DEPARTMENT OF TRANSPORT

OFFICE OF ROAD SAFETY

DOCUMENT RETRIEVAL INFORMATION

Report No.	Date	ISBN	Pages
CR 11	1980	0 642 51114 4	iii + 68

Title and Subtitle

ALCOHOL AND CRASHES
Identification of Relevant Factors in this Association

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Keywords

Random breath tests, Roadside survey, Accidents, Accident causation, Alcohol countermeasure program, Drinking drivers

Abstract

Factors in the association between alcohol and road accidents were investigated by collecting information on breath alcohol concentrations of a sample of the general driving population and of control drivers who were matched with intoxicated accident-involved drivers. The relevance of the results of these investigations to drinking driver countermeasures is discussed and recommendations are made for further investigations and for changes in current practices.

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Road Accident Research Unit

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Sponsored by the
Office of Road Safety
of the
Commonwealth Department of Transport

ACKNOWLEDGEMENTS

The survey of breath alcohol levels of the general driving population and the case-control study were based on feasibility trials conducted in 1978 by N.D. Brewer, O.T. Holubowycz, A.J. McLean and B.L. Sandow. The pilot study was carried out by O.T. Holubowcyz and A. Puddy, who also assisted with the main surveys which were performed by S. Gilroy, X. Ilic, P. Sinnott and T. Tucker.

Members of the Traffic Section of the Highways Department of South Australia assisted with the identification of signalised locations that were suitable for roadside breath testing.

The sponsorship of the Office of Road Safety of the Commonwealth Department of Transport is gratefully acknowledged. The following staff members of the Office assisted at various stages of the project: C. Boughton, I.R. Johnston, D. Murray and R. Ungers.

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1. INTRODUCTION

The general aims of the project were to describe and to measure the association between alcohol consumption and road crash involvement so as to make practicable the development of more successful countermeasures than those currently available.

Two investigations are reported here:

(1) A survey of the extent of alcohol usage by the general population of drivers.

(2) A study of the relationship between a driver's blood alcohol concentration (BAC) and his probability of being involved in a serious crash.

These reports are followed by a discussion of their relevance to existing drink-driving countermeasures.

Development of the Project

This project followed on from the Adelaide in-depth accident study (McLean and Robinson, 1979). During that study measurements were obtained of the blood alcohol concentrations (BACs) of the road users who were actively involved (drivers, riders and pedestrians) in a ten per cent representative sample of accidents to which an ambulance was called. Three hundred and four accidents were investigated in the inner metropolitan area of Adelaide during the twelve months from the end of March, 1976.

The collection of BAC readings from a control sample of non-accident-involved drivers was considered during the in-depth study and a feasibility trial was conducted of a procedure whereby breath alcohol tests were administered while a driver was waiting at a red traffic signal. This procedure, which is described in detail in Section 2, proved to be satisfactory but the work involved in collecting a large enough control sample was too great to carry out as part of the in-depth study.

Having demonstrated the feasibility of the method of data collection it was then apparent that, in addition to obtaining BAC readings for a control sample, it would be practicable to conduct a survey of the BACs of the general population of drivers.
To ensure comparability with the data from the in-depth study and the controls, the survey was planned to cover the same part of the Adelaide metropolitan area.

2. ALCOHOL USAGE BY THE GENERAL POPULATION OF DRIVERS

2.1 METHOD OF INVESTIGATION

Measurement of Blood Alcohol Concentration

Blood alcohol concentrations (BACs) were estimated by measuring the concentration of alcohol in the breath. This yields a value for the BAC which may not be as accurate as the value obtained by the analysis of a blood sample but it nevertheless may be more relevant as a measure of intoxication simply because it estimates the concentration of alcohol in the blood in the lungs rather than in an arm. The former sample is more likely to resemble the blood supplied to the brain (for a discussion of this topic see the report of the Law Reform Commission, 1976).

The breath alcohol meter used was the Alcolmeter PST. This meter is readily portable, its dimensions being approximately 130 by 65 by 30 mm. The dial is calibrated to the nearest 0.01 gm. of alcohol per 100 ml. of blood over a range from zero to 0.30. The breath sample is obtained by having the subject take a deep breath and then blow into an open-ended plastic tube that is attached at its mid-point to the meter. Towards the end of the exhalation a button is pressed which acts to draw in to the meter a small sample of the exhaled air. The meters were calibrated daily against an alcohol vapour standard that was equivalent to a BAC of 0.08.

Testing Procedure

We neither had nor requested any authority to require a driver to stop and to allow his breath alcohol level to be measured. Consequently considerable emphasis was placed on developing a testing procedure which would be unobtrusive and yet successful. Because we could not stop cars we were restricted to approaching a driver when his car was stationary, such as at a red traffic signal. Even then we judged it to be important that we should not detain the driver any longer than he would normally be stationary, partly because we wanted to minimize the risk of the driver refusing to cooperate but also because it would be particularly hazardous to have an investigator standing in the carriageway alongside a stationary car when other traffic was free to move past.

After successful feasibility trials a pilot study was carried out in late January and early February, 1979, to finalise the procedure to be adopted and to determine the suitability of various locations for use as sampling sites.

Two teams, each comprising a male and a female investigator, were recruited for work on this survey. A Road Accident Research Unit vehicle, clearly marked as such, was parked as close to the final approach to the sampling site as was considered safe, often off the carriageway. This provided a convenient and rapid way for the investigator to assure an anxious driver that he or she was, in fact, from the Road Accident Research Unit. Alternative techniques, such as use of a written certificate or card, were considered for this purpose but were rejected because there was not sufficient time available for a driver to read even a short statement if a breath sample was to be obtained before the end of the red phase. The investigator told the driver that he or she was from the University Road Accident Research Unit, that we were not the Police, and that we were measuring breath alcohol levels of drivers. The driver was then asked to take a deep breath and blow through the tube attached to the breath alcohol meter. This procedure required about 25 seconds, including the time necessary to walk out to the stopped car and then to walk back to the side of the road, and so signalised locations at which the usual duration of the red phase on the selected approach was at least 30 seconds were preferred for use as sampling sites.

The other investigator was stationed at the side of the road, usually on a traffic island. He or she wrote down the following information, which was provided by the first investigator: the breath alcohol reading (BAC), the estimated age group (under 21, 21 to 29, 30 to 50 and over 50 years of age) and the sex of the driver, together with a subjective assessment of whether the driver had been drinking. This second investigator also watched for the yellow signal to appear for the end of the preceding green phase for other traffic and, if the investigator taking the breath alcohol reading was still on the carriageway, blew a whistle to warn him or her to leave the road before the signal controlling traffic travelling in the sampled direction changed to green. At each site the two investigators each took about the same number of readings, so as to control as far as possible for any sex-related refusal bias (which was not apparent in the final results).

The driver of the first car (including also station wagons, utilities and panel vans) to stop for the red signal was approached. Drivers of commercial vehicles and riders of motorcycles were not sampled, for several reasons. In the case of buses, large trucks and motorcycles it was difficult to communicate with the driver or rider in the circumstances under which this survey was conducted. For example, motorcyclists were excluded because of the difficulties associated with talking with a rider who is wearing a full-face crash helmet.

Sampling Technique

The inner metropolitan area of Adelaide was divided into four regions, and five sites were selected in each region, together with a specified direction of travel at each site (Figure 2.1). The aim of these selections was to obtain a sample of drivers which was not unduly biased by location or direction of travel, and hence reasonably representative of the car traffic operating in the metropolitan area.

The sampling times would, ideally, have been selected so that each site was sampled on each day of the week and at each hour of the day. This would have required at least 20 x 7 x 24 = 3360 sampling sessions and the associated salary costs were far in excess

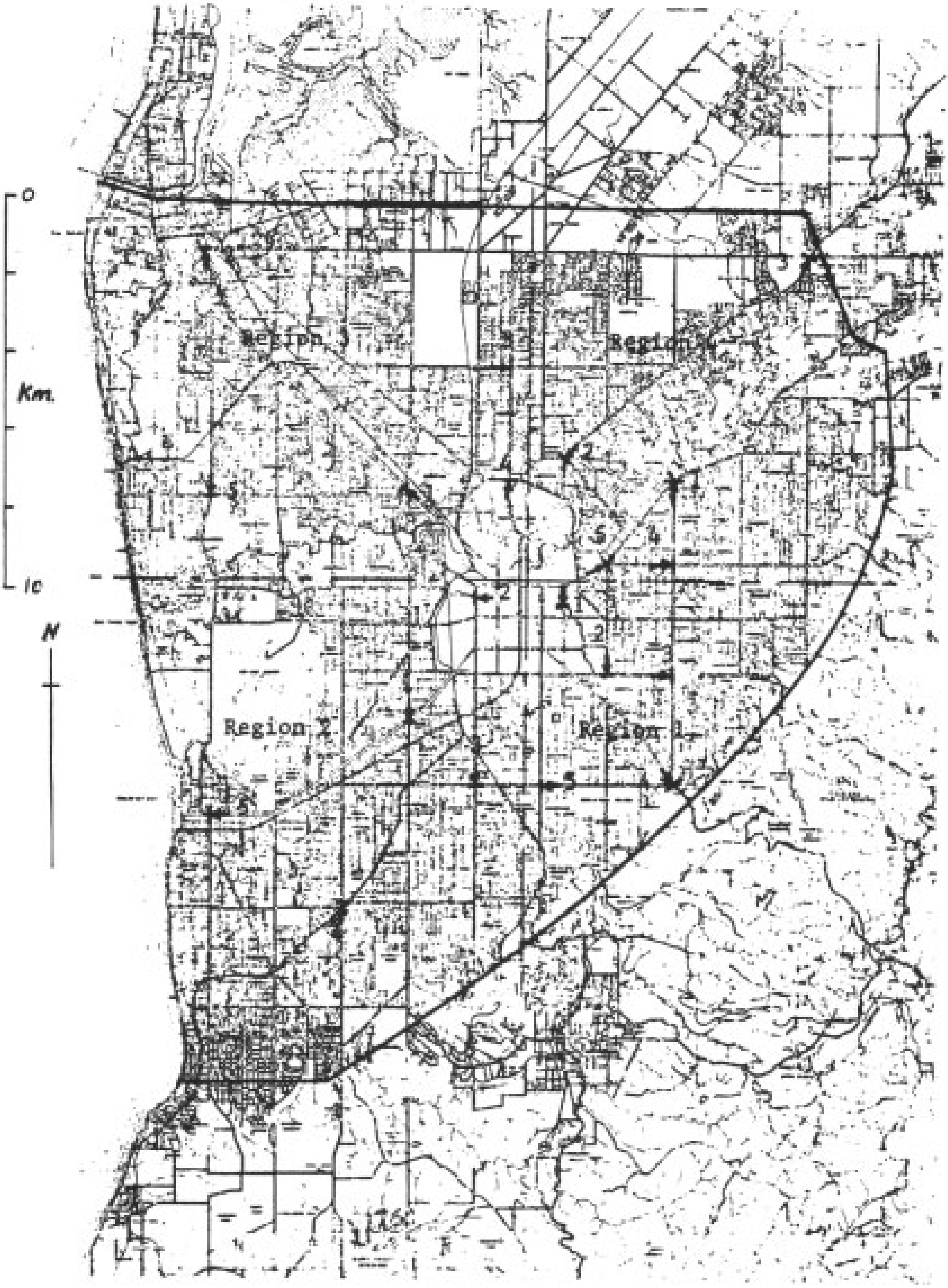

FIGURE 2.1: Sampling Area, Showing Regions, Locations and Directions Sampled

of the funds available. By dividing the week into ten time of day, day of week periods on the basis of assumed uniformity of drinking and driving behaviour during any one period (using the results of the pilot survey as a guide), the number of sampling sessions was reduced to 20 x 10 = 200. The periods chosen are shown in Figure 2.2. This technique allowed for period "A", say, to be sampled on any day from Monday to Friday. Each session was nominally one hour long but this included the time needed to travel between sites. The actual time spent sampling breath alcohol levels was therefore about 40 minutes in each session.

The survey commenced on March 18, 1979 and ran, at the rate of about 60 sessions per week, regardless of weather conditions, until April 12, 1979. Some sampling sessions which had been missed, for reasons such as sickness, or which had been unsatisfactory because very few cars had been passing in the specified direction, were rescheduled and were conducted during the following weeks.

2.2 RESULTS

In the course of the survey 3,349 drivers were asked to cooperate, and breath alcohol readings were obtained from 3,073, the refusal rate being 8.2 per cent.

BAC by Time Period

Table 2.1 presents the BACs for all drivers for each of the ten time periods shown in Figure 2.2. The periods from 9 a.m. to

Time of Day	Day of Week						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
3 a.m. – 9 a.m.	A	A	A	A	A	B	B
9 a.m. – 3 p.m.	C	C	C	C	C	D	E
3 p.m. – 9 p.m.	F	F	F	G	G	H	H
9 p.m. – 3 a.m.	I	I	I	J	J	J	I

FIGURE 2.2: Sampling periods.

TABLE 2.1: BAC[1] BY TIME PERIOD FOR THE GENERAL POPULATION OF DRIVERS

Time Period	BAC					Number	Number
	Zero	> Zero	≥0.05[2]	≥0.08[2]	≥0.15	sampled	refused
9 pm - 3 am:							
Thurs-Sat	71.1%	28.9%	16.1%	11.7%	1.8%	273(100%)	23
(J)	*5.4*[3]	*5.4*	*4.6*	*3.8*	*1.6*		
Sun-Wed	74.8	25.2	12.2	7.8	1.7	230	39
(I)	*5.6*	*5.6*	*4.2*	*3.5*	*1.7*		
3 am - 9 am:							
Sat-Sun	81.2	18.8	7.2	3.9	1.7	181	21
(B)	*5.7*	*5.7*	*3.8*	*2.8*	*1.9*		
Mon-Fri	95.8	4.2	2.8	2.3	1.4	214	11
(A)	*2.7*	*2.7*	*2.2*	*2.0*	*1.6*		
9 am - 3 pm:							
Sat	91.9	8.1	0.8	0.8	0.3	357	35
(D)	*2.8*	*2.8*	*0.9*	*0.9*	*0.6*		
Sun	96.9	3.1	1.0	0.3	-	391	29
(E)	*1.7*	*1.7*	*1.0*	*0.5*			
Mon-Fri	96.8	3.2	0.5	0.2	-	405	20
(C)	*1.7*	*1.7*	*0.7*	*0.4*			
3 pm - 9 pm:							
Sat-Sun	86.4	13.6	3.8	2.7	1.2	338	37
(H)	*3.7*	*3.7*	*2.0*	*1.7*	*1.2*		
Mon-Wed	92.1	7.9	0.8	0.3	-	369	37
(F)	*2.7*	*2.7*	*0.9*	*0.6*			
Thurs-Fri	92.1	7.9	1.9	0.3	-	315	24
(G)	*3.0*	*3.0*	*1.5*	*0.6*			

Notes: [1] Blood Alcohol Concentration (gm/100 ml)

[2] The percentage > Zero includes the percentages ≥ 0.05 which includes the percentage ≥ 0.08, etc.

[3] Percentages in script indicate 95% confidence limits eg: 71.1 ± 5.4

3 p.m., Monday through Friday, and at the same time on Sunday, had the lowest percentages of drinking drivers (3.2 and 3.1 per cent respectively). The highest percentage of drinking drivers in this Table (28.9) was in the 9 p.m. to 3 a.m. period on Thursday/Friday through to Saturday/Sunday. In this time period 16.1 per cent of the drivers were above 0.05, 11.7 per cent above 0.08 and 1.8 per cent above 0.15.

The precision of the percentages listed in Table 2.1 is indicated by the number shown under each percentage. When comparing two percentages, the observed difference, if any, is likely to have arisen by chance if the total of the two numbers in italics is larger than that difference.

No overall percentages are listed in Table 2.1 because simply taking the totals for each of the BAC categories makes no allowance for major variations in the sampling fraction (the number of drivers sampled as a fraction of all drivers on the roads during the time period) over the ten time periods. However the relative magnitudes of these sampling fractions were estimated using an approximation to the total weekly traffic flow in each of the ten periods, as shown in Appendix C. The number of cases in each BAC category in Table 2.1 was then multiplied by the reciprocal of the relative sampling fraction (the "Weighting Factor" in Table 2.2) for the corresponding time period.

TABLE 2.2 BAC OVER ALL TIME PERIODS FOR THE GENERAL POPULATION OF DRIVERS

Time Period	BAC (observed number of cases)				Observed Total	Weighting Factor[1]	BAC (weighted number of cases)				Weighted Total
	Zero	≥ 0.05	≥ 0.08	≥ 0.15			Zero	≥ 0.05	≥ 0.08	≥ 0.15	
A	205	6	5	3	214	0.136	27.88	0.82	0.68	0.41	29.10
B	147	13	7	3	181	0.024	3.53	0.31	0.17	0.07	4.34
C	392	2	1	-	405	0.228	89.38	0.46	0.23	-	92.34
D	328	3	3	1	357	0.058	19.02	0.17	0.17	0.06	20.71
E	380	4	1	-	391	0.051	19.38	0.20	0.05	-	19.94
F	340	3	1	-	369	0.166	56.44	0.50	0.17	-	61.25
G	290	6	1	-	315	0.119	34.51	0.71	0.12	-	37.49
H	292	13	9	4	338	0.107	31.24	1.39	0.96	0.43	36.17
I	172	28	18	4	230	0.054	9.29	1.51	0.97	0.22	12.42
J	194	44	32	5	273	0.057	11.06	2.51	1.82	0.29	15.56
Total	2740	122	78	20	3073	1.000	301.73	8.58	5.34	1.48	329.32
%[2]	89.2	4.0	2.5	0.7	100.0	-	91.6	2.6	1.6	0.4	100.0

Notes: [1] See text

[2] The weighted percentages (on the right of the last row) are a more accurate estimate of the true overall BAC distribution

The weighted overall BAC distribution, shown on the right of the last row of Table 2.2, is therefore more accurate than the distribution shown on the left of that row because allowance has been made for the biasing effects of the variations in the sampling fraction. The application of this procedure results in lower percentages of drivers in the positive BAC categories listed, which is to be expected because most of the positive BAC levels were observed at those times when traffic flows were below average, and hence the sampling fractions were greater. Overall, 8.4 per cent of the drivers in the Adelaide metropolitan area had been drinking, 2.6 per cent were above 0.05, 1.6 per cent above 0.08 and 0.4 per cent had a BAC above 0.15.

BAC by Age and Sex

The BAC distributions by estimated age and sex of the driver are shown in Table 2.3. It is important to note that no allowance has been made in this Table for variations in the sampling fraction, as was done in Table 2.2. The actual percentages listed should therefore not be relied on as accurate estimates in themselves but rather as a means of comparing the experience of male and female drivers and of male and female drivers of different ages.

Male drivers were more likely to have been drinking than were female, and their BACs were generally higher than those for female drivers. None of the females under 21 years of age or over 50 had been drinking. There are some other trends noticeable by age of driver in Table 2.3 but they may have arisen by chance.

TABLE 2.3: BAC[1] BY AGE AND SEX FOR THE GENERAL POPULATION OF DRIVERS

Age and Sex of Driver	BAC					Number Sampled	Number Refused
	Zero	> Zero	≥ 0.05[2]	≥ 0.08[2]	≥ 0.15		
All Males	87.3% *1.4*[3]	12.7% *1.4*	4.7% *0.9*	3.1% *0.7*	0.7% *0.3*	2270(100%)	221
All Females	94.4 *1.6*	5.6 *1.6*	2.0 *1.0*	1.0 *0.7*	0.4 *0.4*	803	55
Males:							
Under 21	88.0 *4.6*	12.0 *4.6*	5.8 *3.3*	4.7 *3.0*	1.0 *1.4*	191	7
21-29	85.6 *2.5*	14.4 *2.5*	5.2 *1.6*	3.5 *1.3*	1.0 *0.7*	735	47
30-50	87.5 *1.9*	12.5 *1.9*	4.8 *1.3*	2.8 *1.0*	0.5 *0.4*	1115	124
Over 50	90.8 *3.7*	9.2 *3.7*	1.7 *1.7*	1.7 *1.7*	0.9 *1.2*	229	43
Females:							
Under 21	96.2 *5.1*	3.8 *5.1*	-	-	-	53	6
21-29	91.5 *2.9*	8.5 *2.9*	3.1 *1.8*	1.1 *1.1*	0.6 *0.8*	351	17
30-50	96.3 *2.0*	3.7 *2.0*	1.4 *1.2*	1.2 *1.1*	0.3 *0.6*	347	22
Over 50	100.0 *0*	-	-	-	-	52	10

Notes: [1] Blood Alcohol Concentration (gm/100 ml.)

[2] The percentage ≥ 0.05 includes the percentages ≥ 0.08 and ≥ 0.15, etc.

[3] Numbers in italics indicate 95% confidence limits (et: 87.3 ± 1.4)

No allowance has been made for variations in traffic flow by time of day (see text and Table 2.2)

BAC by Time of Day

Table 2.4 lists the overall BAC distribution by time of day. No allowance has been made for variations in the sampling fractions by day of week or time of day. The former is unlikely to have a marked effect (see Appendix C).

The highest percentage of drinking drivers was observed in the six hours from midnight, for all days of the week (Table 2.4). Almost one third (32.2 per cent) of all 307 drivers sampled during these hours had been drinking, one fifth (20.2 per cent) were above 0.05 and 14.0 per cent were above 0.08. One driver in 30 (3.3 per cent) was above 0.15. Overall, more than half (56 per cent) of the 77 drivers in this survey who were above the legal limit of 0.08 were on the roads between midnight and 6 a.m. (this figure is obtained by calculating the total number (77) of drivers above 0.08 from Table 2.4). The 12 hours from 6 a.m. to 6 p.m. contained only one-seventh (14 per cent) of the drivers who were above the legal limit.

BAC by Region of the Adelaide Metropolitan Area

The four regions used for sampling purposes differ in several respects. In general, the north-western region is relatively industrial whereas the south-eastern region is almost exclusively residential, with some local commercial development. As shown in Table 2.5, there were no statistically significant differences in the drinking patterns of drivers in these four regions of the Adelaide metropolitan area.

TABLE 2.4: BAC BY TIME OF DAY FOR THE GENERAL POPULATION OF DRIVERS

Time (hours)	BAC Zero	> Zero	≥ 0.05	≥ 0.08	≥ 0.15	Total
0000-0559	67.8% *5.2*	22.2% *5.2*	20.2% *4.5*	14.0% *3.9*	3.3% *2.0*	307
0600-1759	94.2 *1.0*	5.8 *1.0*	1.2 *0.5*	0.6 *0.3*	0.1 *0.1*	1912
1800-2359	85.5 *2.4*	14.5 *2.4*	4.3 *1.4*	2.8 *1.1*	0.9 *0.6*	854
Total	89.2 *1.1*	10.8 *1.1*	4.0 *0.7*	2.5 *0.6*	0.7 *0.3*	3073

Note: No allowance has been made for variations in traffic flow by time of day (see text and Table 2.2)

TABLE 2.5: BAC BY REGION OF METROPOLITAN ADELAIDE FOR THE GENERAL POPULATION OF DRIVERS

Region	BAC Zero	> Zero	≥ 0.05	≥ 0.08	≥ 0.15	Total
South-eastern	90.9% *2.0*	9.1% *2.0*	4.3% *1.4*	3.0% *1.2*	0.8% *0.6*	776
South-western	88.1 *2.2*	11.9 *2.2*	4.5 *1.4*	2.8 *1.1*	0.5 *0.5*	797
North-western	89.4 *2.2*	10.6 *2.2*	3.2 *1.3*	1.7 *0.9*	0.5 *0.5*	758
North-eastern	88.3 *2.3*	11.7 *2.3*	3.9 *1.4*	2.7 *1.2*	0.8 *0.6*	742
Total	89.2 *1.1*	10.8 *1.1*	4.0 *0.7*	2.5 *0.6*	0.7 *0.3*	3073

Note: No allowance has been made for variations in traffic flow by time of day (see text and Table 2.2)

TABLE 2.6 BACs AND REFUSALS BY SUBJECTIVE ASSESSMENT OF PRESENCE OF ALCOHOL FOR THE GENERAL POPULATION OF DRIVERS

	Subjective Assessment			
	Had not been drinking	Had been drinking		
BAC		Not affected	Affected	Total
Zero	2730[1]	9	1	2740
	99.6[2]	0.3	0.0	81.8[3]
	84.9[3]	9.0	2.9	
0.01-0.04	185	26	0	211
	87.7	12.3	0	6.3
	5.8	26.0	0	
0.05-0.07	27	17	0	44
	61.4	38.6	0	1.3
	0.8	17.0	0	
0.08-0.14	32	20	6	58
	55.2	34.5	10.3	1.7
	1.0	20.0	17.6	
0.15+	7	6	7	20
	35.0	30.0	35.0	0.6
	0.2	6.0	20.6	
Refused breath test	234	22	20	276
	84.8	8.0	7.2	8.2
	7.3	22.0	58.8	
Total	3215	100	34	3349
	96.0[2]	3.0	1.0	100.0

Notes: [1] Number of drivers

[2] Percentage of row total

[3] Percentage of column total

Correction for Refusal Bias

As noted earlier, the overall refusal rate was 8.2 per cent. This rate was higher among those drivers who were thought by the investigator to have been drinking (Table 2.6). This means that the percentages in the preceding Tables of drivers who had positive BAC levels are likely to be under-estimates. For example, the (unweighted) overall percentage of drivers who were above 0.08 (2.5 per cent, Table 2.2) would probably have been at least 4.6 per cent had readings been obtained from all of the drivers who were approached (ignoring the bias due to varying sampling fractions, as noted above). The method used to calculate this correction is presented in Appendix A. The extrapolation of this correction factor to the weighted percentage of drivers who were above 0.08 (Table 2.2) yields a figure of 2.9 per cent. Therefore the actual population percentages, not biased by differing sampling fractions or refusal rates, probably lie just above the unweighted and uncorrected overall percentages listed in Table 2.2.

There was negligible difference in the refusal rates for the four interviewers; they were 7.9 per cent, 8.0 per cent, 8.4 per cent and 10.4 per cent. There were greater differences in the frequency with which the individual interviewers thought that a driver who refused to cooperate had been drinking. These percentage rates were (in the same order of interviewer as above) 21.7, 22.5, 14.5 and 4.0. The low percentage for the fourth interviewer suggests that the above correction for refusal bias may still result in an under-estimate

This refusal bias may have been balanced to some degree if some of the sampled drivers had had their last drink within 15 minutes of being tested, which would be likely to produce an artificially high estimate of the blood alcohol levels for those drivers. However, this effect would not produce any change in the percentage of drivers having a positive blood alcohol level. One of the criteria for site selection was that there be no hotel adjacent to a sampling location so as to reduce the chances of this happening.

2.3 DISCUSSION

The sampling procedure proved to be satisfactory in that the breath testing was conducted without having either to stop or to delay the drivers who were approached. No reference has been found to any other survey of this type that has been conducted without involving the police. **The refusal rate of 8.2 per cent** was lower than the corresponding rate in some surveys conducted with police assistance in other countries (see Appendix B).

An important disadvantage of this procedure was that there was insufficient time to question the driver, let alone conduct a structured interview. This meant that the age of the driver had to be estimated and information such as the time elapsed since the last drink and the driver's customary drinking behaviour could not be obtained. Consideration was given to asking the drivers to stop at the side of the road after leaving the intersection but this was not attempted for several reasons, including safety.

The survey was conducted in less than one month and so no assessment could be made of any seasonal variations in the frequency of drinking and driving.

The implications of the results of the survey for drink-driving countermeasures are discussed in Section 4.

3. ALCOHOL AND THE RISK OF ACCIDENT INVOLVEMENT

3.1 METHOD OF INVESTIGATION

The aim of this part of the study was to quantify the association between a driver's blood alcohol concentration (BAC) and the risk of that driver being involved in a casualty accident. This was done by comparing the BAC's of drivers who were involved in casualty accidents (the 'cases') with those of non-accident-involved drivers (the 'controls'). The study was confined to drivers of cars and car-derivatives such as panel vans and utilities. Drivers of taxis and of larger commercial vehicles were not included, nor were riders of motorcycles.

Accident-Involved (Case) Drivers

The case drivers were obtained from the Adelaide in-depth study files (McLean and Robinson, 1979). The in-depth study was based on a representative sample of accidents to which an ambulance was called in metropolitan Adelaide in a 12 month period from March, 1976. Of the 374 car drivers who were actively involved in the accidents covered by the in-depth study 299 were selected as cases for the present investigation. BAC readings were not obtained from 53 of the remaining 75 drivers, one driver was not identified and the remaining 21 were excluded from the case group because inadequate information was available on the route that they had followed prior to the accident or because they were drivers of taxis.

Most (239) of the 298 case drivers had a BAC of zero. The distribution of the positive BAC readings is shown in Table 3.1.

Non-Accident-Involved (Control) Drivers

The matching criteria for the selection of the control drivers were: age and sex of driver and the time, day of week and place of the accident.

The age of the control driver was estimated by the survey worker and matched to one of four age groups: under 21 years of age, 21 to 29, 30 to 50 and over 50. Time of day was matched to within one hour for most cases but day of week was matched on the basis of the ten time of week periods adopted for the general population survey (see Figure 2.2). The place at which the control drivers were breath-tested was a signalised intersection on or near to the route that the case driver followed prior to the accident, sampling traffic travelling in the same direction as the case driver. The locations selected in some instances were based on the route that the case driver would have followed had he not been involved in the accident.

Breath testing of the control drivers was performed during June and July, 1979. Seasonal variation could not therefore be included as a factor in the matching criteria but, when relevant, lighting conditions were given precedence over time of day when scheduling the sampling of control drivers.

TABLE 3.1: BLOOD ALCOHOL LEVELS OF CASE DRIVERS AND OF CONTROL DRIVERS

	CASE DRIVERS		CONTROL DRIVERS	
BAC	Number	% of Total	Number	% of Total
Zero	240	80.3	1096	91.9
0.01	2	0.7	14	1.2
0.02	3	1.0	26	2.2
0.03	3	1.0	13	1.1
0.04	2	0.7	7	0.6
0.05	4	1.3	8	0.7
0.06	4	1.3	10	0.8
0.07	3	1.0	4	0.3
0.08	1	0.3	-	-
0.09	3	1.0	6	0.5
0.10	2	0.7	2	0.2
0.11	2	0.7	2	0.2
0.12	2	0.7	4	0.3
0.13	4	1.3	1	0.1
0.14	4	1.3	-	-
0.15	1	0.3	1	0.1
0.16	2	0.7	-	-
0.17	1	0.3	1	0.1
0.18	2	0.7	1	0.1
0.19	1	0.3	-	-
0.20	2	0.7	-	-
0.21	-	-	-	-
0.22	2	0.7	-	-
0.23	3	1.0	-	-
0.24	2	0.7	-	-
0.25	2	0.7	-	-
0.26	1	0.3	-	-
0.27	-	-	-	-
0.28	-	-	-	-
0.29	-	-	-	-
0.30	-	-	-	-
0.31	-	-	-	-
0.32	-	-	-	-
0.33	-	-	-	-
0.34	-	-	-	-
0.35	1	0.3	-	-
Total	299	100.0	1196	100.0

Sampling Procedure

The sampling procedure was similar to that used in the general population survey (Section 2.1). As in that survey the team members estimated the age of the driver of the first car to stop at a red signal but then did not approach the driver unless he or she appeared to be in the same age group, and of the same sex, as the case driver. The breath samples were obtained in the manner described in Section 2.1. BAC readings were obtained from four age/sex matched control drivers at each site. The work schedule allowed for a sampling time of about 40 minutes at each site. Most of the samples of four control readings were obtained in one session but in a few instances a second visit to the site was necessary.

3.2 RESULTS

The BAC readings for the two groups of drivers are listed in Table 3.1. There were no control drivers with a BAC above 0.18 but there were 14, or 4.7 per cent, of the accident-involved or case drivers above that level.

The association between accident involvement and blood alcohol concentration is expressed in terms of an accident involvement ratio for selected groupings of BACs (Table 3.2). The accident involvement ratio for a given BAC grouping is four times the number of case drivers divided by the number of control drivers (the factor of four allows for

for the other groups are also divided by 4(240)/1096 (shown as 0.88 in Table 3.2).

TABLE 3.2: ACCIDENT INVOLVEMENT RATIO BY BAC

BAC	Case Drivers (A)	Control Drivers (B)	4A/B[1]	Accident-Involvement Ratio (R)
Zero	240	1096	0.88	1.00
0.01-0.03	8	53	0.60	0.69
0.04-0.06	10	25	1.60	1.83
0.07-0.09	7	10	2.80	3.20
0.10-0.14	14	9	6.22	7.10
0.15+	20	3	26.67	30.44
Total	299	1196	1.00	-

Note: [1] Allows for there being four control drivers for each case driver.

Calculation of the precision of these estimates of the accident-involvement ratio (R) is best performed by making use of a logarithmic transformation (Gart, 1962). This is so because the range of this ratio is zero to infinity and under the null hypothesis that a driver with a positive BAC does not have a greater, or lesser, risk of accident involvement than does a driver with a BAC of zero the mode of the distribution of the ratio is at 1.00. A log transformation renders this very skew distribution more nearly normal. The variance of the transformed ratio is:

$$\text{Var } (\ln \hat{R}) = \frac{1}{n_a p_a q_a} + \frac{1}{n_b p_b q_b} \qquad \ldots(1)$$

where 'p' is the proportion of drivers with a positive BAC (at the level for which R has been calculated) and 'q' is the proportion with a zero BAC. The subscripts are 'a' for cases and 'b' for controls and 'n' is the total number of drivers, being the sum of n_a and n_b.

The following example illustrates the use of this method to calculate 95 per cent confidence limits for the accident-involvement ratio for the BAC = 0.01-0.03 group. **Table 3.3 lists the relevant** data. The values for the variables in Equation (1) are:

$$n_a = 248 \qquad p_a = \frac{8}{248} \qquad q_a = \frac{240}{248}$$

$$n_b = 1149 \qquad p_b = \frac{53}{1149} \qquad q_b = \frac{1096}{1149}$$

TABLE 3.3: DATA USED IN CALCULATION OF VARIANCE OF THE ACCIDENT-INVOLVEMENT RATIO

BAC	Case Drivers (A)	Control Drivers (B)
Zero	240	1096
0.01-0.03	8	53
Total	248	1149

$$\hat{R} = \frac{8}{240} \cdot \frac{1096}{53}$$

$$\hat{R} = 0.689$$

and $$\ln \hat{R} = -0.3725$$

$$\text{Var}(\ln \hat{R}) = \frac{248}{8(240)} + \frac{1149}{53(1096)}$$

$$= 0.12917 + 0.01978$$

$$= 0.14895$$

95% confidence limits

for $\ln \hat{R}$ $$= -0.3725 \pm 1.96\ (0.14895)^{\frac{1}{2}}$$

$$= -0.3725 \pm 0.7564$$

$$= -1.1289 \text{ and } + 0.3839$$

Converting back to the original arithmetic scale gives:

95% confidence limits for $\hat{R}$ = 0.69 are 0.32 and 1.47

Table 3.4 lists these confidence limits for all of the accident-involvement ratios listed in Table 3.2

TABLE 3.4: 95% CONFIDENCE LIMITS FOR ACCIDENT-INVOLVEMENT RATIOS

	Accident-Involvement Ratio		
BAC	Lower limit	Estimated value	Upper limit
Zero	-	1.00	-
0.01-0.03	0.32	0.69	1.47
0.04-0.06	0.87	1.83	3.85
0.07-0.09	1.20	3.20	8.48
0.10-0.14	3.04	7.10	16.6
0.15+	8.97	30.4	103.3

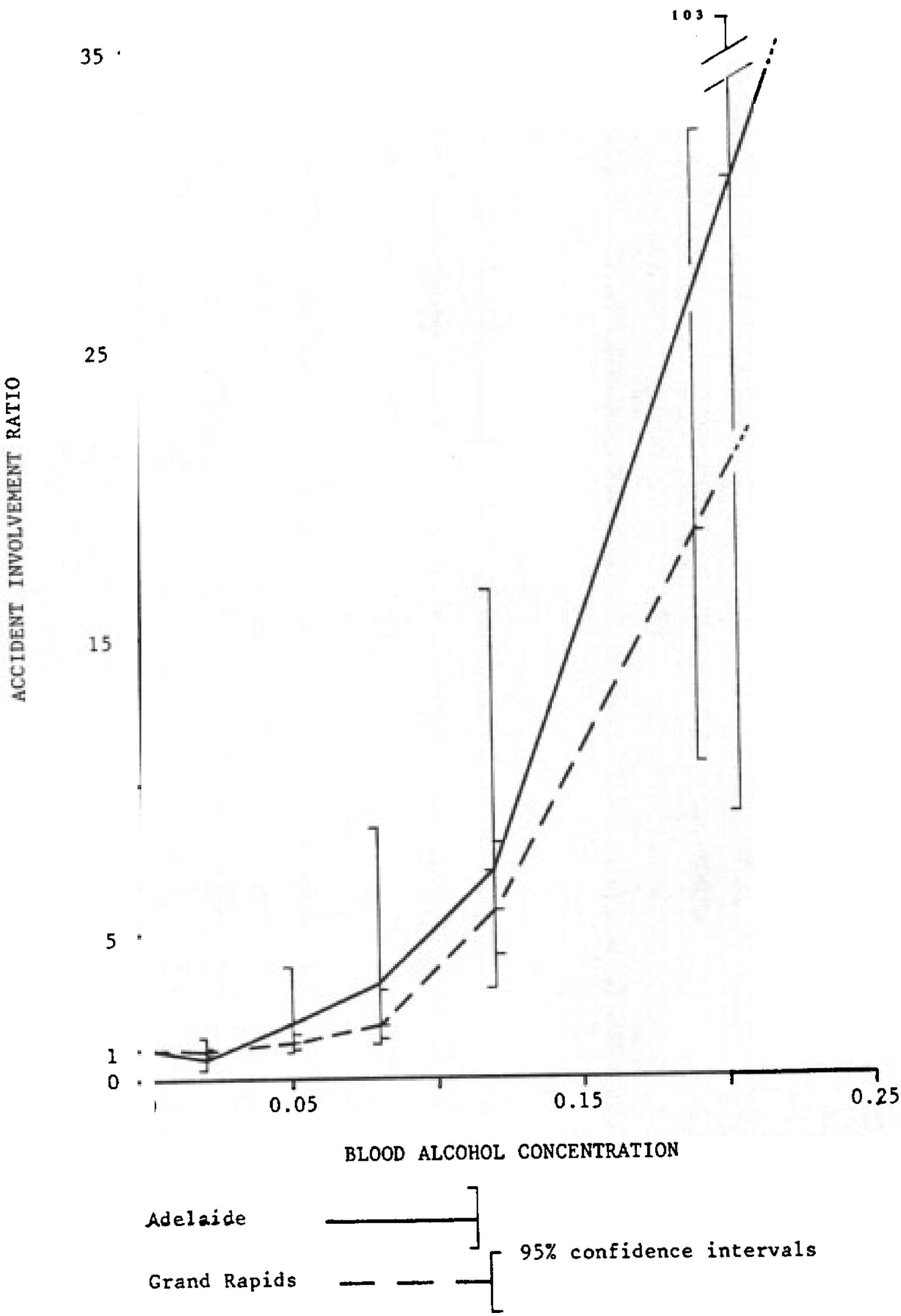

Figure 3.1: Accident involvement ratio and the blood alcohol concentration

The accident-involvement rati from this study are listed in Table 3.4 and plotted against BAC in Figure 3.1. It can be seen that there is a rapid increase in the risk of being involved in an accident for BACs above 0.12 (the data points for the above 0.15 groups are plotted at the average BAC for this category).

Refusal to Participate in the Control Group

The refusal rate was 4.4 per cent (55 drivers refused to cooperate out of the 1251 who were approached). There were some indications that those drivers who refused were more likely to have been drinking than were those who cooperated. The subjective assessments made by the team members of whether or not a driver appeared to have been drinking resulted in an estimate that 2.1 per cent of the cooperating drivers were in that category (the actual figure from the BAC readings was 8.4 per cent), whereas 30.9 per cent of those drivers who refused were thought to have been drinking.

The bias that may have been introduced into the calculation of the accident involvement ratio by these refusals probably was less in practice than is indicated by the above figures. This is because the refusals occurred more often in association with control drivers with positive BACs. For example, the control drivers who were tested only because a previous driver at that site had refused (that is, they replaced the refusal) included an above average percentage who appeared to the team members to have been drinking: 5.5 per cent compared to 1.9 per cent for the other control drivers (the corresponding percentages based on the BAC readings were 14.5 and 8.1).

The net effect of the refusal bias is difficult to quantify with confidence, partly because of the compensating effect noted in the previous paragraph. Nevertheless the following calculation does indicate the need for caution when interpreting the results of this study.

Allowance for Refusal Bias

As noted above, 55 drivers refused to cooperate in the survey and 17 of them appeared to have been drinking. Of the 55 drivers who were selected to replace those who refused only three appeared to the team members to have been drinking. In fact eight of the "replacement" control drivers were found to have been drinking when the BAC readings were examined. On this basis, it could be that as many as 8/3 (17) = 45 of the 55 drivers who refused may have been drinking.[1] Subtracting the eight known drinking drivers in the replacement group from these 45 leaves a total of 37 drivers who may have been drinking but who were not included in the calculation of the risk estimates because they refused to cooperate. The effect that this would have on an estimate of the risk of a drinking driver being involved in an accident is shown in the following calculations based on the data in Table 3.5.

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[1] The relevant values for the terms in Equation A2 of Appendix A were: $Pr(D|\bar{R}) = 17/55$, $Pr(D|\bar{A},R) = 0/47$ and $Pr(D|A,R) = 3/8$

TABLE 3.5: CORRECTION FOR REFUSAL BIAS

BAC	Case drivers	Control drivers: As tested	Control drivers: Adjusted for refusal bias
Zero	240	1096	1059
Positive	59	100	137
Total	299	1196	1196

$$\hat{R} \text{ as tested} = \frac{59}{240} \cdot \frac{1096}{100}$$

$$= 2.69 \qquad (3.1)$$

$$\hat{R} \text{ adjusted} = \frac{59}{240} \cdot \frac{1059}{137}$$

$$= 1.90 \qquad (3.2)$$

From these calculations it is apparent that this adjustment for possible refusal bias has resulted in a reduction of 29 per cent in the accident involvement ratio. In other words, the results of this study may overestimate the magnitude of the association between drinking and the risk of accident involvement.

3.3. DISCUSSION

This study differed from other roadside breath alcohol surveys in that the method used to obtain breath alcohol readings from the control drivers was unobtrusive. Whereas in other studies the control drivers were stopped, usually by a police officer, so that they could be asked to cooperate, in this study they were approached after they had stopped at a red traffic signal and were free to continue on when the signal changed to green. This meant that no special authority was required to conduct the study, apart from the customary notification of the relevant public agencies, including the police.

The disadvantages of this method of investigation were that the members of the research team were at greater risk of being struck by a vehicle than they would have been had they remained at the side of the road, although a police officer would be at risk of such an accident when stopping a car. Fortunately there were no untoward incidents of this type in the study. The lack of time to interview the drivers was a major limiting factor on the use that could be made of the breath alcohol data, as is discussed below.

Comparison with the Results of other Roadside Surveys

The corresponding results from the study conducted in Grand Rapids, Michigan in 1962-63 (Borkenstein, Crowther, Shumate, Ziel and Zylman, 1964) are listed in Table 3.6 and plotted in Figure 3.1.

Apart from the lowest BAC category (0.01 to 0.03) the Adelaide accident involvement index is consistently higher than that for Grand Rapids. This may be due to chance variation but the consistent nature of the difference suggests that this is not an adequate explanation. The possible magnitude of the effect of refusal bias on the Adelaide results is sufficient in itself to account for the observed difference between the two estimates of risk. The fact that the Adelaide case drivers had been involved in accidents to which an ambulance was called, whereas the Grand Rapids study was based on any road accident that was reported to the police, may also have played a role in the production of the observed differences in the risk estimates.

TABLE 3.6: ACCIDENT-INVOLVEMENT RATIOS BASED ON DATA FROM THE GRAND RAPIDS STUDY[1]

BAC	Accident-Involvement Ratio: Lower limit[2]	Estimated value	Upper limit[2]
Zero	-	1.00	-
0.01-0.03	0.79	0.91	1.05
0.04-0.06	1.04	1.20	1.50
0.07-0.09	1.33	1.77	3.13
0.10-0.14	4.10	5.72	7.99
0.15+	10.65	18.46	31.98

Note: [1] From Table 17, Borkenstein et al (1964)
[2] 95 per cent confidence limit

Table 3.7 presents the results of similar calculations based on data from a case-control study conducted in Vermont by Perrine, Waller and Harris (1971). The case BACs were drawn from drivers who had been involved in fatal accidents. The accident-involvement ratios at each BAC interval are higher than those in the Grand Rapids study and, with one exception, in the study that is reported here (referred to below as the "Adelaide" study).

Both the Adelaide and the Grand Rapids studies showed an apparent reduction in the risk of accident involvement for drivers who had a very low BAC, compared to that for drivers with a BAC of zero. Allsop (1966) has shown that in the Grand Rapids study this apparent reduction was an artifact associated with the habitual drinking experience of the driver. He showed that all drivers experienced an increased risk of being involved in an accident as their blood alcohol levels increased, even for very low BACs, and that the rate of increase was greater for drivers who were not experienced or heavy drinkers. Furthermore, experienced drinkers had a lower risk of accident involvement when sober than did infrequent drinkers. This latter result again is probably an artifact arising from an association between the high accident risk levels of young persons who are inexperienced at both driving and drinking. In the Adelaide study we had very detailed information on all of these factors for the case drivers (from the data files of the Adelaide in-depth study) but, for the reason noted above, no information on experiential factors from the controls. Consequently it has not been possible to examine the role of such factors in this study.

The risk of accident involvement at a BAC of 0.05 does not appear to be meaningfully different from that of a sober driver in either study, even though there is a statistically significant increase in risk in the Grand Rapids data. At 0.08 and above the increase in risk is of both practical and statistical significance in both studies.

TABLE 3.7: ACCIDENT-INVOLVEMENT RATIOS BASED ON DATA FROM THE VERMONT STUDY[1]

BAC	Accident-Involvement Ratio		
	Lower limit[2]	Estimated value	Upper limit[2]
< 0.02	-	1.00	-
0.02	0.29	1.26	5.31
0.04-0.06	0.43	1.45	4.84
0.07-0.09	1.72	4.10	9.65
0.10-0.14	9.50	21.47	47.76
0.15+	25.52	54.39	113.96

Notes: [1] Table 6-2, Perrine et al (1971)

[2] 95 per cent confidence limits

4. RELEVANCE TO POSSIBLE COUNTERMEASURES

The results from this project have presented, for the first time in Australia, the distribution of drinking drivers by blood alcohol concentration (BAC), time of day and day of week as well as by age group and sex. The case-control study has quantified the association between a driver's BAC and the risk of involvement in a casualty accident, again for the first time in Australia.

4.1 REDUCTION OF THE FREQUENCY OF DRIVING WHEN INTOXICATED

Legal Blood Alcohol Limits for Drivers

The legal limit for a driver's blood alcohol concentration in South Australia is 0.08. The determination of the legal limit is, properly, a political decision but it can be noted that no evidence has been produced by this project that would provide strong support for a change in the 0.08 limit.

The apparent slight reduction in the risk of accident involvement at very low BACs (Figure 3.1) is similar to that recorded in the Grand Rapids study (Borkenstein et al, 1964). As noted in the discussion of Figure 3.1, Allsop (1966) has shown that this reduction is apparent rather than real. For all drivers in the Grand Rapids study the risk of accident involvement increased with increasing BAC, the rate of increase in risk being greater for inexperienced than for experienced drinkers, but experienced drinkers had a lower accident risk when sober, probably because they were an older group. This suggests that it may be worthwhile to conduct a trial of a lower legal BAC limit for young or newly-licensed drivers on the assumption that they are likely to be inexperienced drinkers. The potential value of such a measure may be able to be determined by further evaluation (see: Drew, 1976) of the Tasmanian law which declares it to be an offence for a first year driver to drive with a positive BAC (Road Safety (Alcohol and Drugs) Act 1970 s.19B).

Detection of Drivers having Illegal BACs

There are at least four reasons to try to detect drivers who have a BAC above the legal limit:

(1) To obtain evidence that an offence has been committed,

(2) To remove the offending driver from the road while he is intoxicated,

(3) To deter drivers from operating with a BAC above the legal limit, and

(4) To determine the frequency with which persons drink and drive.

Information on a driver's BAC may also be used in sentencing, in the processing of insurance claims and, rarely, in the treatment of any injuries sustained in an accident.

Testing Methods:

The various methods available for estimating a driver's BAC are discussed in Report No.4 of the Law Reform Commission (1976). In South Australia a screening breath test may be administered, using the Alcotest device, followed by a Breathalyzer test if the result of the screening test suggests that the BAC may be above 0.08. A blood test is required of any person, over the age of 13 years, who is treated at a major hospital for injuries sustained in a road accident. Various aspects of these procedures are discussed below under the heading "Implementation of Testing".

Testing Procedures: Random and Prior Cause Testing of BAC:

As has been noted often (e.g.: Law Reform Commission, 1976) there is no agreed definition of random testing. However the term generally refers to the police being empowered to require a driver to submit to a breath or blood alcohol test without first having any reason to suspect that he may have been drinking.

The alternative to "random" testing is for the police to be empowered to require a breath or blood test if they have some cause to suspect that a driver might have alcohol in his blood or be affected by alcohol. The definition of "cause" in this context varies from one jurisdiction to another. In South Australia recent legislation has specified involvement in an accident or the commission of any moving violation as sufficient cause (in addition to requiring a blood test if treated at a hospital). A comparison of these definitions both within Australia and internationally is contained in the Law Reform Commission report (1976). Perhaps the simplest requirement is the one recommended by that Commission, and in operation in England. It specifies that the suspicion of the presence of alcohol in the blood is sufficient cause for a police officer to require a driver to submit to a screening breath test.

Random testing, as defined above, is used in Belgium, the Netherlands and Sweden (Law Reform Commission, 1976), and in Australia in Victoria (e.g.: Cameron, Strang and Vulcan, 1980) and the Northern Territory.

Implementation of Testing:

In practice the South Australian BAC testing procedure is weighted against the injured driver who is treated at a major hospital after being injured in a road accident.[1] As noted above, the attending medical officer is required by law to take a sample of the driver's blood which is then analysed to determine the BAC. Should this procedure be considered to be likely to endanger the

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[1] The relevant South Australian legislation is contained in Section 47 of the Road Traffic Act 1961-1979.

patient it need not be performed, but this happens rarely in the major metropolitan hospitals (Samples were taken from 118 of 120 drivers in the Adelaide in-depth study : see McLean, Aust, Brewer and Sandow, 1980).

By comparison, the investigating police officer may (not "shall") require a driver who has been involved in an accident to submit to a screening test (again, with the proviso that it is not likely to be injurious). In the Adelaide in-depth study only 17 of the 275 accident-involved drivers who were not conveyed to hospital were asked by the police officer to take a screening test whereas the research teams, operating independently from the police, tested 215 of these drivers. There were 23 drivers with a BAC $>$ 0.08, eleven of whom were detected by the police (the BACs of those who were not detected ranged from 0.09 to 0.23).

Had the police tested all of the drivers who remained at the scene of the accident 8.4 per cent of the tests would have given a BAC estimate above 0.08. As it was, 64.7 per cent of the 17 drivers who were tested by the police were in that category. The blood samples taken in the hospitals were found to have BACs above 0.08 in 17.8 per cent of the cases.

Other requirements may also result in a driver with a BAC above 0.08 being more likely to be apprehended if he is taken to a major hospital for medical treatment. A breath test administered by the police must be performed within two hours of the accident but a blood sample can be taken in a hospital up to eight hours after the accident. The BAC based on analysis of this sample is used as evidence for prosecution by the police, despite Section 47(b)(2) of the Road Traffic Act which states that the driver's blood alcohol concentration is to be established "at any time within two hours after that offence (of driving with an illegal BAC) is alleged to have been committed." (words in parentheses added).

It is obvious that if a driver has an illegal BAC at some considerable time, say six hours, after the accident then it is virtually certain that his BAC at the time of the accident was well above the legal limit. But this difference, in practice, between the two hours permitted for breath testing and eight hours for obtaining a blood sample can be important if a driver leaves the scene of an accident (other than to go to hospital for treatment) before the arrival of the police. Even if the driver can readily be traced, such as by returning to his home, the two hour period may not be long enough for the police to make contact with him and to conduct a screening test followed, if necessary, by a Breathalyzer test. In Norway the law provides that a driver should not consume alcohol or drugs within six hours of driving if he understands or should understand that police investigations might be carried out due to his driving (Law Reform Commission, 1976, para.96). There may be value in the introduction of a similar clause into the relevant legislation in South Australia, together with an extension of the time available to the police to conduct a test.

It also seems to be reasonable to require an uninjured driver who has been involved in an accident in which someone has been injured to remain at the scene until the police arrive, or to otherwise make himself available for a screening breath test. Such a procedure is not at present practicable for drivers involved in less severe accidents because the police are rarely in attendance.

It is clear from the results quoted above from the in-depth study (which was based on a ten per cent representative sample of accidents to which an ambulance was called) that screening tests applied to all drivers involved in accidents that are attended by police may yield no more than one illegal BAC out of ten tests. Nevertheless, this should not be used to justify selective testing of only a small fraction of these drivers. There are two reasons for this. The first is that it seems to be desirable to avoid, as far as possible, placing the police officer in a situation in which his action, or decision not to act, determines whether or not a person is at risk of being charged with an offence that may lead to a term of imprisonment (apart from the very rare cases in which a breath test might be injurious). The second reason is that the police report is the basic source of routinely recorded information on road accidents. As noted above, either police attendance at the accident site, or the admission of an injured driver to a hospital for treatment, is necessary for the presence of alcohol to be detected and recorded. Bias due to variations in the rate of police attendance can be allowed for to some extent when working with the data contained in the police accident report form but there is no way to allow for variations in the rate of application of screening tests when the police are in attendance.

If these two reasons are accepted as sufficient justification to require the universal screening of accident-involved drivers then the police officer would not have to rely on his subjective assessment of whether a driver has been drinking when deciding whether or not to conduct a screening test. Subjective assessment can be unreliable as a means of detecting drivers having a BAC above 0.08, as shown by the fact that only half of the drivers who were above 0.08 in the survey of the BACs of the general driving population were thought by the investigators to have been drinking (Table 2.6) and by the low percentage of drivers above 0.08 who were tested by the police in the Adelaide in-depth study (see earlier in this Section).

The discussion thus far has dealt with the implementation of screening tests following an accident but the arguments for universal testing of accident-involved drivers apply equally to drivers who are charged with a moving violation. As far as possible the decision to administer a screening test should be determined by legislation rather than by the police officer's subjective assessment.

This does not mean that there is no merit in the recommendation of the Law Reform Commission that the police be empowered to require a driver, or person in charge of a motor vehicle, to submit to a screening test if "they have reasonable cause to suspect that such persons have alcohol in the body" (para.264). The Commission also states that "It is unacceptable that the police should be powerless to intervene in the case of an obviously intoxicated person attempting to start his car in a hotel car park" (para.318). There may, of course, be great differences in the degree of impairment consequent on "having alcohol in the blood" and being "obviously intoxicated". But the subjective assessment of intoxication is an even worse guide to the presence of an illegal blood alcohol level (identifying only 16.7 per cent of those above 0.08 in Table 2.6) than is the subjective assessment of whether or not a person has been drinking (50 per cent). Therefore if the police were to be given the authority to test an "obviously intoxicated" driver there is evidence to support an extension of that authority to include the testing of a driver who is reasonably suspected of having alcohol in his body. If it can be assumed that most persons who leave a hotel bar are in this category then the data in Table 2.6 suggest that screening on this basis alone might result in about one test in four (23.4 per cent) yielding a result above 0.08 (based on all positive BACs).

The regulation of such wide-ranging powers may well prove to be a straightforward matter, but it is fraught with many more potential problems than the testing of drivers who come to the attention of the police because they have committed a moving violation or been involved in an accident. Even so, it does seem to be unreasonable to require the police to either ignore an obviously intoxicated person as he enters a car and drives off or to follow his car in the expectation that he might commit a moving violation or be involved in an accident. In such a situation the prime concern should be to protect the driver and his passengers, if any, from a presumably well above average risk of being involved in an accident and hence of being injured.

Therefore it is suggested that consideration be given to listing a different procedure for the police to follow with a person who is in charge of a motor vehicle when having a BAC above 0.08 if the offence is detected in this way, without the driver first coming to the attention of the police by breaking one of the stipulated traffic laws or by being involved in an accident. An appropriate procedure might be to detain the driver, or in some other way prevent him from driving, until such time as his BAC has diminished to a safe level. Similar reasoning might well be used to justify the detention of pedestrians who are obviously intoxicated.

Whatever authority is assigned to the police in this regard a decision must still be made as to how best to deploy their resources on a geographical as well as on a temporal basis. It is not uncommon for certain regions of a city to be regarded as being worse than others as far as the incidence of drinking and driving is concerned but this information often comes from the results of police testing and may, at least in part, reflect earlier decisions on the deployment of police traffic units. The data in Table 2.5 suggest that there were minor differences in the percentage of drivers above 0.08 in the four listed regions of metropolitan Adelaide (although these differences could have arisen by chance, the generally higher social status south-eastern region had a higher percentage than the industrialised north-western region).

Recording the Results of BAC Tests

Even with the present selective BAC testing by the police in South Australia the BAC information recorded on the police accident report form is of value. Nevertheless there are three ways in which this recorded information might be made more useful for research, and thereby prevention, purposes.

The first of these would involve a change from selective to mandatory breath testing by the police, as discussed earlier in this Section. The criteria for requiring a driver to submit to a screening test would then be more clearly defined and this in turn would greatly facilitate the accurate interpretation of the recorded BAC data.

Because the result of a screening test is not quantifiable other than as positive or negative when an Alcotest device is used there is rarely any information recorded on BAC levels below 0.08. If an alternative screening device were used, such as the Alcolmeter P.S.T., which gives a reading of the estimated BAC, then it would be possible to record BAC readings from screening tests, many of which would be below 0.08, as well as readings from Breathalyzer or blood tests. The Alcolmeter P.S.T. does have the disadvantage of having to be calibrated frequently, whereas the Alcotest does not (being a disposable unit) but the more detailed information that is provided by the Alcolmeter may be thought to at least compensate for this disadvantage. Should the recording of BAC readings from screening tests become practicable it would be desirable also for the means by which the reading was obtained to be recorded (e.g.: Alcolmeter, Breathalyzer or blood test).

Finally, with the present stipulation in South Australia that a blood sample shall be taken from an injured driver at any time within eight hours of the time of occurrence of the accident it would be valuable to have recorded, together with the BAC reading, the time at which the blood sample was taken. If this were to become common practice it would be worthwhile to include in the record the time at which a Breathalyzer test was conducted, although the two-hour time limit means that the test BAC reading is unlikely to differ from the driver's BAC at the time of the accident by much more than a reduction of 0.03.

Effectiveness of Testing

There are three main criteria that can be used when assessing the effectiveness of a blood alcohol testing program. They are: changes in the proportion of drivers who have been drinking and in their BACs; changes in the accident rate; and changes in the casualty (death and/or injury) rate. The last two criteria are the ones of ultimate concern but unless information is also available on any changes in the pattern of drinking and driving it may be difficult to demonstrate conclusively that, say, a reduction in the fatality rate following the introduction of a new or modified BAC testing program was in fact due to the introduction of that program and not to other factors.

Measurement of the BACs of the general driving population for this purpose should include a record of, at least, the approximate age and sex of each driver tested. This will enable some allowance to be made for the possibility that the testing program might have more effect on one age group than on another. Klette (1977) has noted that "While the Swedish approach seems to have been relatively effective in relation to drivers in general, who usually seem to be able to separate drinking from driving, it appears to have failed with the young drivers and the ones with alcohol problems."

The effectiveness of any intervention program is also likely to vary with time. For example, the introduction of the Breathalyzer legislation in the United Kingdom in 1967 was followed by a marked reduction in alcohol-related accidents but this effect lasted for only three years (Ross, 1975). While some reduction is better than none, a program having more lasting effectiveness is obviously to be preferred.

The value of random testing has been queried because of the absence of any demonstrable long-term effectiveness (Law Reform Commission, 1976). But it is not clear that any form of BAC testing, whether it be random or otherwise, has been effective in producing a lasting reduction in the rate of occurrence of alcohol-related accidents. As Harvard (1977) has noted, this lack of understanding derives largely from an absence of data on the distribution of alcohol in the driving population. In this respect the results presented in Section 2 of this report do provide the necessary basis for an evaluation of the effectiveness of any changes to the drink-driving legislation in South Australia.

Road Safety Education

In the Adelaide in-depth accident study at least 40 per cent of the 70 drivers[1] who had positive BACs thought that their driving performance suffered negligible or no impairment after they had consumed quantities ranging from ten to 20 glasses of some alcoholic beverage (McLean et al, 1980). Ryan and Salter (1977) reported a similar result from a study of a sample of drivers who were admitted to hospital for treatment of injuries sustained in road accidents in Melbourne. Henderson and Freedman (1977) in commenting on the

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[1] The 59 case drivers in Section 3 were selected from this group of 70 drivers.

findings from a survey of attitudes to drinking and driving in Sydney (Freedman, Henderson and Wood, 1973) have noted that "One important influence on social attitudes to drinking and driving is ignorance of the scientific facts on alcohol and driving impairment."

Even a driver who does realize that driving with an elevated BAC places him at an above-average risk of being involved in an accident rarely has any direct means of accurately estimating his blood alcohol level. The most frequent comment made by the drinking drivers who were breath-tested in the roadside surveys in this project was that they had never before had the opportunity to have their BACs measured. In the absence of a reasonably accurate and inexpensive breath-alcohol meter a driver can only estimate his BAC in terms of the number of drinks he consumes and the duration of the drinking session. Keeping count of the number of drinks can be impractical in some situations but the wide dissemination of the information needed to estimate one's BAC in this way is to be strongly recommended.

In addition to this basic information relating the rate of alcohol consumption to a person's blood alcohol concentration there may be value in emphasising that the rate of increase in the risk of accident involvement varies with the BAC level and with certain driver characteristics. Because of this latter factor the curve relating accident risk to BAC in Figure 3.1 can be misleading.

As Hurst (1973) has noted, a curve such as this presents average results based on those who drive at the listed BACs. Consequently, even at low BACs, the curve in Figure 3.1 under-estimates the rate at which the risk of accident involvement increases with increasing BAC for an inexperienced drinker, as noted in the discussion of the results of Section 3. Hurst (1973) presents a graph based on the Grand Rapids data (Borkenstein et al, 1964) that indicates that as the BAC increases from 0.02 to 0.06 an experienced drinker's accident risk shows only a negligible increase whereas the risk for an inexperienced drinker may be increased six-fold. At much higher blood alcohol levels the curve in Figure 3.1 more accurately represents the accident risk of experienced drinkers, simply because they comprised a higher proportion of the case drivers at those BACs.

For all drivers the risk of accident involvement increases more and more rapidly as the actual BAC increases. This means that the last drink in a drinking session is likely to result in a disproportionate increase in a driver's accident risk.
Referring to Figure 3.1, it can be seen that if a driver has a BAC of 0.12 one more drink will increase his risk of being involved in an accident by as much as, say, half of all of the drinks consumed earlier in that session. Any countermeasure that reduces the frequency with which intoxicated drivers have "just one more drink", or discourages hosts from urging their guests to have "one for the road", may prove to contribute to a reduction in the frequency of alcohol-related accidents.

Much of the driving with elevated blood alcohol levels is done late at night, as is well known (and quantified by the results presented in Section 2). This suggests that there may be some benefit in ensuring that there is an efficient public transport service available at those times at which many drinkers are returning home. Such a service may not be widely used by persons who have driven to their place of drinking but it would make it practicable to encourage drinkers to leave their cars at home. West and Hore (1980) have suggested that the slogan "Don't drink and drive" should be changed to "Don't drive to drink" because "the temporal sequence of the (latter) message would have two effects 1) it would remove the element of choice (of whether to drive after drinking) and 2) prevent alcohol from having any influence on the driver's risk-taking behaviour." (entries in parenthesis added).

In this discussion of needs that might be met by appropriate road safety education or propaganda there has been little reference to the means by which drivers might be encouraged to act on such information. The sole comment on this ultimately important aspect is left to Chapman and Rubenstein (1977) who have noted that "planned strategies for public information and expectations about self-regulation are based on the assumption that knowledge is causally and importantly related to behaviour. It seems that in this respect, addiction workers have learnt little from the failure of the information-based illicit drug education campaigns of the late 1960s". Chapman and Rubenstein recommend that "health and traffic authorities" should "have a good look at all the various emotional desires or needs of people that are given expression in drinking behaviour and in drinking and driving behaviour. They should accept that these desires are real and activating first, and bad/unhealthy second. The debate that distinguishes between needs and wants and concludes that wants are somehow lesser is an example of the unreal helper mentality at its worst."

4.2 REDUCTION OF THE FREQUENCY AND SEVERITY OF ALCOHOL-RELATED ACCIDENTS

Road User Behaviour

The preceding discussion has been concentrated on ways in which drivers might be dissuaded from driving when intoxicated, with brief mention of possible police action to detain obviously-intoxicated road users. Whereas the aim of those measures was to reduce the frequency of alcohol-related accidents, the reduction of the severity of the accidents of that type that do occur may be able to be achieved by influencing the behaviour of the occupants of the vehicle, as well as that of the driver.

For example, the number of persons injured in alcohol-involved crashes may be reduced by publicity aimed at making it more socially acceptable to refuse to travel with an intoxicated driver.
The intoxicated driver is a greater danger to both himself and his passengers than he is to other road users (because of the light traffic conditions late at night, when a relatively high proportion

of drivers are intoxicated, they are particularly likely to be involved in single vehicle crashes). By reducing the occupancy of vehicles driven by intoxicated drivers the number of persons at risk of injury decreases.

4.3 FINDING MEASURES THAT WORK

The survey of breath alcohol levels of drivers was not the first to have been conducted in Australia. The results of police Breathalyzer tests and analyses of blood samples have been reported on many occasions (see: Bibliography, Law Reform Commission, 1976) and a survey to assess the effect of the introduction of breath-testing legislation has been conducted in Canberra (Duncan, 1976). But even such basic information as the way in which drinking and driving in Australia varies by time of day and day of week was not available from those investigations. It is presented for the first time in Section 2 of this report.

The investigation of the association between drivers' BACs and the risk of accident involvement (reported in Section 3) had never been attempted before in Australia. It is one of only a dozen such studies conducted anywhere in the world and the only one to have been carried out without involving the police.

The experience gained in the Adelaide in-depth accident study has facilitated the interpretation of the results of this project, even though it has led us to question the validity of some of the assumptions on which existing countermeasures are based.

There are few unequivocal results available on the effectiveness, let alone the cost-effectiveness, of current programs aimed at controlling the drink-driving problem. This conclusion applies to the whole range of countermeasures, from breath tests through to the penalties prescribed for drink-driving offences. But this does not mean that new approaches should not be tried until they have first been shown to be effective. What it does mean is that both new approaches and existing programs should be evaluated to find out if they are worthwhile. If we then retain the measures that work, and abandon those that do not, we have some hope of controlling this "cruel and intractible" problem.[1]

[1] Quote from Mr. Justice Kirby's foreword to the report of the Law Reform Commission.

5. RECOMMENDATIONS

Method of Investigation

The method of investigation described in Section 2 proved to be a satisfactory way to obtain BAC readings of drivers. It does have some limitations however, including those noted in Section 2.3. Therefore it is recommended that: *This method of roadside breath testing be assessed for use in rural areas at low traffic volume STOP sign controlled intersections*, and that: *A trial be conducted of ways to obtain additional information, such as age and drinking experience, from the drivers who are tested in this type of roadside survey.*

Drink-Driving Legislation and Enforcement

The results of the survey of BAC levels in the general driving population and of the study of the association between a driver's BAC and his risk of accident involvement are relevant to legislation aimed at controlling the problems associated with drinking and driving. The following recommendations relate specifically to the existing South Australian legislation but the reasons underlying them may be considered to have wider relevance.

As noted in Section 4, no evidence has been produced by this project that would provide strong support for a change in the existing 0.08 legal limit. It is therefore recommended that: *The legal BAC limit of 0.08 for motor vehicle operators be retained.* However, analyses of similar work have shown that the risk of accident involvement at a given BAC is influenced by other factors (Allsop, 1966, and Hurst, 1973). Consequently: *Consideration should be given to the introduction on a trial basis of a lower legal BAC limit, such as 0.04, for motor vehicle operators who are under 19 years of age.* (The legal drinking age in South Australia is 18 and a person can obtain a driver's licence at 16 years of age.)

Certain matters relating to the enforcement of the existing legislation by the police have been questioned in Section 4. It is recommended that: *The provisions for police enforcement in the existing drink-driving legislation be reviewed.*

Both random testing and testing on the suspicion of the presence of alcohol in the blood have been discussed in Section 4. There may be potential and possibly complementary benefits associated with these two approaches; those associated with the former approach being primarily in the nature of general deterrence whereas the latter approach may be primarily a means of protecting intoxicated road users from the relatively high risk of being

injured while intoxicated. Therefore it is recommended that:
The police be empowered to conduct random breath testing and testing on the suspicion of the presence of alcohol in the blood and that these new procedures be introduced at different times and in such a way that their effectiveness can be evaluated.

Data Collection

The earlier recommendation for the review of the provisions for police enforcement of the existing drink-driving legislation envisaged, inter alia, that the police officer shall be required to administer a screening breath test under those circumstances in which he now may do so. This would have the incidental but important advantage of ensuring the more nearly complete screening of drivers who are involved in accidents or who are charged with moving violations (under the existing legislation). If the screening tests were conducted with a device that gives a BAC reading, such as the Alcolmeter P.S.T., and these readings were recorded then the BAC data from such sources could usefully be compared with the results of BAC surveys of the general driving population. For these reasons it is recommended that:
Consideration be given to requiring police officers to administer screening breath tests to drivers in those circumstances in which they now may do so and to performing the screening test with a device that gives a BAC reading, the results of the test being recorded.

Education

On the basis of the experience gained in conducting this project and in the Adelaide in-depth study it is recommended that: *The information needed to enable a driver to estimate his* BAC *on the basis of his rate of drinking should be disseminated widely, together with information showing that for all drivers the risk of accident-involvement increases with increasing* BAC.

Because the rate of increase in the risk of being involved in an accident increases with increasing BAC: *Road safety educational material should emphasise that one drink "for the road" might well be as potentially hazardous for the driver and his passengers as five or more drinks consumed earlier in the drinking session.*

In order to assist in deterring intoxicated drivers from driving or to reduce the occupancy of their vehicles and thereby reduce the number of road users exposed to the relatively high risk of injury associated with vehicles driven by intoxicated drivers, it is recommended that: *Publicity material be developed with the aim of making it more socially acceptable to refuse to travel with an intoxicated driver.*

Effectiveness of Countermeasures

As noted at the end of Section 4, new countermeasures should not be rejected until they have been shown conclusively to have been effective elsewhere, if only because the value of few of the existing countermeasures is well established. What is important is that: *Both new approaches and existing programs should be evaluated to find out if they are worthwhile. Those that work should be retained and those that do not should be discontinued.*

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APPENDIX A

CORRECTION FOR REFUSAL BIAS

The following method of correcting for refusal bias in roadside breath alcohol surveys was presented by Hurst and Darwin (1977). It is based on the assumption that a given BAC will lead to the same subjective assessment of the drinking status of both a driver who cooperates and one who refuses. This leads directly to the hypothesis that:

$$\Pr(D|A,C) = \Pr(D|A,\overline{C}) \quad \text{and} \quad \Pr(D|\overline{A},C) = \Pr(D|\overline{A},\overline{C}) \quad \ldots \text{(A1)}$$

Where A is the event that the driver had a BAC $\geq$ 0.08 (say),

$\overline{A}$ is the event that the driver's BAC was $<$ 0.08,

D is the event that the driver was assessed as having been drinking,

$\overline{D}$ is the event that the investigator judged that the driver had not been drinking,

C is the event that the driver cooperated with the investigator,

$\overline{C}$ is the event that he refused to cooperate.

Hurst and Darwin (1977) then show that the probability that a driver who refused to cooperate had a BAC$\geq$0.08 is:

$$\Pr(A|\overline{C}) = (\Pr(D|\overline{C}) - \Pr(D|\overline{A},C))/(\Pr(D|A,C) - \Pr(D|\overline{A},C)) \quad \ldots \text{(A2)}$$

Estimates of the probabilities on the right side of equation (A2) can be obtained from Table A1, which is based on the data in Table 2.6.

TABLE A1: BACs AND REFUSALS BY SUBJECTIVE ASSESSMENT OF PRESENCE OF ALCOHOL FOR THE GENERAL POPULATION OF DRIVERS

Cooperated in Testing	BAC Reading	Subjective Assessment Had been drinking: No ($\bar{D}$)	Yes (D)	Total
Yes (C)	$< 0.08(\bar{A})$	2942	53	2995
Yes (C)	$\geq 0.08(A)$	39	39	78
No ($\bar{C}$)	-	234	42	276
Total		3215	134	3349

$$\Pr(D|\bar{C}) = 42/276 = 0.1522$$

$$\Pr(D|\bar{A},C) = 53/2995 = 0.01770$$

$$\Pr(D|A,C) = 39/78 = 0.5000$$

Substituting these values in equation (A2) yields:

$$\Pr(A|\bar{C}) = 0.2789$$

which can be compared with $\Pr(A|C) = 78/3073 = 0.02538$.

This means that the estimated probability of a driver who refused to cooperate having a BAC $\geq$ 0.08 was eleven times (0.2789/0.02538) greater than the corresponding probability for a driver who did cooperate.

The effect that this has on the estimated probability that a driver had a BAC $\geq$ 0.08, after correcting for the refusal bias, is given by equation (A3).

$$\Pr(A) = \Pr(C).\Pr(A|C) + \Pr(\bar{C}).\Pr(A|\bar{C}) \qquad \ldots (A3)$$

From Table A1, $\Pr(C) = 3073/3349 = 0.9176$

and $\Pr(\bar{C}) = 1-\Pr(C) = 0.0824$

Hence $\Pr(A) = 0.0463$.

In other words, after correcting for refusal bias the estimated percentage of the drivers who were approached who had a BAC ≥ 0.08 has increased from 2.5 to 4.6 per cent. If the above calculation is based on drivers who were judged to have been intoxicated rather than on drivers who were assessed as having been drinking then the corrected estimated percentage ≥ 0.08 becomes 5.9 per cent. However this latter corrected estimate is of low precision because it is based on only one driver in the "BAC < 0.08 and assessed to have been intoxicated" category.

APPENDIX B

REFUSAL RATES IN ROADSIDE BREATH-TEST SURVEYS[1]

Author	Per cent refused	Police involved	Location
Holcomb (1938)	1	Yes	Evanston, Illinois
Lucas (1951-52)	NK[2]	NK[2]	Toronto, Ontario
NK[2] (1956-56)	0	Yes	Bratislavia, Czechoslovakia
(1959-60)	0.5	Yes	New York
Borkenstein (1962-63)	2	Yes	Grand Rapids
Perrine (1969)	7	Yes	Burlington, Vermont
NK (1969)	0.5	NK	France
NK (1970, 1971)	14, 13	Yes	Netherlands
(1970, 1971)	1	Yes	Oslo, Norway
Transport Canada (1974)	6	Yes	Alberta
Wolfe (1974)	11.8	Yes	US National

Notes: [1] From Carr et al (1974)

[2] Not known (as listed in referenced report).

APPENDIX C

DERIVATION OF WEIGHTING FACTORS FOR TABLE 2.2

TABLE C1: Traffic Flows by Time Period

Time Period	Traffic Flow[1]	Weighting Factor[2]
A	121583	0.136
B	21651	0.024
C	203538	0.228
D	51847	0.058
E	45320	0.051
F	147613	0.166
G	106053	0.119
H	95032	0.107
I	47697	0.054
J	50725	0.057
Total	891059	1.000

Notes: [1] Total for five sites around the sampling area (Source: Highways Department of South Australia.)

[2] Traffic flow for each time period divided by the total traffic flow.

The derivation of weighting factors for other time of day/day of week groupings is complicated by the fact that the time of week periods chosen (A through J) extend over more than one day, etc. However traffic flows by day of week are relatively constant, ranging from a totalof 121231 vehicles on Sundays to 137183 vehicles on Fridays for the same five sites as in Table C1.