segregated clear-records drivers. There is a big difference in BAC distributions of the different groups (See Figure 9). Even if only BAC's exceeding 100 mg/100 ml are taken into account, by far the highest average BAC is found for those convicted of driving while intoxicated.
Next, Perrine et al. examined, from the various groups, only drivers older than 25 with BAC's exceeding 100 mg/100 ml. This was done to make the groups as comparable as possible beforehand. In this way, the groups become smaller, however, and the results less reliable. Comparison of the various groups shows the average number of past 'citations for moving traffic violations' and also the average number of licence suspensions to be the highest for the group convicted of driving while intoxicated.

Although the above findings are of course only a selection from the results as a whole, it is difficult to build up any coherent pattern. The researchers' own final conclusions vary also. Perrine et al. and Clark stress the similarity between the various groups of drivers with high BAC's, while Thomas points out the differences. To avoid drawing premature conclusions, the latter attitude is advisable.

The research results can perhaps be reconciled better against the background of the following description of the situation.
Driving with a positive BAC occurs mainly during weekend evenings as a consequence of social activities.
Drivers who then drive are a selection from drivers as a whole based on their need for social contact; driving in circumstances more dangerous than in daytime is not something insurmountable to them.
The group of drivers with positive BAC's differs in a number of respects (including age) from that with negative BAC's. Driving in a state more dangerous than sober is not insurmountable for the former.

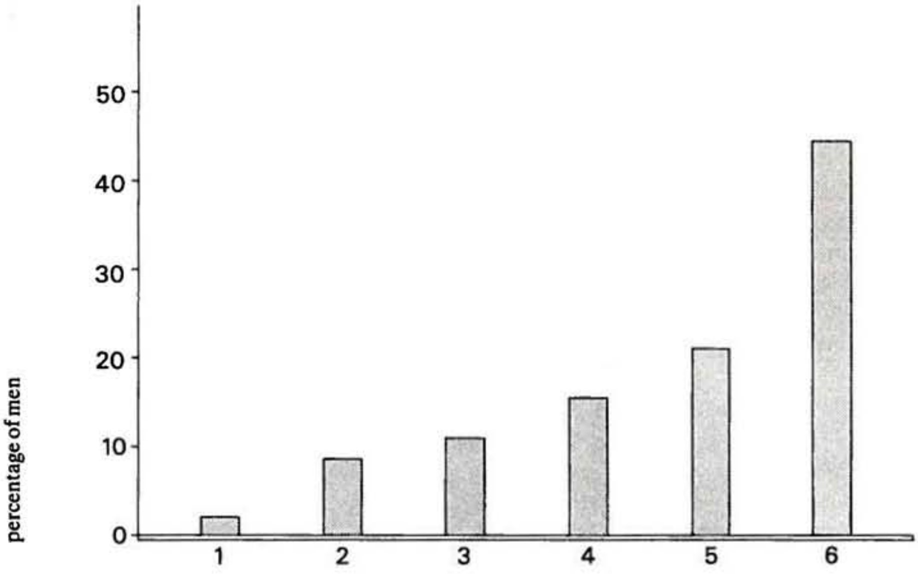


Figure 8. Percentage of men with previous arrests for driving while intoxicated and similarly defined offences among men with no crashes or traffic citations(1), with citations for run-of-the-mill moving traffic violations (2), with crashes not involving alcohol (3), with arrest warrants for ignoring traffic citations (4), with crashes involving alcohol or hit-and-run crashes (5), and with arrests for driving while intoxicated and related offences (6) Oakland, California, 1965 (according to Waller, See Haddon, 1970).

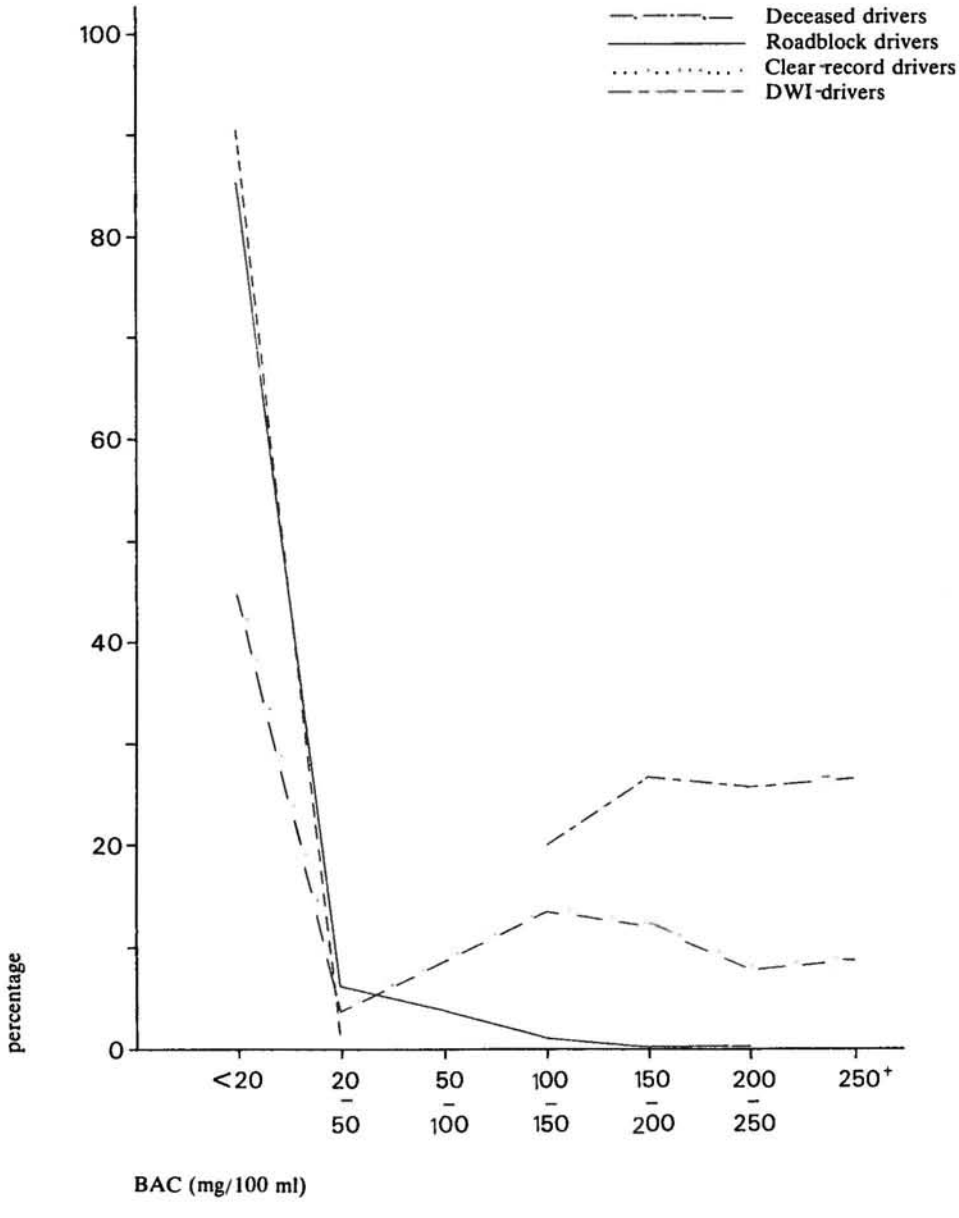


Figure 9. Distribution of BAC (mg/100 ml) for deceased, roadblock, clear record and DWI-drivers (according to Perrine et al., 1971).

The high-BAC group is a selection from the total group with positive BAC's. A high BAC may be exceptional, especially among younger drivers. In the case of older drivers with fixed habits it may be a temporary or permanent problem or give expression to this. The group of drivers with high BAC's involved in an accident has a higher average BAC than the total high-BAC group. Moreover, it cannot be discounted that the BAC/accident-risk ratio may vary with personal characteristics. Such characteristics may in turn be associated with both accident risk and drinking.
The group convicted of driving while intoxicated is likewise a selection from the total high-BAC group. This is based not only on BAC level, but also because they have characteristics that bring them more to the attention of the police or cause them more accident involvement. This means that research findings for drivers convicted of driving while intoxicated do not automatically apply to all drivers having a greater accident risk owing to a high BAC.

In The Netherlands, Buikhuisen (1973) carried out research into drivers convicted of driving while intoxicated. They proved both before and after conviction to have committed more traffic crimes than a group of drivers comparable in age, sex and occupational aspects. They also proved to have committed more crimes of other kinds.
In other Dutch research (Buikhuisen & Van Weringh, 1968) it was examined whether there was any difference among drivers convicted of driving while intoxicated between those who repeat this traffic crimes and those who do not. Differences were found, inter alia, in age, occupational aspects, drinking habits and BAC when stopped. Furthermore, the repeaters proved to have worse criminal records. They proved to have committed more alcohol-traffic crimes, while they had also committed more other traffic crimes and other crimes. Whether drinking-drivers will appear to be repeaters can best be derived from a combination of their criminal records, their ages and occupational aspects. Nevertheless, predictability of their behaviour is low for practical purposes.
Buikhuisen et al. (1968) made a number of psychological tests of persons convicted of driving while intoxicated and serving their sentences in a special prison. The results are compared with national standards for such tests and with the score of a control group (comparable in age, sex and occupation). The conclusion was that persons convicted of driving while intoxicated are anything but an average group as regards their personalities. It has already been indicated, however, that perhaps they are also not an average of the group of drivers with an increased accident risk owing to a high BAC.
There is no ready-made answer to the question of the extent to which problem drinkers and alcoholics contribute to the problem of driving while intoxicated. It depends partly on the group of drivers taken as the basis, and on the definitions of 'problem drinker' and 'alcoholic'.
Lastly, reference may be made to the publications by SWOV (1969) and Voas (1973) on the characteristics of drinking-drivers. Where the findings coincide, they can be briefly summarised as follows.
Males in the 30-50 age group are overrepresented among drinking-drivers. They are often unattached persons in the lower socio-economic classes. The latter two characteristics apply particularly in the USA and do not necessarily apply automatically in Europe. For they are related to overall social conditions.

5. Effectiveness of measures against drinking-driving

The most common measures against drinking-driving are: making this punishable on the basis of statutory BAC limits, detecting and punishing or treating offenders, and publicity campaigns. The introduction of a statutory BAC limit may be isolated, or may be combined with one or more other measures.

5.1 **Statutory BAC limits**

5.1.1 *Great Britain*

Great Britain introduced a statutory BAC limit of 80 mg/100 ml in 1967. It is often quoted as a successful measure against drinking-driving. It gave the police an opportunity to demand a qualitative breath test in certain cases, possibly followed by a blood test. An extensive publicity campaign was organised to introduce the change in the law.

Reports by the Transport and Road Research Laboratory (TRRL) provide material for evaluating its effectiveness. In addition to accident statistics, there is a sample of road-traffic casualties of 16 years and older, whose BAC's were determined. Since drinking occurs mainly at night, the statistics are subdivided into nighttime (22.00 - 4.00 hours) and daytime (4.00 - 22.00 hours).

Table 5 (compiled by Sabey & Codling, 1975) shows the numbers of casualties after the new legislation as compared with those before its introduction.

At nighttime there was a steep drop in the number of casualties to both motor-vehicle drivers and passengers and also pedestrians immediately after introduction of the Act. After about four years, however, the number of driver casualties was back at the pre-introduction level. The number of passenger casualties increases slowly, and the number of pedestrian casualties increases still slower.

In daytime, there are no pronounced differences in the number of casualties before and after introduction of the legislation. The minor differences that do exist may be caused by unknown factors which also continue into the night. For this reason, nighttime casualties are also shown in Table 5 as percentages of the total numbers for daytime and nighttime. These percentages show about the same pattern as the absolute numbers of nighttime casualties.

Figure 10 shows the percentage of drivers fatally or seriously injured at night (22.00 4.00 hours) by age groups. At first there was a decline in all age groups after introduction of the legislation. But this was followed by an increase, which was more pronounced among young people than others. Particularly in the 16-19 age group, the percentage of nighttime casualties quickly rises above the pre-introduction level.

In the daytime, too, there are remarkable trends in the number of casualties by age groups (See Table 6, compiled by Codling, 1975). For the 16-19 age group is a continuous fall since the legislation. The number of nighttime casualties will therefore have to go on decreasing at least as much if the percentage of casualties during

Casualties (Period Oct-Sept) each year	Main drinking hours 10 pm – 4 am		Rest of day		Percentage in drinking hours	
	Killed	All injured	Killed	All injured	Killed	All injured
Motor vehicle drivers	N	N	N	N	%	%
1966-67	757	34,793	1,788	114,204	29½	23½
	% change		% change			
1967-68	− 39	− 35	− 10	− 6	22½	17½
1968-69	− 29	− 28	− 2	− 6	23½	19
1969-70	− 13	− 22	+ 4	− 3	26	20
1970-71	− 2	− 17	+ 10	− 4	27½	21
1971-72	− 1	− 15	+ 4	− 5	29	21½
1972-73	+ 7	− 8	+ 7	− 1	30	22
Passengers	N	N	N	N	%	%
1966-67	702	36,544	1,008	86,237	41	30
	% change		% change			
1967-68	− 38	− 38	− 3	− 5	31	21½
1968-69	− 30	− 29	+ 7	− 5	31	24
1969-70	− 21	− 21	+ 5	− 2	34½	25½
1970-71	− 15	− 19	+ 7	− 5	35½	26½
1971-72	− 11	− 19	+ 4	− 6	37	26½
1972-73	− 12	− 15	+ 2	− 4	37½	27½
Pedestrians	N	N	N	N	%	%
1966-67	721	9,465	2,443	76,535	23	11
	% change		% change			
1967-68	− 31	− 19	− 5	− 1	17½	9
1968-69	− 26	− 20	− 7	− 2	19	9
1969-70	− 22	− 15	− 4	0	19	9½
1970-71	− 22	− 14	− 2	− 3	19	10
1971-72	− 22	− 16	0	− 1	18½	9½
1972-73	− 24	− 15	− 3	− 3	19	10

Table 5. Trends in casualties to different classes of road user (Sabey & Codling, 1975).

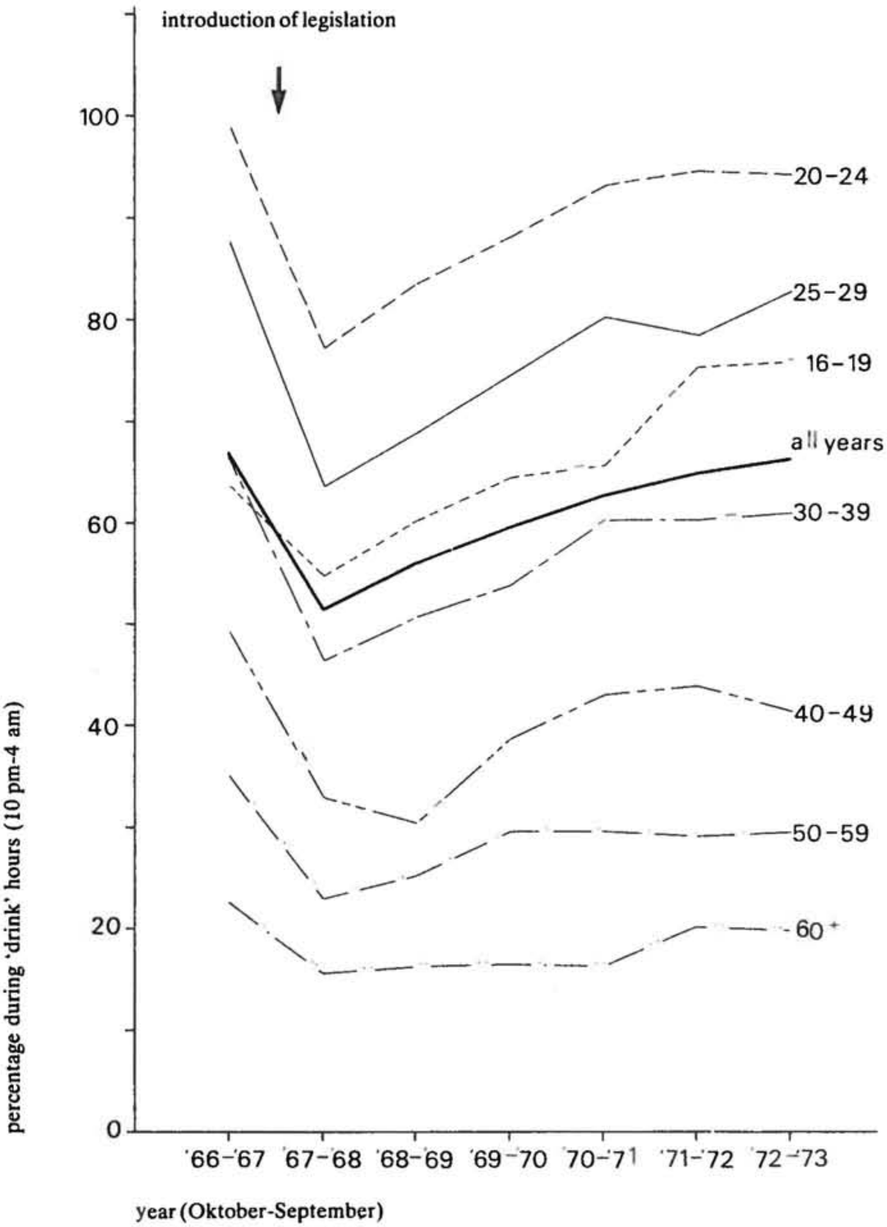


Figure 10. Motor vehicle drivers fatally or seriously injured: percentage during 'drink' hours (10 pm-4 am) by age group (according to Sabey & Codling, 1975).

Time of day	Period (Oct-Sept)	Age groups 16-19	20-24	25-29	30-39	40-49	50-59	Over 59
Main drinking hours	1967-68	− 24	− 34	− 41	− 42	− 47	− 47	− 37
	1968-69	− 21	− 24	− 28	− 30	− 37	− 41	− 29
	1969-70	− 16[1]	− 16	− 13	− 21	− 30	− 24	− 18
	1970-71	− 14[1]	− 10	− 4	− 7	− 20	− 20	− 7
	1971-72	− 11	− 11	− 1	− 10	− 18	− 22	+ 13[1]
	1972-73	− 9	− 5	+ 17	− 2	− 23	− 24	+ 28[1]
Rest of day	1967-68	− 6	− 3	− 5	− 7	− 11	− 13	− 3
	1968-69	− 13	+ 1	+ [illegible]	+ 2	− 2	− 10	+ 5
	1969-70	− 16	+ 2	+ 12	+ 7	− 2	− 5	+ 20
	1970-71	− 16	− 1	+ 12	+ 8	− 2	− 1	+ 34
	1971-72	− 28	− 4	+ 20	+ 5	− 2	− 1	+ 31
	1972-73	− 27	+ 4	+ 32	+ 12	0	− 4	+ 38

* Note: all percentages changes in the main drinking hours (except those marked [1] are significantly different from the corresponding percentages for the rest of the day: statistical tests indicate a 5 per cent level of significance in the probability of a change occuring by change is 1 in 20 or less.

Table 6. Percentage changes in motor vehicles drivers killed or seriously injured since the legislation and by age groups (Codling, 1975)

these hours is not to rise automatically. Other age groups, however, show an increasing absolute number of daytime casualties. This applies especially to the 25-29, 30-39 and 60 and older age groups.
There is no explanation for this in the reports mentioned. But it cannot simply be concluded that the causes of such striking changes in daytime also continue similarly into the night. The different trends in the percentages of nighttime accidents in the various age groups cannot therefore be explained simply by the differing effects of the new legislation upon the various age groups.

There is a more direct connection between the BAC's of deceased road users and the effect of the Act. Since there were many more positive BAC's at nighttime than in daytime both before and after the Act, this distinction will have to be maintained in tracing developments after introduction of the Act. If the BAC distribution remains the same for day and night separately, but there is a movement in the ratio of daytime and nighttime casualties, then the BAC distribution for daytime plus nighttime changes too. In this event, it would be only partly true to conclude that there was either more or less drinking. Table 7 (from Codling & Samson, 1974) gives the BAC's of deceased motor-vehicle drivers for two-hour periods. The trend differs per period from year to year. In view of the small absolute numbers, no clear pattern is detectable from this however. In the total daytime hours there is a decrease in positive BAC's immediately after introduction of the Act, with a gradual recovery (in four years) to the old level. As regards total nighttime hours, the Act appears to have had a pronounced effect in the first year after its introduction. In subsequent years, however, there are both big increases and decreases in positive BAC's. If these differences are not coincidental, a suitable explanation will have to be sought for them too.
Sabey & Codling (1975) also present BAC's of deceased motor-vehicle drivers by age groups, and of passengers and pedestrians. Since none of these surveys makes any subdivision based on time, this may lead to misleading opinions. In the case of pedestrian fatalities, moreover, there was hardly any change in BAC distribution over the years.

A number of questions therefore remain regarding the impact of the British legislation on both drinking and accidents. There is in any event a general concensus that the effect has as good as disappeared after a number of years.

The publicity accompanying the introduction of the 80 mg/100 ml limit in Britain was investigated by means of research interviews with adults (Sheppard, 1968). After its introduction, attitudes towards the new Act and the police proved to have changed little. Familiarity with the Act was already great, but increased still further after its introduction. More drivers were able to mention a quantity of alcohol consumed which they said corresponded to the BAC limit; the average quantity mentioned fell, although the quantity mentioned in many answers was higher than was realistic or desirable. The quantity of alcohol people thought they could legitimately consume did not change, nor did their habits regarding the place of drinking. Drivers did, however, say that they drove themselves home less often after drinking out. In view of these findings it is reasonable to assume that the effect of the legislation upon drivers' BAC distribution is determined not by drivers realizing the

Time of Day	Dec. 1966 - Sept. 1967			Dec. 1967 - Sept. 1968			Dec. 1968 - Sept. 1969			Dec. 1969 - Sept. 1970			Dec. 1970 - Sept. 1971		
	Sample size	Percentage exceeding 9 mg	80 mg	Sample size	Percentage exceeding 9 mg	80 mg	Sample size	Percentage exceeding 9 mg	80 mg	Sample size	Percentage exceeding 9 mg	80 mg	Sample size	Percentage exceeding 9 mg	80 mg
0- 2	48	85	63	25	60	32	28	75	54	38	68	50	35	77	63
2- 4	18	67	50	10	70	70	14	79	79	11	82	73	19	74	58
4- 6	13	31	23	4	50	25	10	20	20	11	45	37	13	54	38
6- 8	30	17	3	27	0	0	42	10	2	37	11	5	36	14	6
8-10	32	9	0	35	9	6	36	8	0	48	8	0	29	0	0
10-12	37	16	5	24	8	0	33	6	0	35	9	3	33	6	0
12-14	38	21	8	35	17	3	33	9	3	38	8	3	36	14	6
14-16	56	36	27	41	15	12	45	22	18	44	25	18	48	27	15
16-18	62	21	10	61	16	3	50	20	8	35	11	0	50	22	10
18-20	50	14	10	32	16	9	52	25	17	43	26	21	29	24	10
20-22	40	30	15	37	19	16	51	26	10	32	44	25	26	50	35
22-24	115	63	49	65	66	37	65	71	48	76	57	38	89	74	58
Totals															
4-22	358	22	11	296	13	6	352	16	8	323	18	10	300	20	11
22- 4	181	67	52	100	64	40	107	70	53	125	59	44	143	72	58

Table 7 . Motor vehicle drivers killed in England and Wales within 12 hours of an accident . Proportions of sample sizes with alcohol present or BAC exceeding 80 mg /100 ml (Samples drawn from Coroners' data) Codling & Samson, 1974).

greater accident risk after drinking. It is, rather, due to the fact that there is a greater presumed chance after drinking of being caught by the police and being punished. Information on police enforcement can be found in an extensive study by Ross (1973) of the British drinking and driving legislation. It can be inferred that the initial reduction in evening accidents can be regarded as the result of a cautious attitude towards the as yet unknown police enforcement. In the course of time, when the chance of detection proves to be not as great as was cautiously assumed, the former behaviour returns. The low chance of being caught is imputed to the slight value of breath analysis as a preliminary test.

5.1.2. *Other countries*

Other countries besides Great Britain introduced statutory BAC limits some years ago. As far as can be ascertained, they are much less effective than in Great Britain.

Canada

At the end of 1969 Canada introduced a statutory 80 mg/100 ml BAC limit. Quantitative breath analysis had already been used earlier on a voluntary basis if there was a suspicion of driving while intoxicated, but is now compulsory. A publicity campaign was organised to introduce the change in the law. Carr et al. (1975) report that after the change the number of officially recorded cases of drinking-driving rose greatly and that knowledge of the Act had also clearly increased. Smart (1972) describes a simply designed investigation which gives an insight into changes in motorists' behaviour. Shortly before and after the change, observations were made near four taverns in the evening hours (18.00 - 22.00) recording the number of cars in the car park, the number of car occupants and the quantity of beer the drivers consumed. All the taverns were in the outskirts of Toronto. Most customers arrived in cars and parked them in the tavern's car park. The taverns served beer only. It was found that the number of cars parked fell greatly at first, but the number of occupants per car and the number of pedestrian customers did not change. The quantity of beer consumed per driver also remained the same.

Data on the effect on road safety are given by Chambers et al. (1975) and Carr et al. (1975). Chambers calculated that in 1970, the first year after the change in the law, there was a statistically significant decrease in the number of road-traffic fatalities and injuries, especially at nighttime, compared with the trend in the previous four years. Carr also gives the numbers of fatal accidents in 1971 en 1972. These are much higher than in 1970 and even higher than the number of fatal accidents in the last four years before introduction of the legislation. Furthermore, the BAC's of deceased drivers (available for three Canadian states) certainly did not decrease in the year after the change, either in total or for drivers dying in single-vehicle accidents.

The introduction of the 80 mg/100 ml limit in Canada thus had a short-lived effect on accidents and casualties, but probably not primarily because drivers drank less.

Carr puts forward the following facts as a possible explanation of the slight effect of the Canadian legislation as compared with the British:

- there is no qualitative breath test in Canada;
- a quantitative breath test can only be demanded by the police if they suspect driving while intoxicated;

- quantitative breath analysis was already used on a voluntary basis before the new legislation;
- publicity was different from that in Great Britain.

As against these possible explanations for the low effectiveness, it can be inferred from the number of officially recorded cases of driving while intoxicated that there is more police supervision in Canada than in Great Britain.

France
France also introduced a statutory BAC limit of 80 mg/100 ml in mid-1970. This made it possible for the police to require a quantitative breath test in certain cases, if need be followed by a blood test. It is not known whether the change in the law was accompanied by publicity or intensified police supervision.
In five departments in the second half of 1969 and 1970 there was an investigation of a random sample of drivers' BAC distribution. The built-up areas of towns with over 5,000 inhabitants were precluded. The 1969 investigation actually covered 15 departments. The five with the highest percentages of drivers with BAC's exceeding 80 mg/100 ml were selected from these. For these departments, the percentages before and after the change were compared (Biecheler et al., 1974). The BAC measurements were made with breath analysers. The percentage of sober drivers proved to have increased after the change (from 50% tot 60%). On the other hand, the percentage of drivers with a BAC exceeding 80 mg/100 ml remained about the same (some 4%). The ineffectiveness as regards this latter group may be attributable to a low degree of acceptance on the legislation by both drivers and police.

Victoria, Australia
The Australian State of Victoria has had a statutory BAC limit of 50 mg/per 100 ml since 1966. There was no publicity at the time of introduction and it had already been compulsory for drivers to assist with a quantitative breath test.
After the change in the law, the number of breath tests increased and the average BAC of suspect drivers fell. The number of accidents apparently remained the same. Simultaneously with the introduction of the statutory BAC limit, however, the closing time for bars was changed from 18.00 hours to 22.00 hours. It is difficult to make any reliable statement about the impact of either of the two measures (Birrell, 1975; see also Section 5.4.).

5.2. **Penalties or treatments**

Penalties and treatments may have either a special deterrent effect or a general deterrent effect. A special deterrent effect is the effect of the penalty or treatment upon the offender. A general deterrent effect is the effect upon the group as a whole, without each individual personally experiencing the penalty or the treatment.

5.2.1. *Special deterrent effect*
As to the special deterrent effect, a relation can be sought between the degree of punishment and the change of repetition. This relation is important, because there are both individual and regional differences in penalties for drinking-driving. Investiga-

tions into this are those by Buikhuisen (1968) and Steenhuis (1972). Of course, they were only able to investigate the differences between existing penalties.
No generally valid statements can therefore be made about the nature or severity of the penalties. They found no differences in the chance of repetition. But it is not out of the question that the group receiving more severe penalties differs from that receiving milder penalties, on points that could not be investigated. In that event the chance of repetition by the more severely punished might have been greater if they had received milder punishment. In other words, the courts might have endeavoured to impose a penalty with an average chance of repetition. The absence of differences in the chance of repetition might then indicate that this was successful to a certain extent.
The existence of such a mechanism, however, is less credible when it is found that there are regional differences in penalties without these leading to differences in the chance of repetition. Cases of drinking-driving in one part of the country are unlikely to differ greatly from those in another.
Whether and, if so, in which cases one penalty is more effective than another could be established with greater certainty if the researcher himself could decide the penalty at random. Blumenthal & Ross (1973) were to have been given such an opportunity. They agreed with the judicial authorities that the penalty for the first conviction for drinking-driving was to be randomly varied for research pruposes between a fine, probation and probation combined with treatment for drinking problems. In practice, however, the courts proved to deviate greatly from the agreed penalties and sometimes even ordered imprisonment. It was established that the chance of repetition within a year did not vary with the different penalties. Remarkably enough, the chance of accidents and traffic offences proved to be greater after acquittal or reducing the charge than after punishment.

The use of some form of treatment instead of the customary penalty has been increasing in recent years, especially in the USA. An extensive study into the effect of various types of treatment was made by Pollack et al. (1972).
Drinking-drivers were placed on summary probation provided they took treatment. The researchers estimated these persons' chance of repetition with reference to biographic characteristics, offences and crimes, and also their own stated drinking and driving habits. They were next divided into six treatment groups and an untreated control group. Data were also collected for a group of drinking-drivers who had been given unconditioned punishment. The researchers report no resemblances or differences between the various groups as regards biographic characteristics for instance. The chance of repetition within a year proved not to differ substantially between the groups. Later, Newman et al. (1974) studied the chance of repetition by the same persons during a period of about two and a half years. In their conclusions they have a more favourable opinion than Pollack et al., on the effectiveness of the various treatment methods.
A large number of American states have demonstration projects against drinking-driving. An aspect of these consists of the courts referring drinking-drivers for brief courses of treatment. Nichols & Reis (1975) describe a method of ascertaining their effect. They distinguish between four kinds of treatment and two types of drinkers: problem drinkers and non-problem drinkers. They could not demonstrate any pronounced differences in the chance of repetition within eighteen months.

The Netherlands have a special open prison for persons convicted of drinking-driving. Dijksterhuis (1975) examined whether detention there has a different effect from normal imprisonment. Detention in the special prison was experienced by the convicted drivers as not having such a negative effect. Neither official statistics nor the drivers' own stated drinking and driving habits indicated any differences in the chance of repetition.
The fact that treatment may lead to less drinking-driving, at least for a specific category of motorists, is evidenced by research by Seixas & Hopson (1973). Their subject group consisted of employees of big companies who had returned to their jobs after treatment for alcohol problems. The reason for treatment in this case was not drinking-driving. In a period of three years prior to treatment the average number of cases of drinking-driving and the average number of accidents in this group had been much higher than the respective numbers for a group of their colleagues comparable in age and sex. In the three subsequent years, the average numbers in the treated group had greatly decreased. Moreover, there was a slight decrease within these three successive years. In the comparable group there was a slight increase in the second three-year period as compared with the first period. After treatment, therefore, there was no longer any difference between the investigated group and the comparable group.

5.2.2. *General deterrent effect*

The possibilities of investigating the general deterrent effect are also limited. Steenhuis (1975) made an attempt to do this, using two regional areas with greatly differing penalties: in the West of The Netherlands, an average of 83% of persons found guilty were sent to prison unconditionally; in the East 24%. Comparison of the BAC distribution of a random sample of motorists in the West and the East at nighttime in the week-end revealed no differences. The motorists also had hardly any idea of the penalty for driving while intoxicated: in the West 13% expected imprisonment; in the East 4%.
Robertson et al. (1972) investigated the general deterrent effect of punishment. After the introduction of a week's imprisonment for drinking-driving the number of road-users' fatalities (related to number of inhabitants) in Chicago seemed to decline. This decline had, however, already been taking place for some time, especially because of a decrease in pedestrian fatalities. Besides this, a control area showed the same phenomenon.

Here again, of course, no opinion can be expressed on the basis of this research as to the effectiveness of milder, more severe or totally different penalties from those which were applied.

5.3. **Publicity**

Publicity may be focused on providing more information on drinking and driving, or on changing public attitudes towards this subject. In such cases publicity helps to ensure that measures against drinking-driving have a greater chance of success. Publicity may, however, also be directed at behavioural change, for which increased knowledge and a change in attitude may be important intermediate stages. As greater emphasis is put on the one objective or the other, the effectiveness of publicity campaigns will also have to be measured differently.

Various researchers (Gibb, undated; Sheppard, 1968; Freedman et al., 1975; Pierce et al., 1975) have demonstrated that publicity may lead to a big increase in familiarity with regulations and police enforcement, for instance.

The effect of publicity on behaviour has been investigated, inter alia, by Farmer & Stroh (1973). This related to a short publicity campaign against drinking-driving in a Canadian community with a local TV network. An area near by was used for comparison. Before and after the campaign a random sample of motorists were questioned at nighttime and were selected with a qualitative breath test for BAC above or below 80 mg/100 ml. If the result of the qualitative breath test was positive, a quantitative breath test followed. The percentage of motorists with BAC's over 80 mg/100 ml was found to have fallen more in the campaign area than in the control area. In fact the percentages were very low in both areas. Bearing in mind the BAC determination method, there was no proof of a favourable effect on drinking and driving.
In Austria, Schmidt (1974) tried with a simple investigation to ascertain the effect of a short campaign on motorists' behaviour. Here again, a random sample of motorists were questioned in the evenings before and after the campaign. An objective BAC measurement could not be made. In so far as differences were found in alcohol consumption as stated by the motorists themselves, these are probably attributable largely to changes in the use of cars due to the energy crisis at the end of 1973.
Hossack (1975) examined a modest publicity campaign in Australia. Going by the BAC distribution of deceased drivers, he concludes that the campaign brought about no behavioural changes.
Publicity campaigns also form part to the demonstration projects in a number of American states mentioned in Section 5.2.1. Wilde (1975) and DOT (1974a) discuss their effect on the BAC distribution of random samples of motorists. Wilde has an unfavourable conclusion regarding the effect, DOT has a favourable conclusion; no account is given of the material presented.

5.4. **Combination of measures**

It can be concluded from the foregoing sections that measures such as penalties and publicity are likely to have only a slight effect on road safety when carried out in isolation. The American demonstration projects endeavoured to apply measures synchronised and supplementary to each other. This applies particularly to police enforcement, judicial programmes, rehabilitation of drinking-drivers, and publicity (DOT, 1972). An official report (DOT, 1974b) provisionally indicates that after one to two years there is a slight decrease in BAC distribution of a random sample of motorists, and a reduction in the number of fatal accidents during the evening.
The conclusion that the reduction in the rate of fatal accidents is due to the projects, however, is refuted by Zador (1974) by reference to data for comparable areas without demonstration projects. Comparison of areas with and without projects disclosed no difference either in the trend of the number of road fatalities for a number of years or in that of the percentage of nighttime road fatalities.

5.5. **Miscellaneous**

Lastly, two measures will be discussed which are likely to have an effect on drinking-driving, although they are not aimed directly at this.
In a number of American and Canadian states the legal minimum drinking age was lowered (mostly from 21 to 18). A series of investigations have been devoted to this: among others by Douglass (1974), Williams et al. (undated), Naor & Nashold (1975), Schmidt & Kornaczewski (1975) and Whitehead (1975).
The most extensive is that by Douglass. The most important factor he employed was the number of male drivers in nighttime single-vehicle accidents. This was because of the constant high proportion of drivers in this group for whom alcohol consumption was recorded. For comparison, Douglass studied data from states where the drinking age had long been lower and those where a high age limit still applied. In the low age-limit states the 18 and 19 age group was most strongly represented among male drivers in nighttime single-vehicle accidents. The degree of involvement in such accidents then declined with rising ages. High age-limit states had two peaks: one at 18 and 19 years and one at 21 and 22 years. In the number of states where the age limit had been lowered, no effect of this was found. In such states the age distribution of male drivers in nighttime single-vehicle accidents, even before the age limit was reduced, resembled that in states where the legal drinking age had already been lower for a long time. The old, high age limit therefore, already had a reduced effect there. In other states, however, an increase was found in the number of nighttime single-vehicle accidents to young male drivers. Hence, in this case, the old, and higher legal drinking age was effective in slowing down a trend to start drinking at a lower age. Douglass quotes research into BAC distributions of random samples of motorists showing that the resemblances and differences in nighttime single-vehicle accidents correspond to the BAC distributions.
Naor & Nashold (1975) find no change in the BAC distribution of deceased young drivers after lowering the legal drinking age. In the state where they carried out their research, however, there was already a low drinking age for beer.

In Australia and New Zealand, hotel bar closing times were changed from 18.00 hours to 22.00 hours. In both countries there was a pronounced movement in the accident peak, viz. from about 18.00 hours to later hours. The movement is still more pronounced on Saturdays than on week-days (hotel bars are closed on Sundays) and is evident both in pedestrian accidents and in single-vehicle accidents and multiple-vehicle accidents. No change seems to have been brought about in the total number of accidents (Raymond, 1969; Toomath et al., 1974) by the altered closing times.

6. Summary and discussion

The research discussed in the foregoing chapters relates mainly to statistics, whether officially recorded or not, of actual road users and casualties. Physiological and psychological experiments can only furnish additional or supporting information and are therefore disregarded in this publication.
In order to measure to what extent drinking contributes to traffic accidents, it is necessary at least to know the number of people killed on the roads who have been drinking. For the USA, the number of road fatalities involving alcohol can be estimated fairly well on this basis: about one-third of the total are 'alcohol fatalities'. For Europe, and certainly for The Netherlands, such estimates are not possible because official records are incomplete and perhaps distorted. But the impression is that the proportion of fatalities involving alcohol in The Netherlands is lower than in the USA.
Since the number of fatalities involving alcohol in The Netherlands is not known, another basis is needed so that measures can be taken. This is formed by the answers to the following questions: how dangerous is it to drive after drinking? And how often do people drive after drinking? The answers should also act as a stimulus to the authorities in the enforcement of measures and as an argument for modifying road users' behaviour.
As to the danger of driving after drinking, the general form of the ratio between BAC and the accident risk is known: the risk increases faster as the BAC becomes higher. The ratio however varies with circumstances and drivers' characteristics. For instance, there are indications that young drivers have a much higher accident risk even at low BAC's, whereas this does not apply to older drivers. Moreover, the results of all the investigations involve some inaccuracy.
The question of how often people drive after drinking can be answered by examining the BAC distribution of random samples of road users. There is increasing interest in this type of research into drinking and driving habits. It not only allows the BAC distribution to be determined, but also how it is related to circumstances, drivers' characteristics and changes in time. Official accident records at most give indications of changes in the number of accidents involving alcohol, types of accident, circumstances and drivers' characteristics. Research into characteristics of high-BAC drivers was until recently carried out especially with persons convicted of driving while intoxicated. There are now sufficient indications that the results of this do not automatically apply to all drivers having high BAC's and hence a greater accident risk.

Only few drivers with high BAC's come into direct contact with the police. Thus in order to reduce the number of such drivers, measures are firstly needed of a general deterrent nature. SWOV (1969) indicates that an important measure is the introduction of a statutory blood alcohol concentration limit. This is sometimes effective and sometimes it is not. It is therefore important to examine the factors that may play a role in this. The following enumeration of factors and their interrelationship is based partly on the literature reviewed in this publication and partly on general knowledge about behaviour modification (SWOV, 1976).

An important factor is the level of a statutory BAC limit. Its choice cannot just be based on the BAC/accident-risk ratio or BAC/performance ratio as found under experimental conditions. Allowance must also be made for the practical possibilities of detecting and prosecuting offenders and the possibilities of clearly defining a BAC limit in terms of drinking behaviour and road safety.
Practical possibilities of detection and prosecution are largely decided by the methods of BAC determination and the instructions that have to be followed for this. In addition, factors in police enforcement are: police views of the risk, extent and nature of drinking-driving; prosecution and penalty practices; public opinion on driving after drinking and, in general, what terms the public and police are on; available police manhours; the judicial authorities' capacity for dealing with offences.
Police enforcement can have considerable influence on drinking and driving behaviour and on the effectiveness of a statutory BAC limit. It must also be assumed that the level and nature of the penalty will have an influence on this, though this has not clearly emerged from the research. It is a question of personal perception of police enforcement, the chance of prosecution and conviction and the possible penalty. Other factors are familiarity with the (changed) legislation, the clarity of 'translating' the BAC limit in terms of drinking behaviour and road safety, and lastly the possibility of alternative behaviour (if drinking don't drive; if driving don't drink).
In all factors influencing drinking and driving behaviour, publicity can have a substantial amplifying effect. Ultimately, the road users concerned are likely to try out the changed situation, especially as regards police enforcement and road safety. This tryout may in turn lead to behaviour adaption. Publicity may play a part in this as well.

Of course it is not only the situation after introducing a statutory BAC limit that determines changes in drinking and driving. In actual fact it is primarily a question of changes in the measures (regulations, police enforcement, prosecution and penalty practice, publicity) as compared with the former situation, and of the aimed-at changes in drinking-driving. In fact the examples in Section 5.5. (lowering the legal minimum drinking age; changing hotel bars closing times) show that driving while intoxicated is closely related to general drinking behaviour.
To achieve optimum effectiveness of a statutory BAC limit all these factors must be taken into account. Isolated measures can be expected to have only a slight effect.

As the effectiveness of general deterrent measures increases (and hence the number of high-BAC drivers decreases and the number detected increases), the importance of special deterrent measures will increase. What possibilities there are in this field cannot be estimated yet. It seems that the special deterrent effect of treatment methods for drinking-driving is not as great as for road-traffic offences in general (SWOV, 1976).

Although enough information appears to be available for adopting general deterrent measures in The Netherlands, a number of aspects still qualify for further research.

The most important one is the relationship between BAC and accident risk in various circumstances and dependent on driver characteristics. Data on this could be obtained by supplementing research into drinking and driving with research into BAC's and other data for accident-involved drivers in the same period of time. Such research could be organised much more simply if, as a routine matter, the BAC of everyone involved in an accident were to be determined. Such a measure would then make it possible to formulate statements on the number and nature of accidents involving alcohol, type of road usage, circumstances, road users' characteristics and changes in these. In this context, it may be added that also data for other road users besides car drivers are urgently needed.

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